PACKAGE OF PRACTICES FOR THE CROPS OF PUNJAB

Kharif 2014

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The Package of Practices for the Crops of Punjab *Kharif* 2014 contains the latest recommendations and readily-usable information provided by the specialists of various departments of PAU through the coordination of the Director of Research. These improved farming techniques for stepping up productivity of cereals, pulses, cotton, sugarcane, oilseeds, fodders and some other crops in Punjab have been discussed and finalised in the Research and Extension Specialists Workshop held on 24-25 February, 2014. It is purposely written in a simple and easy-to-understand language because these recommendations are intended for the use of the field level extension workers and the farmers of Punjab.

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CONTENTS

CAUTION

Chemicals used to control insects, diseases and weeds are poisons for human beings. Farmers are cautioned to use these poisons carefully to avoid any effect on human health. For safe use of these chemicals see Annexure VI given at the end of this book.

Note :

1. For proper presentation of information on pesticides, fungicides, etc., it is sometimes necessary to use the trade name of the product or equipment. No endorsement of the named product or equipment is intended nor criticism implied of a similar product or equipment not mentioned in this book.
2. Volume of spray material to be used for controlling different insects and diseases of various crops is based on the usage of shoulder-mounted knapsack sprayer having "fixed type hollow cone nozzle." Spray volume may vary when other types of sprayers/nozzles are used for this purpose.
3. It should, however, be ensured that the actual amount of insecticides recommended in the "Package of Practices" should not be reduced. For proper control of weeds, it is always necessary to use flood jet or flat fan spray nozzles.
4. The use of endosulfan 35 EC is not recommended till the decision of Hon'ble Apex Court.

List of Pesticides Restricted or Banned in the Country

a. Pesticides restricted for use

1.	Aluminium phosphide	It is to be sold only to government undertakings/ organisations and to be used under strict supervision of government experts or Pest Control Operators.
2.	DDT	Restricted for use in public health only.
3.	MEMC (methoxyethyl mercuric chloride)	–
4.	Methyl bromide	Restriction for its sale and use is similar to that of Aluminium phosphide.
5.	Sodium cyanide	Use of sodium cyanide shall be restricted for fumigation of cotton bales by Plant Protection Advisor to the Govt. of India.
6.	Lindane	Use of Lindane formulations generating smoke for indoor use is prohibited in India. It can be used for control of insect pests of field crops.
7.	Methyl parathion	Use is permitted only on those crops where honey bees are not acting as pollinators.
8.	Monocrotophos	Banned for use in vegetables
9.	Fenthion	Banned for use in Agriculture except for locust control.

b. Pesticides banned for use in agriculture in India

S. No.	*Name of Pesticide*	*S. No.*	*Name of Pesticide*
1.	Aldicarb	16.	Heptachlor
2.	Aldrin	17.	Maleic Hydrazide
3.	BHC (HCH)	18.	Menazon
4.	Calcium cyanide	19.	Nichotine sulphate
5.	Captafol	20.	Nitrofen
6.	Chlorobenzilate	21.	Paraquat-di-methyl sulphate
7.	Chlordane	22.	Pentachloro Nitrobenzene (PCNB)
8.	Copper acetoarsenite	23.	Pentachlorphenol (PCP)
9.	Dibromochloropropane (DBCP)	24.	Phenyl mercury acetate (PMA)
10.	DDT	25.	Sodium methane arsonate
11	Dieldrin	26.	TCA (Trichloro acetic acid
12	Endrin	27.	Tetradifon
13	Ethylene dibromide	28.	Toxaphene
14.	Ethyl mercury chloride	29.	Metoxuron
15.	Ethyl parathion	30.	Chlorofenvinphos

c. Pesticide formulations banned for use

1. Carbofuran 50% SP
2. Methomyl 24% L
3. Methomyl 12.5% L
4. Phosphamidan 85% L

IMPORTANT NOTICE

The information on performance of recommendations given in this book holds good only when used under optimum conditions. Their performance may either change in due course of time due to several factors or can vary under different systems of management. Mishandling/negligence of the user can also result in damage/ loss/non-reproducibility of result.

All disputes are subject to Ludhiana Jurisdiction only.

1. CEREALS

RICE

Rice occupied 28.45 lakh hectares with total production of 113.74 lakh tonnes during 2012-2013. The average grain yield of rice was 39.98 q per hectare (16.0 q per acre). The average yield in terms of paddy in Punjab was 24.0 quintal per acre.

Important Points :

* Use laser land leveler for precision land leveling before puddling to enhance on farm water use efficiency and other farm inputs. (Appendix III).
* Restrict to timely sowing of nursery (Second fortnight of May) and timely transplanting schedule (Second fortnight ofJune) for better grain quality, water saving and low build up of stem borers.
* Use nitrogen judiciously based on Leaf colour chart (LCC). Excessive use of nitrogen fertilizer encourage multiplication of insect pests particularly whitebacked plant hopper in PR 114 and false smut disease in PR 116.
* To control brown leaf spot, sheath blight, sheath rot, false smut, kernel smut and white backed plant hopper, give recommended chemical sprays at right stage (see Plant Protection). For the management of bacterial leaf blight, grow Rice varieties PR 123, PR 122, PR 121, PR 115, PR 113 and PR 111 which are resistant to most of the pathotypes of bacterial leaf blight pathogen or PR-118, PR-116 and PR-114 which are resistant to some of the pathotypes of bacterial leaf blight pathogen.
* To save water, plant early maturing variety PR 115.
* Stop irrigation about a fortnight before maturity.
* Avoid transplating paddy in poor sandy soil.
* Harvesting should be done strictly at proper maturity and varietywise. Manual threshing may be encouraged for better quality.
* Plant hoppers feed at the base of rice plants and are often overlooked. Their damage is noticed only when the crop is hopper burnt. Hence regular monitoring of insect population is necessary.
* Use of synthetic pyrethroids leads to increase in the population of plant hoppers. Hence these insecticides should not be used for the control of rice insect-pests.

Climatic Requirements :

Rice is best suited to regions of high temperature, high humidity, prolonged sunshine and assured water-supply. A temperature range of 20 to 37.5°C is required for its optimum growth. The

crop requires a higher temperature at tillering than that during early growth. The temperature requirement for blossoming ranges between 26.5 and 29.5°C. The humidity needs vary according to the variety. For early types, the favourable range of humidity is 83 to 85 per cent and for the late ones, it is 67 to 68 per cent. In Punjab, the rice season extends from May to November.

Soil Type :

Rice can grow well on soils with low permeability and over a wide range of soil reaction viz. pH 5 to 9. Generally, the loamy soils are the best for rice cultivation.

Rotations :

Rice-Wheat/Berseem/Linseed/Gram/Barley/Winter Maize, Rice-Wheat-Sathi Maize/Summer Moong/Green manuring, Rice-Celery (Khurasani ajwain), Rice-Potato/Peas-Celery, Rice-Potato-Potato/Sathi Maize/Summer Moong/Sunflower/Celery/Wheat/Cucurbits,* Rice-Toria-Sunflower, *Rice-Gram-Summer Moong, Rice-Gobhi Sarson-Summer Moong*

Improved Varieties :

PR 123 (Subject to the approval by SVAC) : It is a semi dwarf, stiff-strawed lodging tolerant variety with dark green and erect leaves. Its' average plant height is 105 cm and matures in about 143 days after seeding. It possesses long slender, clear translucent grains with excellent cooking and eating quality characteristics. It is resistant/moderatly resistant to the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab State. Its average paddy yield is 29.0 quintals per acre.

PR 122 (2013) : It is a semi-dwarf, stiff strawed variety having dark green erect leaves. Its average plant height is 108 cm. It matures in 147 days after seeding. It possesses long slender translucent grains with good cooking quality. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab State. Its average paddy yield is 31.5 quintals per acre.

PR 121 (2013) : It is a short statured, stiff strawed lodging tolerant variety with dark green and erect leaves. It attains an height of about 98 cm. It matures in 140 days after seeding. Its grains are long slender, translucent with good cooking quality. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab State. Its average paddy yield is 30.5 quintals per acre.

PR 118 (2003) ***:*** It is a semi-dwarf, stiff strawed and lodging tolerant variety. It has dark green, erect leaves. Its average plant height is 104 cm. It matures in about 158 days after seeding. Its grains are medium slender with good cooking quality. It is resistant to some of the pathotypes of bacterial blight pathogen prevalent in Punjab. Its average yield is 29 quintals per acre.

PR 116 (2000) ***:*** It is a semi-dwarf, stiff strawed, lodging tolerant variety. It has light green erect leaves. It grows on an average 108 cm tall. It matures in about 144 days after seeding. It possesses long slender translucent grains with very good cooking quality. It is resistant to some of the pathotypes of bacterial blight pathogen, prevalent in Punjab. Its average yield is 28 quintals per acre.

PR 114 (1999) ***:*** It is semi-dwarf, stiff strawed variety having narrow, dark green erect leaves. It attains an average height of about 102 cm. It matures in about 145 days after seeding. It possesses extra long, clear translucent grains with very good cooking quality. It is resistant to some of the

pathotypes of bacterial blight pathogen prevalent in Punjab. Its average yield is 27.5 quintals of paddy per acre.

PR 111 (1994) ***:*** It is a short statured and stiff strawed variety having erect leaves. Its average plant height is about 97 cm. It matures in about 138 days after seeding. Its grains are long, slender and clear with very good cooking quality. It is resistant to most of the pathotypes of bacterial blight pathogen prevalent in Punjab. Its average yield is 27 quintals per acre.

PR 115 (2000) ***:*** It is short-statured stiff strawed variety with dark green erect leaves. Its average plant height is about 100 cm. It has long erect flag leaf which provides protection against birds damage. Its grains are long slender, translucent with good cooking quality. It matures in about 125 days after seeding. It is resistant to most of the pathotypes of bacterial blight prevalent in Punjab. Its average yield is 25 quintals of paddy per acre.

PR 113 (1998) : It is short-statured, stiff strawed variety having dark green erect leaves. Its average plant height is about 105 cm. Its grains are bold and heavy. It matures in about 142 days after seeding. It is resistant to most of the pathotypes of bacterial leaf blight pathogen prevalent in Punjab State. Its average paddy yield is 28.0 quintals per acre.

Other varieties

Pusa 44 : It is a long duration variety and is **susceptible to all the prevalent pathotypes of bacterial blight in the state.**

HKR 47 : It is of medium duration variety. It is **susceptible to all the prevalent pathotypes of bacterial blight in the state. It is prone to lodging.**

HKR 127 : It is a medium duration variety and **susceptible to most of the prevalent pathotypes of bacterial blight in the state.**

Agronomic Practices :

Application of farmyard manure/poultry manure/press mud/green manure : Apply six tonnes of farmyard manure per acre and save 16 kg of N (35 kg of urea). Since farmyard manure is not available in needed quantities, green manuring by *dhaincha*/cowpea/sunhemp is a very practicable alternative.

After harvesting wheat or any other preceding crop, apply *rauni* and sow 20 kg *dhaincha* seed presoaked in water for 8 hours or 12 kg/acre of cowpea (20 kg if bold seed is used) or 20 kg/acre of sunhemp up to the first week of May. Apply 75 kg superphosphate per acre to *dhaincha*/cowpea/ sunnhemp in soils testing low in P and omit application of phosphorus to the succeeding rice crop. Burry 6 to 8 weeks old *dhaincha*/cowpea/sunhemp one day before transplanting of paddy. *Dhaincha* should be prefered in *kallar* and recently reclaimed soils. This practice results in a saving of 25 kg of N (55 kg urea) per acre.

To get higher yield practise green manuring and apply recommended dose of nitrogen (50 kg N/acre) to rice grown in loamy sand to sandy loam soils. Green manuring with dhaincha also ameliorates iron deficiency in rice. Apply six tonnes of pressmud or 2.5 tonnes of poultry manure per acre to rice and reduce the fertilizer N dose by half and omit the application of fertilizer P to rice even on soils testing low in available P.

Land Preparation : (i) Repair all bunds. Obtain a fine well levelled puddled field to reduce water loss through percolation, to maintain good seedling vigour and to control weeds.

(ii) Use laser land leveler for precision land leveling before puddling to enhance on farm water use efficiency and other farm inputs.

Seed Rate and Seed Treatment : Dip the seed in suitable lots in water contained in a tub/ bucket. Stir the seed and remove immature grains which float at the top. The heavy seeds will settle down at the bottom. Eight kg of heavy seed is sufficient for transplanting an acre. Heavy seed ensures healthy, sturdy and uniform seedlings. Soak the selected seed in 10 litres of water containing 20 g Bavistin 50 WP (carbendazim) and 1g Streptocycline* (streptomycin + tetracycline) for 8 to 10 hours before sowing.

Nursery Raising : The time and method of sowing are important for getting healthy seedlings.

(i) Time of Nursery Sowing : 15th to 30th May is the optimum time of sowing for all the recommended varieties.

(ii) Land Preparation, Fertilizers and Method of Sowing : Mix 12 to 15 tonnes of well-rotten farmyard manure or compost per acre in the soil. Irrigate the field to permit the germination of weeds. Plough the field twice after about a week to kill germinated weeds. Thereafter at the time of nursery sowing, flood the field and puddle it well. Bullock drawn and tractor-drawn puddling implements are available for this purpose (Annexure III).

Apply 26 kg urea and 60 kg single superphosphate per acre to the soil at the last puddling. For raising healthy seedlings broadcast @ 40 kg/acre zinc sulphate heptahydrate (21% Zn) or 25.5 kg zinc sulphate monohydrate (33% Zn) per acre to nursery. Prepare plots measuring 10m x 2m or of any other convenient size.

Pre-germinate the wet, treated seeds by spreading them uniformly, 7-8 cm thick, over wet gunny bags and cover them with wet gunny bags. Keep the layer of seeds moist by sprinkling water on it periodically. The seeds sprout in about 24 to 36 hours.

Sow the pre-germinated seed @ 1 kg/20 sq. metres by broadcasting. Keep the soil moist by irrigating the plot frequently. To check the damage from birds, broadcast a thin layer of well-decomposed farmyard manure immediately after broadcasting rice seed. Apply another dose of 26 kg urea per acre about a fortnight after sowing so as to get the seedlings ready for transplanting in 25-30 days. However, if a nursery of about 45 days or above is to be transplanted, apply another dose of 26 kg urea after four weeks of sowing. In case, any insect attack or disease appears in the nursery, adopt the recommended plant protection measures.

Irrigate the nursery regularly. The seedlings are ready when they are 20-25 cm tall or with 6 to 7 leaves. If the seedlings in the nursery show the yellowing of new leaves, spray them three times with 0.5-1 per cent ferrous sulphate solution (0.5-1 kg ferrous sulphate dissolved in 100 litres of water per acre) at weekly intervals. If the leaves turn rusty brown after becoming yellow, give a spray

* Chemical belongs to green chemistry category.

of 0.5% zinc sulphate heptahydrate solution (0.5 kg zinc sulphate heptahydrate dissolved in 100 litres of water) or 0.3% zinc sulphate monohydrate solution (0.3 kg zinc sulphate monohydrate dissolved in 100 litres of water per acre).

Caution – ***To avoid the mixing of varieties in the field, do not grow the rice nursery at the site of the last year's threshing.***

(*iii*) *Weed Control :* *Swank* and some other annual grasses are the main problems in rice nursery. These weeds can be controlled by the application of 1200 ml per acre of any of the liquid formulations of Butachlor 50 EC or Thiobencarb 50 EC (See Page 7) mixed with 60 kg of sand after 7 days of broadcasting pre-germinated rice seed. These herbicides can also be applied on a moist soil 3 to 7 days before puddling and broadcasting of pre-germinated rice seed. Alternatively apply SOFIT 37.5 EC (Pretilachlor + Safner readymix) @ 500 ml/acre as sand mix 3 days after sowing of pre-germinated rice seed.

Preparation of Mat-type nursery for paddy transplantation :

Select the mat type paddy nursery location having fertile soil preferably of medium type where irrigation water is available and minimum transportation distance of seedlings to the field. The field should be preferably laser leveled and 20 m away from the tubewell and trees to avoid shade, debris and damage by birds. If required, priers to nursery sowing mix the farm yard manure to the soil and irrigate the field. After proper moisture level till the field with rotavator/tiller and one to two plankings to destroy the germinated weeds and to pulverize the soil. There should be no stones or other hard material in the soil mixture.

Spread 50-60 gauge, 90 cm wide polythene sheet with 1-2 mm dia perforations over it. Place one or more iron frames having compartments of size 40x20x2 cm for manually operated transplanter, 45x21x2 cm for engine operated transplanter and 58x28x2 cm for self propelled transplanter over the polythene sheet. Number and size of compartments vary according to machine specifications. Polythene sheets weighing 350 g spread to a length of about 20 meters (for about 200 mats) is sufficient for preparing seedlings for one acre. Fill the soil from both sides in the frames uniformly upto the top surface. Spread about 50-60 g of pre-germinated seed evenly in each compartment to achieve uniform density of 2 or 3 seedlings/sq cm in the mat. For uniform seed distribution, use nursery sowing seeder. The length of nursery sowing seeder is to be equal to width of frame and has openings of 1 cm diameter on full length of the roller. About 10-12 kg seed is sufficient to sow about 200 mats required for transplanting one acre. Cover the seeds by a thin layer of soil and sprinkle water by hand sprayer for proper setting of the soil. Lift frames and put these at the next place and repeat the above procedure for sowing the required number of seedling mats. Two persons can sow seedlings for 3-4 acre in a day.

After sowing, irrigate the field, but the flow of water for first 2-3 irrigations should be very mild and level should be uniform so that there is no damage to newly formed mats. Care must be taken that the seedling mats are always wet. Spray the seedlings after an interval about 10 days with 300g urea for 200 mats. The seedling mats become ready after 25-30 days of sowing. Drain the water from the nursery field a few hours before nursery uprooting. Give a cut with a sharp blade along the nursery boundaries of the mat. The uprooted nursery mats are ready for transport to the field. One person can uproot and transport seedling for one acre in a day.

Unpuddled direct seeded rice

Direct sowing of rice can also be practised with the adoption of following points to make this technology a success :

1. Sow rice by direct seeding only in medium to heavy soils and its cultivation is not successful on light textured soils due to severe iron deficiency.
2. Proper control of weeds is very essential for raising a healthy crop of direct seeded rice .
3. Ensure its proper establishment by sowing it with rice drill.
4. For direct sowing, sow during first fortnight of June by using 8 to 10 kg seed per acre with tractor drill at 20 cm row spacing. For controlling weeds, apply Stomp 30 EC (pendimethalin @ 1.0 litre/acre with in two days of sowing followed by Nominee Gold/Taarak/Wash out/Macho 10 SC (bispyribac) 100 ml per acre/Segment 50 DF (azimsulfuron) @ 16 g per acre at 30 to 35 days after sowing. Spray these herbicides uniformly by mixing them in 150 to 200 litres of water per acre and use flat fan/flood jet nozzle for spray. Use Nominee Gold 10 SC when the crop is infested with *swank* and paddy *mothas* and Segment 50 DF can be used only if paddy *mothas* are present in the field. Sowing of short duration varieties should be preferred. Apply 60 kg nitrogen (130 kg Urea) per acre in three equal splits at two, five and nine weeks after sowing. Phosphorous and Potash should be applied only if the soil test shows deficiency of these nutrients. Skip phosphorus application to DSR when sown after wheat grown with recommended phosphorus. To fulfill the water need of the crop, apply irrigation at 5 days interval depending upon the soil type. The interval may be adjusted with rainfall. Stop irrigation 10 days before harvesting. Depending upon the soil type, there will be saving of 10-15 per cent irrigation water in Direct Seeded Rice as compared to transplanted rice.
5. For direct seeding PR 115 is the most suitable variety.

Transplantation :

(*i*) ***Dates of Transplanting :*** Time of transplanting is a single factor which influences rice yield substantially. For getting maximum yield of rice and for the timely vacation of the field for sowing wheat and other crops adopt the following transplanting schedule :

Second fortnight of June	PR 123, PR 122, PR 121, PR 118, PR 116, PR 114, PR 113 and PR 111
Under late sown conditions	PR 115

(*ii*) ***Age of Seedlings at Transplanting :*** Start uprooting the nursery when the seedlings become 25 to 30 days old. As the transplanting proceeds, use seedlings from the same nursery sown in May. Seedlings older than 30 days upto 55 days give better yield under late transplanting for long duration varieties. However, in short duration varieties (PR 111 & PR 115) seedlings of 25-30 days should be preferred.

(*iii*) ***Uprooting of Seedlings :*** Irrigate the nursery before uprooting. Wash the seedlings in water to remove mud.

(*iv*) ***Method of Transplanting : (a) Flat puddled transplanting :*** Transplant seedlings in lines at 20 x 15 cm (33 hills/sq m) for normal and 15 x 15 cm (44 hills/sq m) for the late transplanting. Put 2 seedlings per hill. The seedlings should be transplanted upright and about 2-3 cm deep. This practice ensures good establishment of seedlings and early tillering, which are essential for good tiller development and synchronous flowering.

(b) Bed transplanting : Transplant 30 days old seedlings on the middle of the slopes of beds prepared with wheat bed planter on heavy textured soils. After field preparation (without puddling), apply basal dose of fertilizer and prepare beds. Irrigate the furrows and immediately transplant seedlings by maintaining a plant to plant distance of 9 cm to ensure 33 seedlings/m^2. During the first 15 days after transplanting irrigation water should be allowed to pass over the beds once in 24 hours. Threreafter apply irrigation in furrows only two days after the ponded water has infiltrated into the soil. Every care should be taken that field does not develop cracks in the furrows. In this way about 25 per cent of total applied irrigation water can be saved without affecting the grain yield. For controlling weeds spray Nominee Gold/ washout 10 SC (bispyribac) at 120 ml per acre in 150 litres of water as post emergence, 20-25 days after transplanting. Hand pulling of weeds can be done, if needed. Follow other cultural practices as recommended for flat puddled transplanted rice.

(c) Mechanical transplanting: Mat type nursery should be transplanted with mechanical transplanter at spacing of 30x12 cm.

Weed Control : Interculture both the early and timely-transplanted crops with a paddy-weeder (Appendix III), 15 days after transplanting and again after a fortnight. Where a paddy weeder cannot be run, handweeding may be done.

The use of herbicides is both efficient and economical. The following herbicides are recommended for use in transplanted rice 2 to 3 days after transplanting.

Name of the herbicide	***Dose/acre***
Butachlor 50 EC	
Machete/Delchlor/Rasayanchlor/Punch/Hiltachlor/ Thunder/Capchlor/Milchlor//Narmadachlor/Fychlor/ Trapp/Teer/Arochlor/Megachlor/Butachlor-Sunbeam/ Markchlor/Paklor/Banweed/Butacid/Jaibutachlor	1200 ml
Butachlor 50 EW	
Fast-mix	1200 ml
Thiobencarb 50 EC	
Saturn	1200 ml
Anilofos 18 EC	
Arozin	850 ml
Anilofos 30 EC	

Name of the herbicide	*Dose/acre*
Arozin/Aniloguard/Libra/Control H-30/Pestoanilofos/ Markanil/Jaifos/Haragro-Anilfos/Padigard	500 ml
Anilofos 50 EC	
Aniloguard	300 ml
Pendimethalin 30 EC	
Stomp	1000 to 1200 ml*
Pretilachlor 50 EC	
Rifit/Eraze/Markpretila/Revenge	600 ml
Pretilachlor 40 EW	
Erijan	750 ml
Pyrazosulfuron ethyl 10 WP	
Sathi	60 g
Oxadiargyl 80 WP	
Topstar	45 g

* In case of Stomp, use lower dose on light soils and higher dose on medium to heavy soils.

The liquid formulation of these herbicides may be mixed with 60 kg of sand/acre and broadcast uniformly in 4-5 cm deep standing water 2 to 3 days after transplanting. These herbicides are highly effective against Swank (*Echinochloa crusgalli*) and give moderate control of other weeds. Arozin/ Anilogaurd/Libra/control H-30/Pestoanilfos/Markanil/Jaifos/Haragro-anilofos have an edge over other herbicides for control of *Ischaemum rugosum* (wrinkle grass).

Alternatively, post emergence application of Nominee Gold/Wash out/Macho/Taarak 10 SC (bispyribac) at 100 ml per acre in 150 litres of water should be sprayed as post emergence, 20-25 days after transplanting. Before spray, the standing water from the field should be drained out and irrigation may be applied 1 day after spray.

THE CONTINUOUS USE OF A SINGLE GROUP OF HERBICIDES YEAR AFTER YEAR RESULTS IN THE APPEARANCE OF NEW WEED TYPES. TO CHECK THIS MENACE IT IS BETTER TO USE DIFFERENT GROUP OF RECOMMENDED HERBICIDES IN ROTATION.

Caution : Use handgloves while applying these herbicides.

Control of Broadleaf Weeds : For control of broadleaf weeds including *Ghrilla* (*Caesulia axillaris*), *Sanni* (*Sphenoclea zeylanica*) etc. Apply Algrip (Metsulfuron) 20 WP @ 30 g per acre in 150 litres of water as post emergence, 20-25 days after transplanting or Sunrice 15 WDG (ethoxysulfuron) at 50 g per acre or Londex 60 DF (bensulfuron methyl) at 40 g per acre or segment 50 DF (azimsulfuron) at 16 g/acre 15-20 days after transplanting. Before spray, the standing water from the field should be drained out and irrigation may be applied 1 day after spray. The spray

should be done on a clear and calm day in order to attain the good efficacy of the applied herbicide. Delay in application results in poor control of these weeds.

Irrigation and Drainage : Provide graded channels for irrigation and drainage. Proper water management holds the key to successful rice cultivation.

Keep the water standing continuously in the crop for two weeks after transplanting so that the seedlings get properly established. Afterwards, apply irrigation two days after the ponded water has infiltrated into the soil. To save irrigation water, irrigate with tensiometer installed at 15-20 cm soil depth at soil matric tension of 150±20 cm or when water level in tensiometer enters yellow strip. Every care should be taken that field does not develop cracks. In this way, irrigation water can be saved without causing any reduction in yield. The depth of standing water should not exceed 10 cm. Drain away excess water before interculturing or weeding and irrigate the field after these operations. Stop irrigation about a fortnight before maturity to facilitate easy harvesting and the timely sowing of the succeeding *rabi* crop.

Note : Ensure timely application of weedicide for all benefits of standing water.

Fertilizer Application.

The following schedule is recommended per acre :

Nutrients (kg/acre)			Fertilizers (kg/acre)			
N	*P_2O_5	*K_2O	**Urea	***DAP	or * Single Super-phosphate	*Muriate of potash
50	12	12	110	27	75	20

These nutrients can also be supplied from the other fertilizers available in the market (Appendix IV)

* Apply only when the soil test shows deficiency of these nutrients See Chaper on Soil Testing.

** Make appropriate reductions for green-manuring and farmyard manure and pressmud applied.

*** When DAP is used, reduce the urea dose by 10 kg.

**** For N, urea or neem-coated urea can be used.

Apply 1/3 nitrogen, the whole of phosphorus and potassium before the last puddling. Broadcast the remaining nitrogen in two splits, one three weeks after transplanting and the other three weeks afterwards. Phosphorus can be top dressed upto 21 days after transplanting. Skip phosphorus application to rice if recommended dose of phosphorus had been applied to the preceding wheat crop. If possible, apply the second and the third split doses of nitrogen when water is not standing in the field. Irrigate on the third day of the application of fertilizer.

Reduce nitrogen dose by one-third while burying summer moong after picking pods one day before transplanting.

Use Leaf Colour Chart (LCC) for need-based nitrogen fertilizer application to rice:

- Apply basal dose of 25 kg urea per acre.
- Start matching colour of the first fully exposed leaf from the top with the LCC at 7 day intervals after 14 days of transplanting.
- Whenever the greenness of 6 or more out of 10 leaves is lighter than LCC shade 4 apply 25 kg urea per acre.
- No urea should be applied if colour of leaves is equal to or darker than LCC shade 4.
- Use of LCC should be discontinued after initiation of flowering and no more urea should be applied.

Note: Need based nitrogen management using LCC holds good for all the prevalent rice varieties grown in all type of soils. Use LCC for applying nitrogen to rice also when fields are amended with organic manures. Always match colour of the leaf with LCC under shade of the body. The leaves selected for measuring leaf greenness should be free of insect-pest incidence. There should not be water stress to the crop and nutrients other than nitrogen should be supplied as per recommendations. The LCC can be purchased from Department of Soil Science and Communication Centre, PAU, Ludhiana.

Caution : ***Excessive use of nitrogenous fertilizers particularly during flowering causes sterility and consequently heavy reduction in yield.***

Zinc Deficiency : The symptoms of zinc deficiency appear 2-3 weeks after transplanting. The lower leaves become rusty brown near the base and ultimately dry up. The seedlings with zinc deficiency remain stunted and tillerless. To control this malady, apply 25 kg of zinc sulphate heptahydrate (21%) or 16 kg zinc sulphate monohydrate (33%)per acre at puddling in case previous crop in this field had shown the symptoms of zinc deficiency. Where the deficiency is noticed in the growing crop, apply this quantity of zinc sulphate as soon as possible.

In highly deteriorated soils, the symptoms of zinc deficiency sometimes appear in patches even after the application of the recommended dose of zinc sulphate. In that event, broadcast 10 kg of zinc sulphate heptahydrate or 6.5 kg zinc sulphate monohydrate per acre mixed with an equal quantity of dry soil on the affected patches.

Iron Deficiency : Under scarcity of water, chlorosis among seedlings appears in the youngest leaf about three weeks after transplanting. Plants die and often the crop fails completely. Start giving copious irrigations as soon as chlorosis appears and give 2 or 3 sprays of one per cent ferrous sulphate solution at weekly intervals (1 kg of ferrous sulphate in 100 litres of water per acre).

Cultivation in Alkali Soils :

(*i*) ***Addition of Gypsum :*** Add Gypsum as per the soil test report and give one or two heavy irrigations.

(*ii*) ***Preparation of Seed bed :*** Do not puddle, because water intake rate in these soils is very low. Irrigate the tilled field and give a light planking to pulverize the clods if any.

(*iii*) ***Transplanting :*** Transplant seedlings a week earlier than the normal time of transplanting,

because the initial growth of plants in alkali soils is slow. Plant three or four 40 days old seedlings per hill. More seedlings per hill are recommended because of higher mortality in these soils.

(*iv*) ***Fertilizer Application :*** Apply 20-25 per cent more nitrogen than in normal soils. Alkali soils are low in organic carbon and the efficiency of nitrogen fertilizer in these soils is also low. Add 60 kg of nitrogen through 130 kg of urea per acre in three splits, 1/3 at transplanting, 1/3 three weeks after transplanting and the remaining 1/3 six weeks after transplanting. Apply the same amount of phosphorus as to the normal soils. In addition, apply 25 kg of zinc sulphate heptahydrate or 16 kg zinc sulphate monohydrate per acre during the preparatory tillage. Where *dhaincha* is grown for green manuring, add the quantity of P_2O_5 recommended for rice to this legume and omit the application of phosphorus to the succeeding rice crop.

Harvesting and Threshing : Harvest the crop just when the ears are nearly ripe and the straw has turned yellow. If harvesting is delayed till the crop is dead ripe, the shattering of grains occurs. The milling quality of the grains is also affected. Combines have been successfully used for harvesting short statured varieties in well drained fields. Tractor-drawn vertical conveyor reaper windrower can also be used for harvesting rice (Appendix III). Thresh the harvested crop the same day and do not leave it in the field exposed to dew. If it has to be left there overnight, cover the heap with a polythene sheet. The grains which remain exposed to dew at night, develop sun cracks during the day and break on milling.

Threshing can be done either by beating the sheaves against some hard surface just after harvesting. Paddy threshers operated by man power, engines or electric motors are also available. Multi-crop threshers can also be used for threshing wheat and paddy. (Appendix III).

Production of Pure Seed : Select a good plot of the standing crop and rogue it thoroughly so that it is made free from all admixtures and diseased plants. Harvest and thresh this plot separately. Dry the produce well and store separately in disinfested bins.

Storing and Marketing : It is in the interest of the cultivator to take his produce from the field to the market directly, as it will save him the labour required for drying and storing. The farmers can also get their produce cleaned and sell it through Mechanical Grain Handling Facilities installed in selected markets of Punjab which save time alongwith monetary incentive from Punjab *Mandi* Board. The produce kept for home use should be dried thoroughly in the sun for about a week and stored in bins or kept in a heap inside the room. The optimum moisture content for storage is 12 per cent.

Management of paddy straw

In Punjab, nearly 22 million tones of paddy straw *(parali)* is produced. Farmers commonly burn the residue in the fields, because the time available for sowing of wheat crop is about 20 days. Farmers must say no to paddy straw burning as there are many ill effects associated with this practice. The burning causes serious environment pollution. The crop residue is a good source of essential plant nutrients. The burning of the residue causes a complete loss of nitrogen and sulphur. The University has given priority to develop crop residue recycling technologies as an alternative to burning. For *in-situ* management of paddy straw, Happy Seeder machine has been developed for sowing of wheat in the combine harvested paddy fields. This technology offers a

variety of benefits such as 60-70% less weed growth, water saving, improved soil health and environment quality improvement. Good quality compost can also be prepared from paddy straw. The method of compost preparation is given in the chapter on Organic Farming at page no 129 Additionally, the use of paddy straw for raising of mushroom has also been tried and a compost formulation based paddy straw + wheat straw (2:1, w/w) has been recommended for button mushroom cultivation. Paddy straw can also be used as a mulching material in different crops and vegetables to improve yield, soil health and save water .

Plant Protection

Insect Pests :

Rice stemborers : The larvae of these insects bore into the stem and cause damage from July to October. The affected young plants show dead-hearts (yellowing and drying of central shoot) whereas the old ones produce empty earheads which turn white and stand erect.

The fields showing more than 5% dead hearts (economic threshold level) should be sprayed with 170 g of Mortar 75 SG (cartap hydrochloride) or 350 ml of Sutathion 40 EC (triazophos) or 560 ml of Monocil 36 SL (monocrotophos) or 1 litre of Coroban/Dursban/Lethal/Chlorguard/Durmet/ Classic/Force 20 EC (chlorpyriphos) in 100 litres of water per acre. Further application of any of these insecticides may be repeated as and when damage reaches economic threshold level.

Leaf folder : The larvae fold the leaves, eat out the green tissue and produce white streaks. The damage is highest during August-October. Spray the crop when the leaf damage reaches 10 per cent (ETL) with 170 g of Mortar 75 SG (cartap hydrochloride) or 350 ml of Sutathion 40 EC (triazophos) or one litre of Coroban/Durmet/ Force 20 EC (chlorpyriphos) or 560 ml of Monocil 36 SL (monocrotophos) in 100 litres of water per acre.

Plant hoppers : These hoppers include, white backed planthopper and brown planthopper. Both nymphs and adults of these pests suck the cell sap particularly from the leaf-sheath from July to October. The crop dries up in patches. As the plants dry up, the hoppers migrate to the adjoining plants and kill them. In a few days, the area of the dry patches enlarge.

About one month after transplanting, a few plants in the field should be slightly tilted and tapped 2 or 3 times at the base at weekly interval. If minimum 5 plant hoppers per hill are seen floating in the water, only then the crop should be treated with insecticide. The plant hoppers can be controlled by spraying 40 ml Confidor 200 SL / Crocodile 17.8 SL (imidacloprid) or 800 ml Ekalux/ Quinguard 25 EC (quinalphos) or one litre Coroban/Dursban 20 EC (chlorpyriphos) in 100 litres of water per acre. Repeat the spray if necessary. **For better effectiveness, direct the spray towards the base of the plants.** If the damage is noticed at hopper burn stage, treat the affected spots along with their 3-4 metre periphery immediately as these spots harbour high population of the insect.

Grasshoppers : The adults and nymphs of the grasshoppers eat the leaves especially in nursery. Insecticides recommended for the control of plant hoppers are also effective for grasshoppers.

Rice hispa : Rice hispa is a serious pest in some areas of the Gurdaspur and Amritsar districts and is also found in the other rice growing areas of the State. The grubs of this pest tunnel

into the leaves, whereas the adults are exposed feeders. The grubs cause damage by producing bold, white streaks on the leaves.

If the attack starts in the nursery, clip-off and destroy the leaf tips of the affected seedlings before transplanting. On the transplanted crop, spray 120 ml Methyl Parathion 50 EC (methyl parathion)/560 ml Monocil 36 SL (monocrotophos)/800 ml Ekalux 25 EC (quinalphos)/one litre Dursban 20 EC (chlorpyriphos) in 100 litres of water per acre with a manually operated sprayer. Repeat the spraying if the attack persists.

Rice root weevil : This weevil is a localized pest in the rice area around Rajpura. However, this pest has also been observed in some other areas in the State. Its white, legless grubs feed on roots in the soil from July to September. The attacked plants turn yellow, stunted and produce only a few tillers.

Apply any of the following granular insecticides in the standing water :- 3 kg of Thimet/Foratox 10G (phorate) per acre.

Warning : Use gloves while applying granular insecticides.

Rice-ear-cutting-caterpillar : The larvae of this insect are gregarious in habit and are commonly known as 'armyworm'. The young larvae feed on leaves, leaving only the mid-ribs and stems. The old larvae cut off the panicles mostly at the base and hence the name "rice ear-cutting caterpillar". This stage of the insect causes serious loss to the paddy crop. The larvae are shy of sunlight and generally feed at night. The damage to paddy crop is caused mostly during September to November.

The insect can be controlled by spraying the crop with 400 ml of Ekalux/Quinguard 25 EC (quinalphos) in 100 litres of water per acre. As the pest is nocturnal in behaviour, the spray should be done in evening hours for getting better results.

Diseases :

Bacterial blight (*Xanthomonas oryzae* pv. *oryzae*) : Greenish-yellow stripes appear along the leaf margins and extend both lengthwise and breadthwise. The leaf starts drying from the tip, becomes white in severe cases and dries up completely. The disease sometimes attacks the freshly transplanted seedlings which start wilting and in a few days the whole clump dries up. The bacterium perpetuates through seed, rice straw, and roots of non-host plants during the off-season. In order to mitigate the losses, adopt the following measures :

(i) For the management of bacterial leaf blight, grow rice varieties PR 123, PR 122, PR 121, PR 115, PR 113 and PR 111 which are resistant to most of the pathotypes of bacterial leaf blight pathogen or PR-118, PR-116 and PR-114 which are resistant to some of the pathotypes of the bacterial leaf blight pathogen.

(ii) Do not apply excessive dose of nitrogen. Nitrogen should not be applied beyond six weeks after transplanting (except when LCC is used).

(iii) Do not pond water in the field.

(iv) Treat seed before sowing to kill primary inoculum, see "Seed Treatment" under Agronomic Practices.

(v) (a) Do not grow nursery under shade.

(b) Rice crop itself should not be grown in the shady area.

(vi) The growing of rice in the area near Bhusa stack (*Kup*) should be avoided.

Bacterial leaf streak *(Xanthomonas oryzae pv. oryzicola)* **:** Small translucent streaks appear in the interveinal areas of the leaf. The streaks gradually enlarge and turn reddish, when the plants near maturity. For control measures, see "Seed treatment" under Agronomic Practices.

Blast (*Pyricularia grisea*) : The fungus causes spindle shaped spots with greyish centre and brown margin on the leaves at maximum tillering. It also causes brown lesions on the neck of the panicle, showing neck rot symptoms and the panicles fall over. The disease is more severe on *Basmati* particularly in the submontaneous areas and under application of heavy nitrogenous fertilizers. Spray the affected crop with Indofil Z-78, 75 WP (zineb)* @ 500 g per acre in 200 litres of water, at the maximum tillering and ear-emergence stages.

Brown leaf spot (*Drechslera oryzae*) : It produces oval, eye-shaped spots with a conspicuous dark-brown dot in the centre and light brown margin. The spot is surrounded by yellow halo. Spots are also produced on the grains. This disease occurs in poor soils, therefore, give adequate and balanced nutrition to the crop. To control the disease, give two sprays of Folicur 25 EC (tebuconazole) @200 ml or Tilt 25 EC (propiconazole) @ 200ml or Indofil Z-78 (zineb)* @500g in 200 litres of water/ acre. The first spray should be given at boot stage and second after 15 days.

Sheath blight (*Rhizoctonia solani*) : Greyish green lesions with purple margin develop on the leaf-sheath above the water level. Later, the lesions enlarge and coalesce with other lesions. The symptoms are usually not distinct till flowering. Its severe attack results in the poor filling of the grains. Burn the rice straw and stubbles after harvesting the affected crop. Avoid the excessive use of nitrogenous fertilizers. Keep the bunds clean by removing the grass.

To control sheath blight, spray the crop as soon as the disease is noticed at boot stage with Folicur 25 EC (tebuconazole) or Tilt 25 EC @ 200ml or Lusture 37.5 SE @ 320 ml or Monceren 250 SC (pencycuron)* @ 200 ml or Bavistin 50 WP (carbendazim)* @ 200g in 200 litres of water per acre by directing the spray towards the base of the plant. Give one more spray after 15 days.

Sheath rot *(Fusarium moniliforme)* : The rot occurs on the uppermost leaf-sheaths where oblong to irregular and grey-brown to light-brown lesions develop. The lesions often coalesce to cover the entire sheath. In severe cases, young panicles either do not emerge or emerge partially. A white-powdery growth of the fungus appears on the panicle inside the sheath. The glumes of infected florets are discoloured, dark-red or purple brown to black and often do not fill. The fungus over-winters in rice straw and grains. Burn the rice straw after harvesting the infected crop. Use disease free seed for sowing. Give two sprays of Tilt 25 EC @ 200 ml or Bavistin 50 WP @ 200 gm in 200 litres of water per acre. The first spray should be given at boot stage and second after 15 days interval.

Stem rot (*Sclerotium oryzae*) : The fungus affects the stem at earing and black lesions are produced on the sheath at water level. Later on, the stem gets infected and rots leading to withering

* Chemicals belong to green chemistry category.

and lodging of the plant. The incidence of this disease has declined on high yielding varieties due to improved cultural practices. Prefer to grow tolerant varieties of the *Basmati* group in the infested fields.

False smut (*Ustilaginoidea virens*) : Its incidence is increasing on high-yielding rice varieties. The fungus transforms the individual grains into large greenish velvety spore-balls. High relative humidity, rainy and cloudy days during the flowering period increase the incidence of the disease. **The application of organic manures and high dose of nitrogenous fertilizers also increase the intensity of attack.**

To control this disease, give first spray of Kocide 46 DF (copper hydroxide) @500 gm or Blitox 50 WP (copper oxychloride) @ 500 g in 200 litres of water per acre at boot stage of the crop in disease prone areas followed by second spray with Tilt 25 EC @ 200 ml in 200 liters of water after 10 days interval.

***Bunt* (*also called Kernel Smut*)** (*Neovossia horrida*) : Only a few grains in the panicle are infected. Frequently, only a part of the grain is replaced by a black powder. Sometimes, entire grain is also attacked and the black powder scatters on to other grains or leaves, and this is often the easiest way to detect the disease in the field. The disease incidence is more on short duration varieties, planted early. Also avoid heavy doses of nitrogenous fertilizers. Two sprays of Tilt 25 EC @ 200 ml in 200 litres of water/ acre at 10% flowering stage and 10 days after should be given for controlling the disease.

BASMATI RICE

Basmati occupies a special status in rice cultivation. Its rice is known for excellent cooking and eating qualities. However, *Basmati* varieties occupy about 20 per cent rice area in the State. To obtain satisfactory yield of *Basmati* varieties the following package of practices are recommended for adoption :

Important Points :

* Restrict to timely sowing and transplanting schedule of basmati varieties for better quality rice.
* Avoid mixing of varieties.
* Monitor the insect-pest population/damage and use recommended control measures.
* All the basmati/aromatic varieties, especially Pusa Basmati 1121 are susceptible to foot rot disease. Use only disease free seed.
* Use seed treatment to avoid seed borne diseases.

Climatic Requirements :

Like semi-dwarf rice varieties, *Basmati* varieties require prolonged sunshine, high humidity and assured water supply. *Basmati* varieties with superior cooking and eating characteristics can be produced if the crop matures in relatively cooler temperature. The high temperature during grain filling period reduces the cooking and eating quality features of basmati rice like kernel elongation and non-stickiness of cooked rice.

Rotations:

Basmati Rice-Wheat/Sunflower, Basmati Rice-Wheat-*Sathi* maize/Summer *Moong,* Basmati Rice-Mentha, Basmati Rice-Berseem (seed), Basmati Rice-Celery-Bajra (Fodder)

Improved Varieties :

Punjab Basmati 3 (2013) – It is a photoperiod sensitive, semi-dwarf lodging tolerant variety which is about 105 cm tall. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen prevalent in the Punjab State. It possesses extra-long slender grains with tip awns which prevent bird damage. The grains are translucent with strong aroma, good cooking and eating quality characteristics. The cooked rice is non-sticky and soft to eat. It matures in about 139 days after seeding. Its average paddy yield is 16.0 quintals per acre.

Pusa Punjab Basmati 1509 (Adhoc) : It is an early maturing basmati variety which matures in about 120 days after seeding. Its average height is 92 cm. It possesses extra-long slender, grains with excellent cooking and eating quality characteristics. Its grains almost double upon cooking and are strongly scented. Its average paddy yield is 15.7 quintals per acre. It will be suitable for multiple cropping system, which will result in higher returns to the farmers. Transplant 25 days old seedlings for better tillering. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the Punjab State.

Punjab Basmati 2 (2008) – This variety is about 125 cm tall and is weakly photoperiod sensitive. It possesses extra long slender grains with excellent cooking and eating qualities. Grains of this variety are strongly scented. Grains almost double upon cooking, are non sticky and soft to

eat. It matures in about 140 days after seeding. Its average yield is 12.6 quintals of paddy per acre. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the Punjab State.

Pusa Basmati 1121 (2008) : It is about 120 cm tall. It possesses extra long slender grains with good cooking quality. It has longest cooked rice length among all the aromatic rice varieties recommended for Punjab. It is photoperiod insensitive and matures in about 137 days after seeding. It yields on an average 13.7 quintals of paddy per acre. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the Punjab State.

Basmati 386 (1995) – This variety is about 180 cm tall and is photo period sensitive. It performs best under medium fertility conditions. Its grains are extra-long, superfine and aromatic. Grains elongate almost double on cooking. The cooked rice is non-sticky and soft to eat. It matures in about 155 days from seeding. Its average yield is 9 quintals paddy per acre. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the Punjab State.

Basmati 370 – This variety is about 165 cm tall, photo period sensitive and lodge under high fertility conditions. It does best on average fertility soils. Its grains are superfine, highly aromatic and elongate almost double upon cooking. The cooked rice is non sticky and soft to eat. It matures in about 150 days. Its average yield is 12 quintals paddy per acre. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the Punjab State.

Aromatic Rice

It includes both basmati and non basmati rice varieties. They have one or more of other attributes of the basmati rice but not all of them.

Punjab Mehak 1 (2009) : It is an aromatic rice variety. It is photoperiod in sensitive and is about 100 cm tall. It possesses extra long slender, clear translucent grains with strong aroma. It has excellent cooking and eating qualities. The cooked rice is non-sticky and soft to eat. It matures in about 125 days after seeding. It is resistant to most of the pathotypes of bacterial blight prevalent in Punjab. Its average paddy yield is about 17 quintals per acre. Transplant 25 days old seedlings for better tillering.

Agronomic Practices :

Agronomic practices like land preparation, seed rate, seed treatment, method of nursery raising, weed control etc. are the same for Basmati varieties as for other semi-dwarf varieties. However, some of the agronomic practices which require special mention are discussed below :

Time of Nursery Sowing : Punjab Basmati 3, Basmati 386 and Basmati 370 are photosensitive. Optimum time for nursery sowing of Basmati 386, Basmati 370 and Pusa Punjab Basmati 1509 is second fortnight of June. Nursery of Punjab Basmati 2, Punjab Basmati 3, Punjab Mehak 1 and Pusa Basmati 1121 may be sown in the first fortnight of June.

Unpuddled Direct Seeded Basmati/Aromatic Rice

Direct sowing of basmati rice can also be practised with the adoption of following points to make this technology a success :

1. Sow basmati rice by direct seeding only in medium to heavy textured soils.
2. Proper control of weeds is essential for raising a healthy crop of direct seeded basmati rice.
3. Ensure its proper establishment by sowing with tractor drawn rice drill.

Direct sowing of Punjab Mehak 1 and Pusa Basmati 1121, can be done during second fortnight of June by using 8 to 10 kg seed per acre with tractor drill at 20 cm row spacing. For controlling weeds, apply Stomp 30 EC (pendimethalin) @ 1.0 litre/acre within two days of sowing. If needed, apply Nominee Gold 10 SC (bispyribac) 100 ml per acre/Segment 50 DF (Azimsulfuron) @ 16 g per acre at 30 to 35 days after sowing. Spray these herbicides uniformly by mixing them in 150 to 200 litres of water per acre and use flat fan/flood jet nozzle for spray. Use Nominee Gold 10 SC when the crop is infested with *swank* and paddy *mothas* are present in the field. Apply 24 kg nitrogen (54 kg urea)/acre in 3 equal splits at 3, 6 and 9 weeks after sowing. Apply P and K only when the soil test shows deficiency of these nutrients. Like puddled transplanted rice, skip phosphorus application to direct seeded basmati rice if recommended dose of phosphorus had been applied to the preceding wheat crop. To fulfill the water need of the crop, apply irrigation at 5 to 7 days interval depending upon the soil type. The interval may be adjusted with rainfall. Stop irrigation 10 days before harvesting.

Time of Transplanting : The time of transplanting is a crucial factor in determining the yield and quality of the *Basmati*/aromatic varieties. *Basmati* 386 and Basmati 370 if transplanted too early in the season have a prolonged vegetative phase resulting into a tall and leafy crop. Such a crop is more prone to lodging because of excessive height and vegetative growth. To check lodging, lopping of the upper half of crop canopy (Basmati 386 and Basmati 370) after 45 days of transplanting may be done. Further it would also reduce stem borer damage. Being photoperiod sensitive these varieties flower when a specific daylength is reached. The early transplanted crop also experiences high temperature at flowering which lowers its cooking quality. Optimum time of transplanting for Pusa Punjab Basmati 1509, Basmati 386 and Basmati 370 is second fortnight of July. Punjab Mehak 1, Punjab Basmati 2, Punjab Basmati 3 and Pusa Basmati 1121 may be transplanted in first fortnight of July.

Age of Seedlings : Seedlings of Basmati/aromatic rice varieties are ready for transplanting when they attain 5 to 6 leaf stage or are 25-30 days old after sowing. Longer stay of seedlings in the nursery bed results into node formation which reduce tillering and yield in Basmati varieties. About 25 days old seedlings of Pusa Punjab Basmati 1509 and Punjab Mehak 1 should be transplanted for better tillering.

Method of Transplanting : Irrigate the nursery before uprooting and wash them to remove mud. Transplant two seedlings per hill in lines at 20 x 15 cm (33 hills/sq. metre) during the optimum period in a well puddled field. In the late transplanted crop the spacing may be reduced to 15x15 cm (44 hills/sq. metre) to cope the reduction in yield.

Fertilizer Application : High doses of nitrogen application to Basmati varieties cause excessive vegetative growth and plant height. This makes the crop more prone to lodging thus resulting into poor yield. Apply 75 kg of superphosphate per acre before last puddling (this application may be skipped if the recommended dose of phosphorus has been applied to the preceding wheat crop). Broadcast 18 kg urea/acre to Basmati 386 & Basmati 370 : 36 kg urea/acre to Punjab Basmati 2, Punjab Basmati 3 and Pusa Basmati 1121 & 54 Kg urea per acre to *Punjab Mehak 1* and Pusa Punjab Basmati-1509 in two equal splits. The first dose should be applied three weeks and the second, six weeks after transplanting. If possible, apply the nitrogenous fertilizer when water is not standing in the field. Irrigate on third day of the application of fertilizer.

Irrigation : Keep the water standing continuously for two weeks after transplanting. Afterwards apply irrigation two days after the ponded water has infiltrated into the soil. The crop should not suffer any water stress particularly during flowering. Stop impounding water about a fortnight before harvesting to facilitate easy harvesting and timely sowing of succeeding *Rabi* crop.

Plant Protection Measures

1. Insect pests :

Stemborers : Basmati/aromatic rice varieties are highly susceptible to stemborers namely yellow stemborer, white stemborer and pink stemborer. The yellow and white stemborers are serious up to flowering stage. The pink stemborer generally appears late and is more serious at/after maximum tillering stage when its damage affects grain formation. It is, therefore, necessary to monitor the crop regularly for stemborer damage. As and when there are more than 2% dead hearts (economic threshold level) in the field, apply the insecticides to manage the borers. The stemborers can be controlled by spraying Mortar 75 SG (cartap hydrochloride) @ 170 g or Coragen 20 SC @60ml or Monocil 36 SL (monocrotophos) @ 560 ml or one litre of Coroban/Dursban/Lethal/ Chlorguard/Durmet/Classic/Force 20 EC (chlorpyriphos) or 15g Fipronil 80% WG (fipronil) in 100 litres of water per acre. These insects can also be controlled by applying 4 kg Ferterra 0.4 GR (Chlorantraniliprole) or 10 kg Padan/Caldan/Kritap/Sanvex/Nidan/Marktap 4G (cartap hydrochloride) or 6 kg Regent/Mortel 0.3G (fipronil) or 5 kg Foratox 10 G (phorate) or 4 kg Dursban 10G (chlorpyriphos) per acre in standing water. Ferterra/Padan/Kritap/Caldan/Sanvex/Nidan/Marktap 4 G/Regent/Mortel 0.3G/Dursban 10G/ Fipronil 80% WG/Mortar 75 SG/Coragen 20 SC also control leaffolder. Use above insecticides alternately.

Rice hispa and Leaf folder : These pests also damages basmati rice in the State. For their control, follow recommendations mentioned at page 11 against these pests.

2. Diseases :

Blast (*Pyricularia grisea*) is relatively more important in Basmati varieties. This fungus causes spindle shaped spots with greyish centre and brown margin on the leaves at maximum tillering stage. It also causes black lesions at the neck of panicle leading to its dropping. For control of this disease, spray Indofil Z-78, 75 WP (zineb)* @ 500 g per acre in 200 litre of water at maximum tillering and ear emergence stages.

Foot-root : This disease is caused by the fungus *Fusarium moniliforme* and it is both seed and soil borne. The infected seedlings turn pale yellow and become elongated. Later on these seedlings start drying from bottom and these usually die. The symptoms also appear after transplanting in the field and the infected plants become taller than the normal plants and are killed after few days. Adventitious roots also appear on the lower nodes. Pinkish growth of the fungus appear on the lower sheaths.

* Use disease free seed
* Dip the seed in Bavistin 50 WP* @ 0.2% (20 g) + Streptocycline* @ 0.01% (one gram) dissolved in 10 litre of water, for 12 hrs + seedling root dip in Bavistin 50 WP* (0.2%) for 6 hrs. before transplanting or dip the seed in Bavistin 50 WP* @ 0.05% (5 g) + Streptocycline* (0.01%) for 12

* Chemicals belong to green chemistry category.

hrs and smear the seeds with talc formulation of *T. harzianum* @ 15 g/kg of seed immediately before sowing and seedling root dip for 6 hrs with *T. harzianum* @ 15 g/litre of water before transplanting.

* Roguing and destruction of infected seedlings in nursery.
* Spray Tilt 25 EC @ 200 ml in 200 litres of water at boot stage of the crop for production of disease free seed.

For the control of various other diseases, insect pests and weeds the control measures are the same as for high yielding varieties.

Harvesting and Threshing :

Basmati/Aromatic rice varieties should be harvested as soon as they mature *i.e.* when the ears are nearly ripe and the straw has turned yellow. Delayed harvesting may cause over-ripening and shattering of grains. The harvested crop should preferably be threshed on the same or next day of harvesting. The delayed threshing causes high shattering losses, reduced head rice recovery and ultimately reduces the market price of paddy.

MAIZE

Maize occupied 129 thousand hectares, with a production of 475 thousand tonnes in the Punjab State. The average yield per hectare during 2012-2013 was 36.8 q per hectare (14.7 q per acre). Proper drainage of excess water during rains is essential to get good yield.

Climatic Requirements :

Maize requires considerable moisture and warmth from germination to flowering. The most suitable temperature for germination is 21^0 C and for growth 32^0 C. Extremely high temperature and low humidity during flowering may damage the foliage, dessicate the pollen and interfere with proper pollination, resulting in poor grain setting. Fifty to seventy-five cm of well-distributed rain is conducive to proper growth.

Soil Type :

Maize thrives better on well drained, sandy-loam to silty-loam soils.

Rotations :

Maize-Wheat/Barley/Potato/*Berseem,* Maize-*Senji*-Sugarcane-Cotton, Maize-Wheat-*Sathi* Maize/*Moong,* Maize-Wheat-*Sathi* Maize/Green Manure, Maize-Potato/Toria-Sunflower, Maize-Potato-Wheat/Sunflower, Maize-Early Pea-Sunflower, Maize-Wheat-Cowpea (fodder)*, Maize-*Raya/ Gobhi Sarson,* Maize-Potato-Summer *Moong,* Maize-Potato-Mentha, Maize (August)-Mentha, Maize-*Gobhi Sarson*-Summer *Moong*

Irrigated Maize :

Improved Varieties : The improved varieties are PMH 1 and PMH 2, *Kesri, Parbhat* and *Punjab Sweet Corn 1.* Of these PMH 1 and PMH 2 are hybrids whereas the others are composites. Special purpose varieties are Punjab sweet corn and Pearl Popcorn. The main advantage of a composite is that its grain produce can be used as seed from year to year as per the method given under production of Pure Seed.

Long Duration Varieties :

PMH 1 (2005) : It has tall plants with well developed root system. The stem has purple coloration and is zig-zag and sturdy. The leaves are medium broad. Tassel is open and medium in size. Ears are medium long with yellow orange flint grains. Its average yield is 21 quintals per acre and matures in 95 days. The plants stay green at maturity.

Parbhat (1987) : This composite has medium thick stem which resists lodging. Plant and ear height is medium tall. Husk covers are well developed. Ears are medium long and thick.. The grains are medium bold, yellow-orange and semi-flint to flint. It yields about 17.5 quintals per acre. It matures in about 95 days.

Medium Duration Variety :

Kesri (1992) : It is an early maturing, high yielding composite with attractive orange-flint

grains. The ears are thick at the base, taper towards the tip and have good tip filling and husk cover. Plant height and ear placement are medium. It matures in about 85 days and its average yield is 16 quintals per acre.

Short Duration Variety :

PMH 2 (2005) : It is a short duration single cross hybrid. It has medium plant height with medium ear placement. Leaves are medium sized and dark green in colour. Tassel is of medium size and semi-open. Silk is of green colour. It has medium long ears. Grains are yellow orange flint with yellow caps. The cob colour is white. It matures in 83 days. Its average yield is 18.0 quintals per acre under irrigated conditions. The hybrid resists lodging and is tolerant to bacterial stalk rot.

Special purpose Varieties :

Punjab Sweet Corn 1 (2008) : It has tall plants with medium thick stem and medium ear placement. Its leaves are broad. Tassel is open with creamish anthers. Ears are medium long and the cob colour is white. Silk colour at the time of emergence is usually creamish. Husk cover is well developed and grains are orange in colour at maturity. This variety is highly suitable for use as sweet corn on commercial basis because its developing and immature grains in green ears possess high sugar content. It matures in about 95-100 days. Its average green ear and grain yield is about 50.0 and 13.0 quintals per acre, respectively.

Pearl Popcorn (1995) : This is a composite variety of popcorn. Its ears are long and thin and grains are small and round. Its average yield is 12 quintals per acre and popping quality is very good. The commercial value of these grains is very high.

Agronomic Practices :

Land Preparation : Give four to five ploughings and plankings to make the seed-bed free from clods and weeds. Use a mould-board plough, disc-harrow or a cultivator for the first cultivation. Level the field to ensure proper irrigation and drainage.

In light to medium textured soils, if stubbles of the previous crop have been removed and there are no weeds, the preparatory tillage can be dispensed with and the crop can be sown directly after a pre-sowing irrigation (rauni) or after rain. The practice will reduce the cost of cultivation of the crop.

Seed-Rate and Seed Treatment : Use 7 kg seed for Pearl Popcorn and 8 kg seed per acre for other varieties. The seed should be treated with a fungicide such as Bavistin 50 WP or Derosal 50 WP or Agrozim 50 WP (carbendazin) @ 3 g per kg seed.

Time of Sowing : Last week of May to *End of June.*

In fields, which are prone to damage through water stagnation, sow the crop in end of May/ early June so that the crop gets firmly established before the rains. Sowing of crop at this time not only gives higher yield but also vacates the field in time for sowing *toria/*potato. Adoption of recommended chemical control for maize borer is very important in early planting.

Higher yield can be obtained by planting in second fortnight of August. Short duration hybrid PMH 2 may be sown for early vacation of fields, otherwise long duration hybrid PMH 1 should be preferred which give higher yield than other hybrids. The maturity period on an average is 115 days for PMH 1 and 100 days for PMH 2 and Prakash which goes on increasing considerably with delay in sowing towards end of August depending upon the prevailing temperature. The sowing may be done on the flat seed bed or preferably on the side of ridge 6-7 cm high followed by earthing up to evade excess water stress in seedling stage. The row to row spacing be kept 60 cm for all hybrids whereas plant to plant spacing be maintained at 20 cm for PMH 1 and 15 cm for PMH2 and Prakash. The other agronomic practices and fertilizers are same as recommended for normal *kharif* crop. The attack of maize borer remains significantly low in August planted crop.

Method of Sowing : Sow the seed 3-5 cm deep in lines with a maize planter or seed-cum-fertilizer drill, provided with a planting attachment, at the distances given below :

Varieties	*Row spacing*	*Plant spacing*
PMH 1, Parbhat and Punjab Sweetcorn 1	*60 cm*	*20 cm*
PMH 2, Kesri and *Pearl Popcorn*	*50 cm*	*15 cm*

Trench Sowing : Maize can be sown in trenches made by tractor/bullock drawn ridger from end-May to mid-June to facilitate easy and economical irrigation during dry and hot weather conditions. Seed drill attachment mounted on the ridger can also be used for sowing by adjusting the position of the tines. Maize crop raised in trenches resists lodging and gives higher grain yield than flat sowing.

Zero Tillage : Maize can also be grown without any preparatory tillage with zero till drill after conventional or zero till sown wheat. If field is infested with weeds, it can be controlled by spraying half litre of Gramoxone (Paraquat) in 200 litres of water before sowing. Zero tillage has the benefits such as saving in diesel and time, reduced environment pollution and saving of irrigation water in first irrigation thus resulting in reduced cost of production. This also helps in timely planting of maize over large areas.

Intercropping : Intercrop one row either of cowpea, maize or teosinte as fodder and groundnut for pods in maize sown at row to row spacing of 60 cm for getting higher productivity and monetary returns as compared to sole maize. Apply recommended fertilizers to maize and on area basis to intercrops. Harvest cowpea, maize and teosinte fodder 45-55 days after sowing.

Hoeing and Thinning : Give two hoeings about 15 to 30 days after sowing. Use a *khurpa* or a V-blade for the first hoeing and wheel-hoe for the second. The crop sown in rows can be hoed with a bullock-drawn *triphali* or with a tractor-drawn cultivator. In case the sowing has not

been done with a planter, thin out the plants at the time of the first hoeing keeping a plant-to-plant distance of 20-25 cm.

Weed Control : Apply Atrataf 50 WP (Atrazine) @ 800 g/acre on medium to heavy textured soils and 500 g/acre in light soils within two days of sowing, in 200 litres of water. In case, herbicide could not be applied as pre-emergence, Atrataf (Atrazine) can also be sprayed as 20 cm wide band (250 g/acre) over the crop rows upto 10 days after sowing followed by hoeing/interculture at 15 to 30 days after sowing or as blanket spray (500 to 800 g/acre depending upon the soil type) upto ten days after sowing.

This herbicide is effective against annual grasses and broad leaf weeds. This herbicide is particularly effective against *itsit* (*Trianthema portulacastrum*). Spray the herbicide uniformly at recommended rates to minimize residual toxicity to crops sown after maize. The spray solution left over in the bucket should not be thrown into the field because it will pose serious adverse effect on the following *rabi* crop. Where *itsit* is not a problem, Lasso 50EC (Alachlor) can also be applied @ 2 litres per acre in 200 litres of water within two days of sowing (pre-emergence). For control of hardy weeds like *Bans patta (Brachiaria reptans)*, Gha *(Arachna racemosa)*, Kaon makki *(Commelina benghalensis)*, pre-emergence tank mix application of atrazine 600 g/acre with Stomp 30 EC (pendimethalin) or Lasso 50 EC (alachlor) or Treflan 48 EC (trifluralin) each at 1 liter per acre dissolved in 200 litres of water should be sprayed. For the control of *Dila/Motha* (*Cyperus rotundus*), apply 2,4-D amine salt 58% @ 400ml/acre as post emergence 20-25 days after sowing by dissolving in 150 litre of water.

For cultural control of weeds, grow one or two rows of fodder cowpea in between maize rows and harvest it at 35 to 45 days after sowing before it starts twining the maize plants and thereafter no weed control operation is required. For inter-cropping of Cowpea use about 2/3rd of recommended seed rate of cowpea i.e. 16 kg per acre for cowpea 88 and 8 kg per acre for Cowpea CL 367. It does not require any additional fertilizer. Sow maize and cowpea simultaneously.

Irrigation and Drainage :

Irrigation : Generally, 4-6 irrigations are required depending on the rainfall. Adequate water-supply is essential throughout the crop season particularly during the pre-tasselling and silking stages.

Drainage and safeguards against excess water : Maize can tolerate heavy rains provided fields are not subjected to excessive soil wetness/flooding for prolonged periods. Flooding particularly at young stage causes a great damage to the crop. To avoid flooding, drain away excess water by making a drain of adequate capacity at the lower end of the field. If such a damage does occur, spray 6 kg urea/acre in two sprays at weekly interval (3% solution) in case of moderate damage or broadcast additional nitrogen @ 12 to 24 kg (25-50 kg urea) per acre in case of moderate to severe damage only after the flooding of the crop is over.

Fertilizer Application : Green manure the field, to be put under maize with any of the crops, namely *Dhaincha* or *Cowpea* or add adequate quantities of organic matter in the form of farmyard

manure or compost before sowing. Cowpea/*Dhaincha/Sunhemp* should be sown during second fortnight of April using 12/20/20 kg seed per acre. Green manure crop should be burried when about 50 days old and allowed to decompose for about 10 days before sowing of maize. In case, summer moong crop is grown the straw should be burried before sowing maize. The application of organic matter to the soil ensures good tilth and improves its water-holding capacity. Apply the following amounts of inorganic fertilizers.

	Nutrients (kg/acre)			*Fertilizers* (kg/acre)*				
	N	P_2O_5	K_2O	Urea	***DAP	or Single Super phosphate	or Nitro-phosphate	**Muriate of potash
Varieties								
PMH 1, Parbhat and Pb. Sweet Corn 1	50	24	12	110	55	150	125	20
PMH2, Kesri and Pearl Popcorn	35	12	8	75	27	75	62	15

Practice green manuring and apply full dose of nitrogen (50 kg N/acre) to get high yield of maize in maize-wheat system. It also improves the soil health.

* These nutrients can also be supplied from other fertilizers available in the market (Appendix IV).

** Apply only if the soil-test shows deficiency of potash.

*** When 27 kg of DAP is used, reduce the urea dose by 10 kg and when 55 kg of DAP is used, reduce the dose of urea by 20 kg and when 125 kg nitrophosphate is used reduce urea dose by 50 kg. when 62 kg nitrophosphate is used reduce urea by 25 kg.

Note : These recommendations are valid for medium fertility soils; for low and high fertility soils see chapter "Soil Testing".

In phosphorus and sulphur deficient soils apply sulphated P fertilizer (13:33:0:15:N:P_2O_5:K_2O:S) if other phosphorus or sulphur containing fertilizers are not available.

To all recommended varieties, drill one-third of nitrogen and the entire quantity of phosphorus and potassium at the time of sowing. If nitrophosphate is used omit urea application at sowing. Top dress one-third of nitrogen at the knee-high stage and the remaining one-third at the pre-tasseling stage.

Planter can be used to drill the seed at the desired spacing and fertilizer at the desired depth simultaneously.

Note : (*i*) If maize follows wheat, which had received the recommended quantities of phosphorus and potassium, omit the application of these nutrients to it.

(*ii*) If more than 6 tonnes of good quality farmyard manure per acre has been applied to the maize crop year after year, omit the application of phosphorus, potassium, zinc and nitrogen recommended as basal dose.

(*iii*) Application of nitrogen fertilizer more than recommended dose is no substitute for FYM/ green manuring.

Use Leaf Colour Chart (LCC) for need-based nitrogen fertilizer application to maize:

- Apply basal dose of 25 kg urea per acre.
- Start matching colour of the first fully exposed leaf from the top with the LCC at 10 day interval after 21 days of sowing.
- Whenever the greenness of 6 or more out of 10 leaves is lighter than LCC shade 5, apply 25 kg urea per acre.
- No urea should be applied if colour of leaves is equal to or darker than LCC shade 5.
- Use of LCC should be discontinued after initiation of silking and no more urea should be applied.

Note: Always match colour of the leaf with LCC under shade of the body. The leaves selected for measuring leaf greenness should be free of insect-pest incidence. There should not be water stress to the crop and nutrients other than nitrogen should be supplied as per recommendations. The LCC can be purchased from Department of Soil Science and Communication Centre, PAU, Ludhiana.

Zinc Deficiency : Zinc deficiency is widespread in areas where the high yielding varieties are grown. The deficiency symptoms appear within two weeks of seedling emergence. A broad band of white or very light-yellow tissue, with reddish veins appears, on each side of the midrib, beginning at the base of the second or third leaf from the top of the plant. The white patch later extends in stripes towards the tip parallel to the midrib. The midrib and the leaf margin remain green. The plants remain stunted and have short inter-nodes. In the case of mild deficiency there is a white stripe in the upper leaves. The mild deficiency disappears by the mid-season, but the silking and taselling are delayed.

Where zinc deficiency had been noticed in the preceding crop, broadcast 10 kg of zinc sulphate heptahydrate (21 %) or 6.5 kg zinc sulphate monohydrate (33 %) per acre at sowing mixed with an equal quantity of dry soil, along rows, hoe it into the soil and then irrigate the field. When zinc sulphate is to be applied after the zinc-deficiency symptoms appear in the crop, apply 10 kg of zinc sulphate heptahydrate (21 %) or 6.5 kg zinc sulphate monohydrate (33 %) mixed with an equal quantity of dry soil along rows, hoe it into the soil and then irrigate the field. When the symptoms are observed late in the season and interculture is not possible, spray zinc sulphate-lime mixture prepared by mixing 1.2 kg of zinc sulphate heptahydrate (21 %) and 0.6 kg of unslaked lime or 0.75 kg zinc sulphate monohydrate (33 %) and 0.375 kg of unslaked lime with 200 litres of water to cover one acre.

Harvesting and Threshing : The maize crop is ready for harvesting even when the stalks and leaves are some what green but the husk cover has dried and turned brown. In the fields where wheat is to be sown, harvest the stalks alongwith the cobs, stack them. Maize dehusker cum thresher (Appendix-III) can also be used for shelling of un-husked maize. However, for better results

maize (with husk) be shelled when the moisture content ranges between 15 to 20 percent. Conventional maize sheller can also be used after removal of ears. After shelling, market the dried grains with about 15 per cent moisture content. Maize shellers operated manually or with power are also available in the market (Appendix III). Conventional grain-combines can also be used for threshing maize with husk to save labour involved in dehusking. However, some adjustments are necessary. The maize ears should preferably be dried for 3 to 4 days after harvesting.

BABY CORN

Baby corn is the young ear of female inflorescence of maize plant harvested before fertilization when the silks have just emerged. The dehusked young ear is eaten raw as *salad* and used for cooking as vegetable, preparing pickle, *pakora* and soup. Baby corn salad and soup is delicacy in hotels, air lines and shipping companies because of crispiness and sweet flavour. Baby corn has export potential as it is very extensively consumed in developed countries. The crop raised for baby corn is terminated in about 60 days and rest of the plant can be used for feeding cattle.

Hybrid Parkash and Composite Kesri are most appropriate varieties for taking baby corn crop, which give on an average 7.0 and 5.7 q/acre yield of dehusked ears respectively. Hybrid Parkash is most suitable as it gives higher yield of uniform and good quality ears. The sowing of baby corn crop can be done at any time during April to August. It is possible to have two or more crops from the same piece of land as this crop terminates in less than 60 days. Staggered sowing should be done to maintain the supply as per requirement. Sow the crop having row to row spacing of 30 cm and plant to plant of 20 cm using 16 kg seed/acre. Apply 24 kg N per acre in two equal splits i.e. at sowing and knee high stage. Pick the young baby corn ears just at the silk emergence stage and ears picked later on would be pithy, woody and of poor quality. Take only three picks from each plant as ears appearing later are not of good quality. It is important to remove the tassel as soon as it appears to check the pollination. Ears with single layer of husk are taken to market after doing dehusking. The other agronomic practices including land preparation, weed control, fertilizer requirement to raise the crop are same as for grain crop.

Production of Pure Seed : Get certified seed of *hybrids* from the Punjab State Seed Corporation or PAU. If the grain-produce of a hybrid crop is used as seed, it will give 15 to 20 per cent less yield.

SEED PRODUCTION OF HYBRIDS

Every year fresh hybrid seed of PMH 1, PMH 2 and Parkash has to be produced for cultivation. The parental lines of these hybrids alongwith their characteristics are detailed here.

i) PMH 1

Female parent LM 13 : The plants are tall with medium ear placement. The brace roots have anthocyanin coloration. The leaves are medium narrow and erect. The tassel is medium dense with many straight branches. The anthers and silks have anthocyanin coloration. The ears

are medium with orange flint medium round grains borne on white cob. It matures in 104 days during kharif and yields about 10 quintals per acre.

Male parent LM 14 : The plants are tall with medium ear placement. The leaves are broad and curved. The stem is zig-zag. The tassel is medium and glumes are devoid of green color. The silk color is whitish. The ears are thick with poor tip filling having yellow round grains borne on white cob. It matures in 106 days and yields about 8 quintals per acre.

ii) PMH 2

Female parent LM 15 : It has short plant height and medium ear placement. The leaves are medium sized, dark green and semi erect. Tassel is medium sized and semi compact. The silks are light green. It has medium round orange flint kernels with slight yellow capping. The cob colour is white. It matures is about 84 days.

Male parent LM 16 : It has medium tall plants with medium ear placement. Leaves have slightly wavy leaf blade. Tassel is medium sized and semi open. The silks are light green. It has orange flint bold round kernels. Ears have completely filled tips. Cob colour is white. It matures in about 88 days.

iii) Parkash

Female parent CM 139 : It has medium tall plants and medium ear placement. The leaves are light green with wavy leaf blade. Its tassel is short and open. The silks are light green. It has orange flint, bold, round kernels. The cob colour is white. It matures in about 88 days and yields 6 quintals per acre.

Male parent CM 140 : It has medium plant height and ear placement. The leaves are semi erect. The tassel is lax and open. The silks are light pink. The kernels are dull to normal orange flint. The cob colour is white. It matures in about 88 days and yields 6 quintals per acre.

The seed production of hybrids can be successfully done in July and first week of August sowing which will escape pollen wash with rains. The seed of hybrids PMH 1, PMH 2 and Parkash can be produced during *Kharif* season by planting in the second fortnight of July.

The following steps are involved in the production of hybrid seed.

i) Obtain fresh seed of both the female and pollinator lines of the hybrids from Punjab Agricultural University every year.

ii) The quantity of seed of parental lines required for sowing one acre of seed plot.

Parkash	CM 139 : 6 kg	CM 140 : 2 kg
PMH 1	LM 13 6 kg	LM 14 2 kg
PMH 2	LM 15 5 kg	LM 16 3 kg

iii) Planting should be done at the spacing 60x15 cm.

iv) Select an isolated field which is located atleast 200-300 metres away (depending on kind of seed) from another maize field or ensure time isolation.

v) Ratio of pollinator and female lines should be kept at 1:3 (one row of pollinator parent and three rows of female parent) for *Parkash*, PMH 1 and PMH 2.

vi) Off type plants should be rogued out before pollination.

vii) All the tassles in the female rows must be removed prior to pollen shedding. Tassels should be removed daily even if there is rain.

viii) 75 kg N per acre should be used in seed production plots. Other nutrients should be applied as for normal commercial crop.

ix) All other cultural practices be used as for normal maize crop.

x) The seed harvested from female rows only should be kept and used as hybrid seed. The male rows should be harvested first and kept separately. This should be followed by harvesting and shelling of female rows. The off type ears should be discarded before shelling.

Seed Production of Composite Varieties :

The grain produce of composite varieties such as *Kesri, Pearl Popcorn, Punjab Sweet Corn 1, Parbhat,* Megha (recommended for cultivation in rainfed areas) and J 1006 (forage variety) can be used as seed for 3-4 years without any marked reduction in yield. To maintain purity and the production potential of these varieties, take the following precautions :

1. Avoid admixture with other varieties.
2. Avoid natural cross-pollination with any other maize variety or hybrid growing in the nearby fields. This can be done by isolating the composite maize plot from other maize fields by having no maize crop in a strip of about 200 metres all around or by growing one acre of composite maize and then selecting ears from the central portion of the field, leaving a 9-metre strip all round.
3. Take about 5,000 maize ears and mix the grains from all of them. Even if the seed requirement is small, never bulk the grains from less than 3,000 ears.

The grain produce of composite varieties may, however, be used as seed from the first year even when conditions No. 2 and 3 have not been met.

Plant-Protection Measures

1. Insect Pests :

Maize borer : The maize borer is a serious pest from June to September. Its larvae first scrape the leaves and then bore into the stem through the whorl or leaf sheath. The central leaves of the attacked whorl get perforated. In a young plant, the growing point is killed and a dead-heart results. Adopt the following integrated control measures :

(i) Kill the borer larvae hibernating in plant remnants like stubbles, stalks, cobs and cores. Plough up the fields after harvesting the maize crop, collect the stubbles and burn them. Use maize stalks, cobs and cores by the end of February. Chop the remaining stalks, if any, for subsequent use. For seed, keep only healthy cobs, free from borer attack.

(ii) Remove and destroy the plants showing severe borer injury, while hoeing the crop.

(iii) Use trichocards having 40,000 eggs of *Corcyra cephalonica* per acre parasitized by *Trichogramma chilonis* on 10-15 days old maize crop. Cut trichocards into 40 strips, each having approximately 1000 parasitized eggs. Staple these strips uniformly on the underside of the central whorl leaves in evening hours. The trichocards should not be applied on rainy days.

(iv) Spray the crop 2-3 weeks after sowing or as soon as borer injury to the leaves is noticed using 60 litres water per acre with knap-sack sprayer with any of the following synthetic pyrethroids :

Sumicidin 20 EC (fenvalerate)	40 ml
Ripcord 10 EC (cypermethrin)	40 ml
Decis 2.8 EC (deltamethrin)	80 ml

Normally no additional spray or granular application is required after the spray with pyrethroids.

OR

Spray as above with any of the following insecticides :

Sevin 50 WP (carbaryl)	100 g

Maize Shoot fly - Shoot fly is the most serious pest of spring sown maize in Punjab. It attacks very young (3-4 days old) seedlings, producing deformed, twisted and dead hearted plants. For the control of this pest, apply Furadan 3G (carbofuran) @ 5 kg/acre or Thimet 10G (phorate) @ 4 kg/acre in the furrows at the time of sowing.

Jassid, thrips, pyrilla, grey weevil* and *leaf-feeding insects– They attack the normal *kharif* crop. Spray Metasystox 25 EC (oxydemeton methyl) or Rogor 30 EC (dimethoate) @ 200 ml per acre in 50 litres of water with manually operated knap-sack sprayer or in 20 litres of water with a low-volume sprayer.

Armyworm and silk cutter – These insects feed on the leaves in the whorl. The pesticides used against the maize borer are effective in controlling these pests also.

Hairy caterpillars – Hairy caterpillars, appearing in an epidemic form, cause serious damage by feeding on the leaves and the tender stems. When young, they feed gregariously. The grown up caterpillars may migrate from one field to another. Adopt the following control measures :

(i) Use light-traps for the destruction of moths.

(ii) Young larvae are gregarious. They can be destroyed by plucking the infested leaves or by pulling out the infested plants and burying them underground.

(iii) The grown up caterpillars can be destroyed by crushing them under feet or by picking and putting them into kerosenized water. If the population is high, control it by sparying 500 ml of Ekalux 25 EC (quinalphos) or 200 ml of Nuvan 100 EC (dichlorvos) in 100-200 litres of water with a manually operated sprayer, per acre.

Mite – The attack of mite is serious in June on the young crop or in September-October when the crop is nearing maturity. The affected leaves turn pale and can be recognized from the presence of dusty webs. Spray 100 ml of monocrotophos in 100 litres of water per acre.

2. Birds (See Chapter Management of Birds)

3. Diseases

Seed rot and seedling blight **(Several fungi)** – Poor germination, unthrifty seedlings and seedling mortality are the symptoms. To control, treat the seed with Bavistin* or Derosal* or Agrozim* @ 3 g/kg seed.

Philippine downy mildew *(Peronosclerospora philippinensis):* Systemic infection is established in young plants, older plants are resistant. The infected plants are conspicuous due to the presence of chlorotic stripes on young developing leaves and pronounced whitish downy growth on all infected tissues. Infected plants are stunted and are highly susceptible to Maydis leaf blight. Most of the infected plants die pre-maturely. Plants that survive either remain barren or develop malformed ears/tassels. To control, protect young seedlings from infection by spraying Indofil M-45 (mancozeb)* @ 200 g/100 litres of water. Give one more spray after 10 days.

Brown stripe downy mildew (*Sclerophthora rayssiae* var *zeae) :* It is characterized by the presence of long, narrow, brownish, interveinal stripes on leaves. Whitish downy fungal growth may be observed on close examination on underside of the stripes. Destroy the collateral host *Takri* grass (*Digitaria sanguinalis*) from the maize field. Keep the fields well drained. Spray Indofil M-45 @ 200 g/100 litres of water after about a fortnight of sowing. Give two more sprays at 10-day intervals. Grow resistant/tolerant varieties.

Maydis leaf blight (*Drechslera maydis*) : This disease is characterized by the presence of spindle shaped, necrotic-to-brown lesions on the leaves. Such lesions may merge to form large, irregular patches. Sometimes the symptoms also appear on leaf sheaths, cob husks and ears. Destroy the infected crop residue in the field. Grow improved varieties. Follow spray schedule as against BSDM.

Late wilt (*Cephalosporium maydis*) : Plants wilt after flowering. The rind and basal internodes become discoloured. On splitting, the discolouration of the pith progressing upward is also seen. Grow improved varieties of maize.

Bacterial stalk rot (*Erwinia chrysanthemi* pv. zeae) – Water soaking and rotting of basal stem especially the leaf sheaths followed by rapid rotting of basal internodes. The rind loses its natural green colour and gives appearance as if boiled in water. The rotten stalks emit a characteristic fermenting odour and may break over from the second or third basal internode. The infected plants wilt. Destroy the diseased plant debris, keep the fields well drained and use improved varieties for its control.

* Chemicals belong to green chemistry category.

MAIZE CULTIVATION UNDER RAINFED CONDITIONS

It is possible to increase its yield per acre by 50-100% by adopting dry-farming practices.

Improved varieties :

PMH 2 (2005) : It is a short duration drought tolerant hybrid. It has medium plant height with medium ear placement. Its leaves are medium sized and dark green. Tassel is of medium size and semi open. Silk is of green colour. Ears are medium long with orange flint grains with yellow caps. The cob colour is white. It matures in about 82 days. Its average yield is 16.5 quintals per acre under rainfed conditions with well distributed rains. The hybrid resists lodging and is tolerant to bacterial stalk rot.

Parkash (1997) ***:*** It is an early maturing single cross hybrid. It has medium tall plants with medium ear placement. Its leaves are dark green, medium sized and semi-erect. Tassel is of medium size and open. Short anthesis-silking interval confers drought tolerance to the hybrid. Ears are uniform and long with slightly blank tip. Grains are attractive orange flint. Cob is thin and white. Plants have stay green characteristic. It matures in about 82 days. It yields 15 quintals per acre.

Megha (1990) ***:*** This composite combines early maturity with drought tolerance and is specifically suited for the rainfed area of the state. It matures in 82 days. It has medium tall plants with medium ear placement. The grains are attractive, medium sized, yellow-orange flint. It yields 12 quintals per acre.

Agronomic Practices

Seed Rate : 8 kg/acre

Time of Sowing : June 20 - July 7

(Preferably sow as early as possible depending on the rains)

Method of Sowing : Sow the seed 3-5 cm deep in lines with row and plant spacing of 40-50 cm and 20-25 cm, respectively.

Moisture Conservation : The monsoon rainfall is adequate but erratic in its distribution. Moisture stress during critical periods of growth is, therefore, experienced. Following moisture conservation practices are recommended.

(*i*) Repair the field bunds and do minor levelling wherever needed before the onset of rains.

(*ii*) Plough the field against slope after the pre-monsoon showers to enhance rain water absorption/ infiltration.

(*iii*) Sowing and other operations should be done on contour/across the slope.

(*iv*) Spread locally available mulching material in the standing maize crop in the last week of August.

***Fertilizer Application*:** It pays to apply fertilizers to the rainfed maize crop. The response to fertilizer varies with the water stored in the soil. In the absence of a soil-test report, apply fertilizer at the following rates.

	Nutrients (kg/acre)			**Fertilizers (kg/acre)*			
Soil type	N	P_2O_5	K_2O	Urea	***DAP	or Single Superphosphate	**Muriate of potash
Sandy loam to clay loam soils with adequate moisture stored	32	16	8	70	35	100	15
Loamy sand to sandy soils with low moisture stored	16	8	4	35	18	50	8

* These nutrients can also be supplied from other fertilizers available in the market (Appendix IV)

** Apply only when the soil-test shows deficiency of potash.

*** Where 35 kg DAP is used, reduce the urea dose by 15 kg and where 18 kg DAP is used, reduce the urea dose by 8 kg.

Note : These recommendations are valid for medium fertility soils; for low and high fertility soils see chapter on "Soil Testing".

Time and Method of Application : Drill 1/2 N and all P and K at sowing and top dress the other half of N one month after sowing.

Note : 1. Omit the application of phosphorus and potassium if maize is adequately fertilized with farmyard manure.

2. Light textured soils e.g. sandy to loamy sand usually have a low water retention capacity and on such soils, wheat followed by maize gives poor yield. For the best results, green manure with sunhemp or grow fodder crop during kharif and take a crop of wheat, wheat + *raya/taramira* in rows during *rabi*.

3. The other agronomic practices like land preparation, seed treatment, hoeing and thinning, weed control, method of production of pure seed of composite varieties and plant protection measures are same as recommended for irrigated maize.

BAJRA

Bajra occupied about 3 thousand hectares, with an average yield of 3.5 quintals per acre during 2012-2013 in the Punjab State. The major *bajra* growing districts are Bathinda, Faridkot, Ferozepur, Moga, Mansa and Sangrur.

Soil and Climatic Requirements :

Bajra can be grown on a wide range of soils, but being sensitive to water logging, it does best on well-drained sandy loam soils. It is a rapid growing, warm weather crop, suitable for areas with 40 to 65 cm of annual rainfall. The rain at flowering washes off the pollen and reduce the seed-set.

Rotations :

Bajra-Wheat/Gram/Barley/*Raya*/*Gobhi Sarson.*

Improved Varieties

***PHB 2884 (Adhoc)* :** This hybrid is 230 cm tall and bears 2-3 productive tillers. It has long ears with average length of 28 cm and girth of 12 cm. Its grains are medium bold and slate in colour. It is resistant to downy mildew, ergot and smut. It matures in 88 days and average grain yield is 13.2 quintals per acre.

PHB 2168 (2006): This hybrid is about 210 cm tall, bears 2-3 productive tillers and matures in 83 days. It has medium long ears having an average length of 26 cm and girth 9 cm. Its grains are medium bold and slate in colour. It is resistant to downy mildew. Its average grain yield is 16.4 quintals per acre.

***PCB 164 (2003)* :** This is dual purpose composite variety having medium thick stalks and flexible stem with average plant height of 207 cm. It matures in 80 days. This variety has long cylindrical dense ears having 27-28 cm length and 8-10 cm girth. The grains are medium bold and light slate in colour. The average grain yield is 15 quintals per acre. It is highly resistant to downy mildew.

PHB 47 (1983) : This thick-stalked, broad-leaved hybrid has delayed senescence and attains height of about 2 metres. Its ears are about 35 cm long, compact and profusely bristled. It bears 2 tillers and matures in about 85 days. The grains are medium bold and slate in colour. It is highly resistant to downy mildew and has slightly better tolerance to ergot and smut diseases. Under irrigated conditions, its grain yield is about 13 quintals per acre.

Agronomic Practices

Land Preparation : Fine seedbed and adequate moisture in the seedbed is conducive to good germination. Prepare the field by giving 2 or 3 ploughings followed by planking.

Sowing Time : In areas of low rainfall, sow bajra in early July. For other areas sow it in the last week of July so that the crop blossoms after the monsoon rains which hinder pollination and reduce yield.

Seed Treatment : Treat the seed before sowing with 3 g of Agrozim 50 WP* + Thiram (1 : 1) or Agrozim 50 WP + Captan* (1 : 1) per kg of seed to prevent seed rot and seedling mortality.

* Chemicals belong to green chemistry category.

Seed Rate and Method of Sowing : One-and-a-half kg of seed is enough for an acre. The seed rate can be reduced to one kg if the seed-bed is well prepared and a uniform distribution of the seed is ensured. Sow the seed about 2.5 cm deep in rows 50 cm apart. Three weeks after sowing, thin the seedlings to 15 cm apart in the rows. If the stand is poor, fill the patches by transplanting the uprooted seedlings.

Fertilizer Application **:** Apply the following dose of fertilizers to bajra.

Varieties	*Nutrients (kg/acre)		Fertilizer (kg/acre)			
	N	P_2O_5	Urea	DAP	or	Single Super phosphate
			Irrigated Conditions			
Hybrid/composite Bajra	40	24	90	55		150
			Rainfed Conditions			
Hybrid/composite Bajra	25	12	55	27		75

***** These nutrients can also be supplied from other fertilizers available in the market (Appendix IV).

Note : (*i*) Apply 10 kg zinc sulphate heptahydrate or 6.5 kg zinc sulphate monohydrate per acre at sowing in zinc deficient soils.

(*ii*) Apply potash if the soil test shows deficiency of potash.

(*iii*) When DAP is used @ 27 and 55 kg/acre, reduce the urea dose by 10 and 20 kg respectively.

(iv) These recommendations are valid for medium fertility soils; for low and high fertility soils see chapter on "Soil Testing".

Time and Method of Application : Under irrigated conditions apply 1/2 N and whole of P with last ploughing. Apply the remaining N in two splits, one at thining & one before ear formation.

Under rainfed conditions apply 1/2 N and whole of P with last ploughing & remaining N about one month later after a shower of rain followed by hoeing so as to mix the fertilizer and also to create a soil mulch.

Weed Control : Interculture the crop three to five weeks after sowing. Avoid deep hoeings near the plants so that their roots are not damaged. Damaged roots reduce mean yield. A wheel-hoe, *triphali* or tractor-drawn cultivator can be used for interculture.

Alternatively, weeds can also be controlled with the spray of Atrataf 50 WP (Atrazine) @ 200 g/ acre within two days of sowing. It provides effective control of annual weeds particularly *itsit/chupati* (*Trianthema portulacastrum*).

Irrigation and Drainage : Generally, two irrigations during the growing period of the crop are enough. Bajra does not tolerate water-logging. So do not allow rain-water to stand for more than a few hours.

Seed Production

Hybrid Varieties : The seed of hybrid varieties should be procured afresh every year from a seed agency. For seed production of hybrid varieties the certified seed of female and male parents should be obtained from a reliable source. The parental lines of hybrids alongwith their characteristics are given below :

1. PHB 2168

Female parent ICMA - 92333 : This male sterile line has an average height of 140 cm having 2-3 tillers and 22-24 cm long ears. It takes 54 days for 50% flowering and matures in 86 days.

Male parent PIB 686 : The restorer line has an average plant height of 150 cm, 26-27 cm long and compact ears, having yellow anthers. It takes about 56 days for 50% flowering and matures in 88 days.

2. PHB 47

Pb. 111A : This male sterile female line is semi-dwarf (138 cm) with compact and about 35 cm long ears having minute bristling. The ears have naked beak at the tip. The anthers are cream coloured. It matures in about 90 days.

PIB 1234 : It has long (30 cm) and profusely bristled ears. It has about 2 m height and matures in about 90 days.

The male and female parents are planted in an isolated field with no *bajra* crop in 200 m around it, in the ratio of 4 female : 2 male rows. Frequent roguing of female and male rows is required to remove off type plants before flowering.

Composite Varieties : After procuring certified seed of composite varieties from a reliable agency the farmers can produce the seed of these varieties by growing in an isolation plot having no *bajra* crop in a strip of about 200 metres on all sides or by harvesting from the centre of about one acre field leaving a strip of approximately 10 metres all around.

Plant Protection Measures

1. Insect Pests

Root bug : This insect causes damage to the *bajra* crop in south-western districts. On the standing crop, spray 2 litres of Malathion 50 EC in 100 litres of water per acre by directing the spray towards the base of the plant. Irrigate or hoe the crop immediately.

Grass-hopper : Dust the crop with Malathion 5% @ 10 kg per acre, for controlling grass-hoppers.

Grey-Weevil, Pyrilla and Fulgorid-See under MAIZE.

2. Birds : (See Chapter Management of Birds)

3. Diseases

Green-ear or downy mildew : The green-ear disease or downy-mildew is caused by *Sclerospora graminicola.* The leaves of infected plants show discolouration, yellowing and whitening. Under humid conditions, the leaves are covered with a downy white growth of the fungus, which is prominent on the lower-surface. The leaves turn necrotic and are torn into shreds. The ears of the infected plants are transformed wholly or partly into green heads of small, twisted, leafy structures. Adopt the following measures to control the disease.

(i) Grow downy-mildew resistant hybrids PHB 2168, PHB 47 and composite variety PCB 164.

(ii) Rogue out the diseased plants early in the season to prevent secondary infection.

(iii) Collect the diseased ears from the crop before harvesting and destroy them by burning.

(iv) Practise five year rotation with other crops.

Grain smut : Smut is caused by *Tolyposporium penicillariae.* Individual grains in an ear get transformed into smut balls which may later burst open to release millions of spores which get disseminated and cause secondary infection on the portion of the ear which is enclosed by the sheath of the upper leaf. The intensity of the attack varies according to the humidity in the area. The following control measures are suggested :

(i) Remove the diseased ears early in the season and destroy them.

(ii) Treat the seed before sowing with an organo mercurial fungicide, viz. 2.5 g of Ceresan/ Agrosan (phenyl mercury acetate) or 3 g of Thiram/Captan* per kg of seed to prevent the introduction of smut into new areas.

Ergot : This disease is caused by the fungus *Claviceps fusiformis.* At blossoming, a pinkish or light-coloured fluid (honey dew) exudes from the spikelets in different parts of the ear. Later dark sticky patches appear on the ear and small dark-brown sclerotia appear in place of grains between the glumes. The seed set is poor or completely inhibited. The ovary is replaced by a fungal mass with many folds on its surface. The fungus perpetuates through the seed-borne and soil-borne sclerotia.

Caution : The contaminated grains, if fed to cattle or used by human beings can cause poisoning. Therefore, take the following precautions :

For Cattle : Do not feed the infected ears showing honey-dew symptoms to cattle. Even the stems and leaves of such plants are not safe as cattle feed. Cut and burn a badly affected crop to reduce the amount of inoculum.

For Human beings : Immerse the grains in 10 per cent salt solution. The sclerotia, being lighter than normal grains, will float. Remove them with a sieve and burn them. Repeat the process two or three times.

Prevention of Ergot : Once the disease appears, it is not possible to eliminate it. Take the following precautions to prevent its spread.

(i) Immerse seed in 10 per cent salt solution and remove the sclerotia and smut-balls by skimming. Then wash the seed in ordinary water and dry it thoroughly before treating it with fungicides, as recommended under Grain Smut.

(ii) At the boot-stage, spray the crop with Cuman L 27% (ziram) using 500 ml of it in 100 litres of water per acre. Repeat 2 or 3 times at 5-day intervals.

(iii) Burn the ears infested with honey-dew, as soon as they are observed in the field.

(iv) After harvesting the crop, bury the debris with a furrow turning plough so that the ergot sclerotia rot in the soil.

(v) After threshing the ergot affected crop, the left-over-ear-heads of *bajra* in the threshing floor should also be burnt.

(vi) Avoid sowing *bajra* next year in a field in which the crop had suffered heavily from ergot.

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* Chemical belongs to green chemistry category.

2. COTTON

Cotton is an important kharif crop of the Punjab State. It was grown on 481 thousand hectares in 2012-2013. The total production was 1627 thousand bales. The average lint yield for the state as a whole was 575 kg per hectare.

Hints for high yield of cotton

1. Grow only recommended varieties/hybrids resistant/tolerant to cotton leaf curl viral disease.
2. Eradicate alternate hosts of cotton leaf curl virus/volunteer cotton plants before sowing, to avoid the multiplication and spread of diseases.
3. Must soak delinted seed in water for 2-4 hours.
4. **Heavy pre-sowing irrigation is must to obtain good germination and early establishment of plants.**
5. Complete the sowing from April to 15 May. It will help to escape the attack of American bollworm to great extent.
6. Avoid sowing American cotton in/or near the orchards.
7. Avoid growing *bhindi, moong, arhar, castor, dhaincha* in and around the cotton fields to avoid simultaneous build up and spread of pests and diseases to cotton.
8. Cultural control is indispensable for management of mealy bug.
9. Regular monitoring followed by campaign is effective strategy for the management of mealy bug.
10. **The incidence of insect pests increases with excessive use of nitrogenous fertilizers, hence use only recommended dose.**
11. Spray to control jassid only when it reaches economic threshold level of second injury grade i.e. marginal cupping of leaves.
12. **Give 4 sprays of 2 per cent potassium nitrate (13:0:45) solution starting at flower initiation, at weekly interval**
13. Avoid using synthetic pyrethroids after September 15 to minimize resurgence of whitefly. Prefer to use triazophos and ethion to control whitefly.
14. Avoid tank mixing and use of readymade insecticidal mixtures.
15. Control American bollworm at the initial stages. Use chlorpyriphos/spinosad/acephate/ indoxacarb for the control of larvae when their length is more than 1.25 cm.
16. Use chlorpyriphos/thiodicarb/acephate/quinalphos against tobacco caterpillar taking into consideration the pest complex.

17. Follow Insecticide Resistance Management (IRM) strategy for effective management of insect pests.
18. Use fixed type hollowcone nozzle which discharges 600 ml of spray material per minute for efficient pest control.

Important hints for Bt Cotton

1. Grow only recommended hybrids Bt cotton NCS 855 BGII, Ankur 3028 BG II, MRC 7017 BG II, MRC 7031 BG II of Bt cotton.
2. Avoid sowing Bt cotton in light sandy soils.
3. Give first irrigation 4-6 weeks after sowing depending on soil type.
4. Control sucking pests and tobacco caterpillar as and when situation arises. Last irrigation in September is must.
5. Grow non-Bt cotton as refuge on the periphery of Bt cotton to prevent development of resistance against Bt in bollworms. If 20 per cent area is under refuge then it should be protected against bollworms by using recommended insecticides but if refuge occupies only 5 per cent area then it should not be protected.

Climatic Requirements :

A daily minimum temperature of 16°C is required for germination and 21°C to 27°C for proper crop growth. During the fruiting phase, the day temperature ranging from 27°C to 32°C and cool nights are needed. The cotton-picking period from mid-September to November must have bright sunny days to ensure a good quality of the produce.

Soil Type :

Cotton can be successfully grown on all soils, except sandy, saline or waterlogged types. Proper drainage of excess water during rains is essential.

Rotations

Cotton – Fallow, Cotton – Wheat/Barley, Cotton – Sunflower, Cotton – Senji/Barseem/Oats, Cotton – Sunflower-Paddy-Wheat, Cotton – Raya

Improved Varieties

American Cotton

RCH 650 BGII (Subject to aprroval by SVAC) : It is a new high yeilding *Bt* cotton hybrid with inbuilt resistance against American, spotted and pink bollworms and tobacco caterpillars. This hybrid is tolerant to parawilt. It has semi-sympodial plant with green broad lobed leaves. It bears big bolls with average boll weight 4.5 g. It gave an average seed cotton yield of 9.5q/acre. The fibre length of this hybrid is 25.5 mm and ginning outturn is 34.1 per cent.

RCH 776 BGII (Subject to aprroval by SVAC) : It is *Bt.* cotton hybrid with inbuilt resistance against American, spotted and pink bollworms and tobacco caterpillars. This hybrid bears 2-3 monopods and 25-29 sympods. It belongs to medium maturity group and gave an average seed

cotton yield of 9.3q/acre. The boll weight of this hybrid is 4.2 g with fluffy opening. It has good fibre properties with fibre length of 27.5 mm and ginning outturn of 33.2 per cent. This hybrid is tolerant to para wilt.

NCS 855 BG II (2013) : It is a new high yielding Bt cotton hybrid with inbuilt resistance against American, spotted and pink bollworms, and tobacco caterpillars; and tolerant to para wilt. It has semi-sympodial plants with green broad lobed leaves, cream flowers. It gave an average seed cotton yield of 9.7 quintals per acre. It has very good fibre properties with fibre length of 28.5 mm and ginning outturn of 35.6 per cent.

Ankur 3028 BG-II (2012) : It is a new high yielding Bt cotton hybrid with inbuilt resistance against American, spotted and pink bollworms, and tobacco caterpillars. This hybrid is morderately resistant to cotton leaf curl virus and tolerant to parawilt. The hybrid has semi-sympodial plant with green, medium size palmate leaves, cream white flowers with pale yellow anthers, medium ovate shaped bolls with fluffy opening. It belongs to medium maturity group and gave an average seed cotton yield of 9.7 quintals per acre. It has very good fibre properities with fibre length of 31.3 mm and ginning outturn of 31.4 per cent.

MRC 7017 BG-II (2010) : It is a new early maturing high yielding Bt Cotton hybrid with inbuilt resistance against American, spotted and pink bollworms, and tobacco caterpillars. This hybrid is also resistant to cotton leat curl virus and tolerant to parawilt. It has semi-sympodial plants with green broad lobed leaves, cream flowers having pale yellow anthers. It belongs to medium maturity group and gave an average seed cotton yield of 10.4 quintals per acre. It has very good fibre properties. With fibre length of 29.7 mm with ginning outturn of 33.6 per cent.

MRC 7031BG-II (2010) : It is a new high yielding Bt cotton hybrid with inbuilt resistance against American, spotted and pink bollworms, and tobacco caterpillers. It is also resistant to cotton leaf curl virus and tolerant to parawilt. The plant of this hybrid possesses green broad lobed leaves and cream flowers with pale yellow anthers. It gave an average seed cotton yield of 9.8 quintals per acre. The fibre length of this hybrid is 29.4 mm and ginning outturn is 33.4 per cent.

LHH 144 (1998) : This is an intra-*hirsutum*, leaf curl virus resistant hybrid, with semi-okra leaves. It has 3-4 monopods, 20-25 sympods and about 151 cm plant height. The average boll weight is 5.5 g. Besides its resistance to leaf curl it is also tolerant to jassid and bacterial blight. It matures in about 180 days and is suitable for cotton-wheat rotation. It recorded an average seed cotton yield of 7.6 quintals per acre. It has 28.8 mm 2.5% span length and 33.0% ginning outturn. LHH 144 has superior medium staple fibre which is suitable for spinning at 40^{s} counts.

LH 2108 (2013) : This is a new high yielding of American cotton variety. The variety has semi-sympodial green plants, medium size palmate leaves, cream white flowers with creamy white anthers and medium ovate shaped bolls with fluffy opening. It bears 1-2 monopods and 24-26 sympods per plant. It matures in 165-175 days with average plant height of 145 cm. It gives an average seed cotton yield of 8.4 quintals per acre. It has 34.8% ginning outturn and 27.9 mm 2.5% span length.

LH 2076 (2008) : It is newly released, high yielding, cotton leaf curl virus resistant variety with green broad lobed leaves and green stem. It matures in 165-175 days with average plant height of

153 cm. It gives an average seed cotton yield of 7.8 quintals per acre. It has 33.4% ginning outturn and 27.1 mm 2.5% span length.

F 1861 (2002) : It is a cotton leaf curl virus resistant variety recommended for cultivation throughout the Punjab State. The plant of this variety bears 1-2 monopods with 13-16 sympods and has an average plant height of 135 cm. It has dark green broad lobed leaves with narrow tips slightly curved upwards. Its maturity period is 180 days. It recorded an average seed cotton yield of 6.5 quintals per acre. It has medium staple with 2.5% span length of 26.3 mm. Its ginning outturn is 33.5% and is spinnable at 30s counts.

Desi Cotton

FMDH 9 (Subject to aprroval by SVAC) : It is a genetic male sterility based *desi* cotton variety with green plant body, narrow lobed leaves, white flowers and red spot inside the petal. It possesses medium size bolls with fluffy opening. It vacates the field in about 160 days for timely sowing of *rabi* crops. Its average yield is 10.0 quintals per acre. Its ginning outturn is 37.3% and fibre length is 23.4 mm. It is resistant to jassid and whitefly and tolerant to *Fusarium* wilt and bacterial blight.

PAU 626 H (2007) : It is an early maturing and high yielding genetic male sterility based *desi* cotton hybrid. Plants of this hybrid have pigmentation on stem and branches, leaves are green of medium size and okra in shape with five lobes. It has pink flowers with yellow anthers. It possesses medium size bolls with fluffy opening. It vacates the field in about 160 days for timely sowing of rabi crops. Its average yield is 9.8 quintals per acre. Its ginning outturn is 40.0% and fibre length is 20.1 mm. It has better tolerance to Fusarium wilt and bacterial blight.

FDK 124 (2011) : It is an early maturing, high yielding variety of *desi* cotton. It has green plant body and narrow lobed leaves. It is synchronous in maturity and takes about 160 days to mature. It is short staple, coarse fibre variety with 2.5 span length of 21.0 mm and ginning outturn of 36.4%. It gave an average seed cotton yield of 9.28 quintals per acre. It is resistant to jassid and whitefly.

LD 694 (2001) : It is a *desi* cotton variety with dark-red pigmented plant body, narrow lobed leaves, pink flowers and red spot inside the petal. It possesses big bolls with fluffy opening. LD 694 matures in about 170 days and is more synchronous in maturity than other released varieties of desi cotton. It is short staple, coarse fibre variety with ginning outturn of 40.9%. It gave an average seed-cotton yield of 7 quintals per acre. It is resistent to jassid and more tolerant to *Fusarium* wilt and bacterial blight.

LD 327 (1987) : It is a high yielding and high ginning semi-sympodial variety. The plants are reddish brown with narrow-lobed deep cut leaves and pink flowers. It possesses big bolls usually with 4-loculi, better opening and easy picking. It vacates the field in about 175 days for the timely sowing of wheat. It is relatively tolerant to Fusarium wilt. Its fibre is short, coarse and suitable for export . Its average yield is 11.5 quintals per acre. Its 2.5% span length is 19.0 mm and ginning percentage is 41.9.

Other Popular Varieties

BCHH 6488 BG II : This hybrid has broad lobed green leaves with cream flowers. It matures

in 165-170 days. It has mean ginning outturn of 34.5 per cent and 2.5% span length of 27.0mm. **It was found susceptible to cotton leaf curl and recorded high incidence of Para wilt.**

BCHH 6588 BGII : This hybrid is also being cultivated by the farmers by the farmers but it has not tested by the Punjab Agricultural University.

Agronomic Practices

Land Preparation : A fine seed-bed is essential for securing a good plant stand.

Seed Rate

Varieties/hybrids		*Seed-rate (kg/acre)*
American Cotton		
Bt Hybrids :	RCH 650 BG II, RCH 776 BG II, NCS 855 BGII, Ankur 3028 BG II MRC 7017 BG II and MRC 7031 BG II	0.750
Non Bt Hybrid :	LHH 144	1.5
Varieties :	LH 2108, LH 2076 and F 1861	3.5
***Desi* Cotton**		
Hybrid	FMDH 9, PAU 626 H	1.25
Varieties :	FDK 124, LD 694 and LD 327	3.0

Acid Delinting of Cotton Seed : Mix 100 g commercial grade concentrated sulphuric acid with 1 kg cotton seed for American as well as *desi* cotton in earthen/plastic container by stirring it vigorously for two to three minutes with a thick wooden or glass rod. As soon as the fuzz gets dissolved, add 10 litres of water, stir well and drain out water through the perforated plastic basket. Repeat these washings three times to make the seed free from sulphuric acid residue. Dip the washed seed for about one minute in sodium bicarbonate solution (12.5 g sodium bicarbonate in 2.5 litres of water) to neutralize the acid residue on the cotton-seed. Give one more washing with water and remove light, damaged and rotten inviable seeds floating on the surface. Dry the healthy fuzz-free seed in the shade by spreading in a thin layer. Treat the dry seed with recommended fungicides.

Precautions

1. Metal or wood container should not be used
2. The operator should wear the plastic gloves
3. The water containing acid and alkali residue should be properly disposed off in the waste land.
4. Inadequate washing and delayed washing of the seed after acid treatment and residual acid on the seed if not neutralized may impair the germination of seed.

Seed Treatment and Seed Soaking : Add half gram (0.5 g) Emisan-6 (methoxiy ethyl mercury chloride) and one fourth gram (0.25 g) of Streptocycline* for one kg cotton seed in one litre

* Chemical belongs to green chemistry category.

of water. In case of acid delinted seed soak the seed for 2-4 hours and for non-delinted seed 6-8 hours. Also add half gram succinic acid in 5 litres of water to promote good establishment of plant stand, better early growth and more yield. After this treatment, the cotton seed should be smeared with Gaucho 70 WS (Imidacloprid) @ 5 g or cruiser 70 WS (Thiomethoxam) @ 3g/kg seed for preventing damage by cotton jassid.

In case undelinted seed is used, rub it with fine earth, cow-dung or ash to remove its fuzz and ensure its uniform distribution.

Time of Sowing : First April to 15th May

Note : Sowing during this period ensures better yield and escapes the attack of insect pests and diseases. Sowing should be done in morning and evening hours.

Sowing and Spacing : Sow in lines 67.5 cm apart with a cotton sowing drill. The plants within rows be kept 60 cm apart at thinning in case of *nerma* and 45cm in case of *desi* cotton. However, for hybrids (both Bt and non-Bt) the plant to plant distance should be kept at 75cm. It may be done after first irrigation or heavy shower. For *desi* cotton hybrid the plant to plant spacing should be kept at 60 cm.

Intercropping : Intercrop one row either of maize or cowpea as fodder and summer moong as grain crop in Bt Cotton sown at row to row spacing of 67.5 cm for getting higher productivity and monetary returns as compared to sole Bt Cotton. Apply recommended fertilizers to Bt cotton and on area basis to intercrops. Harvest maize and cowpeas fodder 45-55 days after sowing.

Ridge sowing : Sowing of cotton on ridges prepared with cotton planter and irrigating the crop in furrows saves considerable amount of irrigation water without reduction in seed cotton yield.

Transplanting of cotton seedlings : For gap filling, 3 week old nursery grown in 4"x6" polythene bags, filled with 1:1 mixture of soil and FYM, can be transplanted.

Weed Control : Hoe two or three times. The first hoeing should be done before first irrigation. For hand weeding, use of a wheel hoe is recommended. A tractor drawn cultivator or bullock driven Triphali can also be used in the early stages of the crop growth but their use after fruit initiation should be avoided. Chemical weed control in cotton is cheap and efficient. For control of weeds particularly *itsit* (*Trianthema portulacastrum*), *Madhana/Makra (Eleusine* spp), apply Treflan 48 EC, Shaktiman Triflurex 48 EC (trifluralin) @ 1.0 litre/acre on a well prepared seed bed and incorporate these herbicides thoroughly in 3-4 cm soil or Stomp 30 EC @ 1.0 litre/acre as pre-emergence within 24 hours of sowing. Weeds start emerging at about 5-6 weeks after application of herbicide. Give one hoeing/interculture around 45 days after sowing to control these weeds.

Alternatively, in place of hoeing/interculture apply Gramoxone 24 per cent WSC (paraquat) 500 ml/acre or Roundup 41% SL/Glycel 41% SL (Glyphosate) 1.0 litre or Excel Mera 71 SG 600 g/acre in 100 litres of water (6-8 weeks after sowing when the crop is about 40-45 cm in height) as a directed spray to control weeds in between the crop rows. To avoid drift, spray these herbicides on non-windy days. The directed spray can be done using knap-sack sprayer fitted with flat fan nozzle and keeping the boom height low (15-20 cm above the ground level) or using a protective hood so

that herbicide does not fall on crop leaves. Both paraquat and glyphosate are non-selective herbicides and can cause injury to the crop if it falls on the crop leaves. However, falling of herbicides on stem of the plant is not harmful. In situations where perennial weeds are a problem, glyphosate is more effective and provides long duration control.

In situations where *itsit* emerges after first irrigation or with the rain shower Stomp @ 1.0 litre/ acre can also be applied as post-emergence after first irrigation to cotton. If the weeds emerge before the application of the herbicide, a light hoeing/interculture may be done as the Stomp does not control the emerged weeds. Dissolve the herbicide thoroughly in 200-250 litres of water/acre and spray it uniformly with a knap sack sprayer fitted with flat fan or flood jet nozzle. The herbicide can also be sprayed with tractor mounted sprayer fitted with flat fan nozzle. For getting good results with the herbicide, following precautions should be taken :

Prepare a fine seed bed free from plant residues and clods, ensure adequate moisture in the field at the time of spray of herbicide, spray of the herbicide should be done either in the morning or evening hours.

Fertilizer Application : Cotton responds well to the application of nitrogen. In certain areas, the crop shows some response to the application of phosphatic fertilizers.

Drill all phosphorus at sowing. Apply half N at thinning and the remaining half at the appearance of the first flower for all varieties. If the soil is low in fertility, the first half dose of N may be applied at sowing instead of at thinning. Apply 20 kg muriate of potash in soils medium in available potassium and 10 kg zinc sulphate heptahydrate (21%) or 6.5 kg zinc sulphate monohydrate (33%) per acre to cotton on light soils. To get higher yields, give four sprays of 2% potassium nitrate (13:0:45) at weekly interval starting at flower initiation in addition to soil applied fertilizers. For high yield and management of leaf reddening in Bt cotton, give two sprays of 1% magnesium sulphate (1 kg magnesium sulphate in 100 litres of water per acre) at 15 days interval during full bloom and boll development stage.

The following fertilizer recommendations are made :

	*Nutrients (kg/acre)		Fertilizers (kg/acre)		
	N	P_2O_5	*Urea*	*DAP or*	*Single Super-Phosphate*
(A) Varieties	30	12	65	27	75
(B) Bt and non-Bt Hybrids	60	12	130	27	75

* These nutrients can also be supplied from other fertilizers available in the market (Appendix IV).

** Where 27 kg DAP is used, reduce the urea dose by 10 kg.

Note : i) Omit application of phosphorus to cotton when it follows wheat which received recommended dose of phosphorus.

ii) In soils testing low in nitrogen and phosphorus apply 25% more fertilizer than the recommended dose, whereas in high nitrogen and phosphorus soils reduce it by 25%.

Irrigation and Drainage :

Cotton requires four to six irrigations, depending upon the seasonal rainfall. The first irrigation should be given 4 to 6 weeks after sowing and the subsequent ones at interval of two or three weeks. Sowing cotton on ridges and irrigation in furrows save considerable amount of water. The crop must not be allowed to suffer for want of water during the flowering and fruiting stages, otherwise a lot of shedding of flowers and bolls will take place resulting in low yield. Cotton during its early growth is very sensitive to water stagnation. Therefore, drain out the stagnant water, if such a situation arises. To hasten boll opening give the last irrigation by the end of September.

Caution : On light soils and in crop sown on ridges, the first irrigation may be advanced if necessary.

Hybrid Seed Production

LHH 144 : This is a cross between PIL 43 (Female parent) having okra lobed leaves and PIL 8 Miah (male parent). The hybrid seed is produced by hand emasculation of flower buds of female parent and pollination by flowers of male parent. The seed of parental lines should be purchased from Punjab Agricultural University every year to maintain genetic purity. The emasculated flower bud is covered with soda straw pipe and the male flower is tied with a 3" piece of a thread in the evening. The tied male flowers are used for pollinating the emasculated female buds in the morning. A piece of thread is tied to the stalk of the bud after pollination which serves as a marker for crossed boll.

Characteristics of Parents

PIL 43 : The female parent of LHH 144 has bushy plant habit with 3-4 monopods, okra type narrow lobed green leaves, creamy white flower and pollen. It has bold seeds. It matures in about 185 days.

PIL 8 : The male parent of LHH 144 has compact plant type with 0-1 monopod and about 130 cm plant height. It has medium lobed green leaves, creamy white flowers and matures in about 165 days.

Isolation of hybrid seed plot : The hybrid seed production field should have an isolation of 50 metres from other American cotton varieties and 5 meters between male and female plots to ensure the genetic purity of the seed.

Seed Rate and Spacing in Hybrid Seed Plot : One acre hybrid seed production plot requires 6 kanal area under female parent and 2 kanal area under male parent with the following seed rate and spacing :

Parental lines	Seed rate (kg/acre)	Spacing (cm) LHH 144
Female	3.0	67.5 x 90
Male	1.5	67.5 x 60

The skipping of one row after every two rows in female plot gives better setting of crossed bolls. In LHH 144 hybrid seed production 50 per cent of the male parent should be sown along with

female parent and the remaining 50 per cent 10-15 days later to get sufficient number of male flowers for crossing.

Roguing :

Off-type plants based on plant colour, leaf shape, flower colour etc., if any, should be rogued to maintain purity of parental lines.

Seed Production Technique :

The F1 hybrid seed is produced by the placement of functional pollen of the desired male parent on to the receptive stigma of the emasculated female at right time. Emasculation of flowers is done from 3 PM to 6 PM by removing the anthers with thumb nail before maturity (anthesis) and pollinate the next morning from 9 AM to 11 AM when stigma is receptive. Avoid too young or too old buds. The male flowers to be taken for pollination should be selfed the previous evening to avoid contamination by insects. For identification of crossed bolls at maturity the crossed flower buds should be tagged. In order to enhance the setting percentage unattempted flowers and naturally formed bolls should be removed. Hybrid seed plot should be kept free from weeds and special care should be taken to prevent damage due to insect pests and diseases.

Picking, Storing and Ginning :

The kapas from crossed healthy and marked bolls should be picked, stored and ginned separately. The cleaned seed should be labelled and stored in a clean dry place. Its genetic purity and germination should be tested before use.

Hybrid Seed Production

PAU 626 H and FMDH 9:

PAU 626 H and FMDH 9 are produced by crossing DS 5 (female parent) with LD 694 (male parent) and HD 402 (male parent) respectively. DS-5 is a genetic male sterile line and, thus there is no need of emasculating the female flowers. Crossing is accomplished by applying pollen from freshly opened flowers of the male parent on the stigma of the freshly opened flowers of the female parent.

Maintenance of Parental lines

Female parent (DS-5) : The male sterile line is maintained by pollinating the male sterile plants with pollen from male fertile plants of the same line. Since male sterility in DS-5 is controlled by a single recessive nuclear gene, so we always get a mixture of male sterile and male fertile plants in 1:1 ratio.

The male sterile plants are identified on the basis of their small, whitish and shriveled anthers. The male fertile plants have well developed anthers and after flower opening the anthers are covered with bright yellow pollen grains. Freshly opened flowers on male sterile plants are pollinated with pollen from male fertile plants in the morning (9.00-11.00 AM). Pollination is done by rubbing the anthers of fertile flowers on the stigma of male sterile flowers. For identification of these artificially pollinated flowers, a thread is tied to the pedicel of the flowers immediately after pollination.

Male parent (LD 694 and HD 402) : This is normal male fertile genotype and is maintained just like other varieties by following normal seed production and certification norms. Care should be taken to maintain maximum genetic purity.

Characteristics of Parents

DS-5 It is a genetic male-sterile line. The male-sterile plants are identified on the basis of their small, shriveled and whitish anthers. It has green plant body with narrow deep cut leaves, creamy white flowers and monopodial plant habit.

LD 694 This male parent has dark-red pigmented plant body, narrow lobed leaves, pink flowers and red spot inside the petal.

HD 402 This male parent has green plant body, narrow lobed leaves, white flowers and red spot inside the petal.

Production of hybrid seed

Isolation of hybrid seed Plot : The hybrid seed production plot should have an isolation of 50 meters from other *desi* cotton varieties and 5 meters between male and female plots to ensure genetic purity of the seed.

Seed rate and Spacing in hybrid seed plot : One acre hybrid seed production plot requires 6 kanal area under female parent and 2 kanal area under male parent with the following seed rate and spacing.

Parental lines	*Seed rate (kg/acre)*	*Spacing (cm)*
DS-5 (Female Parent)	2.0	67.5 x 45 cm
LD 694 (Male Parent)	1.0	67.5 x 45 cm
HD 402 (Male Parent)	1.0	67.5 x 45 cm

The skipping of one row after every two rows in female plot gives better setting of crossed bolls.

Rouging : In the female parent, 50% plants are expected to be male-fertile. These plants are identified by examining the first opened flower and rouged out. This is necessary to obtain a pure stand of the male-sterile plants.

Crossing Procedure : For production of hybrid seed, freshly opened flowers of the male parent (LD 694/HD 402) is used as source of pollen. Pollen is applied in the morning (9.00-11.00 AM) by rubbing anthers of the male flower on the stigma of freshly opened flowers of female parent (DS-5). For identification of crossed bolls, threads are tied to the pedicel of cross pollinated flowers. In order to enhance the setting percentage, unpollinated flowers and naturally pollinated bolls should be removed. Hybrid seed plot should be kept free from weeds and special care should be taken to control insects and diseases. The crop should not suffer from moisture stress at flowering stage as it will lead to shedding of flowers/bolls.

Picking, Storing and Ginning : The *Kapas* from crossed healthy and marked bolls should be picked, stored and ginned separately. The cleaned seed should be labeled and stored in a clean dry place. Its genetic purity and germination should be tested before use.

Plant-Protection Measures

1. Insect Pests Management (Bt cotton)

Bt cotton does not provide effective control of sucking pests and tobacco caterpillar.

Sucking Insect Pests : Among sucking pests, jassid, aphid, whitefly and mealy bug are most serious on Bt cotton and they cause maximum damage during July-September. Nymphs and adults of jassid suck sap from leaves and cause shedding in case of severe infestation. Whitefly adults and nymphs suck sap from leaves and excrete honey dew on leaves which become sticky. Affected leaves and seed cotton turn black due to development of sooty mould. Aphids appear sporadically. The nymphs and adults of aphid suck sap and excrete honey dew on leaves on which black fungus develops. Petioles, internodes, flowers, buds, mature bolls and even leaves fall down and growth of the plant is retarded.

Tobacco caterpillar : It is a polyphagous pest. The larvae cause serious damage to crop from August to October. The small larvae are black whereas grown up larvae are dark green with black triangular spots on body. Its moths lay eggs in masses covered with brown hairs on the lower side of mature leaves. After hatching, first and second instar larvae feed gregariously and skeletonize the foliage. Later on grown up larvae disperse and feed singly. Besides leaves, they also damage the buds, flowers and green bolls.

Spotted, pink and American bollworms may also attack Bt cotton late in the season. Due to attack of these bollworms shedding of flowers and bolls may occur.

For effective protection of Bt cotton, it is necessary to adopt the following Integrated Pest Management strategies.

A. Cultural and Mechanical Control

* Grow only recommended Bt cotton hybrids.
* Avoid growing castor, *moong, dhaincha* and *bhindi* in and around the Bt cotton. These are the most preferred hosts of tobacco caterpillar, helping the pest to multiply and shift to cotton.
* Keep the fields free from the weed, *itsit* as it acts as an alternate host of tobacco caterpillar.
* Egg masses and young larvae of tobacco caterpillar feeding gregariously should be collected along with leaves and destroyed.

Management strategy for Mealy bug

I. During off-season

i. Prevention of carryover of pest

- Spray of infested plants/rows of cotton after last picking is useful.
- Dislodge the mealy bugs by shredding the infested sticks against ground and destroy them by burying deep in to the soil.
- Stack the cotton sticks from infested rows separately and use these sticks on priority as fuel, by end of February.
- Remove the stacks of cotton stick from the fields or houses before end February and destroy the mealy bugs by burying them in the soil.

- Do not allow the grazing of sheep and goats and other farm animals in mealy bug infested fields, although sheeps and goats feed on left over bolls to control pink bollworm.
- Prevent the movement of sticks from the infested areas to the new areas.
- Do not stack the cotton sticks in the field.

ii. On alternate hosts

- Eradicate the weeds like *kanghi buti* and *peeli buti*, congress grass, *puthkanda, gutputna, bhakhra, itsit* and *tandla* growing on field bunds, wastelands, roadsides and irrigation channels/ canals. Repeat these operations at monthly interval upto the end of April.
- Do not throw the uprooted infested plants in cotton fields/water channels to check further spread.
- The trees/fruit plants near cotton fields harboring mealy bug population should be sprayed with recommended insecticides.

II. During crop season

- Sow only recommended hybrids/varieties of Bt cotton, because undiscript hybrids/varieties of Bt cotton help in faster multiplication of mealy bug.
- Grow bajra, maize and jawar as barrier crops, being least preferred hosts
- Do not grow guara, okra in or around the cotton crop as these are most suitable hosts for the multiplication of mealy bug.
- The pest is initially restricted to a few plants in a row, thus spot treatment of pest with recommended insecticides on cotton crop is advocated.
- Thorough coverage of plant with insecticides is essential to check the multiplication of mealy bug.
- Restrict the movement of workers in the infested fields to prevent further spread of pest.
- Control the mealy bug by spraying any of the insecticides given in table 1.

B. Monitoring of bollworms and tobacco caterpillar with sex pheromones

The monitoring of bollworms and tobacco caterpillar should be done with the initiation of flowering stage of crop. Observations on moth catch should be recorded on every alternate day. This monitoring strategy will help in making decision for effective management of bollworms and tobacco caterpillar.

Pink bollworm: Use Sticka/Delta traps with at least 10 micro litre of gossyplure and place it at 15 cm above crop canopy. Replace the lure after 15 days and use 1 trap/ha.

Spotted/Spiny bollworms: Use Sleeve/Moth catch traps for spotted bollworms and replace the lure at 15 days interval. Place the trap at 15 cm above the crop canopy and use 2 traps/ha.

American bollworm: Use Sleeve/Moth catch traps with at least 2 mg of pheromone and place it at 15 cm above crop canopy. Replace the lure after 15 days and use 2 traps/ha.

Tobacco Caterpillar: Use Sleeve/Moth catch trap for tobacco caterpillar. Replace the lure after every 15 days. Place the trap 15cm above crop canopy and use 2 traps/ha.

C. Chemical Control

Sucking insect pests : The decision regarding spray of insecticides should be taken based on economic threshold (ETH). Initiate spray against jassid whenever some of the fully formed leaves in the upper canopy show curling and yellowing at the margins on 50 per cent of the plants. Sprays against whitefly should be done when population reaches six adults per leaf in the upper canopy of plants before 10 AM or when honey dew appears on 50% of the plants. Spray against aphid should also be done on the appearance of honey dew on 50% plants. Spray the crop as soon as the crawlers/adults of mealy bug appear on the cotton plant. (Table 1).

Tobacco Caterpillar : Bt cotton does not provide protection against tobacco caterpillar. Tobacco caterpillar can cause severe damage to the Bt crop if not controlled in time. For effective control of this pest, insecticides mentioned in Table 2 should be sprayed when the need arises.

Bollworms : Bt cotton provides effective protection against all cotton bollworms. However, regular monitoring should be done at weekly interval during reproductive phase. Farmers should examine their fields twice a week in order to ensure that bollworms damage does not exceed 5 per cent in shed flowers and bolls. For this purpose divide the field into four quarters and collect 25 freshly shed flowers and bolls at random in each quarter. The bolls damaged by bollworms will have feeding holes or their larvae. In case the damage exceeds 5 per cent, the crop should be sprayed immediately and thereafter spray as when need arises. If at all American bollworms cross ETH level during late crop season, use insecticides as mentioned in Table 2. Prefer spinosad and indoxacarb for the control of American bollworm during September.

Resistance Management : To avoid the development of resistance in bollworms to Bt cotton, 20 per cent area should be sown under non-Bt cotton hybrids around Bt cotton. The refuge should be non-Bt version of the same hybrid. But if it is not possible, the farmers can use non Bt varieties/ hybrids like LH-1556, F-1861, LH-2076, LHH-144 recommended by PAU as refuge. The non-Bt hybrids should be protected against damage by insect pests as mentioned in case of non-Bt cotton hybrids. Alternatively 5 per cent area of non-Bt hybrids can be sown around Bt cotton and this should be kept unsprayed.

2. Insect Pests Management (Non-Bt cotton)

Sucking Insect Pests : (See under Bt-cotton)

Bollworms : Bollworms are the most harmful insects which attack cotton in the Punjab. Spotted bollworms damage growing points during May-June and cause heavy shedding of squares, buds, flowers and bolls during July to October. The American bollworm causes severe shedding of fruiting bodies during September-October especially on American cotton. The colour of its larvae greatly varies. They have one line on upper side and two wavy lines on lateral side of body. Their body also has sparse hairs. Pink bollworm does maximum damage from mid-July to mid-October. Due to severe attack of bollworms, the plants continue to grow without having adequate number of bolls.

Tobacco caterpillar : (See under Bt-cotton).

The larvae of leaf-roller, semi-loopers, hairy-caterpillars and bud moth may also appear sporadically and damage the crop during July-October.

For effective protection of cotton, it is necessary to adopt the following **Integrated Pest Management approach** based on cultural, mechanical and chemical control measures :

(A) Cultural and Mechanical Control

* Burn all trash collected during the ginning process. Remove all seed from the ginneries by the end of April. Fumigate the seed left uncrushed in the mills before end of May with Celphos/ Phostoxin/Delicia @ one 3-g tablet per cubic metre space, giving an exposure of 48 hours or use two tablets with an exposure of 24 hours. No un-fumigated seed should be retained or sold by the ginneries. Only cotton-seed cake (*khal*), should be fed to the cattle and no seed should be kept for this purpose.
* The seed meant for sowing should be acid-delinted in the ginneries before it is sold. The acid-treatment kills the larvae of the pink bollworm and the bacterial pathogen of bacterial blight. It also removes fuzz and thereby facilitates mechanical sowing.
* Even the apparently healthy seed-cotton (*kapas*) may be harbouring larvae of pink bollworm. Hence, *kapas* retained by the farmers should be ginned by the end of March and seed fed to cattle. If this seed is to be retained for sowing, it should be acid-delinted/fumigated or thoroughly dried in the sun in a thin layer for 3-4 consecutive days in April.
* Sow only recommended varieties/hybrids because they are moderately resistant to jassid and due to their early maturity they also escape the late-season attack of bollworms.
* Terminate the crop as early as economically feasible. For this purpose give last irrigation by end of September. It would reduce bollworms damage and their carryover.
* After the last picking, allow sheep, goats and other farm animals into cotton fields to feed on plant debris and un-opened bolls.
* Stacking of cotton sticks in a shaded place and in horizontal position favours the survival of the over wintering larvae of pink bollworm. Stacking in the field helps in easier spread of the first brood. Therefore, bundles of sticks should be stacked vertically in the open within the village premises. Before stacking the sticks, dislodge the burs and unopened bolls by beating them against the ground or just pluck them. The burs and bolls so collected should be burnt immediately.
* Uproot and destroy the alternate host plants of spotted bollworms/*kanghi buti* and *peeli buti*, growing on field bunds, water channels and waste land in the area during the off-season of cotton.
* Avoid growing *bhindi, moong* and *arhar* in the cotton crop and as border rows in order to reduce the incidence of *Helicoverpa*, spotted bollworms, jassid and whitefly. *Bhindi, moong, dhaincha* and castor are also the most preferred hosts of tobacco caterpillar, helping the pest to multiply and shift to cotton. The above pests on these crops grown in the vicinity of cotton fields, should be properly controlled in order to check their migration to the cotton crop.
* Egg masses and young larvae of tobacco caterpillar feeding gregariously should be collected along with leaves and destroyed.

(B) Monitoring of bollworms with sex pheromones : (See under Bt-cotton).

(C) Chemical Control

Sucking pests : (See under Bt-cotton).

Table 1. Insecticides for the control of sucking insect pests

Insecticides	*Dose*	*Brand (s)*
	Jassid	
Neonicotinoids		
(a) Seed treatment: At the time of sowing smear the seed with any of the following insecticides.		
i) Imidacloprid	5 g/kg seed	Gaucho
ii) Thiamethoxam 30 FS	7 g/kg seed	Cruiser
(b) Spray : Spray any of the following insecticides, if incidence is noticed in standing crop.		
i) (a) Imidacloprid 200 SL	40 ml/acre	Confidor
(b) Imidacloprid 555	40 ml/acre	Confidence
(c) Imidacloprid 17.8 SL	40 ml/acre	Imidacel/Markdor
ii) Thiomethoxam 25 WG	40 g/acre	Actara/Extra super/Dotara
Pyridine Carboxamid		
iii) Flonicamid 50 WG	80g/acre	Ulala
	Whitefly	
Organophosphates		
i) Diafenthiuron 50 WP	200 g/acre	Polo
ii) Spiromesifen 240 SC	200 ml/acre	Oberon
iii) Triazophos 40 EC	600 ml/acre	Sutathion
iv) Ethion 50 EC	800 ml/acre	Fosmite/E-mite/Volthion
	Mealy Bug	
(a) Carbamate Group		
Thiodicarb 75 WP	250 g/acre	Larvin
Carbaryl 50 WP	1 kg/acre	Sevin/Hexavin
(b) Organophosphates		
Profenophos 50 EC	500ml/acre	Curacron/ Carina/Profex/ Celcron
Quinalphos 25 EC	800ml/acre	Ekalux/ Quinalphos/ Quingaurd

Insecticides	*Dose*	*Brand (s)*
Acephate 75SP	800g/acre	Orthene/Asataf/ Starthene/Markphate
Chlorpyriphos 20 EC	2000ml/acre	Coroban/Dursban/Durmet Chloruard/Radar/Lethal Force/Markpyriphos
(c) Insect growth regulator		
Buprofezin 25 EC*	500 ml/acre	Applaud/Tribune

* Use this pesticide as first spray for the control of mealy bug as this pesticide is safe for natural enemies.

Tobacco Caterpillar : (See under Bt Cotton).

Bollworms : In order to control bollworms, conduct sprays on different varieties during their effective boll formation period based on economic threshold (ETH). Farmers should examine their fields twice a week in order to ensure that bollworms damage does not exceed 5 per cent among the freshly shed fruiting bodies (squares, buds and young bolls). For this purpose divide the field into four quarters and collect 25 freshly shed fruiting bodies at random in each quarter. The fruiting bodies damaged by bollworms will have feeding holes or their larvae. In case the damage exceeds 5 per cent, the crop should be sprayed immediately and thereafter spray as when need arises. The effective boll formation period of different varieties/hybrids of American cotton during which spray of insecticides should be done is as follow :

Effective boll formation period in different varieties/hybrids of American Cotton

Variety/hybrid	*Effective boll formation period*
LH 1556	4th week of July to mid September
LH 2076, F 1861 and LHH 144	2nd week of August to 1st week of October
Long duration undescript varieties	3rd week of August to end October

3. Insect Pests Management *(Desi Cotton)* :

In case of *desi* cotton, the first spray against bollworms should be done when 25 per cent plants start producing squares. Subsequent spray should be need based.

Detopping : *Desi* cotton grown on medium to high fertility soils generally attain unmanageable height for effective spraying against bollworms. The top portion of plants with excessive height usually remain unsprayed. Fruiting bodies of these uncovered plant portions contribute very little towards yield but greatly help in bollworms build up. Plants attaining height more than 1.5m should be detopped as and when required by using pruning scatteur/sickle/green mulberry stick.

Insecticide Resistance Management (IRM) Strategy: IRM is component of Integrated Pest Management (IPM) programme. The adoption of this strategy helps in reducing/delaying the insecticide resistance to insects. It also increases functional life of the insecticides.

1. Sucking pests management (Sowing – first week of July)

i) Sow recommended varieties which are resistant to sucking pests and cotton leaf curl virus to avoid early sprays.

ii) Destroy alternate hosts of cotton leaf curl virus and whitefly.

iii) Timely sowing, judicious use of fertilizers, irrigation, proper spacing and clean cultivation will prevent the early build up of pests and help conserve natural enemies.

iv) Treat seed with Gaucho/Cruiser to control the cotton jassid in susceptible cultivars.

v) Do not use any insecticide during this period to conserve natural enemies.

vi) Do not spray against thrips and black semilooper, as they do not cause any economic damage to the crop.

2. Sucking pests and bollworms management (second week of July–first week of August)

vii) Avoid the use of synthetic pyrethroids for the control of spotted bollworms (SBW). Use them only if endosulfan fails to give satisfactory control.

viii) Avoid the use of chloronicotinoid compounds against jassid as these are toxic to natural enemies.

ix) Do not use organophosphates/carbamates against bollworms.

3. Bollworms and tobacco caterpillar management (Mid to end August)

x) Use profenophos/quinalphos/carbaryl flubendiamide in alternation with synthetic pyrethroids for the control of bollworms.

xi) Prefer the use of acephate for the control of grown up larvae of American bollworm. It will also provide effective control of tobacco caterpillar.

xii) Use spinosad only in case of severe infestation of American bollworm.

4. Bollworms and tobacco caterpillar management (September-October)

xiii) Use profenophos/triazophos/quinalphos/thiodicarb/flubendiamide for younger larvae of American bollworm. Prefer chlorpyriphos for grown up larvae. Chlorpyriphos, thiodicarb and quinalphos will also provide effective control of tobacco caterpillar.

xiv) Use indoxacarb/spinosad in case the American bollworm is serious.

xv) Use triazophos/ethion for the management of whitefly. It will also provide effective control of pink bollworm and spotted bollworms.

Table 2. Insecticides for the control of bollworms in cotton

Insecticides	*Dose/acre*	*Brand (s)*
	Pink and spotted bollworms	
A. Synthetic Pyrethroids		
i) Alphamethrin 10 EC	100 ml	Fastac/Alphagaurd/Merit Alpha
ii) β-cyfluthrin 0.25 SC	300 ml	Bulldock
iii) (a) Cypermethrin 10 EC	200 ml	Ripcord/Bilcyp/Bullet/Ustad/Cypergaurd
(b) Cypermethrin 25 EC	80 ml	Cymbush/Cyperkill/Hillcyper/Colt/Basathrin/ Agrocyper/Cypergaurd
iv) Deltamethrin 2.8 EC	160 ml	Desis/Rukrain/Decicare

Insecticides	*Dose/acre*	*Brand (s)*
v) Fenvalerate 20 EC	100 ml	Sumicidin/Fenval/Agrofen/Fenlik/Triumph-card/SB Fenvalerate/Milfen/Markfenval
vi) Fenpropathrin 10 EC	300 ml	Meothrin
Pink, spotted and younger larvae of American bollworm		
A. Carbamates		
i) Carbaryl 50 WP	1 kg	Sevin/Hexavin
ii) Thiodicarb 75 WP	250 g	Larvin
B. Organophosphatic		
iii) Profenophos 50 EC	500 ml	Curacron/Carina/Profex/ Celcron
iv) Monocrotophos 36 SL	500 ml	Phoskill/Monocil/Monolik/Kadett/SB Monocrotophos/Luphos/Azophos/Corophos/ Milphos/Markphos
v) Quinalphos 25 EC	800 ml	Ekalux/GAIC Quinalphos/Quingaurd
vi) Triazophos 40 EC	600 ml	
vii) Ethion 50 EC	800 ml	Fosmite/E-mite/Volthion
C. Miscellaneous group		
viii) Flubendiamide 480 SC*	40 ml	NNI 0001
Grown up larvae of American bollworm		
A. Organophosphates		
i) Acephate 75 SP	800 g	Orthene/Asataf/Starthene/Markphate
ii) Chlorpyriphos 20 EC	2 litres	Coroban/Dursban/Durmet/Chlorgaurd/ Radar/Lethal/Force/Markpyriphos
B. Naturalyte		
iii) Spinosad 48 SC	60 ml	Tracer
C. Oxadiazine		
iv) (a) Indoxacarb 15 SC	200 ml	Avaunt
(b) Indoxacarb 15 EC	200 ml	Avaunt
D. Miscellaneous group		
v) Pyridalyl 10 EC	300 ml	Sumipleo
vi) Chlorantraniliprole 18.5 SL*	60 ml	Coragen
Tobacco caterpillar		
A. Carbamate		
i) Thiodicarb 75 WP	250 g	Larvin
B. Organophosphates		
ii) Acephate 75 SP	800 g	Orthene/Asataf/Starthene
iii) Chlorpyriphos 20 EC	2 litres	Coroban/Dursban/Durmet/Chlorgaurd/ Radar/Lethal/Force
iv) Quinalphos 25 EC	800 ml	Ekalux/GAIC Quinalphos/Quingaurd
C. Insect Growth Regulator		
v) Novaluron 10 EC*	150 ml	Rimon
D. (vi) Pyridalyl 10 EC	300 ml	Sumipleo
(vii) Chlorantraniliprole 18.5 SL*	60 ml	Coragen

* Chemicals belong to green chemistry category.

Note :

a) Regularly monitor the pest population.

b) For effective insecticide resistance management do not repeat the insecticide of same group in subsequent sprays.

c) Do not use mixtures of insecticides as they will result in faster development of resistance and resurgence of pests.

d) Do not use synthetic pyrethroids on cotton for the control of bollworm complex after mid September.

e) Repeat the spray immediately if it rains with in 24 hours after spray.

f) If hairy caterpillars damage cotton crop during June-July use 500 ml quinalphos 25 EC or 200 ml of Nuvan/ DDVP 100 in 100 litres of water per acre.

g) Never follow the wrong advice of the pesticide dealers.

h) Cotton is highly sensitive to the 2, 4-D weedicide. Some farmers spray the ester form of 2, 4-D for controlling weeds in maize grown near the cotton fields. Owing to the volatile nature of 2, 4-D ester, its vapours cause serious injury to the cotton crop. Hence avoid the application of this herbicide in maize, if cotton is grown in the adjoining fields. The other precautions are :

(1) After using 2, 4-D on any crop, fill all spraying equipment as well as tubs, buckets, etc. with 0.5 per cent washing soda solution (500 g of washing soda in 100 litres of water) in the evening. Next morning, flush all equipments thoroughly with fresh water.

(2) To avoid the use of contaminated insecticides on cotton. It is advisable to test insecticide at least two weeks in advance on a few plants. If the insecticide is contaminated with 2, 4-D the tender leaves and shoots could become distorted and lancolated within 10 days. Reject such an insecticide.

Spray Technology

The insecticides recommended for control of sucking pests, bollworms and tobacco caterpillar should be sprayed using 125-150 litres spray material per acre with the manually operated knapsack sprayer or 75 litres with the shoulder-mounted power sprayer and tractor mounted sprayer. Quantity of spray material may vary with different types of sprayers and nozzles. However, actual amount of insecticide recommended should not be reduced.

Making pathways by pressing the branches on both sides helps in efficient spraying. Make such pathways at 2 meters distance for the manually operated knapsack sprayer and at 4 meters for the shoulder-mounted power sprayer.

Tractor mounted sprayer should have 13 triple action nozzles fixed on the boom at 75 cm distance from each other. Each nozzle should discharge 500-600 ml spray material per minute. The tractor should be operated at 4.0 and 2.5 km per hour speed for spraying against sucking pests and bollworms, respectively. Use the same tyre tracks and run the tractor in the same direction for all sprays. Keep the spray boom about 50 cm above the crop canopy. Each run of the tractor should cover about 10 meters width of the crop.

2. Diseases

Leaf curl : Disease is caused by whitefly transmitted virus. The diseased plants become stunted and have twisted internodes. Leaves remain small, show cupping and curling. Veins on the

lower-side of the leaves become thickened with netted appearance. Small leaflets (enations) also develop on the under side of the leaves on the main as well as lateral veins. Number of fruiting bodies are reduced in the diseased plants.

The disease can be reduced by adopting the following measures:

(i) LHH 144 and *desi* cotton varieties are resistant to leaf curl virus. LH 1556 and F 1861, LH 2076 are tolerant to this disease.
(ii) Avoid growing American cotton in and around citrus orchards and adjoining *bhindi* crop.
(iii) In non Bt cotton use 4 Kg seed per acre and go on uprooting and destroying the infected plants upto initiation of fruiting phase.
(iv) Protect the crop against whitefly vector at 4-5 leaf stage by using recommended insecticides.
(v) Follow clean cultivation and destroy *Kanghi buti (Sida* sp.) and *Peeli buti (Abutilon* sp.) which act as collateral hosts.
(vi) Destroy volunteer/ratoon cotton plants during the off season.

Root rot : This disease is caused by *Rhizoctonia solani* and *R. bataticola.* The main symptom is sudden and complete wilting of plant. The disease spreads in field in round patches. The affected plants can be pulled out very easily. The disease starts much early but wilting takes place quite late. The bark of the roots is broken into shreds and gives foul smell.

Bacterial blight : It is caused by *Xanthomonas axonopodis pv. malvacearum* which survives in seed and plant debris. Lesions on the leaves appear as minute, water-soaked, angular spots, which subsequently turn brown and then are transformed into black angular dead lesions on both sides of the leaf. The bacterium also infects the young developing bolls and causes small, round, water soaked spots depressed in the centre. Spray with Blitox 50 WP (500 g) + Agrimycin (20 g)/ Streptocycline* 3 g per acre at 15-20 days interval starting just after the first shower of rain. Three sprays will be enough. The quantity of water will depend upon the crop growth and the spray pump to be used.

Anthracnose : It is caused by *Glomerella gossypii* which survives on crop debris in the soil. It produces small, round reddish spots on leaves, bracts and bolls. The disease is severe at the seedling stage.

Leaf blight : The disease is caused by *Helminthosporium speciferum.* The fungus generally attacks the seedling causing pre and post emergence deaths. Light brown spots occur on the leaves. During severe infection, there is shedding of leaves, flowers and bolls.

The fungus *Alternaria gossypina* also causes blightening of the leaves. In the early-stages, the spots have a pale green area with irregular margins. As the spots enlarge, irregular concentric zones are formed. Sometimes severe shedding of leaves occur due to this disease. The plants with low vigour because of drought or deficiency of potash favour the development of this disease.

Leaf spots : The disease is caused by *Myrothecium roridum* and the symptoms appear on leaves, bracts as well as on bolls. The disease is characterized by circular to semicircular brown coloured spots with broad violet margins. At later stages, shield shaped, small size fruiting bodies

* Chemical belongs to green chemistry category.

Table 3. Performance of various insecticides against insect pests and safety to natural enemies of cotton

Insecticides	Insect Pests							Natural enemies	Remarks
	J	W	MB	PBW/ SBW	ABW Young	ABW Grown up	TC		
A. Organophosphates									
Monocrotophos	Good	Poor	Poor	Good	Poor	Poor	Poor	Highly toxic	Excessive use can cause resurgence of whitefly and American bollworm
Profenophos	Poor	Poor	Very good	Good	Good	Poor	Poor	Toxic	--
Quinalphos	Poor	Poor	good	Good	Good	Poor	Very good	Toxic	Excessive use can cause resurgence of Jassid
Chlorpyriphos	Poor	Poor	Very good	Good	Very good	Very good good	Very good good	Highly toxic	Excessive use can cause resurgence of Jassid .
Acephate	Good	Poor	Very good	Good	Very good	Very good	Very good	Toxic	Excessive use can cause resurgence of whitefly and American bollworm
Triazophos	Poor	Very good	Poor	Good	Good	Poor	Poor	Toxic	--
Ethion	Poor	Very good	Poor	Good	Good	Poor	Poor	Toxic	-
B. Synthetic pyrethroids									
Alphamethrin, b-cyfluthrin cypermethrin, deltamethrin, fenvalerate, fenpropathrin	Poor	Poor	Poor	Very good	Poor	Poor	Poor	Toxic	Excessive use can cause resurgence of whitefly and American bollworm, high level of resistance to American bollworm
C. Carbamates									--
Carbaryl	Poor	Poor	Good	Good	Good	Poor	Poor	Toxic	Excessive use can cause resurgence of mite
Thiodicarb	Poor	Poor	Very good	Good	Good	Poor	Very good	Toxic	Excessive use can cause resurgence of mite

1	2	3	4	5	6	7	8	9	10
D. Naturalyte								-	
Spinosad	Poor	Poor	Poor	Good	Very good	Very good	Poor	Safe	Safer to the natural enemies
E. Oxadiazine									
Indoxacarb	Poor	Poor	Poor	Poor	Very good	Very good	Poor	Toxic	-
F. Miscellaneous group									
Flubendiamide	Poor	Poor	Poor	Very good	Very good	Good	Poor	Safe	Safe to the natural enemies
Chlorantraniliprole	poor	poor	poor	very good	very good	very good	very good	Safe	-
Pyridalyl	poor	poor	poor	good	good	good	very good	toxic	-
G. Insect Growth Regulator									
Novaluron	Poor	Poor	Poor	Good	Very good	Good	Very good	Safe	Safe to the natural enemies
Buprofezin	--	--	Very good	-	-	-	-	Safe	Safe to the natural enemies

J= Jassid; W= Whitefly; MB=Mealy bug; SBW= Spotted bollworm; PBW= Pink bollworm; ABW= American bollworm; TC= Tobacco caterpillar

appear in the central necrotic portion of the spot. The pathogen is a seed borne and also survives on the dead leaves. High humidity and intermittant rains are congenial for the development of the disease.

Another type of leaf spot disease which is caused by *Cercospora sp.* generally appears towards the end of the season. It produces small, circular spot having white centre with purple margin. In advance stages, necrotic central portion may fall out giving shot hole appearance.

To control anthracnose, leaf blights and leaf spots, the crop should be sprayed alternately with Blitox 50 WP or Captan 83* (500 g in 200 litres of water) at interval of 15 to 20 days starting just after the first shower of rain. Two to three sprays will be enough.

Wilt : It is a fungal disease caused by *Fusarium oxysporum f.sp. vasinfectum*. The pathogen of disease is both soil and seed-borne. In the diseased seedlings and plants, the leaves loose their turgidity, first turn yellow, then brown, start wilting and finally drop off. Discoloration of the leaves start from the margins and spreads towards the mid-ribs. The older leaves are affected first, followed by the younger ones towards the top. Wilting may be complete or partial. In the later case only one side of the plant is affected while the other remains apparently healthy. In complete wilting, the plant remains stunted, wilt rapidly and dies. The most prominent diagnostic symptom of the disease is browning and blackening of the vascular tissues. Five to six year rotation with non-host crops may help in controlling the disease. In the infested field, sow LD 694 variety of desi cotton since the same is tolerant to wilt. In the highly infested fields grow American cotton because it remains free from this disease. For the chemical control of wilt soak 3 kg seed in 6 litres of water containing 6 g of Bavistin*/Derosal* for 6-8 hrs. (non delinted seed) or 2-3 hrs. (acid delinted seed).

Grey mildew : Grey mildew or *dahiya* disease caused by *Ramularia areola* occurs sporadically during humid weather. It appears on leaves as dull white, irregular, transluscent spots bordered by veinlets with frosty growth on the lower surface of the leaves. It may cause defoliation and premature boll opening.

Tirak : It is a physiological disorder. It is characterized by the yellowing and reddening of leaves, followed by the bad opening of the bolls. The disease appears now and then. The attack is more pronounced in the dry belt adjoining Rajasthan and Haryana. It is particularly serious in pockets where cotton suffers from persistent drought, inadequate water supply, nutrient deficiency on light sandy soils, too early sowing or lack of plant protection measures. These factors may operate singly or in different combinations. Spells of high temperature prevailing during the flowering and fruiting further aggrevate the intensity of this malady. Judicious fertilization and timely watering particularly during flowering and fruiting stages, and the adoption of recommended plant protection schedule help to mitigate the intensity of this disease.

Parawilt : Parawilt is a physiological disorder and no pathogen is involved. It can occur when crop is applied irrigation or after heavy rains occur. Plants show sudden drooping of leaves which ultimately get wilted but the root system remains intact. The affected plants can be saved by spraying cobalt chloride @ 10mg per one litre of water (10 ppm) immediately after the appearance of symptoms. There would be no recovery if permanent wilting has already set in.

* Chemicals belong to green chemistry category.

Defoliation in cotton : Chemical defoliation with single spray of Ethrel 39% (Ethephon 39%) @ 5.0 ml/litre of water should be applied in last week of October. It leads to 85-90% defoliation after seven days of spray. Defoliation allows better sunlight penetration thereby resulting in early and uniform boll opening with increased productivity.

Picking : Cotton should be picked clean and dry to get a good price in the market. *Desi* cotton is ready for picking in the third week of September. Picking should be done after every 8-10 days to avoid loss because of the *Kapas* falling to the ground. Do not keep the picked cotton in wet water channels in the field, as this practice impairs the quality of cotton. Store kapas in a dry godown. Keep produce of different varieties separately.

Removal of cotton sticks : Soon after the last picking, remove the cotton sticks alongwith the roots from the field and bury the remaining plant debris with furrow turning plough as sanitary measure against pests and diseases. Use or burn cotton sticks by the end of February at the latest.

Use two-row tractor operated Cotton Stalk Uprooter for uprooting of Cotton stalks. The Cotton Stalk Uprooter should be operated at a speed of 7 to 9 km/hr and at a depth of 12 to 15 cm with 45hp tractor for efficient field operation. This equipment will provide 10 to 15% more cotton sticks by weight than conventional manual stalk chopping method with a field capacity of 1.25 to 1.50 acre/hr.

Marketing Hints

1. Kapas should be picked dry, free from trash, with no dew on it.
2. The first and the last picking are usually of low quality and should not be mixed with rest of the produce. High-grade kapas mixed with low grade kapas sells at a relatively low price.
3. Store kapas in damp proof and rat-free room.
4. Store different varieties separately.

3. PULSES

MOONG

Moong occupied 5.1 thousand hectares and the total production was 4.5 thousand tonnes during 2012-2013. Its average yield was 877 kg per hectare (350 kg per acre).

Climatic Requirements :

Moong is considered to be the hardiest of all pulse crops. It requires a hot climate and can tolerate drought also. It is also suitable as a summer crop.

Soil Type :

A well-drained loamy to sandy-loam soil is suitable. Saline-alkaline or waterlogged soils are unsuitable.

Rotations :

Moong - Raya/Wheat

Summer *Moong-Kharif Moong*-Raya/Wheat

Improved Varieties :

PAU 911 (2007) - Its plants are erect, compact, determinate and medium statured (about 70 cm). Podding is profuse and each pod contains 9-11 seeds. It is fairly resistant to mungbean yellow mosaic virus (MYMV), cercospora leaf spot (CLS) and bacterial leaf spot (BLS). It matures in about 75 days. Grains are shining green and medium bold with good cooking quality. The average grain yield is 4.9 quintals per acre.

ML 818 (2003) - Its plants are erect, determinate and medium statured (75 cm). Pod formation is profuse and each pod contains 10-11 seeds. It has moderate degree of resistance to mungbean yellow mosaic virus and good resistance to cercospora leaf spot and bacterial leaf spot diseases. It is also tolerant to whitefly. It matures in about 80 days. Its average grain yield is 4.9 quintals per acre. Its grains are medium bold, shining green with good cooking quality.

ML 613 (1995) – Its plants are determinate and medium statured (85 cm). Pod formation is profuse and each pod contains 11-12 seeds. It is tolerant to mungbean yellow mosaic virus, cerospora leaf spot and bacterial leaf spot diseases. It is fairly tolerant to whitefly and jassids. It matures in about 85 days. It yields 4.3 quintals per acre. It possesses bold green and shining grains with very good swelling capacity and cooking quality.

Note : Cultivation of Kharif season moong variety ML 613 can also be done under rainfed conditions in Gurdaspur, Hoshiarpur and Ropar districts. The cultivation of variety PAU 911 is recommended for whole Punjab except south-western districts (Bathinda, Mansa, Faridkot, Mukatsar and Ferozepur).

Agronomic Practices :

Land Preparation–Give two or three ploughings to the land followed by planking to crush the clods and eradicate the weeds.

Seed Rate : Use 8 kg seed per acre.

Seed Inoculation : Inoculate the *moong* seed with recommended *Rhizobium* culture at the time of sowing. Wet the seed recommended for one acre with minimum amount of water. Mix thoroughly one packet of *Rhizobium* with it on a clean pucca floor and let it dry in shade. Sow the seed immediately. The inoculation of seed with culture increases the grain yield by 12-16 per cent. The *Rhizobium* inoculation and fungicide can be applied simultaneously. The culture is available with the Department of Microbiology, Punjab Agricultural University, Ludhiana.

Seed Treatment : Treat the seed with Captan* or Thiram @ 3 g per kg of seed against seed borne diseases.

Time and Method of Sowing: Sowing should be done in the first fortnight of July at a row spacing of 30 cm. The plant distance should be about 10 cm and sow 4 to 6 cm deep with seed drill/*pora*/*kera.* For getting higher yield, adopt bi-directional method of sowing *i.e.* sow the crop in both directions at 30 cm row spacing using half the seed rate in each direction. In bi-directional sowing, weeds should be controlled through chemicals as per recommendations given under weed control.

Zero Tillage : *Moong* can be grown without seed bed preparation with zero till drill after conventional or zero till sown wheat without any adverse effect on yield. If field is infested with weeds, these can be controlled by spraying half litre of Gramoxone (paraquat) in 200 litres of water before sowing.

Weed Control : One or two hoeings are recommended to keep the weeds under check. Give the first hoeing four weeks after sowing of the crop and second hoeing, if needed, about two weeks thereafter.

Weeds can also be controlled by applying Basalin 45 EC (fluchloralin) @ 600 ml per acre or Treflan 48 EC (trifluralin) @ 800 ml per acre on well-prepared seed-bed and then sow crop on the same day. Alternatively, spray 1.0 litre Stomp 30 EC (pendimethalin) or apply 600 ml Stomp 30 EC and one hoeing about four weeks after sowing. Stomp should be sprayed within two days of sowing of the crop. For spraying herbicides, use 150-200 litres of water per acre. These herbicides provide good control of many annual grasses and broad-leaf weeds in early growth stages but do not control perennial weeds.

Irrigation : Irrigation is required for the *kharif* season crop if the rain fails.

Fertilizer Application : Drill at sowing 5 kg of N (11 kg of Urea) alongwith 16 kg of P_2O_5 (100 kg of single superphosphate) per acre to *moong*. (See chapter on Soil Testing).

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* Chemical belongs to green chemistry category.

Harvesting and threshing

The crop should be harvested when 80% of the pods mature. Harvest the crop with sickle. Do not uproot the plants. Spike tooth type power thresher for wheat can be used to thresh *moong* after proper modifications (See Appendix-III). When about 80% of the pods mature, Gramoxone (paraquat) @ 800 ml per acre can be sprayed using 150-200 litres of water for drying of crop foliage for combine harvesting of the crop.

Plant-Protection Measures (*Moong* and *Mash*)

1. Insect Pests

The *kharif* season *mash* and *moong* crops are attacked by green jassid, whitefly, flea-beetle, grey-weevil, semi-looper and hairy caterpillar. They damage the leaves occasionally. The black aphid attacks the flowers and pods.

Jassid, Aphid, Whitefly and the Flea-beetle :- These insects can be controlled by spraying the crop with any of the following insecticides, using 80 litres of water per acre with a manually operated sprayer.

375 ml of Malathion 50 EC (malathion)

250 ml of Rogor 30 EC (dimethoate)

250 ml of Metasystox 25 EC (oxydemeton methyl)

Whitefly can also be controlled by spraying 40 g thiamethoxam 25 WG or 600 ml triazophos 40 EC using 80-100 litres of water per acre. Repeat the spray at 10 days interval if necessary.

Hairy Caterpillar : The body of the caterpillar is covered with hair. The caterpillar eats the green matter of leaves, leaving behind only the midribs. The crop may be totally denuded due to severe attack. When young, they feed gregariously but on few plants in scattered spots. Adopt the following control measures.

(i) Young larvae are gregarious. They can be destroyed by pulling out the infested plants and burying them underground.

(ii) The grown-up caterpillars can be destroyed by crushing them under feet or by picking and putting them into kerosenized water. If the population is high, control it by spraying 500 ml of Ekalux 25 EC (quinalphos) or 200 ml of Nuvan 100 (dichlorvos) in 80-100 litres of water with a manually operated knapsack sprayer per acre.

Semi-looper : The larvae are green in colour measuring 2-4 cm in length. When touched, they form a loop. The larvae feed extensively on the leaves of *mash* and *moong*. In case of severe damage, the plants are totally defoliated within a few days. It can be controlled by spraying 200 ml of Nuvan 100 (dichlorvos) in 80-100 litres of water per acre.

Tobacco caterpillar *(Spodoptera litura)* : It is a polyphagous pest. The small larvae are black whereas grown up larvae are dark green with black triangular spots on body. Its moth lays eggs in masses covered with brown hairs on the lower side of leaves. After hatching, first and second instar larvae feed gregariously and skeletonize the foliage. Later on the grown up larvae disperse and feed singly. Besides leaves they also damage buds, flowers and pods.

Cultural control : Egg masses and young larvae of tobacco caterpillar feeding gregariously should be collected along with leaves and destroyed.

Chemical control : It can be controlled by spraying any of the following insecticides using 100 litres of water per acre with manually operated knapsack sprayer.

150 ml of novaluron 10 EC

800 g of acephate 75 SP

1.5 litres of chlorpyriphos 20 EC

Spray the crop as soon as the pest appears in the field and repeat after 10 days, if necessary.

Blister beetle : Blistle beetle is diurnal and general feeder. Adult beetles are robust with bright black and red stripes on the forewings. When disturbed, the beetles emit a fluid containing cantharidin that causes blisters on human skin. The adult beetles attack pigeonpea, mungbean, urdbean and other pulse crops. The major damage is caused at the flowering stage. They feed on tender buds and flowers of the plant, thus preventing grain formation.

Blister beetle can be controlled by spraying deltamethrin 2.8 EC @200ml or indoxacarb 14.5 SC @200ml or acephate 75 SP @800 g per acre using 80-100 litres of water per acre with manually operated knapsack sprayer. Spray the crop on pest appearance in the evening hours and repeat the spray after 10 days, if necessary.

Pod borer *(Helicoverpa armigera)* : The larvae damage the crop by feeding on leaves, flower buds, flowers, pods and seeds in the pods thus causing heavy loss in yield. The larvae may be pale green, yellow, brown or black in colour measuring about 3-5 cm in length when full grown. Larval presence can be observed from damage to plant and from dark green faeces below the plants on the soil. The larvae fall on the ground when plants are shaken vigorously. Spray the crop at the appearance of larvae with indoxacarb 14.5 SC @ 200 ml or acephate 75 SP @ 800 g or spinosad 45 SC @ 60 ml in 100 litres of water per acre using a knapsack sprayer at the start of pod formation and repeat after two weeks if necessary.

Mite : The mite causes webbing on the underside of the leaves which turn pale. Such infected leaves turn light-brown to dark reddish-brown. It can be controlled by spraying the crop with 150 ml of Rogor 30 EC (dimethoate) in 80-100 litres of water per acre.

Dhora (*Callosobruchus* spp.) : For its control see Appendix II.

2. Diseases

Yellow mosaic virus : It is a virus disease transmitted by whitefly and is more severe on *moong.* The leaves of the diseased plants develop irregular yellow and green patches. Infected plants bear no or only a few pale pods.

Control

1. Rogue out the affected plants early in the season.
2. Grow yellow mosaic virus tolerant varieties of *moong* PAU 911, ML 818, ML 613 and *mash* varieties, *Mash* 114*,* and *Mash* 338.
3. Control whitefly as recommended under “Insect Pests”.

Cercospora leaf spot : These are caused by *Cercospora cruenta* and *C. canescens.* The disease spots are circular, brown and necrotic which coalesce to cover bigger area and cause defoliation.

Control

1. Treat the seed with 3 g of Captan* or Thiram per kg of seed.
2. Grow disease resistant varieties of *moong* PAU 911, ML 818, ML 613 and *mash* varieties, *Mash* 114 and *Mash* 338.
3. Spray the crop with zineb 75 WP (Dithane Z-78)* @ 400 g in 100 litres of water per acre at 10 days interval twice or thrice at disease appearance.

Root rot : Root rot caused by *Macrophomina phaseolina* produces dark lesions on leaves, branches, stems and roots. The tissues of the affected portion become weak and easily shred. Pycnidia can be seen on the affected portion. For control, treat the seed before sowing with Captan or Thiram @ 3 g/kg seed.

Anthracnose : It is caused by *Colletotrichum lindemuthianum.* The spots are slightly depressed with dark centre. Lesions rapidly coalesce to girdle stems, branches, peduncles and petioles. Adopt control measures given under Cercospora leaf spot.

Bacterial leaf spot : Bacterial leaf spots caused by *Xanthomonas campestris pv. phaseoli* are circular to irregular and brown. Use disease free seed. *Moong* varieties PAU 911, ML 818, ML 613 and *mash* varieities *Mash* 114 and *Mash* 338 are fairly resistant/tolerant to this disease.

Web blight : It is caused by *Rhizoctonia solani.* It starts from leaf laminae or petioles or the young branches. Eventually, the top of plants become blighted and patches of such plants are conspicuosly seen in the field. Whitish web-like growth develops on leaves in humid weather. Dark brown sclerotia develop on infected tissue. Infection on crop comes from the weeds in the field. Keeping the field weed-free helps to check the disease.

* Chemicals belong to green chemistry category.

MASH

Mash was grown on 2.2 thousand hectares and the total production was 1.0 thousand tonnes in the Punjab State during the year 2012-2013. The average grain yield was 186 Kg per acre.

Climate and Soil Requirements :

Mash thrives in a hot and humid season (July to October). However, short duration types (70 to 75 days) can be grown in the central and sub-montaneous tracts in summer (March to June). *Mash* can do well on all soils ranging from sandy loam to heavy clay except the saline-alkaline or water logged soils. Its cultivation improves soil fertility. The *mash*-wheat rotation is suitable for irrigated areas.

Improved Varieties

Mash 114 : (2008) : This variety is recommended for the whole Punjab state. Its plants are dwarf, erect and compact with determinate growth habit. It is a short duration variety and matures in about 83 days. Podding is profuse and each pod contains about 6-7 seeds, which are bold, black and possess very good culinary properties. Average grain yield is about 3.6 quintals per acre. It is fairly resistant to yellow mosaic virus, bacterial leaf spot and cercospora leaf spot diseases.

Mash 338 (1993) : This variety is recommended for the whole Punjab State. Plants are dwarf, erect and compact with determinate growth habit. It is a short duration variety and ripens in about 90 days. Podding is profuse and each pod contains about 6 seeds, which are bold, black and possess very good culinary properties. Average grain yield is about 3.5 quintals per acre. It is fairly resistant to yellow mosaic virus, bacterial leaf spot and cercospora leaf spot diseases. It is also tolerant to jassids and whitefly.

Agronomic Practices

Land Preparation : One or two ploughings followed by planking are enough. At sowing field should be free from weeds.

Seed Rate : Use 6-8 kg seed per acre. Use bold seeds retained over the sieve with a mesh size of 3.6 mm for higher yields.

Time and Method of Sowing : Sow the irrigated crop from 15 to 25 July in the Sub-montaneous region and from last week of June to the first week of July in other area of the state. The rainfed crop may be sown with the onset of the monsoon. It should be sown in lines, 30 cm apart by using the *kera*/*pora* method or with a seed drill, 4 to 6 cm deep.

To make cultivation of *mash* more economical, maize may be inter cropped at every fifth row. The rows 30 cm apart should be oriented preferably along North-South direction.

Mash and maize inter crop culture should be fertilized as per recommendation for *mash* at the sowing time. Subsequent top-dressings of N to maize rows be carried out at the recommended level and proportionate to area under maize.

Weed Control : Hoe the crop one month after sowing. Later, the crop covers the ground well and does not allow the weeds to come up.

Weeds can also be controlled by applying Stomp 30 EC (pendimethalin) @ 600 ml per acre and one hoeing 25 days after sowing or Stomp 30 EC @ one litre per acre. Stomp should be sprayed within two days of sowing of the crop. For spraying herbicide use 150-200 litres of water per acre. The herbicide provides good control of many annual weeds in early growth stages but does not control perennial weeds.

Irrigation : The crop normally needs no irrigation. If the rains fail for a long period, then apply one irrigation.

Fertilizer Application **:**

Drill at sowing, 5 kg of N (11 kg of Urea), alongwith 10 kg of P_2O_5 (60 kg of single superphosphate) per acre.

Harvesting **:**

Harvest the crop when the leaves are shed and most of the pods turn greyish black. The matured crop should not be uprooted.

Plant Protection Measures : (See under *moong*)

ARHAR

Arhar is hardy crop and requires very little investment. It was grown on 3.1 thousand hectares and the total production was 2.8 thousand tonnes during 2012-2013. It gave an average yield of 357 Kg per acre.

***Soil Type* :**

Arhar grows well on a wide range of soils. It does best on fertile and well drained loamy soils. The saline-alkaline or waterlogged soils are unfit for its cultivation.

Rotations :

Arhar-Wheat/Barley, *Arhar-Sufed Senji-Sugarcane*

Improved Varieties :

PAU 881 (2007) : It is an early maturing variety with indeterminate growth habit. It matures in about 132 days and vacates the field well in time to sow the succeeding wheat crop. Its plants are about 2 meter tall. Pod formation is profuse and each pod contains about 3-5 yellow brown and medium sized seeds. Its average grain yield is 5.6 q/acre.

AL 201 (1993) : It is an early maturing variety with indeterminate growth habit. It matures in about 140 days and vacates the field by the end of October permitting timely sowing of the succeeding wheat crop. The plants are erect and about 2.5 metre tall. The main stem is much longer than the side branches and its flower is yellow with prominant red streaks on the standard petal. Pod formation is profuse and each pod contains 3-5 yellowish brown and medium sized seeds. The average grain yield is about 6.2 q per acre.

AL 15 (1981) : It is a short duration variety with determinate growth habit. This variety matures in about 135 days and vacates the field by the end of October permitting timely sowing of the succeeding wheat crop. The plants are compact and short-statured attaining a height of about 1.5 to 1.8 metre. Pods are borne in clusters at the top of the plant and maturity is relatively synchronous. Podding is profuse and each pod contains 3-5 yellowish brown and medium sized seed. It gives an average yield of 5.5 q per acre.

Agronomic Practices :

Land Preparation : Prepare the land well to free it from clods and weeds. Planking should follow each ploughing.

Seed Rate : Use 6 kg of seed per acre.

Seed inoculation : The arhar seed should be treated with the recommended *Rhizobium* culture before sowing. Wet the seed recommended for one acre with minimum amount of water. Mix thoroughly one packet of *Rhizobium* culture with seed on a clean pucca floor and let it dry in shade. Sow the seed immediately. The inoculation of the seed with *Rhizobium* increases the grain yield by 5-7%. *Rhizobium* and fungicide can be applied simultaneously. The culture is available with the department of Microbiology, Punjab Agricultural University, Ludhiana.

Seed Treatment : Treat the seed with Captan* or Thiram @ 3 g per kg of seed, against seed-rot and seedling-blight.

Time and Method of Sowing : Sow the crop in the second fortnight of May for obtaining high grain yield as well as early maturity of the crop for timely sowing of the succeeding crop. The row spacing of 50 cm and the plant spacings of 25 cm are recommended for all the varieties. Timely sowing and the maintenance of optimum plant population are essential for obtaining a good yield.

Zero tillage : Arhar can also be sown without any tillage operation with zero till drill after conventional or zero till sown wheat without any adverse effect on yield. If field is infested with weeds, these can be controlled by spraying half litre of Gramoxone (paraquat) in 200 litres of water before sowing.

Intercropping : Short duration variety of *moong* ML 613 can be successfully grown between the rows of *arhar.* It will yield about 1.2 quintal of grain per acre without reducing the yield of *arhar.*

Fertilizer Application **:**

The following doses are recommended:

*Nutrient (kg/acre)			Fertilizer (kg/acre)			
N	P_2O_5	**K_2O	Urea	***DAP or	Single Super Phosphate	Muriate of potash
6	16	12	13	35	100	20

* These nutrients can also be supplied from other fertilizers available in the market (Appendix IV).
** Apply only when the soil test shows deficiency of potash.
*** Where DAP is used, omit nitrogen application. Drill all fertilizers at sowing.

Note : In *arhar*-wheat rotation, if *arhar* follows wheat, which received recommended dose of P, omit its application to *arhar*.

Weed Control : Two hoeings may be given, one about three weeks and the other about six weeks after sowing. Weeds can also be controlled by applying Stomp 30 EC (pendimethalin) @ 1 litre/acre or Stomp 30 EC (pendimethalin) @ 600 ml/acre followed by hand weeding six to seven weeks after sowing. Stomp should be sprayed as pre-emergence i.e. within two days of sowing of the crop using 150-200 litres of water per acre.

Irrigation : Apply the first irrigation 3 to 4 weeks after sowing. Further irrigation may be given only if the rains fail. After mid-September, do not apply irrigation otherwise the maturity of the crop will be delayed.

Harvesting : Crop ripens by the end of October.

Plant-Protection Measures

1. Insect Pests

Blister beetle : Regarding pest see under moong.

* Chemical belongs to green chemistry category.

Control : Blister beetle can be controlled by spraying deltamethrin 2.8 EC @200 ml or indoxacarb 14.5 SC @ 200 ml per acre using 100-125 litres of water per acre with manually operated knapsack sprayer. Spray the crop on pest appearance in the evening hours and repeat the spray after 10 days, if necessary.

Pod borer complex : Pod borers especially spotted for borer (*Maruca vitrata*) and Gram pod borer *(Helicoverpa armigera)* are the most important insect pests of arhar. The larvae of these borers are of different sizes and colours. They feed on leaves, flower buds, flowers, pods and seeds in pods, thus causing heavy loss in grain yield. Larval presence can be confirmed from damage to plant parts and from dark-green faeces below the plants on the soil. Spray the crop on the appearance of larvae at pod initiation/podding stage with indoxacarb 14.5 SC @ 200 ml or spinosad 45 SC @ 60 ml in 100-125 litres of water per acre using manually operated knapsack sprayer. Repeat the spray whenever necessary.

Precautions : Because honey bees and other pollinators may be killed by the use of above insecticides it is, therefore, advised to spray the crop during evening as the population of these pollinators is minimum at that time.

2. Diseases

1. Cercospora leaf spot : Leaf spots are caused by *Cercospora cajani.* Greyish brown to dark spots are produced on the under surface of the leaf. Often several spots coalesce to form irregular blotches. Sometimes lesions occur on petioles and stems. Infection causes premature defoliation of leaves. Use disease free seed to reduce the infection. Treat the seed with Captan* or Thiram @ 3g per kg seed.

2. Bacterial leaf spot–This disease is caused by *Xanthomonas campestris pv. cajani.* Angular dark-brown spots appear on the leaf surface and usually concentrated on one side of the mid-rib. Spots may develop on vein, petioles, main stems and branches. Use disease free seed to reduce infection.

3. Phytophthora stem blight : It is caused by *Phytophthora drechslera f.sp. cajani.* The disease affects young seedlings as soon as they emerge and get killed. On stem, brown to black necrotic lesions are produced, which have definite margin and slightly depressed. In some cases stem swollens into a cankerous structure at the edge of the lesion which may break at the lesions site. The leaflet lesions are circular to irregular in shape and whole foliage can become blighted.

Avoid sowing *arhar* in soil with poor drainage and follow rotation in badly infested fields.

4. Sterility mosaic : The causal agent of sterility mosaic is transmitted by an eriophyid mite (*Aceria cajani*). Typical symptoms are mild mosaic and either no or little flowering and pale green colour of the leaves. The leaves are crowded and auxiliary buds give rise to bushy growth.

Control : *Arhar* and some of its wild relatives such as *Cajanus platycarpus* are the only recorded hosts. Destroy wild species and do not allow any *arhar* plant standing around the sugarcane, cotton and other fields during winter season in order to check the primary source of infection.

* Chemical belongs to green chemistry category.

RICEBEAN

Ricebean is a crop of tropical and sub-tropical regions. It has high yield potential and is resistant to yellow mosaic virus.

Climatic Requirements :

Ricebean requires hot and humid season (July to November). It does well in the temperature range of 18 to 37^0C.

Areas for which recommended : Submontaneous and Central districts.

Soil Type :

It should be grown on relatively well-drained fertile and loamy to sandy loam soils. It does not perform well on light and poor fertility soils. Sandy, waterlogged or saline-alkaline soils are not suitable for its cultivation.

Rotations :

Ricebean–Wheat (late sown), Ricebean–Potato (Spring), Ricebean–Sunflower, Ricebean–*Moong* (Summer), Ricebean–Summer fodders

Improved Variety :

RBL 6 (2002) : Medium maturing variety of photosensitive nature having resistance to fungal, bacterial and specially viral diseases. Growth habit is spreading with many lateral intertwining branches having vigorous growth. Pod formation, development and maturity are synchronous. Seeds are light green and bold. The seeds are immune to stored-grain insect pests. It matures in 125 days under irrigated conditions, its average grain yield is about 6 quintals per acre.

Agronomic Practices

Land Preparation : A fine seedbed is essential for obtaining a good plant stand.

Seed Rate : 10-12 kg per acre.

Time and Method of sowing : Sowing should be done between first to third week of July. Sow the crop at 30 cm row spacing and maintain plant spacing at 10-12 cm. Sowing may be done by using *kera/pora*/seed drill. To obtain better plant stand, the crop should be sown under good *wattar* conditions.

Fertilizers : Drill 6 kg of N (13 kg Urea) along with 8 kg of P_2O_5 (50 kg single superphosphate) per acre at sowing. On poor fertility soil, add 10-15 tonnes of well-rotten farmyard manure.

Weed Control : One or two hoeings (30 and 50 days after sowing) are needed to control weeds.

Irrigation : Give irrigation during monsoon period in case of failure of rains. Apply 2 or 3 irrigations in post-monsoon period.

Harvesting :

Harvest the crop when about 80 per cent of the pods turn brown and during morning hours to avoid shattering. As the plants are intertwined, harvest the crop by rolling the plants in small patches.

Storage :

The grains are resistant to pulse beetle and may be stored after sun drying without any seed treatment in dry bins or in gunny bags kept on wooden racks.

Plant-Protection Measures

1. Insect Pests : (See under *moong*)

2. Diseases

RBL 6 is highly resistant to yellow mosaic virus. Ricebean is moderately susceptible to root-knot nematodes which are a serious problem in light soils (sandy and loamy sand). Do not grow ricebean on such soils.

SOYBEAN

Soybean is a high value crop with multiple food, feed and industrial uses. Edible oil, soymilk and its products, bakery products, antibiotics and fresh green beans are some of its major uses. Soybean has a potential to play an important role in crop diversification in the state.

Soil Type :

Soybean can be grown on a wide range of soils but thrives on fertile, non-saline/alkaline and well drained loamy soils.

Rotations :

Soybean-Wheat /Barley, Soybean-*Gobhi* sarson (Transplanted)

Improved Varieties

SL 958 (Subject to aprroval by SVAC) : It has shining, light yellow coloured with black hilum. Its grains contain 41.7 per cent protein and 20.2 per cent oil. It is highly resistant to yellow mosaic virus and soybean mosaic virus. It takes about 142 days to mature. Its average yield is 7.3 quintal grains per acre.

SL 744 (2010) : It has shining, light yellow coloured grains with grey hilum. Its grains contain 42.3 per cent protein and 21.0 per cent oil. It is resistant to yellow mosaic virus and soybean mosaic. It takes about 139 days to mature. Its average yield is 7.3 quintals grains per acre.

SL 525 (2003) : It has uniformly bold, shining, cream coloured grains with light black (grey) hilum. Its grains contain 37.2 per cent protein and 21.9 per cent oil. It is resistant to yellow mosaic virus and tolerates stem blight and root-knot nematode. Crop matures in 144 days. Its average yield is 6.1 quintals grains per acre.

Agronomic Practices

Land Preparation : Give two ploughings to the field, followed by plankings to free it from clods and bring it into good tilth to ensure good germination.

Seed Rate : Use 25-30 kg seed per acre.

Seed Inoculation : Moisten the seed recommended for one acre with minimum amount of water and mix throughly one packet of *Bradyrhizobium* sp. (LSBR 3) with it and let it dry in the shade. Sow the seed immediately. Inoculation of seed with culture, enhances grain yield by 4-8%

Seed Treatment : Treat the seed with Captan* or Thiram @ 3 g per kg of seed against soil-borne diseases. If soybean is being sown for the first time in the field, use bacterial culture only.

Time and Method of Sowing : Sow the crop in good moisture conditions with a pre-sowing irrigation *(Rauni)* before the monsoon has set in. Heavy rains after sowing affect soybean germination adversely. Sow the crop in the first fortnight of June. Sow the seeds 2.5 to 5.0 cm deep in lines 45 cm apart with a plant-to-plant spacing of 4-5 cm.

* Chemical belongs to green chemistry category.

Zero Tillage : Soybean can also be sown without any tillage operation with zero till drill after conventional or zero till sown wheat without any adverse effect on yield. If field is infested with weeds, it can be controlled by spraying half litre of Gramoxone (Paraquat) in 200 litres of water before sowing.

Grow Soybean on Raised Beds : Sowing of soybean in medium to heavy soils should be done on beds spaced 67.5 cm apart (37.5 bed top, 30 cm furrow) by using wheat bed planter. Sow two rows per bed using same quantity of seed, fertilizer and following other cultivation practices as in flat sown soybean. Irrigation is applied in furrows by taking care that beds are not inundated. This practice not only saves the crop from damage by rains especially at emergence but also saves about 20-30 per cent irrigation water along with increased yield over conventional flat sowing method. Ensure good moisture conditions while sowing, in case it is not so apply irrigation in furrows within 2-3 days after sowing for optimum germination and emergence.

Intercropping : Soybean can be successfully intercropped with maize. Sow one line of soybean between the lines of maize spaced 60 cm.

Mulching : The rows should be covered with wheat or paddy straw to ensure proper germination and seedling emergence.

Weed Control : Weeds can be controlled by giving two hoeings at 20 and 40 days after sowing. Alternatively, use of Stomp 30 EC (pendimethalin) can be made @ 600 ml/acre within one to two days of sowing. Dissolve the recommended quantity of the herbicide in 150 to 200 litres of water/acre and spray uniformly. This herbicide provides an effective control of annual grasses and broadleaf weeds. In case weeds appear in the late stage, one hoeing may be given after about 40 days of sowing. Alternatively weeds can be controlled by post emergence application (15-20 DAS) of Parimaze 10 SL (imazethapyr) @ 300ml/acre for control of mixed flora of weeds including grasses, broadleaves and sedges.

Irrigation : If the rains are good and well distributed, there may be no need of irrigation. Otherwise crop will require 3 or 4 irrigations. One irrigation at the time of pod-filling is very useful.

Fertilizer Application : Apply 4 tonnes of FYM per acre to soybean to get higher yield. Also use bacterial culture and apply at sowing 12.5 kg of N (28 kg of Urea 46% N) and 32 kg P_2O_5 (200 kg of single superphosphate 16% P_2O_5). However, apply only 24 kg of P_2O_5 (150 kg of single superphosphate 16% P_2O_5) per acre to soybean when it follows wheat which had received recommended dose of phosphorus. For obtaining higher yields, in addfition to the recommended dose of fertilizers, spray 2% urea (3 kg in 150 litres of water per acre) at 60 and 75 days after sowing.

Green manure the field with Sunnhemp using 20 kg seed/acre during second fortnight of April. Green manure crop should be buried when about 40-50 days old and allow to decompose for about 5-7 days before sowing of soybean. Practice green manuring and apply full dose of nitrogen

(13 kg N/acre) to get high yield of soybean in soybean-wheat system. The practice of green manuring also improves the soil health.

In phosphorus and sulphur deficient soils apply sulphated P fertilizer (13:33:0:15::N:P_2O_5:K_2O:S) if other phosphorus or sulphur containing fertilizers are not available.

Harvesting :

Harvest the crop when most of the leaves fall off and the pods change colour. Do not delay harvesting otherwise the shattering of pods will take place. During threshing, avoid severe beating or trampling as it reduces the quality and germination capacity of the seeds.

Storage :

The moisture content of grains should not exceed 7 per cent. The grains should be stored in dry bins or in bags kept on wooden racks.

Plant-Protection Measures

1. Insect Pests

The hairy caterpillar, flea-beetle, tobacco caterpillar and whitefly damage this crop. For controlling these pests see under Moong.

2. Diseases

Yellow mosaic virus : It is a viral disease and is transmitted by whitefly. Disease appears as a blend of yellow and green patches on the infected leaves. Infected plants bear a few pale pods. Follow the control measures against whitefly as given under moong.

4. SUGARCANE

Sugarcane occupied about 83 thousand hectares in Punjab during 2012-2013. The average cane yield was 285.0 quintals per acre. The average sugar recovery was 9.1 per cent.

Hints for obtaining high yield of sugarcane

Plant crop

1. Plant seed from a healthy and absolutely disease free seed crop of recommended varieties only.
2. Use recommended seed rate to ensure good stand of the crop.
3. Do not plant the crop in a field where preceding sugarcane crop was infected with red rot or wilt.
4. Avoid late planting of sugarcane as it reduces tillering and is more attacked by insect pests especially shoot borer.
5. Keep the crop free from weeds using recommended chemical and cultural control measures.
6. Do not apply excessive dose of nitrogen than recommended. Over dose will cause lodging of the crop, resulting in poor cane yield and quality.
7. Do not allow the crop to suffer from drought especially during hot months.
8. Do not allow the crop to lodge. To prevent it, earth up the crop in May-June and prop up the crop in August-September.

Ratoon crop

1. Do not ratoon a diseased crop.
2. Do not harvest the crop to be ratooned before the end of January.
3. Harvest the crop as close to the ground as possible.
4. Remove late tillers and water shoots.
5. Remove the trash and irrigate the field.
6. Interculture the crop with tractor drawn tillers to control weeds during early stages of growth. Alternatively, adopt chemical control measures.
7. Plant gaps with three budded setts in the beginning of March.
8. Inspect the ratoon crop regularly to prevent the attack of shoot borer and black bug, as it is more prone to the damage by these insects.

Hints for obtaining high sugar recovery

1. Do not plant whole area under a single variety. Plant recommended early, mid and late maturing varieties in the ratio of 3 : 2 : 1 on area basis.
2. Avoid excessive irrigation and late application of nitrogen when the crop is near maturity.

3. Save the crop from lodging by earthing up and propping.
4. Save the crop from diseases and insect pests by following recommended control measures.
5. Protect the crop from frost by irrigating it during frost period.
6. Harvest the crop at proper maturity stage. Ratoon crop of a variety should be harvested first as it matures earlier than the plant crop.
7. Ensure removal of roots, mud, trash and immature tops (spindles) at the time of harvest.
8. Supply cane to the sugar mills without excessive binding material immediately after harvesting as staling reduces sugar recovery.

Climatic Requirements :

Sugarcane is best suited to regions having tropical climate, but it can be grown successfully in sub-tropical areas also. In the Punjab, about 80 per cent of the total growth of the crop takes place during July, August and September owing to favourable temperature and humidity.

Soil Type :

Sugarcane can be successfully grown on all types of soils ranging from sandy loam to clay loam. It, however, thrives best on well-drained loamy soils.

Sugarcane is semi-tolerant to sodicity and/or salinity. Sustainable sugarcane yields with assured levels of sugar recovery can be successfully obtained in sodic and saline-sodic soil/irrigation water conditions by adopting the following practices :

1. If the soil/irrigation water is sodic, apply gypsum @ 50% of gypsum requirement on cumulative basis after the harvest of the crop or well decomposed farm yard manure @ 8 tons per acre before sowing. Higher and complimentary benefits can be obtained if both gypsum and FYM are used simultaneously.
2. If the soil/irrigation water is saline or saline-sodic, apply only FYM. Do not apply gypsum with such a water.
3. In south-western districts of Punjab under saline water conditions, CoJ 88 should be grown.

SPRING CANE

Rotations :

Rice (short duration)–Rabi fodder/Potato-Sugarcane ratoon I-ratoon II-Wheat, Rice/*kharif* fodder-*Toria*/*Raya*-Sugarcane-ratoon I-Wheat, Maize/Cotton-*Senji*-Sugarcane-ratoon I-ratoon II-Wheat, *Arhar*-Oat/*Senji*-fodder-Sugarcane-ratoon I-ratoon-II-Wheat.

Improved Varieties

1. Early-Maturing Varieties

CoJ 85 (2000) : It is a shy tillering variety with thick* green coloured canes. The average cane yield of plant crop is 306 quintals per acre. Its juice contains 16-17% sucrose in the month of November and 18-18.5% in December. It is tolerant to most of the prevalent pathotypes of red rot disease and tolerates low temperature stress too. It is an average ratooner and susceptible to red stripe disease. Due to its heavy canes it is prone to lodging, hence requires proper earthing up.

CoJ 83 (1992) : The canes of this variety are medium thick, greenish yellow in colour. It is a good germinator and gives an average stalk population. The average cane yield is 300 quintals per acre. Its juice contains 16-17 per cent sucrose in November. It has field tolerance to prevalent isolates of red rot disease. It is tolerant to frost. It performs better under high fertility soils with frequent irrigations.

CoJ 64 (1975) : This variety is a good germinator, with profuse tillering and medium-compact growth. Its canes are medium thick, greenish yellow, solid and weighty. The average cane yield is 300 quintals per acre. The sucrose content in juice in November is 16-17 per cent. It has become highly susceptible to red-rot. It is susceptible to top borer. Quality of *gur* is excellent.

2. Mid-Season Varieties

CoPb 91 (Subject to the approval by SVAC) : The canes of this variety are tall, thick and yellow green in colour. The average cane yield is 410 quintals per acre. Its juice contains 17% sucrose in the month of January. It is tolerant to the prevalent pathotypes of red rot disease. It is a good ratooner.

CoH 119 (2008) : The canes of this variety are tall, thick and greenish in color with prominent weather and ivory marks. The average cane yield is 340 quintals per acre. Its juice contains 16.5-17.0% sucrose in the month of January. It is tolerant to the prevalent isolates of red rot disease. It is an average ratooner and tolerant to frost.

CoJ 88 (2002) : The canes of this variety are tall, medium thick and greyish green in colour. The average cane yield of the plant crop is 337 quintals per acre. Its juice contains 17-18% sucrose in the month of December. It tends to behave as early-mid in maturity and also suitable for saline water conditions. It is tolerant to the prevalent isolates of red rot disease. It is an excellent ratooner. It is good for cogeneration. Quality of *gur* is excellent.

CoS 8436 (2000) : It is a short statured variety with sturdy, thick canes and is tolerant to lodging. It has greenish yellow canes. It is a good germinator and gives an average stalk population.

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* Medium thin, medium thick and thick canes means up to 1.5 cm, 1.5 to 2.5 cm and above 2.5 cm respectively.

The average cane yield of the plant crop is 307 quintals per acre. It has high tolerance to red rot disease. Its juice has 17-18% sucrose in January. It performs better in high fertility soils with frequent irrigation.

3. Late-Maturing Varieties

CoJ 89 (2004) : This is a suitable variety for late planting. The canes of this variety are tall, medium-thick, greyish-yellow in colour. Average cane yield of plant crop trials is 326 quintals per acre. It is a very good ratooner. It has loose leaf sheath clasping and hence, easy to detrash. It matures in mid-Feb. Its sucrose content in juice ranges from 17-18 per cent. It is tolerant to prevalent isolates of red rot disease. It is also suitable for co-generation. Quality of *gur* is good.

Management of Seed Crop :

To obtain disease-free seed, a separate seed nursery should be maintained. Do not use the commercial crop for seed, as many pests and diseases go un-noticed in such a crop. Alternatively, tissue culture raised plants can also be used to raise a healthy seed crop. The plants should be spaced 60 cm apart with a row to row to spacing of 90 cm, followed by immediate irrigation. The crop thus raised should be used for raising a subsequent seed crop by planting three budded setts, following conventional practices. For seed production, the following package of practices are recommended :

(i) Obtain the seed stalks propagated from the moist hot-air-treated seed. The treated seed is planted at the Research Stations and is further propagated at the sugar factory farms and the farms of selected cane growers. This seed is supplied to the growers to raise the seed-crop.

(ii) Plant the crop in the last week of March.

(iii) Give a fertilizer dose of 90 kg of N per acre. Apply nitrogen in 3 equal doses at planting, in May and in mid-July. High dose of nitrogen will result in good quality of immature cane-seed.

(iv) Follow the plant protection schedule strictly to keep the crop free from insect pests and diseases.

(v) Frost injury results in low germination of sugarcane. Therefore, protect the seed crop against frost by irrigating it frequently during December and January.

Agronomic Practices

Land Preparation : Give four to six ploughings to produce good tilth. Each ploughing should be followed by planking. Use a furrow turning plough for the first ploughing.

Sub soiling : Cross sub soiling at 1.0 m spacing should be done once in three to four years before preparing the field. This is done by tractor drawn sub-soiler to the depth of 45-50 cm. Do planking to break the clods and then prepare seed bed. This will help in breaking the hard pan, help in increasing water infiltration rate and better penetration of sugarcane roots.

Seed Selection : The seed should be free from red-rot, wilt, smut, ratoon-stunting and grassy shoot diseases. Use only the top two-third portion of the selected canes for planting.

Seed Rate : Use 20 thousand three-budded sets or 15 thousand four-budded sets or 12 thousand five-budded sets per acre. Longer sets are particularly good for rain-fed conditions. In

other words, 30-35 qtls of seed depending upon the variety is required for sowing one acre sugarcane crop. Due to its thick canes, seed rate of CoJ 85 should be kept about 10% higher (on weight basis).

Seed Treatment : To improve germination, dip the cane setts in 0.25% of Emisan 6 or Bagalol 6 or 0.25 per cent solution of Tilt 25 EC or water soaking for 24 hours before planting i.e. 250 g of Emisan 6 or Bagalol 6 or 250 ml of Tilt 25 EC in 100 litres of water to treat cane seed for one acre. Take out the seed setts immediately after dipping them in the solution.

Soil Application of pesticides : Sprinkle 2 litres of Lindane/Kanodane/Markdane/Gammax 20 EC (gamma BHC) diluted in 500 litres of water per acre with a sprinkling can or apply 7.5 kg granules of Sevidol 4 : 4 G (gamma BHC + Carbaryl) or apply 10 kg Regent/Mortel 0.3 G (fipronil) per acre over seed setts in furrows before covering them with soil for the control of termites. Application of Regent/Mortel 0.3 G (fipronil) also protects the crop from attack of early shoot borer. Or apply 10 kg Regent/Mortel 0.3 G (fipronil) or Padan/Caldan/Kritap 4 G (Cartap hydrochloride) mixed in 20 kg moist soil/sand or 45 ml Imidagold 17.8 SL (Imidacloprid) or 2 litres of Durmet/Classic/Dursban/ Markpyriphos 20 EC (chlorpyriphos) in 400 litres of water/acre with sprinkling can along the rows at post germination stage (about 45 days after planting). Earth up slightly and follow with light irrigation. This treatment will protect the germinating crop against the attack of termites and shoot borer and also increase the efficiency of nitrogen.

Time of Planting : Mid-February to the end of March is the optimum time for planting sugarcane in the Punjab. Do not plant early maturing varieties after March.

Avoid late planting. If at all late planting has to be done, adopt the following practices :

(i) Plant CoH 119 and CoJ 89

(ii) Use higher seed-rate, viz. 30 thousand three-budded sets per acre.

(iii) Treat the cane sets with Agallol/Aretan/Emisan/Bagalol.

(iv) Control the shoot-borer effectively as it is particularly serious in the late-planted crop.

Spacing and Method of Planting : Plant in rows 75 cm apart and give planking. The tractor drawn sugarcane planter (Appendix III) can also be used for planting.

Use two-row tractor operated sugarcane cutter planter. The complete sugarcane which is fed by the labour sitting on the machine is cut automatically into pieces before dropping into the furrows. Fertilizers and chemicals are also applied simultaneously. The seed rate varies from 32 to 35q/ acre. The labour requirement is 33 man-h/2.5 acre. Length of sets varies from 23 to 42 cm. The speed of operation is 1.20 to 1.90 km/h. The capacity of machine varies from 2-3 acres/day. The machine can save about 25% cost of operation in comparison to traditional method. Use this machine on custom hiring basis.

Adopt paired row trench planting for saving irrigation water. Plant two rows of sugarcane in 30 cm broad and 20-25 cm deep trenches. Place the cane setts at the bottom of the trenches and cover with the soil left in between two rows. Distance between two trenches should be 90 cm. Trenches can be drawn using newly developed tractor operated PAU designed trencher. In addition

to water saving, this method gives comparatively higher cane yield, easy propping up operation and reduces lodging.

Adopt trench planting to save the crop from lodging. Make 20-25 cm deep trenches with or tractor-drawn ridger. Place the cane sets at the bottom of the trench and cover with a 5 cm of soil layer. Apply irrigation immediately and again 4 or 5 days afterwards.

Sugarcane can also be planted in standing wheat crop sown by furrow irrigated raised bed (FIRB) planter. The furrow should be reshaped in January to loosen the soil. Apply irrigation in reshaped furrows preferably in the evening before planting. Plant sugarcane setts the next day by pressing into the soil manually. Sugarcane is planted in pre-opened furrows between the beds, using treated 3 budded setts, during the second fortnight of February to March.

Intercropping of Summer *Moong,* Summer *Mash* and Mentha : Intercrop one row of summer moong or summer mash in between two rows of sugarcane to get an additional grain yield of 1.5 to 2 qtl/acre of summer moong/summer mash. This does not affect the cane yield but improves the soil fertility.

Practice	*Summer moong*	*Summer mash*
Variety	Recommended	Recommended
Seed rate/acre	4 kg	5 kg
Time of sowing	March 20 to April 10	March 15 to April 7

Mentha can also be grown as an intercrop. Plant one row of mentha between two rows of sugarcane. Mentha and sugarcane can be planted simultaneously in the first fortnight of February. Use one quintal of mentha suckers per acre. In addition to fertilizers recommended to sugar-cane apply 18 kg N (39 kg Urea) and 10 kg P_2O_5 (62 kg Super Phosphate) per acre. Half N and full phosphorus may be applied at planting and remaining half N about 40 days after planting. Take only one cutting of Mentha.

Fertilizer Application : These recommendations are valid for medium fertility soils for low and high fertility soils see chapter on "Soil Testing".

	**Nutrients (kg/acre)*		*Fertilizers (kg/acre)*	
Crop	**N	P_2O_5)	Urea	Single Superphosphate
Plant crop	60	as per soil test	130	as per soil test
Ratoon crop	90	as per soil test	195	as per soil test

* These nutrients can also be supplied from other fertilizers available in the market (Appendix IV). If the soil test is low apply 12 kg Phosphorus/acre.

** Reduce the Nitrogen dose from 60 to 45 kg if sugercane is grown after potato crop.

Note : Sugarcane does not respond to potash in Punjab.

Apply 8 tonnes FYM/press-mud per acre fifteen days before planting and mix into the soil with a bullock drawn plough or tractor tiller. In case of trench planting, apply the press-mud at the base of the trench and mix it into the soil with a kasola. In case FYM/press-mud is applied, reduce the dose of nitrogen from 60 to 40 kg/acre. However, on coarse textured soils if FYM is applied in addition to the recommended dose of fertilizers and no reduction in nitrogen application is made, approximately 10% higher yields can be obtained. On sandy soils, nitrogenous fertilizer may be applied after irrigation in moist soil and the number of splits may be increased. Application of *Azotobacter/Consortium* biofertilizer @ 4 kg/acre in the furrows at the time of planting would be helpful in increasing the cane yield. The culture is available with the Department of Microbiology, Punjab Agricultural University, Ludhiana.

Iron deficiency has been observed both in the ratoon and plant crops on light-textured and calcareous soils. Deficiency symptoms first appear in young leaves as yellow stripes between the green veins. Later, the veins also turn yellow. In severe cases, leaves become white and the plants remain stunted. Spray the crop 2 or 3 times with 1% solution of ferrous sulphate (1 kg ferrous sulphate in 100 litres of water) at weekly intervals soon after the symptoms appear.

Method of Application : (i) **Plant Crop** : Apply one half dose of nitrogen as top dressed/ drilled alongside the cane rows with first irrigation after germination. Top dress or drill the remaining half dose of nitrogen along side the cane rows in May or June. Apply full dose of phosphorus (based on soil test) in furrows below the cane sets at the time of planting.

(ii) **Ratoon Crop** : Top-dress one third of nitrogen in February with the first hoeing, one-third in April and the remaining one-third in May. Phosphorus (on the soil-test basis) should be drilled along the cane rows at the time of first cultivation in February.

(iii) **Rainfed Crop** : If the moisture in the soil is optimum, apply one half of the dose of nitrogen at planting. In case the moisture is deficient, the whole dose should be applied with the onset of rain.

Weed Control : Two or three hoeings are necessary to keep down the weeds. Hoeing can be economically done with a bullock-drawn horse-hoe/plough/triphali or with a tractor-drawn tiller. The spreading of trash-blanket between the cane rows after the emergence of the shoots helps to suppress weeds. This practice has the added advantage of conserving soil moisture particularly in rainfed areas.

Chemical Weed Control : It is economical to control weeds with herbicides. A pre-emergence application of Sencor 70 WP (Metribuzin)/Tafazine (simazine)/Atrataf 50 WP/Solaro 50 WP/Masstaf 50 WP/Markazine 50 WP (Atrazine)/Karmex 80 WP/Klass 80 WP (Diuron) @ 800 g per acre in 225 litres of water within two or three days of planting effectively controls the broadleaf weeds and annual grasses. For control of hardy weed *Bans Patta (Brachiaria reptans)* use only Sencor 70 WP (Metribuzin)/ Karmax 80 WP/Klass 80 WP (Diuron). For fields infested with *dila* (*Cyprus rotundus*), one post-emergence application of 2, 4-D (sodium salt 80%) @ 800 g per acre in 225 litres of water is recommended. In fields infested with *Ipomoea* sp (climbing vel) and other broad leaf weeds, apply 2,4-D (sodium salt 80%) @800 g/acre or 2,4-D (amine salt 58%) @400 ml/acre by dissolving in 225 litres of water when these weeds are in 3 to 5 leaf stage.

In spring cane, intercropped with summer moong or summer mash, a pre-emergence application of Stomp 30 EC (Pendimethalin) within two days after planting of intercrops at the rate of

1.0 litre/acre in 225 litres of water is recommended for weed control. For garlic intercropped in autumn sugarcane, one pre emergence application of Stomp 30 EC (pendimethalin) @1.0 litre within two days of planting or Goal 23.5 EC (oxyfluorfen) @ 400 ml/acre within one week of planting garlic in 225 litres of water is recommended for weed control.

Irrigation and Drainage : Because of dry and hot season, April to June is the most critical period for the growth of sugarcane. During this period, irrigate the crop at 7 to 12 days interval. During the rainy-season, adjust the frequency of irrigation according to rainfall. Drain away excess water from the sugarcane fields if these get flooded during the rainy season.

During winter (November to January), irrigate the crop at monthly intervals. To save the crop from frost, apply one irrigation around mid-December and another in the first week of January.

Straw Mulching : After germination is complete by mid-April, spread uniformly paddy straw or rice husk or sugarcane trash or tree leaves at the rate of 20-25 quintals per acre between the rows of canes. Mulching reduces soil temperature and conserves soil moisture. It also suppresses weeds and reduces the incidence of shoot-borer. Straw-mulching increases the yield of sugarcane both under rainfed and irrigated conditions.

Prevention of Lodging : To prevent the crop from lodging, adopt the following measures :

(i) Earth up heavily the flat-planted as well as the trench-planted crop in the end of June before the onset of the monsoon. Trench-planting is particularly effective in preventing lodging.

(ii) Prop the crop in the end of August or in the beginning of September by using the trash-twist method which consists of the tying of a single cane row instead of tying two rows together. Twist the leaves and the trash to make a rope and pass it alternately along the cane stools in the row. This method does not hinder the growth and photosynthesis of the plants as in the case when two cane rows are tied together.

Protection from frost : Protect the crop from frost as under :

(i) Grow frost-resistant varieties viz. CoJ 64, CoJ 83, CoJ 85, CoJ 88, CoPb91, CoS 8436, CoJ 89 and CoH 119.

(ii) Raise a bumper crop with adequate fertilization, irrigation and plant protection measures, because a poor and stunted crop suffers more from frost.

(iii) Prevent lodging, as a lodged crop suffers heavily from frost.

(iv) Irrigate the crop, as adequate soil-moisture during the frosty period keeps the soil comparatively warm and saves it from frost. Irrigate the harvested fields if meant to be ratooned. Plough the patch of land between the cane rows.

(v) In frosty areas, plant sets only from the top portion of the cane, as these buds are less damaged by frost than those elsewhere. The top portion can be buried in the soil during the frosty spell and taken out in the spring for planting.

AUTUMN CANE

Sugarcane can also be grown successfully as autumn crop with various intercrops. The growing of intercrops in autumn cane will enhance the total productivity/net profit per unit area per unit time. Recommendations concerning intercrops are given in the table further.

Rotations :

Kharif fodder/Green manure/Maize/Rice (short duration) *Moong*-Sugarcane with intercrop (*Raya*/Potato/Wheat/Winter Maize/*Gobhi Sarson*/cabbage) ratoon I-ratoon II-Wheat.

Improved Varieties : Plant CoJ 85 or CoJ 64 or CoJ 83.

Agronomic Practices

Time of Planting : 20th September to 20th October. The planting should not be delayed.

Seed Rate : Twenty-thousand three budded or 15000 four budded, or 12,000 five budded sets per acre. The seed for autumn planting should be obtained from a well grown spring or autumn crop.

Spacing and Method of Planting : Flat planting in rows 90 cm apart. Adopt paired row trench planting method as discribed in spring planting.

Fertilizer Application : 90 kg N per acre, 1/3 dose of N should be applied at planting, 1/3 at the end of March and the remaining 1/3 by the end of April. Phosphorus and potash should be applied on soil test basis. The fertilizer for intercrops are shown in table. Time and method of application is the same as per its pure crop.

Chemical Weed Control : In autumn planting of cane, a pre-emergence application of Atrataf 50 WP (Atrazine) within two or three days after sowing of winter maize as intercrop at the rate of 600 g per acre in 225 litres of water is recommended for weed control.

For wheat intercropped in autumn cane, one post emergence application of Isoproturon @ 500 g/acre after 30-40 days of sowing is recommended for weed control. For raya inter-crop one post-emergence application of Isoproturon @ 400 g/acre after 25-30 days of sowing controls the weeds effectively.

For garlic intercropped in autumn sugarcane, one pre emergence application of Stomp 30 EC (pendimethalin) @ 1.0 litre within two days of planning or Goal 23.5 EC (oxyfluorfen) @400 ml/ acre within one week of planting garlic in 225 litres of water is recommended for weed control.

Irrigation : First irrigation one month after planting, followed by three irrigations upto February and subsequent irrigation as per the recommendations for the spring crop.

Other recommendations are the same as for the spring crop.

Ratoon Management: Improve the yield of the ratoon crop as under:-

(i) Do not harvest the crop to be ratooned before the end of January. If the crop is harvested earlier, there will be poor sprouting of the stubbles due to low temperature during December and January.

INTERCROPS IN AUTUMN SUGARCANE

Name of Intercrop	Variety	Sowing/ planting time	Seed rate (kg/acre)	No. of rows between the two cane rows	No. of rows between the rows of intercrop	Spacing recommended per acre	Fertilizers	Harvesting time	Remarks
Potato intercrops	Chandermukhi or any other short duration	20 Sept. to 15th Oct.	800	1	–	35 kg N (78 kg Urea) 16 kg P_2O_5 (100 kg single superphosphate) 35 kg K_2O (60 kg muriate of Potash)	End of Dec.	Wheat & onion can also be taken after harvesting potato crop in end-December.	
Wheat	Recommended varieties	Last week of October to 15th Nov.	16	2	20 cm	25 kg N (54 kg Urea) 12 kg P_2O_5 (75 kg single superphosphate) 12 kg K_2O (20 kg muriate of potash)	Mid-April		
Raya (Brassica juncea)	Recommended varieties	Whole of October	1	2	30 cm	20 kg N (44 kg Urea) 8 kg P_2O_5 (50 kg single superphosphate.)	Mid-March	Sow *raya* either with planting of sugarcane Oct. or after giving first irrigation.	
Gobhi Sarson (B. napus)	GSL-1 or GSL-2	October 10 to 31	1	1	–	10 kg N (22 kg Urea) 6 kg of P_2O_5 (37.5 kg single Super Phosphate)	First fortnight of April		
Toria sown (Bcampestris) var. *Toria*	Recommended varieties	20th Sept. to end Sept.	1	2	30 cm	15 kg N (33 kg Urea) 5 kg P_2O_5 (32 kg single super phosphate)	End Dec.	Wheat can also be after *toria* harvesting.	

Name of of Intercrop	Variety	Sowing/ planting time	Seed rate (kg/acre)	No. of rows between the two cane rows	Spacing between the rows of intercrop	Fertilizers recommended per acre	Harvest-ing time	Remarks
Winter maize	Partap 1	25th Oct. to 10th Nov.	7		1	45 kg N (98 kg Urea) 16 kg P_2O_5 (100 kg single super phosphate) 8 kg K_2O (14 kg muriate of potash)	May	Sow maize after irrigation. It can however, be sown with residual moisture in third week of October.
Cabbage	Recommended variety	Last week of October to November	–	1	–	25 kg N (54 kg Urea) 12.5 kg P_2O_5 (78 kg single super phosphate) 12.5 kg K_2O (20 kg muriate of potash)	January & February	Transplant 4 to 5 weeks, old seedling from end of October to November
Radish	Recommended variety	October	4-5	2	30cm	25 kg N (54 kg urea) 12 Kg P_2O_5 (75 kg SSP)	January	-
Peas	Recommended Varieties	October	22	2	30 cm	14 kg N (31 kg urea) 10 kg P_2O_5 (100 kg SSP)		
Gram	Recommended varieties for different zones under irrigated conditions.	25th Oct. to 10th Nov.	12	2	30 cm	6 kg N (13 kg urea) + 8 kg P_2O_5 (50 kg S.P.)	April	-
Garlic	Recommended	4th week of Sept. to first week of Oct.	112 to 125 kg	3	15cm	10 ton FYM, 25 kg N (54 kg Urea), 12 kg P_2O_5 (75 kg single superphosphate)	April	For garlic intercropped in paired row trench planted sugarcane use 85 to 95 kg garlic seed, 7.5 ton FYM, 19 kg N (41 kg Urea) and 9 kg P_2O_5 (56 kg single superphosphate)

(ii) Soon after the early varieties are harvested in November or December, remove the trash and irrigate the field. When the soil attains the optimum moisture conditions, loosen it by hoeing, ploughing or interculture with a tractor-drawn tiller. Do not cover the stubble with cane trash.

(iii) Harvest the canes as close to the ground as possible to promote better sprouting. If still some big stubbles are left, shave or lop them off close to the ground. Also remove late tillers or water-shoots, as they inhibit the full sprouting of the stubbles.

(iv) Plough the harvested field twice with a desi plough or with a tractor-drawn tiller to check weeds. Alternatively, adopt chemical weed-control measures.

(v) The stand of the ratoon crop can be improved by planting the gaps with three budded sets in the beginning of March.

(vi) The nitrogen requirement of the ratoon crop is one and a half-times than that of the plant crop. Hence, apply 90 kg N per acre to the ratoon crop in three split doses–one third in February-March, one-third in April and the remaining one-third in the beginning of June. Drill phosphorus along the cane rows in March on the basis of a soil test.

(vii) Shoot-borer, top-borer and black bug appear in the ratoon crop. Control them as soon as noticed.

Gur Making :

The best quality *gur* and *shakkar* are obtained from CoJ 64 and CoJ 88. The quality of *gur* and *shakkar* from CoJ 83, CoJ 85, CoS 8436 and CoJ 89 is average to good. Use an efficient good cane-crusher for extracting juice.

For clarifying the juice, add sukhlai emulsion. Sukhlai is a shrub which grows in the Shivalik Hills and is available at Hoshiarpur. For preparing emulsion, soak the dry bark of sukhlai in a bucket of water for 24 hours. Then rub the bark to obtain a thick mucilaginous fluid. Add about one litre of this fluid to 100 litres of cane juice when the scum begins to rise in the pan. Make 'Jalandhar Special Furnace'. It can boil about 100 litres of cane juice per charge in about one hour.

Crushing schedule of sugarcane varieties for sugar mills of Punjab

*Varieties**	*Crop(s)*	*Months*
CoJ 64 and CoJ 83, CoJ 85 and CoJ 88	Ratoon (A&S) & Plant (A)	November, December and January
	Plant (S)	February
CoPb91, CoS 8436, CoH119 and CoJ 89	Ratoon (S)	January, February and March
	Plant (S)	March and April

* Varieties are written in the order of preference for crushing (A-Autumn; S-Spring)

Note :

a) The above crushing schedule would give sugar recovery of 10.5 per cent if Varietal raio Early (Spring : Autumn) : (Mid) : (Late) : 3 (2:1) : 2:1 is maintained, respectively.

b) Proportion of Ratoon crop : Plant crop is maintained as 1 :1

Plant-Protection Measures

1. Insects-Pests

Pyrilla : Pyrilla reduces cane yield and sugar recovery heavily. When the attack is severe it becomes difficult to make *gur*. This pest appears in April-May and again in August-September. The leaves of the damaged crop turn yellow. Later on owing to the development of a fungus, the crop turns black and the tops become unfit for feeding to cattle. The incidence of this pest is particularly high in a luxuriant crop and in the interior of field.

Whitefly : The damaged crop looks pale during August-October. The leaves turn black owing to the development of a fungus. The underside of the leaves is full of nymphs and pupae which suck the sap from the leaves. Spray the crop with 40 ml Confidor 200 SL (imidacloprid) or 600 ml Hostathion 40 EC (triazophos) in 150 litres of water per acre with a manually operated sprayer.

Black bug : The attacked crop looks pale. The black adults and pink young nymphs suck the sap from the leaf-sheaths. This pest is active during April to June. Spray the crop with 350 ml of Dursban/Lethal/Massban 20 EC (chlorpyriphos) in 400 litres of water per acre with manually operated sprayer. Direct the spray material into the leaf-whorl.

Sugarcane mite : The mite appears from April to June and feeds on the lower side of the leaves under a fine web. The leaves turn red and later appear to be burnt. The growth of the affected crop is retarded during the pre-monsoon period. *Baru* (*Sorghum halepens*) is the alternative host plant from which this mite spreads to the sugarcane crop. So destroy the weed, if growing near the sugarcane fields.

Sugarcane thrips : The thrips damage the crop from April to June. This pest suck the sap from the partly opened leaf and tips of the younger leaves, resulting in withering and drying of leaftip, which get rolled inwardly. The thrips prefer plant crop than ratoon crop.

Termite : The termite appears during April to June and again in October. It destroys the germinating buds and causes the drying up of shoots after germination. To avoid its attack, apply only well-rotten farmyard manure and remove the stubbles and debris of previous crop from the field. For the control of termites sprinkle 2 litres of Lindane/Kanodane/Markdane/Gammax 20 EC (gamma BHC) diluted in 500 litres of water per acre with a sprinkling can or apply 10 kg Regent 0.3 G (fipronil) per acre or apply 7.5 kg granules of Sevidol 4:4 G (gamma BHC+carbaryl) or 15 kg Kanodane 1.3 DP mixing in 20 kg moist sand/soil before the setts are covered with soil by planking. At post germination stage (about 45 days after planting) the chemical control measures against termite are the same as given under the shoot-borer.

Early shoot-borer : This pest appears from April to June and causes dry dead-hearts which can be easily pulled out. To control it,

1 Plant the crop early, i.e. before the middle of March.

2. Apply 10 kg granules of Regent/Mortel 0.3 G (fipronil) before the setts are covered with soil by planking.

OR

Apply 10 kg of granules of Padan/Caldan/Kritap 4 G (cartap hydrochloride) or 10 kg Regent/ Mortel 0.3 G (fipronil) mixed in 20 kg moist sand/soil or 45 ml Imidagold 17.8 SL (Imidcloprid) or 2

litres of Durmet/Classic/Dursban/Markpyriphos 20 EC (chlorpyriphos) in 400 litres of water/acre with sprinkling can along the rows at post-germination stage (about 45 days after planting). Earth up slightly and follow with light irrigation.

OR

Use Tricho-card having 20,000 eggs of *Corcyra cephalonica* parasitized (seven days old) by *Trichogramma chilonis* per acre at 10 days interval from mid-April to end-June. These eggs are fixed on cards of 10x15 cm size. Cut the cards into 40 pieces/strips, each having approximately 500 parasitized eggs. Staple these pieces.strips on the lower surface of the leaves uniformely at 40 spots per acre during evening hours. Normally 8 releases are required. The tricho-cards should not be stapled on rainy days.

Top-borer : This pest appears from March to October and causes severe damage during July-August. The central leaf of the cane top dries up and turns dark. The other typical symptoms are the shot-holes in the leaf, white or red streaks on the upper side of the leaf midrib and bunchy tops from July onwards. To control it, 1. Collect and destroy its moths and egg-clusters. 2. Cut the attacked shoots at the ground level from April to June. 3. Use Tricho-card having 20,000 eggs of *Corcyra cephalonica* parasitized (seven days old) by *Tricogramma japopnicum* per acre at 10 days old interval from mid-April to end-June. The method to use these cards is given under early shoot borer.

Apply 10 kg granules of Ferterra 0.4 GR* or 12 kg Furadan/Diafuran/Furacarb/Carbocil/Fury encapsulated 3G (carbofuran) or Thimet/Foratox/Granutox/Phoril/Volphor/Umet encapsulated 10 G (phorate) at the base of the shoots in the last week of June or in the first week of July only if the top borer damage exceeds 5% level. Earth up slightly to check the granules from flowing with the irrigation water and irrigate the crop immediately. This operation will control the third brood of the top-borer which does the maximum damage. Take the following precautions in using carbofuran and phorate :

i) Use rubber gloves while applying carbofuran/phorate granules. Never handle these granules with bare hands.
ii) Mix it with the moist soil to reduce the chances of its falling into the eyes of the person applying it.
iii) The person applying these granules should not eat or drink anything without washing his hands thoroughly with soap.
iv) Carbofuran/phorate treated sugarcane grasses and weeds should not be fed to cattle for about one month after the treatment.

Gurdaspur borer : This borer appears from June to October and causes the withering of the central leaves (notably the 5th leaf) followed by the total drying up of the tops. The affected canes break at the point of attack with a slight jerk. Rogue out canes showing withered tops in the afternoon every week from June to September. The tops should be cut off well below the point of attack. The timely rogueing of affected plants is very important for controlling the pest. Bury the rogued-out plants. Do not ratoon a heavily affected crop. Plough up the fields not meant for ratooning and destroy the stubbles before June.

* Chemical belongs to green chemistry category.

Stalk borer or Tarai borer : This pest is active throughout the year. The larvae overwinter in the stubble and water-shoots. The attack remains low during April-June and increases in July. Its incidence is highest during October-November. There are no outward symptoms of the attack of this pest. Entrance or exit holes on the attacked canes can be seen only after stripping. A larva sometimes damages upto 3 nodes and the cane may be attacked at several places. The cane yield and sugar recovery are adversely affected in the case of serious attack. The control measures against the pest are as under :

1. Do not use the cane-seed from the infested field.
2. Staple 40 *Tricho*-cards (5 cm x 2.5 cm) hard paper piece glued with 7 days old eggs of laboratory host, *Corcyra cephalonica* parasitized by *Trichogramma chilonis* to the under-sides of sugarcane leaves from July to October at 10 days interval. Each card should have approximately 500 parasitized eggs and be spread uniformally at 40 spots per acre. Normally 10-12 releases are required.
3. At harvest, do not leave the water-shoots in the field.
4. Do not ratoon a heavily infested crop. Plough the affected fields, collect the stumps and destroy.

Rats : Being a long duration crop, sugarcane provides an excellent shelter to rats and suffers heavy damage. The rat, *Bendicota bengalensis*, which digs extensive burrows with characteristic soil heaps, is often abundant in sugarcane. A lodged crop gets highly damaged. For effective rat control in sugarcane, see New Chapter 'Control of Rats and Mice'.

2. Diseases

Red rot : Red rot is caused by the fungus *Colletotrichum falcatum* The disease appears from July till the crop is harvested. The third or fourth leaf of cane top shows yellowing at first while rest of the leaves also loose colour afterwards and dry up. Later, the whole clump dries up. On splitting open the cane, the tissue is found to be reddened but the discoloration is not uniform and is interspersed with white patches running across the width of the split cane. The pith of affected cane emits alcoholic smell. The control measures against this disease are as under :

(i) For planting use seed from absolutely disease free seed plot.

(ii) Do not plant sugarcane in the disease affected fields for one year.

(iii) Grow varieties fairly resistant to red rot.

(iv) Crush the affected crop early and plough up the fields soon after harvesting the crop. Collect and burn the stubbles.

(v) Rogue out and bury or burn the diseased canes. Uproot the entire clumps and not merely the affected stalks.

(vi) Do not ratoon the diseased crop.

Wilt : This disease is caused by *Cephalosporium sacchari* or *Fusarium moniliforme*. It appears from July till the crop is harvested. The leaves of the affected cane at first turn yellow and finally the top dries up. On splitting open a diseased cane, the pith shows a dirty red discoloration. Near the nodes, the discoloration is invariably darker than that in the remaining portion of the internodes. The affected stalks become light and hollow. The control measures against this disease are the same

as those of red rot. As the causal fungus persists in the soil over long period, the affected field should not be put under sugarcane for 3 years.

Smut : Smut is caused by *Ustilago scitaminea*. This disease is prevalent throughout the year but is severe from May to July and again in October-November. Its incidence increases in the ratoon crop. It is easily recognised by the appearance of long whip-like shoots covered with dusty black mass of spores. These whips may arise from the top of the canes as well as from the lateral sprouted buds. Adopt the following control measures :

(i) Use only smut free canes for seed. Reject even the healthy looking canes in the diseased stools or those growing in the vicinity of the smutted clumps.

(ii) Remove the smutted whips gently (without shaking) after putting them inside a closely woven drill bag. Then uproot the entire diseased clumps and burn or bury them deep. Immerse the bag used for collecting the smutted whips in boiling water for 5 minutes after every rogueing of the crop.

(iii) Do not ratoon the smutted crop.

(iv) For surface disinfestation of seed cane (See Seed treatment).

Ratoon Stunting : A coryniform bacterium (*Clavibacter xyli)* has been found to be associated with the disease. The affected crop remains stunted with thin canes. The leaves are comparatively pale and the roots are poorly developed. The disease can be identified by slicing mature canes longitudinally a little below the rind with a sharp knife. In the lower part of the node, parallel to the zone of the whitish waxy band, the pith shows discolored dots, commas and straight or bent streaks upto 2 to 3 mm in length. They may be yellow, orange, pink, red or reddish brown. Do not use the diseased crop for planting. Select the cane-seed from a vigorously growing and healthy crop. The moist hot air treatment of seed canes at 54°C for 4 hours is effective in destroying the causal organism. Do not ratoon the diseased crop.

Grassy Shoot Disease : The disease is caused by mycoplasma like bodies. The affected plants give rise to numerous thin tillers, the leaves become reduced in size, thin and narrow and usually turn chlorotic. If the attack is light, one or two weak canes may be formed. Uproot and destroy the affected clumps immediately after appearance. The moist hot air treatment of the seed-canes at 54ºC for 4 hours inactivates the causal organisms of this disease. Its incidence increases in the ratoon crop, therefore, do not ratoon the diseased crop.

Red Stripe : Red stripe is a bacterial disease caused by *Pseudomonas rubrilineans*. It appears during June-August. The affected leaves show bright red streaks which are long, narrow and run longitudinally on the leaf-blade, causing the rotting of tops in severe cases. Rogue out the affected canes and burn or bury them.

Top Rot (Pokkah Boeng) : This disease is caused by *Fusarium moniliforme*. It appears during the rainy season from July–September. The young leaves in the top portion of the plant become chlorotic at the base and get distorted and shortened. They turn dark red and fall off gradually. In severe cases, the rotting of the top portion of the cane occurs. Remove the affected clumps and bury them.

Stinking Rot : This rot is caused by *Pseudomonas aeruginosa*. The disease appears during the rainy season from July to September. The cane tops dry with the rotting of upper portion or the whole of the stalk. A diseased cane emits a foul smell. Rogue out and burn the severely attacked canes.

Leaf Scald : The disease is caused by the bacterium *Xanthomonas albilineans*. Whitish or cream coloured one or two narrow stripes are observed on the leaf extending sometimes down to leaf sheath. The affected plants produce side-shoots starting first from lower nodes with similar stripes on young leaves. The stripes become reddish and later the leaves start withering from top downwards giving scalded appearance. On splitting open the affected canes, reddish brown vascular streaks are observed in the internodes. Sometimes affected plants suddenly wilt and die without any obvious internal symptoms. As the disease is sett-borne, healthy and disease free seed should be planted. Treatment of seed-cane with moist hot air at 54ºC for 4 hours inactivates the bacterium. Sterilization of cutting knives by flaming or by dipping in 2% Lysol solution during seed preparation should be practised to minimise spread of the disease. Rogue out the diseased clumps.

5. OIL SEEDS

GROUNDNUT

Groundnut was grown on 1.7 thousand hectares and its production was 3.0 thousand tonnes during 2012-2013 in Punjab. The average yield of groundnut in Punjab was 6.95 quintals per acre.

Climatic Requirements :

A well distributed rainfall of at least 50 cm during July, August and September is essential for the rainfed crop.

Soil Type :

A well-drained sandy soil overlaying a loamy sub-soil is considered ideal for the rainfed crop. Where irrigation facilities are available, loamy sand and loamy soil can also be put under groundnut.

Rotation :

Groundnut–Late Kharif Fodder/Gobhi sarson+Toria /Potato/Peas/Toria/Rabi crops rotation can be taken up successfully where irrigation facilities exist.

Avoid sowing groundnut in the same field year after year, as this practice results in heavy build-up of soil-borne diseases.

Improved Varieties

Irrigated

SG 99 (2004) : It is a bunch type variety recommended for sowing in sandy to loamy sand soils in Kharif season. Its average pod yield is 10 quintals per acre. The pods are medium in size with slight beak and moderate constriction. The pods are borne around the main root, which allows easy harvesting of crop with minimum crop losses. It has 66 per cent shelling outturn, 54 g 100 kernel weight and 52% oil content. The kernels have light brown colour. It matures in about 123 days. It is tolerant to bud necrosis disease.

M 522 (1995) : It is a semi spreading type variety recommended for sowing in sandy to loamy sand soils in kharif season. It yields about 9 quintals per acre of pods. The pods are medium bold in size with mostly two kernels per pod. The pods are borne towards the main root. It has 68% shelling outturn, 65 g 100 kernel weight and 51 per cent oil content. The kernels have light brown colour. It matures in about 120 days.

SG 84 (1986) : It is recommended for sowing in spring and kharif seasons. It is a bunch type variety with profuse primary and secondary branches. Its average pod yield is 8-10 quintals per acre. The pods are medium in size with one or two kernels, slight beak and medium constriction. The kernels are light brown. It has a shelling outturn of 64 per cent with a 100 kernel weight of 49 g and

oil content of 50 per cent. It matures in 120-130 days. The nutritive value of the straw has been adjudged comparable to that of *berseem* and *cowpea* hay.

Agronomic Practices

Land Preparation : Plough the land twice soon after the previous crop has been removed. Give a third ploughing if necessary for rainfed crop, in the end of June or early July. Use harrows or tillers for this cultivation (Appendix III). Very deep ploughing is not necessary, except in lands infested with *kans* or *doob.*

Preparation and Treatment of Seed : Hand-shell healthy and well-developed pods about a fortnight before sowing. Shelling can be done efficiently with a pedal-operated sheller. Its output is 6 to 8 times more than that of manual shelling. Discard very small, shrivelled and diseased kernels. Treat the selected kernels with 5 g of Thiram or 3 g of Indofil M-45* per kg of kernels.

Time and Method of Sowing : Sow the rainfed crop with the advent of monsoon in the last week of June or in the Ist week of July. Complete the sowing as early as possible. Delayed sowing causes progressive reduction in the yield of pods. Where irrigation facilities are available, sow kharif groundnut from end April to end May with a pre-sowing irrigation to get higher yield and also get the field vacated in time for the sowing of wheat. Immediately after sowing groundnut, the field should be divided into small plots of suitable size by making bunds for giving protective irrigation in case of need.

Sow seed about 5 cm deep with a drill. Planters are also available for sowing groundnut (Appendix III).

Seed Rate and Spacing : The following seed rates and spacings are recommended for different varieties :

Variety	*Spacing (cm)*	*Seed-rate/acre (kg)/(kernels)*
M 522	30 x 22.5	38
SG 99	30 x 15	40
SG 84	30 x 15	38

Fertilizer Application **:**

The following fertilizers and their doses are recommended :

*Nutrients (kg/acre)			Fertilizers (kg/acre)			
N	P_2O_5	**K_2O	Urea	Single Superphosphate	Muriate of potash	Gypsum
6	8	10	13	50	17	50

* These nutrients can also be supplied from other fertilizers available in the market (Appendix IV).

** Apply only when the soil-test shows deficiency.

Note : These recommendations are valid for medium fertility soils; for low and high fertility soils see chapter on "Soil Testing".

* Chemical belongs to green chemistry category.

Broadcast gypsum and drill all fertilizers at sowing. Prefer P from superphosphate. In the wheat-groundnut rotation, if the recommended dose of phosphatic fertilizer has been applied to wheat, its application to groundnut can be omitted.

Zinc Deficiency : The leaves in the upper half portion of the plant get reduced in size and become light yellow in colour. When the deficiency is severe, the plant growth is stunted and the kernels are shrivelled. Apply 25 kg zinc sulphate heptahydrate or 16 kg zinc sulphate monohydrate per acre. This dose will be sufficient for 2 to 3 years.

Weed Control : Give two hoeings, the first three weeks after sowing and the second three weeks thereafter. Weeding can be done with a wheel-hoe before the weeds make excessive growth. Weeds can also be controlled effectively with Lasso 50 EC (alachlor) herbicide @ 2 litres dissolved in 200 litres of water per acre as a pre-emergence spray within two days of sowing groundnut. Another option is to spray Basalin 45 EC (fluchloralin) @ 600 ml per acre in 200 litres of water uniformly on a well-prepared seed bed and incorporate before sowing or sow groundnut on the same day. However, hardy weeds such as Gha (*Arachne racemosa*), Kaon makki (*Commelina benghalensis*) etc. can be controlled effectively with preplant application of Treflan 48 EC (trifluralin) @ 600 ml or pre-emergence application of Lasso 50 EC (alachlor)/Stomp 30 EC (pendimethalin) @1.0 litre per acre each followed by one hand weeding 45 days after sowing.

Irrigation : Two or three irrigations may be necessary depending upon the seasonal rainfall. Give first irrigation at flowering. If the rainfall during the preceding period is not adequate apply one or two, more irrigations, depending upon the time of recession of monsoon, during the pod formation period for proper development of pods. Another irrigation a few days before the harvest may be given for full recovery for pods from soil. The residual moisture from this irrigation should be used for sowing of wheat or other *rabi* crops after groundnut.

Harvesting and Threshing : The kharif sown rainfed crop is normally ready for harvesting towards the beginning of November. A reliable indication of maturity is the uniform yellowing of leaves as well as the shedding of older leaves. Crop sown during end April-end May is ready for harvesting after the monsoons are over towards end of August and September. The tractor-mounted groundnut-digger shaker developed at the Punjab Agricultural University may be used for quick harvesting (Appendix III). For its efficient harvesting, the soil should have adequate moisture and the crop should not be over-ripe. Leave the harvested crop in small heaps for two days for curing.

After curing, collect the crop at one place and give 2 or 3 shakings and beatings daily for 2 to 3 days with a toothed rake or *trangli* to separate pods and leaves from the stalk. Collect the pods and leaves into a heap and winnow. Tractor operated thresher can be used in place of manual threshing after curing to save labour and time.The pods should be sun-dried, for 4 or 5 days before storage.

Production of Pure Seed : Pull out the off-type plants when full plant growth has been attained and again at the time of harvesting.

Plant Protection Measures

1. Insect-Pests

Aphid : The pest becomes serious when the rainfall is low. It weakens the plant by sucking the

cell sap, particularly from the growing points. It can be controlled by spraying 250 ml of Malathion 50 EC or 150 ml of Rogor 30 EC in 80 litres of water, as soon as the pest appears.

White-grub : This insect is serious in some areas only. The adult beetles emerge from the soil during June-July with the first showers of rain. They congregate on the nearby trees such as ber, guava, rukmanjani, grapevines, almonds etc. and feed on their leaves during night. The eggs are laid in the soil and the larvae (grubs) hatching from them eat away the rootlets or root hairs of the groundnut plants. The damaged plants look pale, wilt and ultimately die. Adopt the following integrated approach for its effective control :

1. Plough the field twice during May-June. It would help in exposing the beetles resting in the soil.
2. Treat the seed before sowing with 12.5 ml of Dursban 20 EC (chlorpyriphos) per kg kernels. For treating the seed, make a thin layer of kernels on tarpaulin or floor and spray the insecticide with the help of a sprayer. Mix it properly and allow to dry. The seed can further be treated with the recommended fungicides.
3. Sow the crop early wherever possible.
4. Kill the beetles by spraying 200 g Sevin/Hexavin 50 WP (carbaryl) in 100 litres of water on the preferred hosts mentioned above. The spray should be repeated after every rainfall till the middle of July.
5. Apply 4 kg Thimet 10 G (Phorate) or 13 kg Furadan 3 G (carbofuran) per acre in the soil at or before sowing.

Hairy Caterpillar : The control measures against this pest are the same as those given under 'MAIZE'.

2. Diseases

Collar-rot and Seed-rot : These diseases are caused by *Aspergillus niger* and other seed and soil borne fungi.

Tikka or Cercospora Leaf-spot : This disease is caused by *Cercospora personata* and *C. arachidicola.* Control the above diseases by adopting the following measures :

(*i*) Select healthy and unblemished kernels.

(*ii*) Treat the kernels before sowing with 5 g Thiram (75%) or 3 g of Indofil M-45 (75%)* per kg of kernels.

(*iii*) Spray the crop with Sultaf 50 WP* (wettable sulphur) @ 500 to 750 g in 200 to 300 litres of water per acre. Give 3 or 4 sprays at fortnightly intervals, starting from the first week of August.

(*iv*) Alternatively, spray the irrigated crop with Bavistin*/Derosal*/Agrozim* 50 WP @ 50-60 g in 100 litres of water per acre. Give three sprays at fortnightly intervals, starting when the crop is 40 days old.

Root knot : This disease is caused by the nematode *Meloidogyne arenaria* and *M. javanica.* It occurs in patches. The affected plants show poor growth with chlorotic leaves. The root knots become stubby. The plants affected early in the season become stunted and bushy.

1. Expose the soil to the sun during May and June to reduce nematode population.
2. Practise green-manuring wherever possible or add organic manures to the soil.

* Chemical belongs to green chemistry category.

SESAME

Sesame (Til) was grown on about 5.1 thousand hectares with a production of 1.6 thousand tonnes during 2012-2013 in the Punjab. The average yield in the Punjab State was 1.29 quintals per acre.

Soil Type :

Sesame thrives best on well-drained, sandy-loam soils.

Improved Varieties

RT 346 (2009) : This variety yields 2.7 quintals per acre. It has profuse branching, long non hairy capsules arranged alternately. It has white, bold seeds which contain 49% oil. It matures in 87 days. It is moderately resistant to *Antigastra* capsule borer.

TC 289 (1986) : This variety yields 2.1 quintals of seed per acre. It has bold seeds which contain 51.6% oil. It takes about 85 days to mature. It has better quality oil having 5% more linoleic acid (an essential fatty acid) than *Punjab Til No. 1.*

Agronomic Practices

Land Preparation : The crop requires a well-prepared seedbed. Give two or three ploughings followed by planking.

Seed Rate and Method of Sowing : The seed rate is 1 kg per acre. Sow the seed at row to row spacing of 30cm. The seed should be sown 4 to 5 cm deep with a *pora* or tube attached to the *desi* plough. After complete germination extra plants should be thinned to maintain plant to plant spacing of 15cm.

Time of Sowing : The crop should be sown in the first fortnight of July after receipt of adaquate rain or with the application of pre-sowing irrigation. The early-sown crop suffers from phyllody–virus disease.

Fertilizer Application : Apply 10 tonnes of farmyard manure per acre before sowing. In poor soils, drill 14 kg N (30 kg of urea 46% N) per acre before sowing. Avoid excessive manuring as it induces heavy vegetative growth.

Weed Control : When sown pure, atleast one hoeing should be given three-weeks after sowing. Weeds can also be controlled effectively by pre-emergence application of Lasso 50 EC (Alachlor) @ 1200 ml/acre dissolved in 200 litres of water within two days of sowing.

Harvesting and Threshing :

Harvest the crop in time, otherwise, the shattering of seeds will take place. The plants turn pale at maturity. After harvesting, tie the plants into small bundles for stacking. Two shakings of the bundles are enough to collect the entire produce.

Plant-Protection Measures

1. Insect-Pests

Sesame leaf webber and capsule borer : The larvae roll the leaves and feed inside these

rolls ; or bore into the capsule and feed on developing grains. If the infestation takes place at early stage, the plants die. It can be controlled by spraying the crop twice (first at pest appearance and then at flowering stage) with 100 ml Sumicidin/Fenval/Agrofen 20 EC (fenvalerate) or 150 ml Decis 2.8 EC (deltamethrin) or thrice with 200 ml Ripcord 10 EC (cypermethrin) in 100 litres of water per acre at pest appearance, flowering and pod formation stage.

Jassid : It causes considerable loss by sucking the sap and transmitting mycoplasma, which induces the malformation of the inflorescence. It can be controlled by spraying the crop with 400 ml of Malathion 50 EC in 100 litres of water with manually operated sprayer at least two times at 2-3 weeks intervals.

2. Diseases

Phyllody : It is caused by a Mycoplasma-like-organism (MLO). The flowers are modified into leaf like structures and do not bear pods. It is transmitted by Jassid (*Orosius albicinctus*). Also rogue out the diseased plants to prevent further spread.

Blight (*Cercospora sesami*) : It appears at flowering as dark brown, angular lesions with grey centre on leaves. It also appears on petiole, stem and pods. The infected plants give blighted appearance and defoliate.

To control the disease spray the crop thrice with Bavistin 50 WP* @ 100 g/acre in 100 litres of water at 10 days interval, just at the appearance of the disease.

* Chemical belongs to green chemistry category.

6. OTHER CROPS

GUARA

Guara is one of the important legume crops which is grown for different purposes such as green fodder, grain, green manure and vegetable. It is known for its drought-resistant and soil renovation qualities. *Guara* seed is used as concentrate for animals and for extraction of gum. Gum extracted from *guara* is an important foreign exchange earner. The gum has several uses in industry and in various food products. The *guara* meal which remains after extraction of the gum from the seed is a high protein cattle feed.

Soil Type **:**

Guara grows well on all types of soil. Well drained, medium to light soils are very suitable.

Improved Varieties

HG-365 **(2013)** : It is an early maturing branched variety. It matures in 105 days. Its average seed yield is 5.3 quintals per acre.

Ageta Guara 112 : Its plants are erect, hairy, unbranched and medium in height (1-1.5 m). It bears clusters of pods at each node and has bold grains. This variety matures from the last week of October to mid-November depending upon the area. Its average yield is 8 quintals per acre.

Guara 80 (1982) : It is recommended for *barani* cultivation throughout the state. It is tall, quick growing, hairy and profusely branched type. It is resistant to *guara* leaf blight and stem breakage. This variety does not possess bunches on each node. Its pods are medium sized and seeds are roundish flat in shape and light grey in colour. It is late maturing variety. It yields 7 quintals per acre.

Agronomic Practices

Land Preparation : One or two ploughings and one planking are sufficient.

Seed Rate and Sowing : Use 8-10 kg seed per acre. The crop under rainfed and low fertility soil conditions should be sown with the onset of rains, but under irrigated and high fertility conditions, the crop should be sown in the first fortnight of July. Irrigated crop may be sown by using *kera* method but the rainfed crop should be sown by *pora* method in rows 45 cm apart. The seed-cum-fertilizer drill can be used for sowing.

Fertilizer Application : Drill 8 kg of N (17 kg of Urea) and 19 kg of P_2O_5 (120 kg of single superphosphate) per acre before sowing in irrigated areas. (See chapter on Soil Testing)

Weed Control : Spray Stomp 30 EC (pendimethalin) @750ml/200 litres of water/acre by using knapsack sprayer having flat fan/flood jet nozzle within 24 hours of sowing.

Irrigation : The crop sown in July generally matures without any irrigation if the rains are normal and timely, otherwise one or two irrigations may be needed. However, the crop should not be irrigated after the third week of September as it delays the maturity of the crop and adversely affects the seed quality.

Plant Protection Measures **:**

The attack of jassid can be checked by 2 or 3 sprayings of 250-450 ml Malathion 50 EC in 100 litres of water (depending upon the height of the crop) with a manually operated sprayer at fortnightly interval.

MENTHA

There are four species : *M. arvensis, M. piperita, M. spicata* and *M. citrata* grown commercially in the Punjab. It occupies about 15000 hectares in the State. Mentha oil obtained by distilling the green herb is used in pharmaceutical, flavour, cosmetic and perfume industries.

***Climatic Requirements* :**

Mentha can be grown all over the Punjab State, wherever assured irrigation is available. It needs a well distributed rainfall of 200-250 cm and bright sunshine for good growth.

***Soil Type* :**

Well-drained, sandy loam to loamy soil with moderate to high organic matter, is best for this crop. The soil should be free from acidity, salinity, alkalinity and water-logging.

***Rotations* :**

Mentha fits well in the following rotations. – Mentha-potato, mentha–*toria*, mentha–oats (for fodder), Mentha-Basmati, mentha–wheat–maize–potato, Mentha-maize-potato and Mentha-maize (August).

Improved Varieties

Punjab Spearmint 1 : The stem is purple-green, branched, erect and hairy. Leaves are simple, opposite, oblong-ovate and dented. The flowers are purplish-white and arranged in long terminal spikes. Its plants are vigorous and on an average attain the height of 75 cm at flowering. The fresh herb contains 0.57% oil, rich in carvone.

Russian Mint : The stem is green, branched, erect, and hairy. The leaves are simple, opposite, ovate, serrate, hairy. The flowers are purplish, minute, borned in cyme. On an average its plants attain an height of about 55 cm at flowering. Its fresh herb contains 0.70% oil with distinct woody flavour for which it is highly demanded by flavour industry.

Kosi**: (Subject to the approval by SVAC)** It is a high yielding variety of Menthol mint (Mentha arvensis L.) It can be planted from end of January to Mid of February. On an average it gives 100-125 q/acre herb yield with oil content of 0.6 - 0.7%. It gives the highest herb and oil yield when harvested at 150 days after planting.

Agronomic Practices

Land Preparation : Two or three ploughings followed by planking are necessary to get a fine seedbed. The field should be free from stubble and weeds.

Seed Rate and Seed Treatment : Mentha is propagated from suckers. About 2 quintals of freshly dug 5-8 cm long suckers are enough for one acre. This quantity can be had from 1/16 acre of mentha. Before planting, the suckers should be washed and dipped into 0.1% Baviston 50 WP* solution (1 g/litre of water) for 5-10 minutes. Fifty litres of the solution is sufficient to dip 40 kg of suckers. The same solution may be used to dip the remaining suckers in 40 kg lots.

Method of Planting : The suckers are laid end to end, 4-5 cm deep in furrows, 45 cm apart and are then covered with soil by planking lightly. For higher biomass production and water saving planting should be done on 67.5 cm wide beds (two rows) or ridges should be made at 60 cm

* Chemical belongs to green chemistry category.

spacing after broadcasting the suckers. Apply paddy straw mulch @2.4 tonnes per acre. Apply a light irrigation after planting. Do not plant sprouted suckers, as most of such suckers die.

Time of Planting : The best planting time is the mid-January to the end of January, however, Kosi can be planted from end of January to mid of February. The crop can also be raised by transplanting in April if adequate irrigation is available.

Inter cropping : Mentha can also be grown as intercrop. Plant one row of mentha between two rows of sugarcane. Mentha and sugarcane can be planted simultaneously in the first fortnight of February. Use one quintal of mentha suckers per acre. In addition to fertilizers recommended to sugarcane apply 18 kg N (39 kg urea) and 10 kg P_2O_5 (62 kg super phosphate) per acre. Half N and full phosphorus may be applied at planting and remaining half N about 40 days after planting. Take only one cutting of mentha.

Mentha can be successfully intercropped with sunflower. Sow two rows of mentha in end January between two lines of sunflower grown at 120 cm x 15 cm in North-South direction. Use 150 kg of mentha suckers per acre. In addition to fertilizers recommended to sunflower apply 23 kg N (50 kg urea) and 12 kg P_2O_5 (75 kg superphosphate/acre). Full phosphorus and half nitrogen be applied at planting and remaining half nitrogen at 40 days after planting.

Onion can be grown as intercrop in mentha. Both mentha and onion should be planted simultaneously from the mid-January to end of January. Plant one row of onion in between the two rows of mentha planted at 45 cm keeping plant to plant spacing of onion of 7.5 cm. Apply additional fertilizer dose of 13 kg N (29 kg urea), 7 kg P_2O_5 (44 kg SSP) and 7 kg K_2O (12 kg MOP) per acre in addition to recommended fertilizer of mentha. Full phosphorus and potash and half nitrogen be applied at planting and the remaining half nitrogen about 40 days after planting.

Fertilizer Application **:**

Mentha responds favourably to organic manuring. Apply 10-15 tonnes of well-rotten farmyard manure per acre before planting. The following quantities of inorganic fertilizers are recommended :

Nutrients (kg/acre)		*Fertilizers (kg/acre)*			
N	*P_2O_5*	*Urea*	***DAP*	*or*	*Single Super phosphate*
60	16	130	35		100

* These nutrients can also be supplied from other fertilizers available in the market (Appendix IV).

** When 35 kg DAP is used, reduce the dose of urea by 15 kg.

Drill one-fourth of nitrogen and the full quantity of phosphorus at planting. Apply another one fourth of nitrogen about 40 days after planting. Add the remaining half dose of nitrogen in two equal splits after the first cutting of the crop. The first split may be applied immediately and the second split 40 days afterwards.

Irrigation : Mentha requires frequent but light irrigations. Irrigate at 10 days interval till the end of March and at five or six days interval till the onset of the monsoon. During the rainy season, irrigate according to the need.

Weed Control : To obtain good yield and high-quality oil, the crop should be kept free from weeds at all the stages of growth. In the early stages of growth, a wheel-hoe may be used. The pre-emergence application of Goal 23.5 EC (oxyfluorfen) at 350 ml/Karmax80 WP (Diuron) @ 300 g per acre or stomp 30 EC (pendimethalin) 1.0 litre per acre or isoproturon 75 WP 400 g per acre can effectively control the weeds in this crop. Dissolve the herbicide in 200 litres of water per acre and spray by knap-sack sprayer fitted with flat fan/flood jet nozzle. However, on light textured soil use of isoproturon should be avoided.

Harvesting and Yield **:**

The crop should preferably be harvested at the flower initiation stage. If the lower leaves of the plants turn yellow and start shedding, harvesting may be done earlier. Harvest the crop, leaving 6-8 cm long stumps to secure better sprouting. Two cuttings can be taken, first in June and the second in September. The yield of the crop is 100-125 quintals per acre of fresh herbs which contains 0.5 to 0.75% oil.

Plant Protection Measures

1. Insects

Termite (*Odentoterms obseus*) : Termites attack the underground parts of the plants and damage the roots and the stems of mentha. Apply 2 litres of Dursban/Radar 20 EC (Chlorpyriphos) per acre. The insecticided should be mixed in 10 kg soil and broadcast uniformly in the field followed by light irrigation.

Cutworm (*Agrotis spp.*) : Cutworms cut the young plants at the ground-level. They remain hidden near the base of the plants during day-time. Adopt control measures given under termite.

Jassid and Whitefly : The attack of these sucking pests adversely affects the plant growth and oil content. Spray Rogor 30 EC (Dimethoate) or metasystox 25 EC (oxydemeton methyl) @ 250 ml per acre.

Foliage Eating Insects : Control the foliage-eating insects by spraying the crop with 1 kg of Sevin 50 WP (Carbaryl) or 800 ml of Ekalux 25 EC (Quinalphos) per acre. For hairy caterpillar, adopt the control measures recommended against the pest under maize.

2. Diseases

Root Rot and Stem Rot (*Rhizoctonia bataticola*) : The infected portion shows brown lesions which turn dark and later increase in size. The leaves wither and die.

Uproot and destroy the infected plants. Do not take the planting stock from an infected field. Avoid growing mentha year after year in the same field. Dip the planting-stock into 0.1% solution of Bavistin 50 WP* for 5-10 minutes.

Processing and Marketing **:**

After harvesting, allow the crop to wilt overnight in the field and subject it to simple distillation, Some private distillation units provide facilities for farmers to extract oil.

* Chemical belongs to green chemistry category.

TURMERIC

Turmeric commonly known as *haldi* is grown for its rhizomes which are used as spice in many culinary preparations. It finds varied use in drug and cosmetic industries. Curcumin, an essential oil (turmerol) and oleorasin are extracted from turmeric.

***Climate and Soil* :**

This crop requires hot and moist climate. It is recommended for cultivation in irrigated areas. Turmeric grows in all types of soils, but it thrives well in drained sandy loam to loamy soils with moderate organic matter content.

Rotations :

Turmeric-onion/Late sown wheat

Varieties

Punjab Haldi 1 (2008) : Its plants are erect and medium in height. Leaves are green and medium in size. Rhizomes are long and medium-thick. Skin colour of rhizomes is brown and the flesh is dark yellow. It matures in 215 days and average yield is 108 quintals per acre.

Punjab Haldi 2 (2008) : Its plants are erect and tall. Leaves are light green and broad. Rhizomes are long and thick. Skin colour of rhizomes is brown and the flesh is yellow. It matures in 240 days and average yield is 122 quintals per acre.

Land Preparation : To get fine seedbed, 2 or 3 ploughings followed by planking are necessary. The field should be free from stubble and weeds.

Seed Rate : Turmeric is propagated through rhizomes. Fresh healthy and uniform sized rhizomes weighing 6-8 quintals are sufficient to plant an acre.

Sowing Time : For getting higher yield, crop is to be sown directly in the field by the end of April. In submontaneous and northern districts, the sowing can be delayed for a week. It can also be raised by transplanting upto first fortnight of June without losing much in yield. For this, rhizomes should be sprouted in the nursery by planting them in close spacing and 35-45 days old seedlings should be transplanted in the field.

Method of Sowing : Healthy and disease free rhizomes are planted in lines, keeping a distance of 30 cm in the rows and 20 cm between the plants. After planting, apply straw mulch @ 2.5 tonnes per acre. Keep the soil moist until the sprouting of rhizomes.

***Fertilizer Application* :** Turmeric responds favourably to organic manuring. Apply 10-12 tonnes of well-rotten farmyard manure per acre before planting or apply 5 tonnes FYM/per acre before planting and 25 kg nitrogen/per acre (55 kg urea) in two equal splits at 75 and 100 days after planting. A basal dose of 10 kg/acre each of phosphorus (60 kg Single super phosphate) and potash (16 kg Muriate of potash) can be drilled at planting.

Irrigation : Turmeric takes a long time to sprout and needs frequent irrigation. Apply light and frequent irrigation.

Weed Control : In order to keep the crop free from weeds, 1 or 2 hoeings may be given.

Alternately, spray Stomp 30 EC (pendimethalin) @ 1300 ml per acre/Sencor 70 WP (metribuzin) 400 g per acre/Atrataf 50 WP (atrazine) @600g per acre by dissolving in 200 litres of water within 2 to 3 days of planting of turmeric. After the spray, spread uniformly paddy straw mulch @ 36 quintals per acre uniformly over the entire field.

Harvesting and Yield **:**

Maturity of turmeric is indicated by the complete yellowing and drying up of the plants. The crop is ready for harvesting in the month of November. The rhizomes are dug up and cleaned to remove the roots and sticking soil.

Seed Production **:**

For keeping the seed for the next sowing, the fresh rhizomes should be kept at a cool and dry place or preferably in cold storage. Alternatively, the rhizomes kept for seed should not be dug up from the soil upto late in winter, but care should be take in that the area kept for seed is not irrigated.

Processing **:**

Boil the cleaned rhizomes in a vessel having narrow mouth after adding water sufficient to cover the rhizomes in it. Boiling should be continued for an hour till the rhizomes become soft. If boiling is to be done under pressure (15 lb/sq. inch), then 20 minutes are sufficient. Boiled rhizomes are dried in the sun. On a small scale, dried rhizomes are polished by rubbing them against a hard surface whereas on commercial scale, special polishing drums are available.

DHAINCHA

Dhiancha (Sesbania aculeata) is an important leguminous crop, generally used as a green manure. When burried as green manure, apart from meeting some of the nitrogen requirement of the succeeding crop, it also improve the physical properties of the soil.

Soil Type :

Dhaincha can grow well on all type of soils but sandy loam to loamy soils are very suitable. *Dhaincha* is relatively tolerant to both salinity and sodicity, however, for optimum yield gypsum should be applied to soils having pH more than 9.3 on soil test basis.

Improved Variety

Punjab Dhaincha 1 : A bold seeded variety having quick growth. It has comparatively more nodules. Its average grain yield is 7-8 quintals per ha. It takes about 150 days to mature.

Agronomic Practices

Seed Rate and Sowing Time : For green manure crop sow 20 kg seed per acre with drill in lines 20-22.5 cm apart from April to July. However, for grain production use 8 to 10 kg seed per acre for sowing from mid-June to mid-July in lines 45 cm apart.

Fertilizer Application **:** Apply 12 kg of P_2O_5 (75 kg of superphosphate) per acre at the time of sowing both for grain as well as green manure purpose. Omit application of phosphorus if recommended dose of phosphorus has been applied to the preceding wheat.

Irrigation : The crop sown for green manure during the summer period require 3-4 irrigations depending upon the prevailing weather conditions. However, the grain crop should not suffer water stress at flower initiation and grain development stages.

Hoeing and Weeding : For grain purpose, the crop may require one hoeing after one month of sowing to keep the weeds under check.

Plant Protection Measures

Insect

Tobacco Caterpillar : The larvae of this insect feed on the leaves of germinating crop. It can be controlled by spraying 150ml of Rimon (Novaluron 10 EC) in 80-100 litres of water per acre.

Harvesting **:**

For grain purpose, crop is ready for harvesting from mid-October to early November depending upon the period of sowing.

SUNNHEMP

Sunnhemp is an important leguminous crop, generally grown as fibre as well as green manure crop. It is very quick growing and has the advantage of tolerating adverse conditions of drought, salinity and acidity and used for reclaiming sodic soils. Incorporation of green matter of sunnhemp in the soil, improves its physical properties, prevents leaching and losses of nutrients, conserves soil moisture and creates access to deep soil layers. Its green manuring can be done after the harvest of wheat.

Climatic Requirements :

Sunnhemp grows well in tropical and subtropical climate, with 50 to 70 cm of well-distributed rainfall during the growing period.

Soil Type :

Sunnhemp can grow well on all types of soils, except waterlogged soils, but loamy sand to loamy soils are more suitable.

Improved Varieties

PAU 1691 : It is a quick growing variety with erect growth habit. The leaves are medium in size and green in colour. The flowers are yellow and pods are initially greenish yellow and turn blackish brown at maturity. It flowers in 60-62 days and matures in 136 days. The seeds are bold and black in colour. It attains the height of 160-220 cm and thus adds 4.0-6.5 tonnes green biomass or 1.0-2.0 tonnes dry biomass per acre to the soil when buried at 45-60 days after sowing. Its average seed yield is 4.8 quintals per acre.

Narendra Sanai-1 : It is a quick growing variety with erect growth habit. The leaves are broad in size and green in colour. The flowers are yellow and pods are initially light yellow and turn brown at maturity. It flowers in 98-100 days and matures in about 152 days. The seeds are bold and black in colour. It attains the height of 160-225 cm and thus adds 3.8-6.2 tonnes green biomass or 0.9-1.8 tonnes dry biomass per acre to the soil when buried at 45-60 days after sowing. Its average seed yield is 3.9 quintals per acre.

Agronomic Practices

Sowing Time : For seed production sow the crop in June. However, for green manuring this crop can be sown from April to July.

Seed Rate and Method of Sowing : For green manure crop sow 20 kg seed per acre either with drill in rows 22.5 cm apart or by broadcast. For seed production sow 10 kg seed per acre with drill in rows 45 cm apart. Soak the seed prior to sowing for better emergence.

Fertilizer Application : Apply 16 kg of P_2O_5 per acre at the time of sowing both for seed as well as green manure crop.

Irrigation : The crop sown for green manure during summer period requires 2-3 irrigations depending upon the prevailing weather conditions. However, the grain crop should not suffer water stress at the time of flowering and grain development stages.

Hoeing : For seed production, the crop may require one hoeing after one month of sowing to keep the weeds under check.

Harvesting : For seed production the crop is ready for harvesting from mid-October to early November, depending upon the period of sowing.

7. FODDERS

Fodder production in the Punjab State has to be substantially increased if the present population of 7.31 million cattle and buffaloes (60.4 million adult animals) is to be provided with sufficient fodder of good quality. The area under fodder crops in the State is approximately 0.86 million hectares and the annual production is about 67.27 million tonnes of green fodder. Each animal gets fodder supply of about 30.46 kg per day. This quantity is very inadequate. On the basis of 40 kg green fodder per adult animal per day, approximately 88.2 mlillion tonnes of fodder will be required. With the introduction of crossbred animals which need more fodder, its deficiency will be further aggravated unless efforts are made to increase the production of fodder.

The supply of protein to animals from legumes is cheaper than from concentrates. The non-legume forages are rich in energy. It is, therefore, essential that fodders are grown as mixtures, in which legumes, such as cowpea, guara and non-legumes, such as maize, sorghum and bajra are grown together. In order to increase the production of *kharif* fodders and to obtain an optimum feed quality, follow the package of practices described below .

Caution : 1. Fodder crops should be grown away from other crops on which insecticides are used frequently to save these from deposits of insecticidal residues due to drifting.

2. In fields where Leader/SF-10 herbicide has been used, do not sow sorghum (jowar) and maize crops in the following season.

MAIZE

Maize is an important *kharif* fodder which takes about 50 to 60 days to become available for harvesting. The fodder is considered good for milch animals. It is grown widely around cities for sale as green fodder in the market.

Climate and Soil Requirements :

Climate, soil requirements and land preparation are the same as given under the maize crop for grains.

Rotations :

Maize-berseem - bajra/Maize+Cowpea

Improved Varieties

J 1006 (1989) : Its plants are tall, vigorous and broad leaved. It is moderately resistant to maydis leaf blight and brown stripe downy mildew diseases. Its ear placement is medium. Ears are long, thick and cylindrical. The grains are white, bold and semi-flint to semi-dent. It yields about 165 quintals of green fodder per acre.

If the seed of J 1006 is not available, maize composite varieties recommended for grain production, viz. ***Parbhat, Kesri and Megha*** may be grown for fodder. However, for growing late

fodder, that is from last week of August onwards, *Kesri* and *Megha* should not be sown as they suffer from cold.

Agronomic Practices

Seed Rate, Seed Treatment and Sowing : Use 30 kg seed per acre. Seed treatment is same as given in grain crop. Maize can be sown from the first week of March onward till the middle of September. Three crops can be taken successfully from the same field. Sow the crop by *kera* or *pora* at a row distance of 30 cm apart. The crop can also be sown with a seed-cum-fertilizer drill. When sown mixed with cowpea, use 15 kg seed of maize with 15 kg of Cowpea 88 or 6 kg of CL 367/ acre. Maize can be grown under no-tillage to obtain the same green fodder yield as after conventional or zero till sown wheat.

Fertilizer Application : Apply ten tonnes per acre of good quality farm yard manure before preparing the land. This application mitigates zinc deficiency and also meets all the P and K needed and one-third of nitrogen. The fodder maize shows a remarkable response to application of nitrogen. To the soils of average fertility, apply the fertilizers as recommended for the composite maize. Drill half N and all P and K at sowing. Apply the remaining nitrogen after 3-4 weeks.

Weed Control : The weed control measures for maize fodder are the same as described under the grain crop. There is a common practice with the farmers to grow pure maize fodder upto end September and this is followed by wheat. In such situations, Atrazine (Atrataf 50 WP) is more safe and its use can be extended upto the first half of September. In cases, where the farmers are not able to use this weedicide within two days of sowing maize fodder, Atrazine (Atrataf 50 WP) can be sprayed at the recommended rate when the weeds are in 2 or 3 leaf stage. However, Atrazine should not be used where maize fodder is sown in mixture with cowpea. In this mixture, spray Stomp 30 EC (Pendimethalin) @ 1 litre in 200 litres of water per acre within two days of sowing. This herbicide holds good for effective control of annual weeds particularly *itsit/chapati* (*Trianthema portulacastrum*).

Seed Production : As recommended for composite maize.

Harvesting : Harvest the crop when the plants are between the milk ripe stage and the dough stage of grain development (50-60 days after sowing). From silking onwards, the nutritive value of the plant is mainly in the grains, hence do not remove cobs from that fodder crop. Preserve surplus fodder maize as silage (see the procedures for hay and silage making).

Plant Protection Measures :

The maize borer attacks the crop from March to October. To control the pest, 2-3 weeks after sowing or when pest attack is noticed in the field, attacked plants should be uprooted and destroyed. The fodder maize cannot be sprayed with all insecticides, as recommended in the case of the grain crop. It can, however, be sprayed with Sevin 50 WP (carbaryl) at 100-150 g per acre against the maize-borer, when an early attack is noticed. A minimum of 21 days, however, must elapse before the sprayed crop is fed to animals. Use 250 to 400 ml of Malathion 50 EC per acre against jassid, thrips and pyrilla depending upon the height of the crop. Control the hairy caterpillar by using Malathion 5% dust at 15 kg per acre. Do not feed the crop to cattle at least for 14 days after it is sprayed with Malathion.

SORGHUM

Sorghum (*jowar*) is a very important *kharif* fodder. It remains green and palatable over a longer period than maize and *bajra* fodders.

Climatic Requirements :

Sorghum grows well in hot and dry climate. Increased humidity enhances the incidence of the red leaf spot disease.

Soil Type :

Sorghum grows on all types of soils, but heavy soils are more suitable. Adequate drainage should be provided.

Improved Variety

SL44 (1974) : It is a sweet, juicy and thin-stemmed variety suitable for cultivation in summer and *kharif* in the irrigated areas of Punjab. Its green and sweet fodder is relished by cattle. It has a high content of digestible dry matter. It is more resistant to red leaf spot disease. It gives about 240 quintals green fodder per acre.

Agronomic Practices

Land Preparation : Good preparation of land is essential to get rid of weeds as well as to enable the crop to attain initial growth. In the irrigated areas, one ploughing with harrow followed by two ploughings with a cultivator should be given before sowing.

Seed Rate, Seed Treatment and Sowing : The seed-rate is 20-25 kg per acre. Sowing commences in the middle of March to obtain early green fodder. The optimum period of sowing is mid-June to mid-July. Treat seed with Emisan 6 @ 2.5 g/kg seed before sowing. Sow with a seed-cum-fertilizer drill or by using the *pora* method in rows 22 cm apart. Sorghum can be grown under no-tillage to obtain the same green fodder yield as after conventional or zero till sown wheat.

Weed Control : Spray Atrataf 50 WP (Atrazine) at 400 g/acre in 200 litres of water within two days of sowing. It provides effective control of annual weeds particularly *itsit/chapati* (*Trianthema portulacastrum*). If guara is grown in mixture with sorghum spray Stomp 30 EC (Pendemethalin) at 1 litre in 200 litres of water per acre within 2 days of sowing. This herbicide also provides effective control of annual weeds particularly *itsit/chapati.*

Fertilizer Application **:** In the rainfed or low rainfall areas, drill 20 kg of N (44 kg urea) per acre in rows at sowing. In high rainfall or irrigated areas, apply 20 kg of N (44 kg urea) and 8 kg phosphorus (50 kg single superphosphate) per acre at the time of sowing and another 20 kg N (44 kg urea) per acre about one month later. Add potassium to the crop on the soil test basis.

Irrigation and Drainage : About five irrigations should be given to the March-June crop and one or two irrigations to the monsoon crop, depending upon the rains. Soil drainage should be good.

Harvesting : Harvest the crop of fodder from boot to milk stage (65-80 days after sowing). Under drought conditions, apply irrigation one week before harvesting the crop.

Seed Production **:** Use 6-8 kg of seed per acre. Sow seed 8 cm deep in 30 cm spaced rows during the last week of June. Apply 16 kg of N (35 kg urea), 8 kg of P_2O_5 (50 kg Single superphosphate) and 10 kg of K (16 kg Muriate of potash) only in potassium deficient soils per acre at sowing and 16 kg N (35 kg urea) 40 days after sowing.

Plant Protection Measures

1. Insect-Pests

Shoot fly : Shoot fly remains active throughout the year but has two peak periods of infestation, viz March-April and August-September. The crop sown from early June to second week of July normally escapes its attack. Early sown (April-May) multicut sorghum hybrids are severely attacked by shoot fly. These should be protected by giving two sprays, first spray at four leaf-stage followed by second spray after one week of the first spray with 250 ml of Malathion 50 EC or 100 g of carbaryl (Sevin 50 WP) in 50 litres of water per acre.

Mite : Mite causes the reddening of leaves and can be controlled by spraying the crop with 250-450 ml of Malathion 50 EC in 100 litres of water per acre.

Other pests : Spray 250-500 ml of Malathion 50 EC in 100 litres of water per acre, depending upon the crop height if there is an attack of grasshoppers, grey-weevils, leaf-hoppers and pyrilla. Against pyrilla, the use of a motorized knapsack sprayer should be preferred.

Caution : (*i*) Do not use Malathion dust, Trichlorphon, Sevithion or Monocrotophos, as they may burn the crop.

(*ii*) Do not feed the fodder to cattle for at least two weeks after spraying.

2. Bird Control : (See under Chapter 'Management of Birds')

3. Diseases

Seed Rot and Seedling Mortality : It is caused by various seed-borne fungi. The infected seeds are shrivelled and dark in colour. Infected seedlings are killed before these emerge out of soil and cause poor stand of the crop. For its control, treat seed with Emisan 6 @ 2.5 g/kg seed before sowing.

Grain Smut : Control grain smut (*Sphacelotheca sorghi*) by treating the seed with sulphur dust @ 4 g/per kg seed before sowing.

Multicut Forage Sorghum

Punjab Sudax Chari 1 : It is a multicut forage sorghum hybrid. Its plants are tall with long broad leaves. Stems are juicy and sweet. It is resistant to red-leaf spot disease. The timely sown crop gives three good cuttings during the summer season and produce 480 quintals green fodder per acre.

Seed Rate and Sowing : Its time of sowing is last week of April to end of May. Use 15 kg seed per acre to get proper plant stand. The sowing may be done in good *watter* conditions in rows 30 cm apart.

Fertilizer Application : For first cutting the fertilizer dose as recommended for single cut sorghum should be applied. However, for subsequent cuttings, apply 40 kg N (88 kg urea) per acre immediately after first irrigation.

Harvesting : The first cutting is ready in 55-65 days after sowing. Subsequently, cuttings can be taken after an interval of about 35-40 days.

Seed Production **:** This multicut *chari* is a hybrid and its seed is to be procured afresh every year from the seed producing agencies. The female parent of Punjab Sudax *Chari 1* is sorghum male sterile line 2077 A and the male parent is Sudan grass SGL 87. The female and male parents are planted in an isolation with a distance of 200 m from another sorghum crop. The female and the male are planted in rows in the ratio of 4 : 2 respectively with row to row distance of 50 cm. Four kg seed of female and 3 kg seed of male parent is required to sow one acre during the last week of June.

BAJRA

Bajra (Pearl millet) is a hardy fodder crop and withstands adverse agroclimatic conditions. It can grow in light soils, with low moisture. It can tolerate hot and dry weather.

Rotations :

Bajra-maize-berseem.

Improved Varieties

PHBF 1 (2009) : It is a hybrid meant for green fodder. It flowers in 50 days. Its plants attain a height of 198 cm. It has succulent stem and multicut nature. It is better in tillering and has long and broad leaves. It is resistant to major diseases and pests. The fodder quality of this hybrid is better than FBC-16 in terms of dry matter intake, digestible crude protein and total digestible nutrients. The average green fodder yield of this hybrid is 256 quintals per acre.

PCB 164 (2003) *:* This is quick growing dual purpose composite variety having medium stalks and flexible stem with average plant height of 207 cm. It flowers in 50 days and plants remain green till maturity. It is highly resistant to downy mildew. Its fodder is of good nutritional quality. On an average, it yields 210 quintals per acre of green fodder and 59 quintals per acre of dry fodder at maturity.

FBC 16 (2003) : It is a composite variety exclusively meant for fodder production. It flowers 8-10 days later as compared to other varieties and hence provides green fodder for a longer period. Its plants attain an average height of about 235 cm and have long and broad leaves which remain green at maturity. It is comparatively resistant to major diseases. In terms of quality, it has higher voluntary dry matter intake and contains low amount of oxalates. Its average fodder yield is 230 quintals per acre.

Agronomic Practices

Time of Sowing : March to August. The March-May sown crop is the main fodder crop. It can be grown in mixture with cowpea.

Land Preparation : Give 2 or 3 ploughings at least 15 cm deep.

Seed Rate and Method of Sowing : The seed rate of bajra is 6-8 kg/acre. Sow by broadcast or in rainfed areas with *pora* in rows 22 cm apart. Bajra can be grown under no-tillage to obtain the same green fodder yield as after conventional or zero till sown wheat.

Seed Treatment : Treat the seed before sowing with 3 g of Agrozim 50 WP*+ Thiram (1 : 1) or Agrozim* 50 WP : Captan* (1 : 1) per kg of seed to prevent seed rot and seedling mortality.

Weed Control : Spray Atrataf 50 WP (Atrazine) @ 200 g/acre in 200 litres of water within two days of sowing. It provides effective control of annual weeds particularly *itsit/chapati*.

Fertilizer Application **:** Add 10 tonnes per acre of farmyard manure or compost before preparing the land and apply 20 kg of N (44 kg urea) per acre in two doses, one half as the basal dose and the second half 3 weeks after sowing when the crop height is 10-15 cm.

* Chemicals belong to green chemistry category.

Irrigation : Two or three irrigations are usually sufficient. In the hot season, however, more irrigations may be required. Standing water is harmful, hence avoid water-logging. It is preferable to give frequent but light irrigation.

Harvesting **:**

The crop should be harvested at ear-initiation or soon after the flag-leaf emergence (45-55 days after sowing). In no case, should it be allowed to go beyond 50 per cent earing. At this stage, the crop has high digestibility. It also escapes the attack of the ergot disease at the flowering stage. If infected fodder is fed to cattle, it can cause "finger-and-toe," disease and abortion.

Seed Production **:**

The patrental lines of the hybrid PHBF 1 along with their characteristics are given below :

Female Parent 408 A : The male sterile line has an average plant height of 140 cm. It takes about 55 days to 50% flowering and matures in 86 days. It has small ears with ear length less than 30 cm.

Male Parent PIB 213 : The average plant height of this line is 150 cm. It takes about 58 days to 50% flowering and matures in 90 days. It has long ears with ear length of 31-35 cm.

The procedure of the seed production of the hybrid and composites and maintenance of the purity are same as given in the grain bajra crop.

Plant Protection Measures

1. Insect Pests

Root bug : This insect causes damage to the bajra crop in south-western districts. On the standing crop, spray 2 litres of Malathion 50 EC in 100 litres of water per acre by directing the spray towards the base of the plant followed by irrigation.

Grasshopper : Dust the crop with Malathion 5% dust @ 10 kg per acre for controlling grasshoppers.

2. Birds : (See Chapter Management of Birds on page no. 152)

3. Diseases

Green ear or Downy mildew : The green ear disease or downy mildew is caused by *Sclerospora graminicola.* The leaves of infected plants show discolouration, yellowing and whitening. Under humid conditions, the leaves are covered with downy white growth of fungus which is prominent on the lower-surface. The leaves turn necrotic and are torn into shreds. The ears of the infected plants are transformed wholly or partly into green heads of small, twisted, leafy structures. Thus always sow resistant varieties.

Grain smut : Smut is caused by *Tolyposporium penicillariae.* Individual grains in an ear get transformed into smut balls which may later burst open to release millions of spores which get disseminated and cause secondry infection on the portion of the ear which is enclosed by the sheath of the upper leaf. The intensity of the attack varies according to the humidity in the area. The following control measures are suggested :

(*i*) Remove the diseased ears early in the season and destroy them.

(*ii*) Treat the seed before sowing with an organo mercurial fungicide, viz. 2.5 g of Ceresan/Agrosan (phenyl mercury acetate) or 3 g of Thiram/Captan per kg of seed to prevent the introduction of smut into new areas.

Ergot : This is caused by the fungus *Claviceps fusiformis.* At blossoming, a pinkish or light coloured fluid (honey dew) exudes from the spikelets in different parts of the ear. Later dark sticky patches appears on the ear and small dark-brown sclerotia appear in place of grains between the glumes. The seed set is poor or completely inhibited. The ovary is replaced by a fungal mass with many folds on its surface. The fungus perpetuates through the seed-borne and soil-borne sclerotia. The contaminated grains if fed to cattle or used by human beings can cause poisoning.

Do not feed the infected ears showing honey-dew sympotoms to cattle. Even the stems and leaves of such plants are not safe as cattle feed. Cut and burn a badly affected crop to reduce the amount of inoculum.

To control it, put the seed in 10 per cent salt solution and remove the sclerotia and smut-balls by skimming. Then wash the seed in ordinary water and dry it thoroughly before treating it with fungicides, as recommended under Grain Smut.

At the boot-stage, spray the crop with Cuman L 27% (Ziram) using 500 g of it in 100 litres of water per acre. Repeat 2 or 3 times at 5 day intervals.

TEOSINTE

Teosinte popularly called *Makchari* is a leafy and succulent fodder. It is closely related to maize but tillers profusely. It can tolerate standing water better than other *Kharif* fodders. It remains green for the longer period and provides green fodder upto November when there is scarcity of fodder.

Climatic and Soil Requirements :

Its climatic requirements are similar to those of maize and it does best under a mild and humid climate. It needs a rich heavy soil and does not make normal growth on light sandy soils.

Improved Variety :

TL 1 (1993) : Its plants are tall, leafy and profusely tillered. It is highly resistant to maize borer and has minor incidence of leaf spot disease. Its leaves remain green upto maturity. Its seeds are hard and slaty-brown in colour. On an average, it yields 225 quintals of green fodder per acre.

Agronomic Practices :

Land Preparation : One ploughing with harrow and two ploughings with cultivator followed by planking are sufficient to prepare the field for sowing the crop.

Seed Rate and Sowing : Sixteen kg seed is sown by *kera* or *pora*/drill at row spacing of 30 cm apart in June-July. Sowing done in August gives low yield. Teosinte can be grown under no-tillage to obtain the same green fodder yield as after conventional or zero till sown wheat.

Weed Control : Spray Atrataf 50 WP (Atrazine) 400 g/acre in 200 litres of water within 2 to 3 days of sowing. It provides effective control of annual weeds particularly *itsit/chapati.*

Fertilizer Application **:** It responds well to high fertility. Apply 8 tonnes per acre farm yard manure before preparing the field and 20 kg N/acre (44 kg urea) at sowing. Broadcast 20 kg N/acre (44 kg urea) after one month of sowing. P and K may be applied on soil test basis if deficient in the soil.

Irrigation : Depending upon the soil and weather, it needs irrigation at an interval of 8-10 days.

Harvesting **:** The crop should be harvested at the appearance of tassel (80-100 days after sowing). At this stage, the fodder is succulent and nutritious. As compared to other *Kharif* fodders, it has the advantage of remaining green and acceptable to the animals for a longer period without much loss of nutrients.

Seed Production **:**

Seed crop should be sown in the last week of June to the first week of July in rows 45 cm apart with a seed rate of 8-10 kg per acre. The crop should be harvested when three-fourth seeds mature. If harvesting is delayed, the mature seeds shatter which are loosely held. The sun dried crop is thrashed by simple beating with sticks or by running a tractor over it. The white seeds are immature, which should be separated before storage. The average seed yield is about 5 quintals per acre.

Plant Protection Measures :

There is no serious insect-pest on this crop, but some times maize borer attacks the crop at the early stages of its growth. The control measures for the borer are the same as given under maize.

NAPIER-*BAJRA* HYBRID

It is a vegetatively propagated *bajra* like grass, developed at the Punjab Agricultural University, Ludhiana. It is perennial but yields most of the fodder between March and November. The crop once planted gives fodder for 2-3 years.

Climatic Requirements :

This hybrid requires hot and moist climate and can be grown under irrigated conditions throughout the Punjab State.

Soil Type

This hybrid can be grown on variety of soils, but heavy soils are best for getting a high tonnage of green fodder.

Improved Varieties

PBN 233 (2000) : It is non-hairy with smooth long and broad leaves. It maintains its active vegetative growth longer than PBN 83 because it sprouts earlier in spring and remains in vegetative growth upto onset of winter. Its winter dormancy period is about 15 days less than PBN 83. It yields 1100 quintals of green fodder per acre.

PBN 83 (1984) : It is a non-hairy, smooth-leaved fast growing and late-flowering hybrid. It maintains its active growth longer in winter and sprouts earlier in spring. It yields 960 quintals green fodder per acre.

Agronomic Practices

Land Preparation : The land should be prepared well and should be free from weeds. Give the first ploughing with a disc harrow and subsequent two ploughings with a cultivator. Planking should follow every ploughing.

Time and Method of Planting : This variety can be planted from the last week of February to May. The planting should be completed by mid-April to avoid high mortality of root slips. The crop planted after May does not give sufficient yield during the *kharif* season. It can be propagated vegetatively from root slips or stem cuttings. Root-slips (30 cm long) or stem cuttings (with two or three nodes) are used for planting. Approximately, 11,000 slips or cuttings are required to plant one acre. A small part of the shoot or root-slip is allowed to remain exposed and the rest of the slip is buried in the soil. The stem cuttings can also be planted like sugarcane sets in 7 or 8 cm deep furrows which are afterwards filled with soil. The furrows may be made with a furrower. The crop should be planted at 90 x 40 cm or 60 x 60 cm apart in lines under good conditions of soil moisture.

Fertilizer Application **:** This hybrid is quick growing and responds to high fertility. Add 20 tonnes of farmyard manure or town compost to the soil before planting and 30 kg of N (66 kg of urea) per acre, fifteen days after planting. Repeat this fertilizer dose after each cutting. Apply 38 kg of P_2O_5 (240 kg of Single superphosphate) per acre to the soil every year in two doses, the first half in spring and the second half during the monsoon.

Irrigation : This crop needs frequent irrigation during hot and dry months. In the mid-season, however, irrigate after every 10 to 14 days. Drain away excess water from the field during the rainy season.

Harvesting **:** The first cutting is ready in about 50 days after planting. Take subsequent cuttings when the crop is about one metre high. If the crop is allowed to grow beyond this height, its nutritive value falls drastically.

If the fodder is not harvested at optimum stage (one metre plant height) and allowed to attain a height more than 2 metre, its use as a sole fodder should be avoided because such fodder becomes more lignified, less palatable and poorly digestible. The feeding of such fodder may cause rumen impaction (Banh) resulting thereby in constipation. In some cases, blood spot may appear with dung.

Intercropping : During winter, when the hybrid is dormant, oats, *senji, metha* or Japan rape can be intercropped.

GUINEA GRASS

It is high quality multi cut summer fodder. Its plants have profuse tillering and more leaves. It can be cultivated as annual as well as perennial fodder crop. The perennial crop maintains active growth from March to November and it remains dormant from December to February.

Climatic and Soil Requirements :

It can be sown all over the state. It does best on well drained soils. Excessive moisture during germination kills the germinating seedling, hence a light irrigation should be given particularly in heavy soils.

Improved Varieties

PGG 518 (1998) : Its plants are erect with profuse tillering and leafy growth. Its leaves are longer and broader than PGG 101. It flowers 5-7 days later than PGG 101 and thus maintains its forage quality for a longer period. The loss of nutrients is less in this variety if harvesting is delayed due to unavoidable circumstances. To harvest maximum nutrients cut the crop for fodder at boot stage. In 5-6 cuttings from May to November, it produces 750 quintals green fodder per acre. It has low degree of seed shattering. Its panicles are initially white in colour which change to light-yellow on maturity.

PGG 101 (1991) : Plants of this variety have profuse tillering and leafy growth. Loss of nutrients in this variety is less on unavoidable delay in harvesting. It has bold seeds which help in better germination. It produces 675 quintals green fodder per acre in 5-6 cuttings from May to November. Harvesting should be done before flowering to get nutritious fodder.

Agronomic Practices

Time and Method of Sowing : Guinea grass may be sown from mid-March to mid-May. Six to eight kg seed is sown by *kera* in furrows 25 cm apart drawn by plough/cultivator. It can also be sown by broadcast in furrows prepared with cultivator followed by light planking with *jindra*/raking. The field should be irrigated immediately after sowing.

Weed Control : It is very essential to spray 500 g of Atrataf 50 WP (Atrazine) in 200 litres of water per acre immediately after sowing so that the weeds do not smother the slow growing seedlings.

Fertilizer Application : Being a multicut grass, it responds to high fertility. Apply 20 tonnes of FYM to the soil before preparing the field. Apply 20 kg N (44 kg urea) per acre 20 days after sowing and the second dose of 10 kg N (22 kg urea) per acre 35 days after sowing. After each cutting apply 30 kg N (66 kg urea) with first irrigation.

Irrigation : First irrigation to guinea grass is given immediately after sowing. Second light irrigation essential for germination is given after about 4-6 days of first irrigation as soon as the surface gets dry. Subsequent irrigations are given at an interval of a week in summer and 10 days during September-November. During rainy season, irrigation is applied as and when needed. Excessive standing water must be drained away at the early seedling stage particularly in heavy soils.

Harvesting : The first cutting in guinea grass is ready in about 55 days after sowing. Subsequent cuttings are taken after an interval of 25-30 days. Harvesting very close to the ground delays the next cutting and may result in the death of stumps particularly in rainy season.

Intercropping of stumps : In a perennial crop, when the grass is dormant in winter, oats or *senji* may be sown in the last week of November between the stubble rows.

Seed Production

The crop sown for fodder is left for seed production in the last week of August and the seed gets matured by mid of October. Plant remains still green when seed matures. The seed crop is ready for harvest when the seed from the tip of the ear starts shattering. All the ears should be removed immediately and the green fodder could be fed to the animals later on. About 250 kg seed can be produced from one acre. One more fodder cutting may be taken from the same crop in November.

GUARA

Guara is a highly nutritious leguminous fodder for the animals. A mixture of sorghum and *guara* is the most popular forage of the state. Its dry pods and husks are relished by the cattle. It also enriches the soil.

***Soil Type* :**

Guara grows well on all types of soils. Well-drained, medium to light soils are very suitable.

Improved Variety

Guara 80 (1982) : It is recommended for *barani* as well as irrigated conditions for cultivation throughout the state. It is tall, quick-growing, hairy and profusely branched type. It is resistant to *guara* leaf blight and stem breakage. This variety does not possess bunches on each node. It is a late maturing variety. It yields about 125 quintals per acre green fodder.

Agronomic Practices

Land Preparation : One or two ploughings and a planking are sufficient.

Seed Rate and Sowing : Use 18-20 kg seed per acre. The crop may be sown from May to mid-August. The sowing should be done with a row to row distance of 30 cm by drill, *pora* or *kera* method. Guara can be grown under no-tillage to obtain the same green fodder yield as after conventional or zero till sown wheat.

***Fertilizer Application*:** Drill 9 kg of N (20 kg urea) and 24 kg P_2O_5 (150 kg Single superphosphate) per acre before sowing in the irrigated areas.

Weed Control : Spray Stomp 30 EC (Pendimethalin) @750 ml in 200 litres of water/acre by using knapsack sprayer having flat fan/flood jet nozzle within 24 hours of sowing.

Irrigation : If the rainfall is well-distributed, the crop does not need any irrigation. Generally, 1 or 2 irrigations are required depending upon the rainfall.

***Harvesting* :** The optimum stage of harvesting is between 90-100 days after sowing, corresponding to 100 per cent of flowering and pod initiation stages, respectively.

Seed Production : As recommended in guara seed crop.

Plant Protection Measures :

Bihar hairy caterpillar attacks the crop during September-October. It can be controlled by collecting and destroying the egg masses and gregarious young larvae of the pest.

COWPEA

The cultivation of cowpea is recommended in the irrigated areas of the Punjab state. It is often grown mixed with maize to get not only a higher yield but also increased nutrients from the green fodder. It enables the dairy cattle to maintain good milk yield during the hot and dry summer.

Soil Type **:**

Well-drained loamy soil is conducive to a proper growth of the crop.

Improved Varieties

CL 367 (2005) : It is dual purpose variety suitable for fodder as well as pulse purpose. Its plants are erect with dark green leaves. It is resistant to yellow-mosaic virus and anthracnose diseases. Its fodder quality is superior in terms of total digestible nutrients (TDN) and digestible crude protein (DCP). It bears large number of pods. Its seeds are small in size and creamish white in colour. The variety is suitable for human consumption because it has very good cooking quality. On an average, it yields about 108 quintals of green fodder and 4.9 quintals of grains per acre.

Cowpea 88 (1990) : This is a dual purpose variety recommended for cultivation throughout the State for fodder and as a pulse crop. It is also highly resistant to yellow mosaic virus and Anthracnose disease. It has large pods and bold seeds. The seed colour which is chocolate-brown is most attractive for culinary purpose. It matures uniformly during second fortnight of October and later on wheat and other *rabi* crops can be sown timely. Its average grain yield is 4.3 quintals per acre. It yields 100 quintals of green fodder per acre.

Agronomic Practices

Land Preparation : Two ploughings followed by plankings are sufficient.

Seed Rate, Seed Treatment and Sowing : For fodder, sow 20-25 kg seed of Cowpea 88 and 12 kg seed of CL 367 per acre from March to mid-July, with a por or *seed-cum*-fertilizer-drill in rows, 30 cm apart. When sown mixed with maize the seed rate is 6 kg of CL 367 or 15 kg of Cowpea 88 and 15 kg of maize per acre. Treat seed with Emisan 6 @ 2.5 g/kg seed or Bavistin 50 WP* @ 2 g/kg seed before sowing against seed rot and seedling mortality. Cowpea can be grown under no-tillage to obtain the same green fodder yield as after conventional or zero till sown wheat.

Weed Control : Spray Stomp 30 EC (*Pendimethalin*) @ 750 ml/acre in 200 litres of water as pre-emergence within 24 hours of sowing. It provides effective control of annual weeds particularly *itsit/chapati* (*Trianthema protulacastrum*).

Fertilizer Application**:** Drill 7.5 kg N (16.5 kg urea) as a starter dose and 22 kg of P_2O_5 (140 kg Single superphosphate) per acre at sowing. In case, cowpea fodder succeeds wheat which had received recommended level of P, omit the application of P to cowpea.

Irrigation and Drainage : The crop sown in May needs fortnightly irrigation till the advent of the monsoon. In all 4 or 5 irrigations will be sufficient. Adequate drainage results in a good yield.

* Chemical belongs to green chemistry category.

Harvesting **:** Harvesting stage of cowpea is between 55-65 days after sowing, which corresponds to pre-flowering stage and would produce good quality fodder.

Seed Production **:** Sow 8 kg seed of cowpea CL 367 in first week of August and 16 kg seed of Cowpea 88 from last week of July to first week of August, in lines 30 cm apart in proper soil moisture. The fertilizer application is the same as for the fodder crop.

Plant Protection Measures :

Jassid and black aphid can be controlled by spraying 200 ml of Malathion 50 EC in 80 litres of water per acre.

Bihar hairy caterpillar (*Bhaboo Kuta*) : It attacks cowpea from August to November. To keep Cowpea free from attack of this pest, plant a row of *til* (Sesamum) around cowpea field at the time of its sowing. Females prefer to oviposit on *til* rows from where larvae in gregarious phase should be collected and destroyed mechanically.

Seed Rot and Seedling Mortality : It is caused by various seed-borne microflora. The infected seeds are shrivelled and discoloured. Infected seedlings are killed before these emerge out of soil and cause poor stand of the crop. For its control treat seed with Emisan 6 @ 2.5 g/kg seed or Bavistin 50 WP @ 2 g/kg seed before sowing.

Stored Grain Insects–Pulse beetle (*Dhora*) causes severe damage to stored cowpea grains. For its control see Stored grain insects Appendix II.

Bird Control : House crows dig out the germinating seeds. For control see chapter on Management of Birds.

Table : The nutritive value of some important *Kharif* fodders :

Fodders	*Crude protein on dry matter basis (%)*	*Total digestible nutrients on dry matter basis (%)*
Maize	11.4	66.2
Sorghum	9.0	55.6
Bajra	8.8	58.2
Teosinte	7.0	60.4
Napier-Bajra hybrid	8.7	59.3
Guinea grass	10.8	62.4
Guara	18.1	60.0
Cowpea	22.5	61.2

FODDER MIXTURES

It is advisable to grow fodders, whenever possible, as mixtures rather than as monocultures. Crop mixtures, which combine a non-legume, such as maize, *jowar*, and *bajra* with a legume, such as cowpea and *guara* provide a balanced diet for animals because legumes are important sources of proteins and non-legumes are rich in energy. These mixtures would often require lower amounts of nitrogen application because of the legume component. Some of these mixtures can be sown more than once during the *Kharif*. Harvest the fodder mixture when maize is in the milk-ripe to dough stages, when sorghum has one-half to one-third heads out and when *bajra* shows the emergence of ears from the flag leaves.

Bajra and sorghum can be successfully grown alone as well as in mixture with *guara* and cowpea in the rainfed *kandi* tract of the State. *Guara* and cowpea are also suitable fodder crops for mono-culture in that area.

SILAGE MAKING

An adequate supply of quality fodders during the lean periods of November-December and May-June can be ensured by preserving the green fodder as silage. Non-legume *kharif* fodders, such as, maize, sorghum, *bajra*, napier bajra hybrid and guinea grass which are rich in sugar and carbohydrates and low in protein possess excellent qualities for conserving as silage.

Stage of Harvesting : Harvest the crop for silage making when nutrient contents are at their peak stage and it has enough dry matter. A crop with 30-35 per cent dry matter conserves into a high quality silage. The optimum time for harvesting fodder crops for ensiling is given below :

Crop	*Stage of harvest*
Jowar and Maize	Flowering to milk stage
Bajra and Teosinte	Boot stage
Napier Bajra hybrid and Guinea grass	1 metre tall

Crops harvested at the above given stages usually have the desired dry matter content. However, napier hybrid and guinea grass need one or two days drying in the field before chaffing to reduce the moisture. To test the proper dry matter content, take a handful of chaffed fodder in between the hands and press it to form a ball. If the hands do not moist ; the fodder has the desired dry matter.

Silo-trench : The size of silo-trench depends upon the number of animals, period for which to be conserved and the availability of green fodder. On an average, in one cubic metre space, 5-6 quintals of chaffed green fodder can be packed. In a 10 metre long, 3 metre wide and 1.5 metre

deep silo-trench about 350-400 quintals of chopped green fodder can be packed. Length and the width of the silo-trench can vary with the number of animals and their fodder requirement, but depth should always be kept at 1.5 to 2 metres. The trench should be made on a high level spot near the animal shed. It should be made pucca and cement plastered.

Method of Silage Making :

1. Chop the harvested crop to the length of 5 to 8 cm and pack into the silo trench.
2. Press the chopped crop in the trench thoroughly with a tractor or bullock and raise it to 1 metre above the ground level, to create proper anaerobic conditions to make quality silage. Every half metre thick layer of chaffed fodder should be regularly pressed.
3. Cover the fodder with 10-15 cm thick layer of *kadbi* or wheat *bhusa*. Put the mud on it and finally mud-plaster. See that the silo-trench is completely air-tight.
4. Alternately, a plastic sheet may also be used to cover the packed forage. Edges of the sheet may be sealed by mud plastering.
5. Keep an occasional watch and if there is any crack or hole, plug it immediately. Silage will be ready within 45 days.
6. Open the silo-pit from one end only and take out the daily requirement of the feed. The remaining silage, if kept covered, stays good till used.

Feeding the Silage : The animals may not like its taste for the first few feedings. Help them to develop the taste by mixing 5 to 10 kg of silage in their green fodder ration for the first 5 to 6 days. After the taste is developed, 20 to 30 kg of silage alongwith other fodders may be fed per head per day.

HAY MAKING

The aim of hay-making is to reduce the moisture content of green fodder to below 15 per cent so that little or no change in nutritive value occurs during storage. The fodder crops having soft stems are suitable for hay-making. In legumes such as berseem, lucerne and cowpea, care should be taken to avoid shattering of leaves during drying. Non-legumes such as maize, *jowar, bajra* are more suitable for silage making than for hay making. Harvest the fodder crops at pre-flowering stage. Chop the fodder to a length of 5 to 8 cm. Spread the chaffed fodder in a 10-15 cm thick layer on a hard-surface to dry it on the sun. The usual threshing floor can also be used for this purpose.

To speed up the drying process, stir the fodder with a rake after every 2 to 3 hours during the day. When thoroughly dried (usually 2-3 days depending on the frequency of stirring), collect the dried material for storage. A practical method of determining the safe limit of moisture content for storage of dried material is to twist some of the stems. If the stem breaks easily, the hay is fit for storage. It can be stored in a room normally used for storing wheat *bhusa*.

A kilogram of dried hay containing 90 per cent dry matter is equivalent to about 6 kilograms of green fodder containing 15 per cent dry matter.

SELENIUM TOXICITY AND ITS CONTROL

Selenium (Se) is an essential element for animal health. Critical level of Se in the fodder is 0.5 mg/kg fodder for the animals and becomes toxic when exceeds 4-5 mg/kg in fodder. Selenium toxicity has been observed in some villages of Hoshiarpur and Nawanshahar districts. Typical Se toxicity symptoms in wheat include snow-white chlorosis with pink colouration at the lower surface of leaf. All the fodders grown on seleniferous soils do not show any visual toxicity symptoms but definitely contain selenium in toxic level for animals which in extreme cases may prove fatal. The typical symptoms of Se toxicity in animals are overgrowth and cracks followed by gradual detachment of the hoof, shedding-off of horn corium, loss of hair, necrosis of tip of tail, loosing body condition, reluctance to move and still gait. Humans of all age groups are affected by the selenium poisoning. Hair loss from the body particularly head, malformation of finger as well as toe nails, blood oozing out from finger tips and progressive deterioration in general health are the typical symptoms of selenium toxicity in human beings.

Control Measures

1. Apply 350 to 400 kg gypsum per acre in alternate year for growing fodder and other crops in seleniferous soils.
2. Prefer oats as a fodder over *berseem*.
3. Avoid feeding the first cutting of *berseem* fodder to animals.
4. Prefer maize, sorgham, *bajra* and guinea grass as fodder crops in the Se contaminated region.
5. Among agro-forestry trees, cultivation of *Poplar/Arjun/*Eucalyptus/Mulberry trees is helpful in removing excessive Se from the soil.
6. Continuous cultivation of *Raya/Gobhi sarson* should be preferred for lowering Se in the affected soil. Oil can be consumed since it contains Se within safe limits.
7. Install deep tubewells in the seleniferous region (preferably at a depth of about 400 ft) for using underground water for irrigation as well as drinking purposes.
8. Follow maize-wheat instead of rice-wheat rotation.
9. Ensure that grass, grains and fodder produced at the toxic sites should not be consumed at all either by human-beings or animals.
10. Se-rich plant materials can be safely disposed off through incorporation up to 20 t/ha in the nonseleniferous soils. However, Se-rich materials should not be disposed off at the same site every year.

8. PROTECTION OF PLANT VARIETIES AND FARMERS RIGHTS ACT-2001

To promote innovation and to meet international obligation, the Government of India enacted "Protection of Plant Varieties and Farmers' Rights Act (PPV&FR Act) 2001. The Rules and Regulation to implement PPV&FR Act were formulated in 2003. For the effective implementation of these rules and regulations, the Government of India established an authority known as "Protection of Plant Varieties and Farmers' Rights Authority in 2005. The authority has one chairperson and fifteen members. The head office of this authority is in NASC Complex, New Delhi. The PPV&FR Authority started functioning from October 2006.

Below given is just the simplified version of PPV&FR Act and cannot be quoted for any legal obligation.

Notable Features of Protection of Plant Varieties and Farmers Rights Act

* Provides an effective system for protection of plant varieties
* Protect the rights of plant breeders to (i) encourage the development of new varieties of plants, (ii) stimulate investment for research and development, both in the public and private sector for the development of new plant varieties, and (iii) accelerate agricultural development in the country.
* Protect the rights of the farmers in respect of their contribution made at any time in conserving, improving and making available plant genetic resources for the development of new plant varieties.
* Facilitate the growth of seed industry in the country which will ensure the availability of high quality seeds and planting material to the farmers.

Under this act, the following rights of the breeders and farmers are protected :

Breeder Rights

* It provides an exclusive right on breeder or his successor or his assignee to produce, sell, distribute, import or export the seed of protected varieties
* The breeder can also authorize any person to produce, sell and distribute the seed of protected varieties under certain conditions laid down in the act

Researchers Rights

* The Researcher has the right to use the protected variety for research purpose and for the development of new varieties.

* However, the authorisation of the concerned breeder will be required for the repeated use of protected variety for the commercialization of the new variety.

Farmers Rights

* Right to save, use, exchange, sow, re-sow, share or the sell the produce of protected variety, except the sale of branded seed.
* Right to benefit sharing from the contribution of his variety or plant material in the development of new variety.
* Right for Compensation for low performance of the protected variety : As per section 39 (2) of the Act the breeder has to disclose to the farmers the expected performance of the protected variety under the given conditions. If the protected variety fails to perform as specified, the farmer has a right for compensation for the low performance.
* Just like breeders, he can register his variety (Farmers variety/ traditional variety)
* Farmers are exempted from the payment of registration fee
* Recognition and Reward to the farmers for conservation of land races and development of farmer's varieties.
* Farmers to be protected from the act of innocent infringement. If the farmers who is not aware of the existence of this act and unknowingly breaks the law of protection, then that farmer will be considered as innocent but he has to prove his innocence before the court.

Who can apply for registration : Any person claiming to be the breeder or his successor or assignee or any person authorized by the breeder; any farmer or group of farmers or farming community.

Types of varieties which can be registered with PPVFRA: Three types of varieties namely Extant, New and Essentially Derived Varieties can be registered with the Protection of Plant Varieties and Farmers' Rights Authority.

Extant Variety

* A variety which is available in India and notified under section 5 of Seed Act (1966)
* A Farmer's variety (a variety traditionally cultivated and evolved by the farmer at his own field, can be a land race or wild relatives)
* A variety which is of common knowledge
* A variety which is in public domain

New Variety : A variety will be registered as a new variety if its seed has not been offered for sale before one year from the date of application for registration. It should confirm the criteria of Novelty, Distinctness, Uniformity and Stability.

Essentially Derived Variety (EDV) : A variety which is derived through single gene transfer, recurrent back cross derivatives, mutants, soma clone variants, CMS lines, polyploids, substitution/

deletion lines all come under EDV. EDV can be registered, if it differs from the initial variety for atleast one character and meets the DUS test.

Varieties which cannot be registered : A variety, which contains any technology that is injurious to the life or health of human beings or animals or plants including terminator technology, shall not be registered.

Crops which can be registered : The protection of Plant Varieties and Farmers Right Authority has started the registration of varieties of 51 species of following 42 crops :

Rice, Wheat (4 species), Maize, Sorghum, Pearl millet, Chikpea, Mungbean, Urdbean, Field pea, Kidney bean, Lentil, Pigeon pea, Cotton (4 (species), Jute (2 species), Indian Mustard (2 species), Rapeseed (2 species), Groundnut, Soybean, Sunflower, Safflower, Castor, Seasame, Linseed, Lucerne, Berseem, Tomato, Brinjal, Okra, Cauliflower, Cabbage, Potato, Onion, Garlic, Rose, Chrysanthemum, Black pepper, Small cardamom, Turmeric, Sugarcane, Ginger, Mango, Isabgol.

Duration of registration : The varieties are registered initially for a period of six years in case of crops and nine years in case of trees and vines. The registration can be renewed up to a maximum period of 15 years in case of crop varieties and 18 years for trees and vines.

Compulsory licensing : If the seed of the protected variety is not available after three years of registration in adequate quantity at a reasonable price, the PPV&FR Authority may grant a license to a third party to undertake the production of the seed of the protected variety, its distribution and sale with limited royalty to the concerned breeder. The duration of the compulsory licence may vary from case to case keeping in view the gestation period and other relevant factors but it shall not exceed the total remaining period of the protection of that variety.

Benefit sharing : On registration of a variety, any person or a group of person can submit his claim of benefit sharing to the PPVFRA in the prescribed form and with prescribed fee if his/her material has been used in the development of a particular variety. The authority shall take the decision on the matter after considering the following points :

1. The extant and nature of use of the genetic materials of the claimant in the development of the variety relating to which the benefit sharing has been claimed; and
2. The commercial utility and the demand in the market of the registered variety relating to which the benefit sharing has been claimed.

Infringement of the act : The Act will be infringed by a person PPV & FR Act if :

1. Any person, not being the breeder of the registered variety or registered agent or registered license of that variety sells, exports or imports or produces the seed of such variety without the permission of the breeder of that variety;
2. Any person who sells, exports, imports or produces any other variety giving the denomination similar to the denomination of the registered variety.

Penalties for infringement : Any person who applies any false denomination to the registered variety or indicates the false name of the country or false name and address of the breeder of that registered variety shall be punishable with an imprisonment of three months to two years or a fine of Rs. 0.5 lakhs to 5 lakhs or both. Similarly, any person who makes false representation with respect to the denomination of a variety or its propagating material registered under the act shall be punishable with an imprisonment of six months to three years or a fine of Rs. one lakh to five lakhs or both. The subsequent conviction of an offence will be punishable for the second and for every subsequent offence with an imprisonment of one to three years or with a fine of Rs. 2 lakhs to 20 lakhs or both.

Note : More information regarding this Act can be sourced from the PPV & FRA website :- www.plantauthority.gov.in

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9. ORGANIC FARMING

Organic farming is a production system which avoids the use of synthetically manufactured fertilizers, pesticides and growth regulators. Organic farming systems rely on crop rotations, crop residues, animal manures, legumes, green manures, off-farm wastes and biological pest control to maintain soil productivity, to supply plant nutrients and to control pests.

The average yield of field crops particularly the cereals grown in the Punjab state is equal or even higher than that obtained in many advanced countries. There is a need to improve the quality along with any further improvement in quantity. Quality produce can only be possible with the adoption of organic farming and there is a need to gradually replace chemical farming system with the organic farming. Apart from improving food quality, soil health can also be maintained and improved with organic farming system.

Farming organically is more than just abandoning chemicals. It requires the elimination of persistent chemicals from soil. Therefore, there is need of conversion period from chemical to organic farming. The period is decided on the basis of the previous use of the land. Generally a three years transition period is required to convert from chemical to organic farming, with all the organic practices during the intervening period. The organic farm has to make sure that there is no run off coming from the adjoining chemical farming plots. There is need to have a buffer around organic field.

During the initial 3-4 years the yields of organically grown crops are generally lower as compared to inorganically grown crops and later on the yield of both the systems becomes equal. The crops can be grown organically in the following cropping systems:

Rice-Wheat

Rice

Soil : The soils having medium to heavy texture with low infiltration rate are preferred.

Seed : The organic produce of previous year is to be used for the subsequent crops. The seed rate is comparable with conventional farming. The seed should not be treated with any chemical.

Nutrition : The nutritional requirement of crop can be met by green manuring with cowpea or sunhemp. Grow cowpea (cowpea 88) or Sunhemp by using a seed rate of 20 kg per acre and incorporate about 50 days old crop just before transplanting the rice/basmati. The green manure crop can be sown directly with no-till drill after harvesting wheat.

Weed Control : The water should be ponded for first 25-30 days. One manual weeding can be done as per need.

Insect-Pest Control : Trichogramma-cards should be stapled at 40 spots in one acre for 5 to 6 times at weekly interval, starting 30 days after transplanting (The Trico-cards can be had from Entomology Department, Punjab Agricultural University, Ludhiana or some other reliable sources).

Wheat

Seed : The seed of recommended varieties can be used. However, it should be of organic produce of the previous year. The seed rate is comparable with conventional farming. The seed should not be treated with any chemical.

Nutrition : The organic sources like FYM and compost enriched with rock phosphate* can be used in raising the organic wheat. The quantity of the organic sources depends on the N content of the source and the organic matter content of the soil. The nitrogen added from the organic source at the rate of 80, 120 and 160 kg N/acre in soils having high, medium and low organic matter content, respectively can give comparable yield to that with recommended levels of inorganic fertilizers in case of double dwarf wheat varieties. The above amount of nitrogen can be obtained from the 8, 12 and 16 tonnes of FYM. The nutritional requirement of 50 kg nitrogen per acre to wheat can also be supplied through FYM (1% N), Vermicompost and Non edible cake, each supplying 1/3 of the total nitrogen requirement. Apply 1.7 t/acre FYM, 1.1t/acre vermicompost (1.5% N) and 0.66 t/acre non edible cake (2.5 per cent nitrogen). The potential yield of *desi* varieties of wheat can be obtained by half the doses of organic sources in respective soils.

Weed Control : Cultural methods recommended for conventional cropping can be used to control the weeds. The practices like dry soil surface mulch, stale seed bed, manual weeding before first irrigation and removal of weed seed at the time of maturity particularly of *Phalaris minor (Gulidanda)* can be followed to control the weeds.

Insect Pest Control : In the organically grown wheat, there is no serious problem of insect-pest. The natural predators *(Coccinella septumpunctata)* becomes active on the appearance of the aphid.

Maize/Soybean-Wheat

The soil, seed rate, spacing etc. are comparable with conventional farming while fertilizers and other chemicals should not be used.

Maize

Tillage : In case of organic farming 3 to 4 extra operations of discing (ploughing) are required in order to properly incorporate the residues of previous wheat crop, farm yard manure and green manuring crop as compared to chemical farming system.

Nutrition : Apply well rotten farm yard manure on dry weight basis @ 8 t/acre during the first five years of the start of organic farming and later on reduce by 50 per cent of this dose of FYM. Incorporate residues of previous wheat crop in the field. The green manuring crop like sunnhemp/*dhaincha* should be sown @ 20 kg seed/acre in the third week of April or immediatly after harvesting wheat which requires 2 to 3 irrigations and incorporate 40 to 45 days old green manuring crop but 5 to 7 days before sowing the maize crop.

Weed Control : The intensity of weeds in the organic system is comparatively more due to addition of farm yard manure, so give hand hoeings twice or thrice to maize crop with wheel hoe/ *khurpa*/*kasola* for proper control of weeds.

Insect-Pest Control : For controlling maize borer and other insects, apply bio-insecticides like Neemazal (1%) @ 120 ml/acre. The maize borer can also be managed by using trichocards having 40,000 eggs of *Corcyra* parasitized by *Trichogramma chilonis* on 10-15 days old maize crop. Cut tricho-cards into 40 equal strips and staple them uniformly on the underside of the central whorl leaves in evening hours. The tricho-cards should not be applied on rainy days.

Soybean

Tillage : In case of organic farming 3 to 4 extra operations of discing (ploughing) are required in order to properly incorporate the residues of previous wheat crop, farm yard manure and green manuring crop as compared to chemical farming system.

Nutrition : Apply well rotten farm yard manure on dry weight basis @ 4 t/acre during the first five years of the start of organic farming and later on reduce by 50 per cent of this dose of FYM. Incorporate residues of previous wheat crop in the field. The green manuring crop like sunnhemp/ *dhaincha* should be sown @ 20 kg seed/ acre in the third week of April or immediately after harvesting wheat which requires 2 to 3 irrigations and incorporate 40-45 days old green manuring crop but 5 to 7 days before sowing the soybean crop.

Weed Control : The intensity of weeds in the organic system is comparatively more due to addition of farm yard manure, so give hand hoeings twice or thrice to soybean crop with wheel hoe/ *khurpa/kasola* for proper control of weeds.

Insect-Pest Control : For controlling white fly and other insects, apply bio-insecticides like Neemazal (1%) @ 120 ml/acre.

Wheat

Tillage : In case of organic farming 3 to 4 extra operations of discing (ploughing) are required in order to properly incorporate the residues of previous maize or soybean crop and farm yard manure as compared to chemical farming system.

Nutrition : Apply well rotten farm yard manure on dry weight basis @ 8 t/acre during the first five years of the start of organic farming and later on reduce by 25 per cent of this dose of FYM. Incorporate residues of maize or soybean in the field.

Weed Control : The intensity of weeds in the organic system is comparatively more due to addition of farm yard manure, so give hand hoeings twice or thrice to wheat crop with wheel hoe/ *khurpa/kasola* for proper control of weeds.

Insect-Pest Control : In the organically grown wheat, there is no serious problem of insect-pest. The natural predators *(Coccinella septumpunctata)* becomes active on the appearance of the aphid.

Maize-potato-onion

The maize-potato-onion cropping system proves highly productive when its nutrition need is fulfilled by applying 1/3 each of FYM, vermicompost and non-edible cake under organic farming. The yield improves when potato is intercropped with radish and onion with coriander which enables

to harvest the comparable yield with the chemical farming even in the first year. The quantity of organic manures to be applied to organic maize for getting 50 kg N/acre is 16.7 q FYM (1% N); 11.1q vermicompost (1.5% N) and 6.7 q non-edible cake (2.5% N)/acre. For potato (75 kg N/acre) the corresponding quantity of FYM/vermicompost and non-edible cake is 25.0, 16.7q and 10.0 q/acre; and for onion (40 kg N/acre) is 13.3, 8.9 and 5.3 q/acre, respectively. The maize crop should be sown during the first fortnight of June, potato in the first fortnight of October and onion in first fortnight of January. Similarly, sow radish in first fortnight of October on the southern side of each potato ridge and dugout radish 2-3 times after 50-70 days after sowing in December. Sow one row of coriander (after five rows of onion) after applying first irrigation to onion after transplanting in the first fortnight of January and harvest green coriander 40 days after sowing and seed coriander in the second week of May.

Maize-Durum Wheat - Cowpea (fodder)

Maize

Seed : The seed should be from the previous organic crop especially when the produce is to be certified by a certification agency. It should not be treated with any chemical. The seed rate and method of sowing is the same as for the conventional farming.

Nutrition : The nutritional requirement of 50 kg nitrogen per acre to maize can be supplied through FYM, Vermicompost and Non edible cake each supplying 1/3 of the total nitrogen requirement. Apply 1.7 t/acre FYM (1% N), 1.1 t/acre Vermicompost (1.5% N) and 0.66 t/acre Non edible cake (2.5 per cent nitrogen).

Weed Management : Herbicides should not be used for the control of weeds. Integrated cultural practices should be adopted to reduce the incidence of weeds and the emerged weeds should be removed manually or mechanically twice or thrice depending upon the weed intensity.

Durum wheat

Seed : The seed should be from the previous organic crop especially when the produce is to be certified by a certification agency. It should not be treated with any chemical. The seed rate and method of sowing is the same as for the conventional farming.

Nutrition : The nutritional requirement of 50 kg nitrogen per acre to durum wheat can be supplied through FYM, Vermicompost and Non edible cake each supplying 1/3 of the total nitrogen requirement. Apply 1.7 t/acre FYM (1% N), 1.1 t/acre Vermicompost (1.5% N) and 0.66 t/acre Non edible cake (2.5 per cent nitrogen).

Weed Management : Herbicides should not be used for the control of weeds. Integrated cultural practices should be adopted to reduce the incidence of weeds and the emerged weeds should be removed manually or mechanically twice or thrice depending upon the weed intensity.

Cowpea Fodder :

Seed : The seed should be from the previous organic crop especially when the produce is to be certified by a certification agency. It should not be treated with any chemical. The seed rate and method of sowing is the same as for the conventional farming.

Nutrition : There is no need to apply any nutritional input to the cowpea fodder in this system as it grows well on the residual fertility of soil.

Weed Management : Herbicides should not be used for the control of weeds. Hoeing may be done depending upon the intensity of weeds.

Turmeric-Onion

Turmeric

Soil : The preference should be given to the best fields on the farm.

Seed : It should not be treated with any chemical. The seed should be from the previous organic crop especially when the produce is to get certified. The seed rate, method of sowing and time of sowing are the same as for the conventional crop.

Nutrition : The nutrition requirement of organic turmeric can be met by applying 6 trolleys of farmyard manure (6 tonnes of fully dried farmyard manure having 1% N). In case of non-availability of required farmyard manure, apply 4 trolleys of farmyard manure (4 tonnes of fully dried farmyard manure) supplemented with 1.3 tonnes of vermicompost (1.5% N).

Weed Management : Weeds should be controlled by manual hoeing or mechanical weeding and no herbicide should be used. Mulching with 2.5 tonnes of any crop residues helps in early emergence of the crop, conserves soil moisture and reduces the incidence of weeds.

Onion

Nutrition : The nutritional requirement of organic onion can be met by applying 4 trolleys of farmyard manure (4 tonnes of fully dired farmyard manure having 1% N). In case of non availability of required farmyard manure, apply 3 trolleys of farmyard manure (2.7 tonnes of fully dired farmyard) supplemented with 9 quintals of vermicompost (1.5% N).

Weed management: Weeds should be controlled by manual hoeing.

Organic fodder production :

The production technology for organic fodders is similar to that of conventional fodder crops except that chemical fertilizers, herbicides, insecticides and fungicides are not to be used on organic crops.

Maize-berseem-bajra : Apply 3.5 tonnes of dry farmyard manure (1% N) per acre and sow maize in 2nd week of August. Harvest it after 50-60 days after sowing between milk ripe and dough stage of grain development. Then apply 1.0 tonne of dry farmyard manure and sow berseem in the 2nd week of October which gives 4-5 cuttings. After berseem harvesting, apply 2.0 tonnes of dry farmyard manure and sow bajra in the 2nd week of June. Harvest it after 45-55 days after sowing at the ear initiation stage. The quantity of farmyard manure may be adjusted as per the nitrogen content of the farmyard manure.

Maize-berseem-maize+cowpea : Apply 3.5 tonnes of dry farmyard manure (1%N) per acre and sow maize in 2nd week of August. Harvest it after 50-60 days after sowing between milk ripe and dough stage of grain development. Then apply 1.0 tonne of dry farmyard manure and sow berseem in the 2nd week of October which gives 4-5 cuttings. After berseem harvesting, apply 3.5 tonnes of dry farmyard manure and sow maize+cowpea mixture in 2nd week of June by using 15 kg seed of maize and 15 kg of Cowpea 88 variety or 6 kg of CL 367. Harvest the mixture after 50-60 days after sowing

at milk ripe to dough stage of grain development in maize. The quantity of farmyard manure may be adjusted as per the nitrogen content of the farmyard manure.

Method of Preparing Phospho-compost

Collect Rice-straw from fields and bring it the composting point near the tubewell on the farm because of easy water availability. It can be made into bundles of convenient size (about 10-15 kilograms).

Prepare large quantity of a "soaking solution" by thoroughly mixing one kg cow dung for every 1000 litre of water in a big tank. (The volume of the tank can be calculated by measuring Length x Breadth x Height of the tank in metres. One cubic metre is equal to 1000 Litres of water). Dip the bundles one by one into the "soaking solution" for 2-3 minutes.

Drain the excess solution by replacing the bundles on a slope lined with a plastic sheet. The drip should be collected and recycled into the tank again. Make 15 cm raised beds 5 metre long and 1.5 metre wide on the ground. This will help in assessing the exact watering of the heap later. Draining of water out of bed is a visual indication of excess watering.

Take the wet rice-straw to the location of the compost heap. Line the bed with 2-6 centimetre diameter tree branches/sticks. This helps in aeration in the heaped rice-straw. The wet rice straw will generally have 70 per cent moisture. Place the wet rice straw on the beds uniformly until 500 kilograms has been stacked. Powdered low-grade rock phosphate (low grade rock phosphate can be had from Rajasthan State Mines and Minerals Ltd 4, Meera Marg, Udaipur 313004) should be mixed @ 6 per cent on dry weight basis of the rice straw approximately. For 500 kilogram of the rice straw, 30 kg of the rock phosphate should be sprinkled uniformly while making the heap after wetting. This will give approximately 1% phosphorus in the final decomposed product. The height of 500 kg rice-straw stack is 1.5 metre approximately. Any quantity of rice-straw can be composed in multiple heaps of 500 kg at one time leaving a passage of 1 metre between the beds.

Cover the heap with a 20-30 centimetre thick layer of unsoaked rice-straw. This will minimize water loss while providing the necessary aeration. The major key to success is the ability to maintain about 70 per cent moisture in the heap. Any major error in this step will delay composting. Water the heaps using watering lance with the help of Tullu Pump. (Note : watering heaps with sprinklers does not work because water generally runs down the sides, instead of going inside the heap. Ensure that the water penetrated the heap by using a lance with a sharp point to pierce the heap of rice-straw. Pierce the lance deepest possible with an aim to water uniformly). Composting can be terminated after 80-90 days by which time it is ready for processing or for field application. By this time its carbon and nitrogen ratio changes to 15:1. At this stage, strands of the rice straw are weak and twisting can readily break a hand-full of it.

Certification of organic produce :

The government of India has formulated certain organic standards for certified organic production and accredited certain inspection and certification agencies to certify organic farms based on these organic standards. The farmers who want to get their farms certified as organic can contact these agencies. The addresses of these inspection and certification agencies can be had from the APEDA website www.apeda.gov.in

10. MULTIPLE CROPPING

Multiple cropping is a system in which more than two crops are grown one after the other on the same piece of land in quick succession during a year. The success of this system depends upon the selection of suitable crops/varieties, availability of labour, farm machinery, irrigation, fertilizers, pesticides, finance, etc. in addition to the required technical know-how. Timely cultural operations, alertness and managerial capability of the farmer are highly critical factors in the success of multiple cropping. The objective is to grow one or two additional crops in between the main season crops. This can be made possible through selection of short duration high yielding varieties, older nursery seedlings under delayed rice transplanting, adoption of minimum tillage and inter-relay cropping and harvesting of wheat and maize by about 5-7 days earlier than the dead ripe stage.

Some of the important high intensity rotations for multiple cropping systems are :

1. *Green manuring (Dhaincha/Cowpea/Sunhemp) - Rice Wheat :* After harvesting wheat apply *rauni* irrigation and sow 20 kg seed per acre of dhaincha (pre-soaked in water for about 8 hours) or sunhemp or 12 kg seed/acre of cowpea upto the end of April. Burry 6-7 weeks old dhaincha/ sunhemp/cowpea 1-2 days before transplanting of paddy in the second week of June. This will help in saving of about 25 kg N/acre for rice besides maintaining the soil health. However, for getting higher productivity of rice, practise green manuring and apply recommended dose of nitrogen (50 kg N/acre) in sandy to sandy loam soil. Likewise sowing of summer moong immediately after the harvesting of wheat in April end, after picking of pods, burying of its stover a day before transplanting of rice also helps to increase the paddy yield and in reducing the nitrogen dose of rice by one-third.

2. Cowpea/Bajra/Maize (fodder) - Maize/Rice-wheat : Grow summer fodder crop (Cowpea/ Bajra/Maize) with recommended seed rate and other practices immediately after the harvest of wheat in the last week in April. These fodder crops will vacate field for timely sowing of the succeeding maize/rice crop. These fodder crops provide green fodder during the lean period in summer in the months of June. A fodder crop of 45-55 days old generally provides 80-100 q/acre of green fodder.

3. Green manuring - Maize-Wheat : Sow a green manure crop of daincha/sunhemp/ cowpea with recommended practices in the last week of April and burry it after 6-8 weeks stage. Allow it to decompose for about 10-12 days before sowing maize in the end of June. This practice will help in maintaining the soil fertility. In green manured field maize crop does not require any more application of organic manure (FYM etc.)

4. Maize/Rice-Potato-Wheat : Grow a short duration variety of maize/rice in mid of June. The short duration crop varieties shall vacate the field in the mid of September for timely sowing of succeeding crop of potato. Sow early maturing varieties of potato like Kufri chandermukhi/Kufri Alankar with recommended practices in the end of September. Harvest 12 weeks old crop of potato and later on sow late sown wheat variety (PBW 373/PBW 590/PBW 509) with 50% recommended N/ acre without P and K application.

5. Maize/Rice-Potato-Summer Moong : As summer moong sown after harvesting of wheat is liable to caught up in early monsoon rains, therefore, for getting successful crop of summer moong (SML-668), it should preferably be sown after seed crop of potato in the second of third week of March. In these cropping sequences maize/rice could be planted in mid June to vacate the field for timely sowing of potato crop in the 2nd fortnight of September. Further, the summer mung after potato do not require any fertilizer application if the preceding potato crop received recommended dose of NPK and FYM.

6. Rice-Potato/Toria-Sunflower : Transplant short duration variety of rice (PR 115) in mid June. This will vacate the field in mid-September. Potato (Kufri chandermukhi/Kufri Alankar) can be sown in the 3rd week of September and harvested in end of December. Alternatively, toria (TL-15) can also be grown after rice. Thereafter sow short duration variety of sunflower in the early January on southern slope of East-Westerly drawn ridges. Apply 12 kg N/acre to sunflower after potato, if the potato crop received recommended level of NPK alongwith 20 tonnes of FYM per acer. Sunflower crop will vacate the field in mid May for timely transplanting of rice.

7. Maize-Potato/Toria-Sunflower : In this system maize could be sown in early June to vacate the field for timely sowing of potato crop in second fortnight of September. Potato can be harvested after twelve weeks in end December. Alternatively short duration variety of *toria* (TL-15) can be grown after maize. Thereafter sunflower (short duration variety) can be grown successfully in early January southern slope of East-Westerly drawn ridges. Apply 12 kg N per acre after potato, if potato crop received recommended level of NPK alongwith 20 tonnes of FYM per acre. The sunflower crop will vacate the field in mid May for timely sowing of maize.

8. Groundnut-Potato/Toria/Pea/late Kharif fodder-Wheat : In groundnut-wheat system, a crop of potato/toria/pea/late kharif maize fodder could be raised successfully. For this sow groundnut (variety SG 99 and M-522) during end of April and first week of May after the harvest of wheat. Further, as groundnut, crop vacates the field in early September, an additional crop of potato or early Pea (Ageta-6 or Arkel) or Toria (TL 15) or late sown maize fodder could be taken during the second fortnight of September. Toria/Pea/late sown fodder and potato vacate the field during December when the late sown wheat (Variety PBW 590, PBW 509 and PBW 373) could be sown. Such a groudnut based cropping systems has been found remunerative.

9. Maize-Potato-Onion *:* This system gives highest net returns with substantial saving of water and gave almost double the productivity than rice-wheat system. For this system sow maize (Paras) in mid-June, potato (Kufri Chandermukhi) in first week of October and onion (Punjab *Naroya*) from 10-15 January for high yield realization. The soil fertility in relation to OC, available N,P and K also improve over time.

10. Groundnut-Potato-Bajra (fodder) : This system gives better productivity levels than rice-wheat system with sizeable saving of water and also ensures improvement in soil fertility. For this system sow groundnut (SG-99, M-522) in first week of May, potato in first week of October and bajra fodder in the first fortnight of March.

11. Basmati Rice-Celery-Bajra (fodder) : This system is more remunerative and productive than the existing basmati rice-wheat system. Transplant basmati rice in mid July which will vacate

the field in mid November. Then grow celery in December which vacates the field in Ist fortnight of May and after this grow bajra crop for fodder.

12. Basmati Rice-Berseem (fodder and seed) : This system provides substaintial net returns than the existing basmati rice-wheat system. Transplant basmati rice in mid July which will vacate the field in mid November. A successful crop of berseem for seed production can be grown in end November after the harvest of basmati rice. It provides three cuttings of green fodder before leaving the crop for seed production.

13. Maize-Potato-Mentha : This cropping system is doubly profitable than rice-wheat system and provides considerable saving of irrigation water. In this system sow maize (Var. Paras) in mid June which will vacate the field in 2nd fortnight of September. Then grow potato (Kufri Chandramukhi) in the first week of October which will vacate the field in mid January and after this grow mentha crop in the second fortnight of January. The soil fertility in relation to OC, available P & K also improves over time.

14. Maize-Wheat/Celery-Bajra fodder : These systems are highly remunerative than rice-wheat system. In these systems, there is also considerable saving of irrigation water. In these systems, sow maize (Var. Paras) in the second fortnight of August which will vacate the field in mid December. Then in the second fortnight of December grow late variety of wheat (PBW 373 or PBW 509 or PBW 590) or transplant celery. Then in the first fortnight of May grow bajra as a fodder and this will vacate the field in the first fortnight of July.

15. Maize/Rice-*Gobhi sarson*-summer Moong : These systems produce more yield and economic returns than the maize-wheat and rice-wheat systems. Therefore, maize should be sown in the first fortnight of June, rice in second fortnight of June, *gobhi sarson* from 10-30 October and summer moongbean in the first fortnight of April. The summer moongbean can be sown without tillage after applying pre-sowing irrigation.

16. Rice-Gram summer Moong : This system produces more yield and economic returns than the rice-wheat system. Therefore, the rice should be transplanted in the second fortnight of June, gram should be sown from 25 October to 10 November in two lines per bed prepared by wheat bed planter and sow summer moongbean in the 2-3 week of April. This system also improves the soil fertility, soil micro flora and fauna over rice-wheat system.

17. Groundnut-Toria + Gobhi sarson : This cropping system produced more yield and economic returns than the maize-wheat and rice-wheat cropping systems. Therefore, the groundnut (SG 99) should be sown in the first fortnight of May. Sow *toria* and *gobhi sarson* in Mid September in alternate rows 22.5 cm apart or sowing *toria* by broadcast and *gobhi sarson* in lines 45 cm apart, using one kg seed rate per acre for each crop. In this system, the *toria* will be harvested around mid December, while *gobhi sarson* will continue in the field till end March. Apply 25 kg nitrogen/acre (55 kg Urea) and 12 kg P_2O_5/acre (75 Kg Single super phosphate) to toria+gobhi sarson at sowing and apply 30 kg N/acre (65 kg urea) after the harvesting of toria with second irrigation.

Fodder cropping system

18. Maize/Summer groundnut-Green onion-Onion : These systems produce higher yield and economic returns than the rice-wheat system. The groundnut should be sown in the second fortnight of May and maize in the first fortnight of June. The bulbs of onion sown in March should be uprooted in the month of June and stored in an airy place. These onion bulbs should be sown in the field after uprooting/harvesting of summer groundnut/maize in second fortnight of September. The green onions are uprooted in the second fortnight of December. For rabi onions, nursery should be transplanted in the first fortnight of January. These onions are ready for harvesting in mid May.

19. Maize-Berseem-Bajra : Sow maize in 2nd week of August and harvest it after 50-60 days after sowing when the crop is between milkripe and dough stage of grain development. Sow berseem in the 1st or 2nd week of October and take 4-5 cuttings. Then sow bajra in 2nd week of June and harvest it after 45 to 55 days after sowing at the start of ear initiation stage.

20. Maize-Berseem-Maize+Cowpea : Sow maize in 2nd week of August and harvest it after 50-60 days after sowing when the crop is between milkripe and dough stage of grain development. Sow berseem in the Ist or 2nd week of October and take 4-5 cuttings. Then sow maize+cowpea mixture in 2nd week of June and harvest it after 50 to 60 days after sowing when the maize crop is between milkripe and dough stage of grain development.

11. SOIL TESTING

Soil testing is the best tool to ensure optimum and balanced use of nutrients. Improper use of fertilizers leads not only to imbalanced nutrition but also deterioration of the environment. Soil testing comprises determination of organic carbon content and the amount of available nutrients besides, the basic characteristics such as soil reaction (pH) and soil salinity (electrical conductivity). Based on the soil test values, the soils are categorized as low, medium and high with respect to the status of available nutrients. Fertilizer recommendations are made for each category, depending upon the crop/cropping sequence in question. General fertilizer recommendations, given in the package of practices (Table 1), pertain to normal soils of medium category.

Table 1. Fertilizer recommendations (kg/acre) for individual crops grown on medium category soils

Crop	Nitrogen	Phosphorus**	
	Urea	Single super phosphate	Diammonium phosphate*
Rice	110	--	--
Basmati Rice	18	--	--
Maize	110	150	55
Bajra	90	150	55
Moong	11	100	--
Mash	11	60	--
Arhar	13	100	35
Groundnut	13	50	--
Soybean	28	200	--
Cotton (Hybrid)	130	75	27
Cotton (Varieties)	65	75	27
Sugarcane (Plant)	130	--	--
Sugarcane (Ratoon)	195	--	--

* For every 50 kg Diammonium phosphate, reduce the dose of Urea by 20 kg

** In wheat based cropping sequences where wheat received recommended amount of phosphorus, application of phosphorus to kharif crops, except soybean, may be omitted in medium category soils.

Nitrogen : Organic carbon content of the soil is considered as an index of available nitrogen and is thus used to make fertilizer recommendations for nitrogen. Based on its content, the soils are categorized as low (less than 0.40%), medium (0.40-0.75%) and high (more than 0.75%). Since the soils low in organic carbon are poor in supplying nitrogen, increase the dose of nitrogenous fertilizer by 25 per cent over the general recommended dose for medium organic carbon soils. On the other hand, in high organic carbon soils, lower this dose by 25 per cent.

Phosphorus : Based on available phosphorus content, soils with less than 5 kg phosphorus/ acre are rated as low, those with 5-9 kg phosphorus/acre as medium, with 9-20 kg phosphorus/acre as high and with more than 20 kg phosphorus/acre as very high. In soils testing low in phosphorus, apply 25 per cent more fertilizer than the recommended dose, whereas in high phosphorus soils reduce it by 25 per cent. In soils testing very high in available phosphorus, omit application of phosphatic fertilizer application for 2-3 years and then get the soil tested to know if the repeat application of phosphorus is required. However, in maize-wheat cropping system, when soil test phosphorus level is more than 16 kg/per acre, there is no need to add any phosphorus fertilizer to both the crops.

Since the organic carbon content also influences the amount of fertilizer phosphorus required, the dose of phosphatic fertilizer should be decided based on both the soil organic carbon and available phosphorus content as shown in table 2. As such, if the soil organic carbon content is 0.4 to 0.6 per cent, reduce the phosphatic fertilizer dose by 25 per cent in medium phosphorus soils, by 50 per cent in high phosphorus soils and omit its application in very high phosphorus soils. If organic carbon content of the soil is more than 0.6 per cent and available phosphorus is 5-9 kg/acre, reduce the dose by 50 per cent. However, if soil phosphorus status is more than 9 kg/acre, omit the application of phosphatic fertilizers. In all other categories viz. soil with less than 5 kg phosphorus/acre irrespective of organic carbon content and soils with less than 0.4 per cent organic carbon irrespective of soil phosphorus status, apply the recommended dose of phosphatic fertilizer.

In Rice, Maize and Cotton following Wheat that received the recommended dose of phosphatic fertilizer, omit its application. In Soybean-Wheat rotation, if recommended dose of phosphatic fertilizer has been applied to Wheat, apply only 150 kg super phosphate instead of 200 kg/acre. However, in soils where wheat did not receive the recommended dose, apply phosphatic fertilizer on soil test basis. In Sugarcane too, the phosphatic fertilizer should be applied only if the soil tests low in available phosphorus.

Table 2. Recommendations for fertilizer phosphorus based on available phosphorus and organic carbon content in soils

Soil organic carbon(%)	*Available Phosphorus (kg/acre)*			
	Low (below 5)	*Medium (5-9)*	*High (9-20)*	*Very High (above 20)*
Below 0.4	25% more than Recommended	Recommended*	25% less than Recommended	Nil
0.4-0.6	25% more than Recommended	25% less than Recommended	50% less than Recommended	Nil
Above 0.6	25% more than Recommended	50% less than Recommended	Nil	Nil

* Fertilizer dose for medium soils as given in table 1.

Potassium : Based on the available potassium status, soils are grouped into two categorizes viz. deficient (less than 55 kg K_2O/acre) and sufficient (more than 55 kg K_2O/acre). Application of potassium is recommended only in soils deficient in available potassium. Since the farmers mostly omit potassium application, it is important to get the soil tested in order to ensure that potassium deficiency does not limit crop yields. Deficiency of potassium is generally confied to the soils in the districs of Gurdaspur, Hoshiarpur, Nawanshahar, Jalandhar and Ropar.

Micronutrients : Micronutrient deficiencies are becoming important yield limiting factors, particularly, in *kharif* crops due to intensive cropping, cultivation of fertilizer responsive high yielding crop varieties and the use of high analysis fertilizers. Based on the critical deficiency values of micronutrients, the soils are categorized as deficient or adequate in respect of different micronutrients.

- In zinc-deficient soils (available zinc content less than 0.6 kg/acre), soil application of 25 kg zinc sulphate heptahydrate or 16 kg zinc sulphate monohydrate per acre is recommended for rice as well as groundnut.
- Application of 10 kg zinc sulphate heptahydrate or 6.5 kg zinc sulphate monohydrate per acre is recommended for maize and cotton. In case of maize, if zinc deficiency symptoms appear late in the season when interculture is not possible, it is advised to spray the crop with a solution prepared by dissolving 1.2 kg zinc sulphate heptahydrate and 600 gram of unslaked lime (or 750 g zinc sulphate monohydrate and 375 gram of unslaked lime) in 200 litre of water per acre.
- Since *kharif* crops, particularly rice and maize are more susceptible to zinc deficiency, application of zinc sulphate should be made preferably to kharif crop in the cropping sequence in order to get maximum benefit.
- Iron deficiency is a common problem of rice grown on highly permeable coarse textured soils and that of sugarcane on highly alkaline soils. It is, therefore, recommended to spray the crops with 1.0 per cent solution of ferrous sulphate initiating at the appearance of deficiency symptoms. Generally, 2-3 sprays carried out at weekly intervals are sufficient.
- Regular green manuring with *dhaincha* before rice transplanting, also helps in reducing the occurrence of iron deficiency in the rice crop.

Salt affected soils : Apart from the nutrient content, the soil texture, its reaction, and degree of salinity or alkalinity also influence the efficiency of applied fertilizers.

For proper reclamation of the alkali (sodic) soils (pH more than 9.3), gypsum application must be accompanied with other management practices. In these soils, it is recommended to apply 25 per cent higher fertilizer nitrogen over that for the normal soils. Crops grown on alkali soils generally show zinc deficiency and require application of zinc sulphate at rates higher than those recommended for normal soils.

Saline soils (electrical conductivity more than 0.8 millimhos/cm) require 25 per cent extra fertilizer nitrogen and addition of organic manures/green manures/crop residues is beneficial. Farmers are advised not to apply gypsum to saline soils.

Keeping in view the resources available with the farmers and the need to get the maximum

profit, the golden rule is "apply fertilizer first in those fields where the nutrient status is low, then in medium and finally (25 per cent reduced fertilizer dose) where soil status is high".

Collection of soil sample

For making fertilizer recommendations in field crops : Scrap away surface litter and make a V-shaped cut with a spade or a *khurpa* to a depth of 6 inches. Remove about 1" thick uniform slice of soil from one side of the cut. Similarly, collect samples from 7 to 8 places in the field of uniform texture and general fertility. Put the samples in a clean bucket, tray or cloth and mix it thoroughly. Take approximately half kg soil in a cloth bag and label it with information such as field number, name of the farmer, address, date of sampling etc. The soil samples are usually collected from fallow fields after the harvest of crops. However, except for rice, soil samples in other crops can also be taken during the standing crops from the area between the rows.

For kallar reclamation : Dig three feet deep pit with one side vertically straight and the other slanting. From the vertically straight side, remove with the help of *khurpa* about 1" thick soil layer to collect about half kg soil from 0-6, 6-12, 12-24 and 24-36 inch depth. Put the soil samples collected from each depth in a separate clean cloth bag and label with the information such as field number, depth of sample, name of the farmer, address, date of sampling etc.

For orchard plantation : Dig a 6 feet deep pit in the centre of the field with one side vertically straight and the other slanting. From the vertically straight side, remove with the help of *khurpa* about 1" thick soil layer to collect about half kg soil from 0-6, 6-12, 12-24, 24-36, 36-48, 48-60 and 60-72 inch depth. Collect and process samples from different depths as described above for *kallar* reclamation. If there is any concretion layer, sample it separately and note down its depth and width.

If the samples are wet, dry them in shade before putting into the cloth bag.

12. RATIONAL USE OF POOR QUALITY IRRIGATION WATER

In about 40% of the total area of Punjab, the underground tubewell waters contain high concentration of salts and their sustained use adversely affects soil health and agricultural production. These waters are either saline (containing chlorides and sulphates of sodium) or sodic (containing carbonates and bicarbonates of sodium). Some of these waters may also contain toxic elements like boron. It is, therefore, of importance that the underground tubewell waters must be got tested from a soil and water testing laboratory so as to know the kind and extent of the problem. Irrigation with waters having very high concentration of salts is not recommended. But waters having low salinity or sodicity can be used by following specific management practices. In Punjab, the problem is mainly due to high sodicity (expressed in terms of residual sodium carbonates, RSC) in ground waters and the following guidelines are recommended for their safe use :

(1) Ensure adequate drainage : In areas receiving poor quality irrigation waters, leaching of excess soluble salts and water from the root zone depth of the soil has to be ensured so as to maintain a favourable salt and water balance. In poorly drained areas and in soils having hard pan at some depths, long term irrigation with poor quality waters results in the build up of salts in the soil much more rapidly than that under well drained soil conditions. Provision of proper drainage is, therefore, a pre-requisite when poor quality waters are to be used for irrigation. Surface drains are cheaper than the sub-surface drains.

(2) Level the land properly : For uniform distribution of irrigation water in the field, the land should be properly levelled. Proper levelling also ensures uniform leaching of soluble salts and waters from the soil. Even with small changes of microrelief in the field, unequal distribution of water and salts takes place.

(3) Use poor quality waters on light textured soils : These soils facilitate leaching of salts applied through irrigation water because of their high infiltration rates. Infiltration rates of the heavy textured soils are low and water applied through irrigation tends to stagnate at the surface for longer periods and after evaporation salinity/sodicity builds up at faster rates in these soils, it is, therefore, recommended that poor quality waters should preferably be used on light textured soils.

(4) Make proper crop selection : There is a wide range in the tolerance of different agricultural crops and their varieties. It is always preferable to grow crops and varieties capable of producing high yields even when irrigated with saline or sodic waters. Only salt tolerant and semi-tolerant crops like barley, wheat, mustard, guar, senji, spinach, turnip, sugarbeet, raya and millets

should be grown. Cotton is sensitive at the germination stage but can be grown if proper germination is ensured by pre-sowing irrigation with good quality water. Pulse crops are sensitive to salinity and sodicity and, therefore, should not be irrigated with poor quality waters. The crops having high water requirements such as rice, sugarcane and berseem should preferably not be grown particularly when drainage is very poor.

(5) Apply gypsum : Poor permeability of soils is commonly observed where irrigation waters containing high bicarbonates of sodium (testing high in RSC) are used. High saturation of the soil with sodium, deteriorates soil structure and results in poor aeration and poor nutrient and water availability to plant roots. The adverse effects of high soil sodium saturation can be offset by gypsum application. Application of gypsum is recommended when RSC of irrigation water exceeds 2.5 me/l. The quantity of gypsum should be got calculated from a soil and water testing laboratory. For each me/l of RSC, the quantity of gypsum (70% purity) works out to be 1.50 q/acre for four irrigations of 7.5 cm each. Gypsum should be applied on cumulative basis (calculated on the basis of number of irrigations) in one dose after the harvest of previous crop. If the soil has already deteriorated, gypsum should be applied on soil test basis. After mixing gypsum in the surface (0-10 cm) soil, heavy irrigation should be given to leach down soluble salts before sowing of the next crop.

(6) Use organic amendments : In calcareous soils with more than 2% calcium carbonate, use organic manures viz. farmyard manure @ 8 tonnes/acre or green manure or wheat straw @ 2.5 tonnes/acre/year for reducing harmful effects of sodic irrigation water.

(7) Irrigate alternate furrows : In cotton growing areas where underground irrigation water is of poor quality, prefer ridge planting of cotton using pre-sowing irrigation with canal water and subsequent irrigations with poor quality tube well water in alternate furrows for sustainable yields. The alternate furrow irrigation with poor quality tube well water also results in saving of irrigation water and check deterioration of soil health.

(8) Use poor and good waters conjunctively : This practice assumes importance particularly when supplies of good quality canal water are inadequate. The poor quality waters should preferably be used to supplement the good quality canal waters. The poor and good quality waters can be used together, either alternatively or by mixing with each other. It is also advisable to use good quality waters in early stages of crop growth and poor quality waters during later stages when the crop can tolerate higher salinity/sodicity levels.

9) Watch the build up of the salinity and sodicity in the soil: When poor quality waters are used on a long term basis the farmers should keep a watch on the build up of salts in the soil by getting the soil samples tested at regular intervals. This will help them in keeping a check on soil deterioration.

10) Use of village pond water for irrigation : Water in village ponds contains essential plant nutrients like nitrogen, phosphorus and potassium. However, it may also contain salts such as carbonates, bicarbonates and chlorides of calcium, magnesium and sodium in undesirable amounts. Therefore, this water should be got tested from the Soil and Water Testing Laboratory and may be used for irrigation as per recommendation.

13. HERBICIDE SPRAYING TECHNOLOGIES AND GENERAL WEED CONTROL

Herbicide Spraying Technologies

The success of chemical weed control depends mainly upon two factors i.e. quality of purchased herbicide and its spraying technology. Sometimes due to faulty application technology even very effective herbicides do not show desirable results as all the weeds will be killed only if they are exposed uniformly to spray fluid, so that the lethal dose can be received by each and every weed plant growing in the field. Majority of the Punjab farmers do not follow proper herbicide application technology due to which unsatisfactory level of weed control is attained. Poor weed control not only leads to yield losses in the present crop but also creates severe weed problems in the succeeding crops by increasing weed seed bank status of the field. So, for efficient weed control and long term dependence on herbicides, spray these chemicals as uniformly as possible with the adoption of following important points:

1. Selection of herbicide: Before the purchase of a herbicide, it is very essential to identify the weeds infesting our crop(s). The weeds can be grass type (monocots) or broad leaf (dicots) for which different herbicides are recommended. Depending upon the dominating weeds in the crop, buy a selective herbicide, which is recommended by Punjab Agricultural University, Ludhiana, from a trusty shopkeeper by obtaining receipt. Never buy unrecommended herbicides from the market as their performance with respect to safety on crop and efficacy on weeds has not been tested by PAU. Similarly, do not purchase unapproved brands of recommended herbicides as these herbicides (unrecommended brands) may prove harmful to crop or may have poor weed control potential. So, always purchase recommended herbicides and recommended brands of approved herbicides by obtaining receipt from the shop keeper.

Always use recommended dose of the herbicides and do not use under or over dose. Apply the herbicides as per their recommended time. There should be minimum gap between application of pre-plant herbicides and sowing as well as between sowing and application of pre-emergence herbicides.

2. Selection of pump and nozzle: Usually farmers use Knap Sack sprayers for spraying herbicides which are quite effective and economical. Besides this, tractor mounted sprayers or power sprayers can also be used. For the application of pre-emergence (before the germination of crop and weeds) herbicides, tractor mounted sprayers are the best as they maintain uniformity of application and their discharge rate is higher which adds to higher efficacy of herbicides. The

efficacy of both pre-plant and pre-emergence (root uptake) herbicides is related with soil moisture i.e. more soil moisture more efficacy of herbicides. For spraying herbicides, always use flat fan or flood jet nozzles because of their uniform spraying pattern. For post- emergence spray of herbicides, use only flat fan nozzle with fine hole with discharge rate of 80-100 litres/acre of water, as these herbicides enter the plant through foliage. Never use cone type (triple action/hollow cone) nozzle for herbicide spray because its spraying pattern is not uniform due to conical boom and drift hazards are also comparatively high due to its very fine droplet size. It is advisable to use multi-boom nozzles as this practice will add to more uniformity of application and helps in saving time required for spraying a unit area. These multi-boom nozzles are available in the market and can be fitted to ordinary Knap Sack sprayers without any alterations.

3. Calibration: Calibration is a procedure by which an estimate regarding amount of water required for spraying a unit area can be made. For calibration, demarcate small plot and measure it. Then pore measured amount of water in the tank of sprayer and spray on the already measured area of land. Measure the amount of water left in the tank and then calculate the amount of water used for spraying the measured plot. Then work out the amount of water required to spray one acre. For example, suppose demarked plot size is 50 square metre (say x sq.m) and 5.0 litre of water (say A litres) has been added to the spray tank before the start of calibration process. Suppose the left over water after spraying is 3 litres (say B litres) and the water used for spraying demarked plot is 5-3= 2 litres (say C litres). In the end calculate water required for spraying one acre as follows :

$$\text{Water required for spraying one acre (litres)} = \frac{\text{Water used for spraying demarked plot (C)}}{\text{Area of plot}} \times 4000$$

$$= \frac{2}{50} \times 4000$$

$$= 160 \text{ litres}$$

After calibration, while spraying operation is on in the field, do not change pump, nozzle and man who had done calibration.

4. Preparation of spray fluid: There are two ways of preparing spray fluid. According to first option, prepare the spray fluid by mixing herbicide in total amount of water needed for spraying one acre which was calculated at the time of calibration. For this, a big container is required. Secondly, dissolve herbicide in less quantity of water and make the final volume in litres equivalent to number of spray pumps required for spraying one acre. First of all pour small amount of water and then one litre of spray fluid into the tank of pump and then pour water up to its full capacity i.e. 15 litres. Stir the spray fluid before each filling because, herbicides especially wettable powders have the tendency to settle down.

5. Quantity/Volume of spray fluid required: For attaining desirable results, different herbicides are required to be sprayed with different volumes of spray fluid. The herbicides which

enter in the plants through leaves require less (80-100 litres/acre) water for spraying in order to achieve better efficiency because higher amount of water used will form bigger droplets and these will bounce-off from the leaves of weeds resulting in low uptake (absorption) of herbicide by these plants. Herbicides belonging to bispyribac metsulfuron and groups (recommended for rice crop) require less amount of water (80-100 litres/acre) for spray as these herbicides only enter the weed plants through foliage. Flat fan nozzles with numbers of 80 800 or 110 900 can be used whose discharge rate varies from 80-100 litres per acre. WSN 24 – flood jet nozzle can also be used for post-emergence application as its discharge rate is less.

During spring or kharif season, some herbicides are applied as pre-plant or pre-emergence and these requires higher amount of water (200 litres) for better results. These herbicides are mostly root uptake herbicides and need optimum moisture for better results. For pre-emergence application always use WSN 78 or WSN 62 – flood jet nozzles whose discharge rates are higher. Under dry conditions, the results are un-satisfactory and under such situations, use of exceptionally higher spray fluid (300-400 litres per acre) may improve herbicide efficacy. Always, use flood zet/ flood cut nozzles for pre-emergence herbicides.

6. Method of spray : After calibration, work out the number of pumps (capacity 15 litres) required for spraying one acre and then divide one acre into number of plots equivalent to the calculated number of pumps required for spraying. For rice 7-8 pumps are required for spraying herbicides and it will be better to divide one acre into 7-8 plots and spray one pump in one plot so that uniformity can be maintained. The spraying should be done at constant pressure which should be between 1.5 to 2.0 bars. In order to maintain constant pressure, a pressure regular valve can be fitted on spray lance of the Knap Sack sprayer. Spray should be done in bands (straight strips) by keeping the spray lance straight. When you reach at the end of field, stop spraying and the second band of spray should be parallel to the first band with slight overlapping. It must be kept in mind during spray that neither there should be more (above 20-30 %) overlapping of spray nor there should be any gap between the two bands. Also, stir the spray fluid thoroughly before each filing particularly of wettable powder herbicides as these have the tendency to settle down in the container. After spraying the whole field, if some spray solution is left, don't use it again for respraying the same field, either use this in another field of same crop or destroy it on uncultivated land.

During spray, keep the height of nozzle at about one and a half feet (half meter) from the ground/ foliar surface. It is usually seen that farmers use cone type nozzles and keep height up to 4-5 feet. They also move the nozzle to and fro so that spray can be done on 8-10 feet wide band in one run only. This is very wrong method of herbicide application and this is the main reason that even with the use of effective herbicides weeds are not controlled satisfactorily. By moving spray lance to and fro, on an average 1/3rd of the field is left without spray, as a result weeds can not be killed uniformly and they not only reduce the grain yield but also produce millions of seeds which germinate in the coming season and create big problem. Always spray at right angle to the direction of the wind and do not spray when wind speed is high i.e. above 4 km per hour.

7. Precautions for herbicide use :

i) Always buy herbicide as well as brands of herbicides which are recommended by PAU and never buy the herbicide on the advice of the shopkeepers.

ii) Receipt must be obtained from the shopkeepers at the time of purchase of herbicide.

iii) Choice of herbicide must be done according to type of weed flora present in the field.

iv) Do not spray empty stomach. Take bath after spray work is completed.

v) Do not spray across the direction of wind but always spray at the right angle to the wind direction.

vi) Clean the pump with soda/surf before and after the spraying operation.

vii) Spray must be done on calm days in straight bands/strips when wind speed is less than 3 to 4 km/hour.

viii) Stir the spray fluid before each filling.

ix) Wear hand gloves during preparation of spray fluid and full sleve shirt & trousers (preferably of plastic) at the time of spray.

x) Use tractor operated sprayer for the application of herbicides either before the emergence of crop or before first irrigation.

xi) Don't use brackish or muddy water for spraying.

xii) Keep the left over herbicides beyond the reach of children by putting labels on them so that they can be used in the coming season.

xiii) Try to keep separate pumps for spraying herbicides than insecticides or fungicides.

General Weed Control

To kill weeds on farm roads, water-channels, etc. spray Gramoxone 24 WSC (Paraquat) at 0.5 to 1.0 litres/acre in 200 litres of water. The lower dose may be used on the actively growing young weeds and the higher dose on the weeds of advanced age. Gramoxone is a contact herbicide and will kill any plant on which it is sprayed. Spray this herbicide on sunny days when there are no strong winds. After use, always flush the spray pump thoroughly with water. Keep the herbicides with its label intact.

Control of Congress grass/Carrot grass *(Parthenium)*

Parthenium commonly known as Congress grass/Carrot grass, is a problem weed in waste lands, orchards and plantation crops. This weed poses a serious health hazards particularly allergy, eczema, asthma and dermatitis. It starts appearing from end February onward and makes luxuriant growth during rainy season, however, the plants dry up during winter. This weed can be controlled by mechanical means such as repeated cuttings and digging. It can also be controlled by spraying Atrazine 50 WP at 1.0 to 1.5 kg/acre as pre-emergence or post-emergence by dissolving in 200 to 250 litres of water/acre. This weed can also be controlled by spraying glyphosate (Round up) at 1.0 litre/acre or at 600 g/acre (Excel Mera). Parthenium plants are more susceptible to these herbicides when sprayed at their active growing stage but before flowering.

14. CONTROL OF RATS

Rats are the most serious pests of crops and must be controlled. By virtue of their extremely adaptable nature, highly intelligent patterns of behaviour and tremendous potential to multiply, they maintain their large populations which cause extensive damage in crop fields. They live in burrows, possess acute senses of smell and taste and are very selective in feed choice. Such characteristics often make their control difficult which require specialized methods quite different from insect and bird pests.

Species and Distributions : The species of rats and mice inhabiting crop fields in Punjab are the Indian mole rat, *Bandicota bengalensis*, the soft-furred field rat, *Rattus meltada*, the Indian bush rat, Golunda ellioti, the Indian gerbil, *Tatera indica,* the short-tailed mole rat, *Nesokia indica*, the house mouse, *Mus musculus*, the field mouse, *M. booduga* and the brown spiny mouse, *M. platythrix*. Of these the Indian mole rat is predominant in paddy and sugarcane, soft-furred field rat and Indian gerbil in cotton, and the Indian gerbil, Mus and soft-furred field rat in rainfed areas growing groundnut. Bet areas have predominant populations of the Indian mole rat while the kandi region has the Indian gerbil and Indian bush rat.

Damage to Crops : The rats and mice cause more damage at seedling and ripening stages of the crops and control operations must be planned accordingly. Average damage by rodents has been recorded to be 4.9% in paddy, 6.4% in sugarcane and 3.9% in groundnut. Heavy infestations may cause damage upto about 20% and the control operations must be intensified in such fields.

Methods of Control : The performance of different control methods vary in different situations and at different stages of the crop. Therefore, best control success can only be achieved if these methods are adopted properly at appropriate timings.

A. Mechanical Control

1. *Killing* : During the irrigation of vacant harvested fields rats coming out of flooded burrows should be killed with sticks.

2. *Trapping* : Use double chambered multi-catch trap with tunnel-type enterance (as developed by P.A.U.) or any other similar trap. Before use wash the traps to remove any odour in them. In crop fields place 16 traps/acre covering runways, damage and activity sites of rodents. In houses, godowns, poultry farms etc., set traps (1 trap/4-8 m^2 area) along the walls, in corners, behind the storage bins and boxes etc. For use in cold stores insulate the tunnel and body of traps by wrapping paper around them.

To enhance trapping, do pre-baiting by placing 10-15 g of plain millet or cracked wheat containing 2% sugar and 2% groundnut or sunflower oil on a piece of paper in each trap for 2-3 days and leave the door of the trap open.

After pre-baiting close the traps by placing 10-15 g of the plain bait on a piece of paper in the main chamber and a pinch of bait on a smaller piece of paper (6 x 6 cm) in the trap tunnel. Trap the rats for 3 consecutive days.

Important **:** Kill the trapped rats by drowning in water and the interval between two trappings in the same location should not be less than 30 days.

B. Chemical Control

Baiting Techniques :

1. Poison bait preparations : The acceptance of poison baits by rodents depends upon the quality, texture, taste and odour of the baiting materials. Therefore, the recommended baiting materials should be used for preparation of poison baits.

(i) **2% Zinc phosphide bait** – Smear 1 kg of bajra or sorghum or cracked wheat or their mixture with 20 grams of groundnut or sunflower oil, 20g of powdered sugar and mix it thoroughly with 25 grams of zinc phosphide.

Caution – Never add water in zinc phosphide bait and always use freshly prepared bait.

(ii) **0.005% Bromadiolone bait** – Mix 20 g of 0.25% bromadiolone powder, 20 grams of groundnut or sunflower oil and 20 grams of powdered sugar in 1 kg of any cereal flour.

Bait Placement and Timings : Baiting in May-June – This period is most suitable for rodent control campaign in large areas. During this period, the rat burrows can easily be located in the fields, on bunds, water channels and surrounding waste lands. Close all the burrows in the evening and in the reopened burrows on the next day insert a paper boat containing about 10 g of poison bait of zinc phosphide or bromadiolone about 6 inches deep in each burrow. In case of burrows of the Indian mole rat, gently remove the fresh soil from the burrow opening to locate the tunnel and then put the poison bait deep inside it.

Crop Wise Baiting Schedule :

1. *Paddy* : Do poison baiting in the month of August. The baiting must be done during dry days and before milky grain stage. Otherwise the rats would avoid poison bait if baiting is delayed.

2. *Sugarcane* : Since sugarcane crop harbours high rodent infestation, poison baiting should be done first in July (after paddy transplantation) and second in October-November (after paddy harvest). At each of these two timings do baiting with zinc phosphide or bromadiolone followed by another baiting after 15 days with an bromadiolone @400 g per acre each. If the crop is to be harvested after January-February, third baiting should be done with bromadiolone @800 g per acre in January.

Caution : A poison baiting with zinc phosphide should never be followed by another baiting with the same posion, because it induces bait shyness in rats.

3. *Groundnut*: Do double rodenticidal baiting with freshly prepared bait of 2% zinc phosphide followed by bait of 0.005% bromadiolone or vice-versa. The first baiting should be done at the start of pod formation (when the crop is of 60-65 days). The second baiting should be done after an interval of one month i.e. before the maturation of pods (90-95 days of crop).

Pre-Baiting : Pre-bating is essential when zinc phosphide baiting is to be done. Bajra or sorghum or cracked wheat or their mixture smeared with oil be laid on pieces of paper at 40 baiting points per acre and about 10 grams of bait at each point for 2-3 days.

Poison Baiting : Place about 10 grams of zinc phosphide or bromadiolone bait at 40 baiting points per acre on dry sites and inside the crop throughout the field covering runways and activity sites of rats.

Safety Measures : Since the rodenticides are highly toxic to humans, domestic animals, pets and birds, the following safety measures must be adopted :

1. Keep the rodenticides and poison baits away from the reach of children, domestic animals, pets and birds.
2. Mixing of rodenticides in the baiting material should be done with a stick, spade or by wearing rubber gloves. Avoid inhailing of poison through mouth and nose. Wash exposed skin and hands after mixing.
3. Household utensils should never be used for preparation of poison bait.
4. Use polythene bags for storage and carrying the poison bait. Burry them after use.
5. Collect and burry the left over poison bait and dead rats from the fields.
6. Zinc phosphide is toxic and there is no antidote for it. In case of its accidential ingestion induce vomitting by inserting fingers in the throat and then rush to a doctor. Vitamin K is the antidote for bromadiolone and can be given to the patient under medical supervision.

C. Environmental Control

Weeds, grasses and bushes should be removed as these provide shelter and food to rodents. Highly infested bunds, water channels and field pavements should be periodically rebuilt to destroy permanent rat burrows.

Waste lands along roads, canals, railway lines, other uncultivated areas and forest strips serve as reservoir of rodents. So, to protect the adjoining crops, rat control operation must be carried out in these areas.

D. Biological Control

Owls, kites, hawks, falcons, eagles, snakes, cats, mongoose, jackals and monitor lizards are the natural predators of rats and mice. These should be protected.

Integrated Approach : No single method is 100% effective in controlling rats and mice. Left over population reproduce reaching the orginal size in a short time. Therefore, adopt an integrated approach by carrying out different methods at different stages of the crop. After harvesting Rabi crops rats must be killed during irrigation and apply chemical measures at appropriate timings in the crop as given above. The left over rats after zinc phosphide baiting should be tackled with bromadiolone. Due to bait shyness zinc phosphide cannot be used in follow up baiting but bromadiolone can be used.

Village Level Campaign

Control of rats and mice in smaller areas usually become ineffective due to their migration from the surrounding untreated fields. Therefore, for better results village level antirat campaigns, to cover maximum possible area, both cultivated and uncultivated, should be organized.

15. MANAGEMENT OF BIRDS

Birds, in general, are both useful and harmful to agriculture. Even the same species may be beneficial or problematic in different situations. Only a few of about 300 species of birds of Punjab cause problems in crop fields and granaries. The rose-ringed parakeet is the only bird that seems to be exclusively harmful to farmers' interests.

Harmful Birds : Parakeet is the major bird pest causing serious damage to almost all cereal crops. It is particularly serious to sunflower. House crows damage sprouting maize and sunflower and maturing maize. Doves and pigeons damage pulses and along with sparrows and weaver birds consume stored paddy worth approximately Rs. 2.4 crores annually in Punjab. Sparrows and weaver birds damage rice nurseries and maturing bajra and sorghum.

Management Techniques for Harmful Birds

A. Mechanical Control :

1. Make false gunshots at different intervals to scare the birds.
2. Fixing of scare crows *i.e.* a discarded earthen pot painted to stimulate human like head supported with wooden sticks and clothed in human dress to give a human like appearance is one of the most effective traditional techniques to keep the birds away. Position, direction and the dress of the scare crow should be changed atleast at 10 days interval. The height of the scare crow should be 1 metre above from the crop height.
3. Use automatic bird scarers by shifting their position periodically and supplementing their noise with actual gunfires. The other simplest method is the use of rope crackers. It involves tying of sets of small fire crackers at a distance of 6-8 inches apart and igniting it from the lower end. The explosions caused by fire crackers on catching fire at different intervals scare the birds feeding on sproutings. Fix up the rope crackers in the centre of the field during sprouting stage whereas in maturing crops fix the rope on a stick in the periphery of the field.
4. To reduce bird damage to maize, reflective ribbons of polyester strips with metallic coating of red colour on one side and silver on the other having 1.5 cm width should be used. Reflective ribbons should be installed about 30 cm above the crop canopy in parallel rows at 5 m distance in North-South direction at the milky stage of the crop. If there are resting sites for birds nearby the fields then one strip of reflective ribbon should also be installed on the boundary of the field. Reflective ribbons for bird scaring is an effective, easy to use and eco-friendly technique for bird management in maize crop.

B. Cultural Practices:

1. The traditional practices of planting 2-3 border rows of less costly crops like millet, maize and daincha equally preferred by birds will reduce the bird pressure to the inside sown cash crops particularly sunflower and maize etc. Moreover, planting of these crops also act as physical barriers/wind breakers and help in preventing lodging of crop during stormy/rainy days.
2. As far as possible sowing of maize and sunflower crop should be avoided at sites most frequently visited by birds or where there are more resting sites like trees, electric wires, buildings etc.
3. To prevent parakeet damage in sunflower and maize crops sowing should be discouraged in small block areas, atleast 2-3 acre block area is more suitable, for lessening bird damage pressure because parakeets prevent feeding/venturing in the core of the field.

C. Alarming Calls

Playing of cassettes available with Centre of Communication, Languages and Culture, PAU of distress or flock calls of parakeets and crows respectively in a tape-recorder at peak volume for 1/2 hr. twice each in the morning between 7.00 to 9.00 a.m. and in the evening at 5.00 to 7.00 p.m. respectively, with a pause of 1 hours, scare the birds or halt their activities for full day in the freshly sown, emerging or maturing crops fields and in orchards. Use of distress or flock calls remain effective for 15-20 days. Better results can be obtained by using this technique in sequence or in combination with other methods as an integrated pest management. For covering larger area use of amplifier and addition of speakers as per requirements can be done.

Conservation of Useful Birds : Predatory birds like owls, falcons, hawks, eagles, kites, etc. eat large number of rats and mice. A single owl normally eats 4-5 rats a day. Insect eating birds like drongo, babblers, shrikes, lapwings, mynas, and many other small birds eat away numerous insect pests. Even granivorous birds like sparrows and weaver birds feed a large number of insects to their young. A single pair of house sparrows feed insects to their young about 250 times a day. Therefore, the useful birds should not be killed. Rather they can be attracted to crop fields in several different ways.

16. BEEKEEPING

Beekeeping implies hiving and managing honey bees in movable frame hives for honey, other hive products and pollination of crops. The agro-climatic conditions in the Punjab are suitable for adoption of beekeeping on commercial scale with only Apis *mellifera* which was introduced and established by PAU. A normal colony of the honey bees has a laying queen, thousands of worker bees and occasionally hundreds of drones. Besides, all stages of brood, honey and pollen are also present.

1. Bee flora

Major utility bee flora in the Punjab includes *Brassica* spp., *Eucalyptus,* Egyptian clover, sunflower, cotton, pigeon pea, wild forest multiflora, *etc.* Important medium utility bee flora include *Dalbergia (tahli),* cucurbits, maize, litchi, *ber,* guava, citrus, *Acacia.* spp. (*khair, Phalahi)* etc.

2. Bee equipment

Main equipment required in beekeeping include ten frame wooden Langstroth hive, bee veil, hive tool, smoker, uncapping knife, drip tray, comb foundation, queen excluder and honey extractor.

3. Season for starting beekeeping

February-March and October-November are the optimum periods for starting beekeeping in the Punjab. Spring season is more suitable for beekeeping as during this period, ample bee flora is available, weather is favorable and due to subsequently increasing day length.

4. Apiary siting

Apiary should be established on an up-land and sufficiently away from the main roads. Hives should be placed under shade during summer and in sunny places during winter. The entrances of hives should preferably be towards south-east direction

5. Seasonal bee management

Seasonal management operations in beekeeping are described below:

A) Spring season (mid February- mid April)

* With warming of the season, unpack honey bee colonies.
* In the beginning of season, examine the colonies on a clear sunny day at noon time, clean the bottom board and burn or burry the collected debris.
* Provide more space as raised combs or frames with foundations to cope up with increased brood rearing and food storage. While providing additional supers, transfer two honey combs with bees from the brood chamber into the super as bait.

* Provide stimulative feeding (sugar: water = 1:2, w/w) in colonies to boost foraging.
* Populous and congested colonies may issue swarms. To check swarming, keep destroying gyne cells raised under swarming impulse, provide more space, scatter brood combs in the colony, clip half of one side wings of the queen or fix queen guard at hive entrance. Divide the colonies with persistent urge for swarming.
* Replace combs older than three years and also queen older than one and a half years of age.
* Check incidence of European foulbrood and Sacbrood diseases and infestation of ectoprasitic mites by following management practices as advised under 'Honey Bee Diseases and Enemies'.
* This period is the best for starting beekeeping, colony multiplication, mass queen bee rearing, royal jelly production and pollen collection for which follow appropriate technology as described under 'Apicultural Diversification'.

B) Summer season (mid April-June)

During summer season, adopt following measures:

* Shift colonies to shady places, preferably under thick canopy.
* Ensure provision of fresh water in/ near apiary for the honey bees by placing water bowls under legs of hive stand, or throwing some sticks in the water reservoir of tubewell.
* **Maximizing Honey Yield:** For maximizing nectar collection from *Berseem* and sunflower, follow the under-mentioned practices:

i) Colonies should be headed by freshly mated, prolific queen bees in the beginning of spring to get the colonies strengthened in advance of nectar flow and not on the honey flow.

ii) Provide required space as and when required.

iii) Curb drone population by removing combs with drone brood cells, destroying drone brood, excluding drones using drone traps, requeening the older drone layer queen bees by freshly mated one and by using only worker brood cell combs or CFs in the brood chamber.

iv) Provide ventilation to colonies to hasten honey ripening by providing more space/ chambers. staggering the chambers, increasing hive entrance size, by providing extra gate in supers and using screened inner covers.

v) Increase colony strength by uniting weaker colonies with stronger ones and following double queen management system.

* Use queen excluder between brood chamber and honey chamber during honey flow.
* Extract sunflower/ *berseem* honey by the end of May, preferably from super.

C) Monsoon season (July -mid September)

Monsoon is harsh period for honey bees. There is scarcity of bee flora in most part of the State, humidity is very high and it is raining for most of the time. Bees exhaust their food storage in its scarcity. Consequently, stronger colonies start robbing weaker ones. Weak colonies are also more prone to the attack of bee enemies and diseases. Higher humidity also adversely affects foraging by

honey bees and often barbates are seen hanging down from the bottom board especially in poorly ventilated colonies. To overcome these problems, following operations are advised:

* Examine the bee colonies very quickly lest robbing starts.
* Clean the hive debris and burn it to get rid of harbouring wax moth inoculum.
* Keep the colonies at raised place and clear the vegetation growing around the colonies to improve ventilation in colonies
* Remove extra empty combs from the colonies and store them under air-tight condition after fumigation.
* Depending upon the colony strength and the need, provide dearth feeding (sugar: water 1:1, w/w) by filling the sugar syrup in one kg tin with a few dried sticks as floats or inverted bottle or division board feeder with a float or polythene bag punctured with paper pin at 4-6 places or empty combs or multipurpose inner cover cum feeder.
* If honey bee colonies are short of pollen, bee collected pollen or pollen substitute patty (mixture of 42 g brewer's yeast + 4 g parched gram flour + 4 g skimmed milk powder kneaded with 50 g of 50 per cent aqueous sugar solution) or pollen supplement patty prepared by adding 10 per cent pollen in the pollen substitute should be provided to the colonies.
* To prevent robbing, following practices should be followed during feeding:

i) Sugar feeding should be given to all the colonies very late in the evening.

ii) Make colonies bee proof, except hive entrance, by plugging cracks and cervices and reducing the entrance to one-bee wide before feeding.

iii) Prevent spillage of feed in the apiary or outside the colonies.

* To check robbing, place grass soaked with one per cent carbolic acid or kerosene oil at the hive entrance of colony being robbed and make a long and one-bee narrow tunnel with mud to the colony entrance or close entrance of the colony being robbed in the case of heavy robbing, spot out and shift the robber colony 3 km away.
* Laying worker/ weak colonies should be united with the stronger colonies using newspaper method.
* Follow recommended practices for the management of bee enemies and diseases etc.
* During early season, colonies may be shifted to sub-mountainous areas to exploit nectar flow from *khair* plantation. In the late season, the colonies may be shifted to Bt cotton and should be placed a little away from the crop to mitigate chances of any pesticidal poisoning from sprays on the crop.

D) Autumn season (mid September -November)

Autumn season is the second best season for starting beekeeping, colonies growth and multiplication. During this season, colonies can be migrated to pigeon pea, *ber,* guava and *toria* growing belts. Almost all the operations that are followed during spring season hold good during autumn season also. By the end-November, extract surplus ripe honey. Don't mix this granulating type of honey with non-granulating types. Towards the end of the season, shift colonies gradually to sunny places.

E) Winter season (December -mid February)

During winter, due to very low prevailing temperature, the bees almost abandon foraging activities. The weaker colonies would reduce/ cease brood rearing. To sustain bee activities, following operations should be followed:

* Shift colonies to *raya* (sarson) growing area of the Punjab, Haryana or Rajasthan.
* Place/ move the colonies to sunny places.
* Examine colonies only on some calm and sunny day during noon time in the beginning of the season.
* Unite weaker colonies with stronger ones, using newspaper method, at the onset of winter.
* Weaker colonies can be united into single chamber using vertical queen excluder.
* Provide supplementary sugar: water (2: 1, w/w) feeding, if required, before winter packing.
* Grow wind breaks, plug cracks and crevices, narrow down the hive entrance and place colonies with entrance facing east- south east to protect bees from chilly winds.
* Provide inner and outer packing to weak colonies using dry paddy straw *(prali)* and polythene sheets.

6. Mass queen bee rearing

Rear queen bees at commercial scale by following 'Doolittle /Larval Grafting method' and 'Karl Jenter /Queen Cup Kit Apparatus' recommended by PAU. The details of these methods are given in a bulletin in Punjabi *'Italian Madhu Makhian di Sambh Sambhal'* a publication of Punjab Agricultural University, Ludhiana.

7. Important bee diseases and enemies

A. Bee diseases

i) European Foulbrood (EFB): It is a bacterial disease in which infected larvae in open cells, first turn dull white to yellowish white, later brownish yellow and then brownish; body segmentation becomes faint, the larvae turn soft and pasty. The dead larvae can mostly be attached to the cell walls in upright condition. Dried scales of the larvae are rubbery and easily removable.

ii) Sacbrood: It is a viral disease affecting very late larval or prepual stages. The head of dead larva / prepupa is predominantly raised and becomes pointed and darker, the affected larva/prepupa turns greyish, then straw coloured and finally to dark colour. Dead brood, upon taking out with forceps, comes out like a water filled sac. Dried dead brood scale is boat /slipper shaped.

Management of Bee Diseases: Isolation of diseased colonies, maintaining hygienic conditions, checking robbing and drifting and avoiding transfer of hive parts from diseased to healthy colonies, requeening, shook swarm and destruction of the severely infected colony help in checking incidence and further spread of the bee diseases to healthy colonies.

B. Bee enemies

i) Wax Moths: Two species of wax moth *viz.* greater wax moth and lesser wax moth are serious pests of honey bee combs. Greater wax moth adults are brownish grey and larger than

those of lesser wax moth which relatively smaller and silver grey without markings on wings. These pests attack live colonies as well as stored combs. Larvae of wax moths eat away the combs by making silken tunnels in the combs. The tunneling by lesser wax moth, through mid rib of combs to the brood cells resulting, fine silken webbings around the bee larvae and perforation of cell cappings result in the death of the bee larvae. Silken webbings by wax moths also adversely affect the emergence of bees. Fully developed larvae spin tough white cocoons around themselves and pupate on the wooden parts of hive in gregarious form. Under severe infestation, comb is reduced to a mass of web remains of comb, silken tunnels and black faecal pellets and colony may abscond.

Management

a. Apiary management: Maintain bee colony stronger, keep bottom boards clean and burry or burn the collected debris, keep cracks and crevices in the hives plugged and remove extra empty combs from the colonies and store them properly after fumigation. Keeping the infested combs in sun during noon hours for a short period also helps in killing the wax moth larvae.

b. Management of stored combs: Keep surplus combs in chambers arranged in stacks and fumigate them with burning sulphur @ 250 g or aluminum phosphide @ 1 g per m^3 of chamber space under air-tight condition and repeat the treatment after 15 days.

ii) Ectoparasitic Mites

a) Brood mite *(Tropilaelaps clareae):* The adult mite is visible with naked eye. It is oblong reddish brown and is seen moving fast on the rims of brood cells. The larvae and nymphs of the mite feed on bee larva, developing pupa and occasionally on the adult. The cappings of affected cells are sunken and sometimes punctured. The infested pupae are sometimes without cappings (bald). The pupae, which survive the attack, develop into deformed bees with malformed and twisted wings. Worker bees discard such deformed individuals and dead pupae out of the hive.

Management: Dust powdered sulphur on top bars of combs @ 1 g per comb for the management of this mite. Alternatively, formic acid (85%) @ 5 ml per day for 14 days, taken in a vial with a thick cotton wick with one end dipped in acid below and the other out side the vial to facilitate evaporation of the acid, placed on bottom board can also be used.

b) Varroa mite*: Varroa destructor* attacks, reproduces and multiplies fast on A. *mellifera.* Adult *Varroa* female is dorso-ventrally flattened, brown to dark brown and shiny, shaped like a tiny crab - more in width than length. Adult males are light yellowish, spherical with lightly tanned legs and smaller than females. In the infested colonies, dark coloured adult mites can be seen on adults and creamy larvae and also on pupae of the honey bee when exposed using a *Varroa* fork. *Varroa* mite feeds on the haemolymph of the developing honey bee pupa and adult bees. Heavily infested, colonies usually show patches of bald brood cells. Pupal anterior appear eaten with grey markings/ specs on head side. Dead or dying newly emerged smaller bees, with malformed wings, legs, thorax and shortened abdomen, may be found on the ground in front of hive. Robbing and drifting further spreads the *Varroa* mite among the healthy colonies.

Management

i) Non-Chemical

a) Trapping *Varroa* on drone brood: *Varroa* mite is more attracted to drone brood. During breeding season, put one or two empty drone brood combs in the centre of the brood nest to trap the mite population. The sealed drone brood comb part is cut and destroyed. Destruction of existing drone brood comb part in infested colony also reduces its carry over.

b) Queen arrestation: Caging queen bee for 2 weeks to create broodlessness condition is also helpful. Alternatively, bees from an infested colony can also be hived in a package hive or an empty Langstroth hive and mite infested brood is destroyed. These adult bees can be re-established through sugar feeding, on new foundations or stored raised combs.

c) Use of screened bottom board and high stand: Screened bottom board combined with the use of high legged hive stand allows mites to fall through the screen on the ground and the fallen mites are unable to crawl back to the brood combs.

d) Sticky paper: The placement of a sticky paper covered with 8 mesh screen on the bottom board or use of *Varroa* bottom board make the fallen mites stuck to it and prevents their return to the brood combs.

e) Dusting icing sugar: Dusting finely ground sugar @ 20 grams per 10 bee frame strength colony, uniformly between the inter-comb spaces in the late evening time, reduces infestation of the mite.

ii) Chemical :

a) Use of formic acid: Treat colonies with formic acid (85%) @ ml per day continuously for two weeks as detailed under brood mite. Avoid spillage of formic acid on body. It should not be used during honey flow.

b) Use of oxalic acid: Trickle 5ml of 4.2 per cent solution (w/v) of oxalic acid prepared in 60 per cent sugar solution in water (w/v) in between every two combs of bees, three times at weekly interval, in the late evening in the infested colony.

iii) Wasps

Yellow spotted brown wasp causes damage to honey bee colonies by catching the bees during monsoon and post monsoon period (July-November) with peak activity in September in the Punjab plains.

Management: Kill the fecundated female wasps during early spring by flapping and destroy newly developed wasp nests either by burning or pesticidal application. Placing obstructions at the entrance or fixing queen guard at hive entrance checks entering of wasps inside the colony or their approaching near hive entrance to catch bees. Placing wasp traps in apiary and use of large mesh nylon nets around the colonies, is also helpful.

iv) Black Ants:

Serious attack of black ants may lead to death of the colony or it absconding. The ant nests in the apiary should be destroyed by drenching with pesticidal applications and then covering the

soil with dry soil. Place the hives on the iron stands with legs in water/used engine oil filled bowls.

v) Bee Eating Birds:

Green bee eater and king crow catch the flying bees/queen bees. Green bee eater is more serious as it attacks the apiary in flocks. These birds should be scared away by the use of tinsel tapes/bird scarer or use of nets around the colonies.

8. Diversification in beekeeping

It refers to obtaining other bee products besides honey also so as to increase the overall productivity of bee colony. The technology to obtain various bee products is briefly given below:

A. Honey extraction

Take out only sealed honey combs without any brood and dislodge bees from honey combs with a bee brush; uncap the wax cappings of sealed honey comb using uncapping knife by placing the combs in a drip tray and extract honey using either tangential or radial, preferably stainless steel honey extractor. In tangential, extractor, keep the top bars of all the honey combs on one side so as to keep the machine in balance. In radial type extractor, top bars should be kept outwards and bottom bars towards central axle of the extractor. After extracting honey from one side, change the side of the combs in case of tangential honey extractor and then extract honey from the other side. When using radial honey extractor, rotation in the reverse direction will ensure honey extraction from the other side of the combs. Filter honey through double fold muslin immediately after extraction. Put emptied combs, back in the honey bee colonies, as many as were drawn out from a particu1ar colony.

B. Purification of bees wax

i) Source of crude bees wax: Cut cappings of sealed honey combs, broken bits of combs fallen into the honey extractor, brace and burr combs, old/damaged combs and deserted wild honey bee combs are the important sources of crude bees wax.

ii) Extraction of bees wax: Soak discarded combs in warm water for a day or so. Put the soaked pieces of combs in a cloth-sack and submerge in boiling water until whole of the wax gets melted. Then squeeze the sack to recover wax through the cloth bag. Alternatively, crude bees wax can be melted by putting directly in boiling water. Then sieve the whole material through wire screen or muslin in some metallic container having narrow bottom and wide top. Gradually the wax will rise to the top, get cooled and hardened into a wax cake which should be taken out by keeping the container inverted. Scrape off the extraneous material adhering to the top and bottom of the wax cake. The bees wax can also be purified by melting it indirectly in water bath i.e. using double walled container having water in the outer jacket and filtering.

C. Other hive products

i) Pollen: Pollen is gathered by honey bees as their proteinaceous food. It can be collected by installing PAU pollen trap at the hive entrance after removing the entrance rod of the wooden hive. On the day of pollen trap installation, do not fully insert pollen detaching strip into the pollen trap. The

detaching strip preferably should be put in place in alternate weeks during the period when pollen availability is plenty. The pollen falls into a tray of the pollen trap and should be collected from the tray on every alternate day and stored in airtight container under refrigerated condition for using it for feeding to honey bee colonies during pollen dearth.

ii) Propolis: Propolis is resinous exudate of plants gathered by bees to plug cracks and crevices in the hive and as an repellent to bee enemies. Propolis can be collected from the hive by using propolis screens, which are placed below the inner cover in the hive for the bees to fill the perforations with propolis, or placing two screens, one each along the inner side of longitudinal planks of the hive. Honey bees fill the empty spaces in the plastic screen with propolis. Then these screens are placed in refrigerator for one day. Bits of propolis are then dislodged by twisting the propolis screen.

iii) Royal jelly: For collection of royal jelly, worker larvae of less than 24 h age should be grafted one each into 60 or 120 queen cell cups in autumn and spring, respectively, in a strong (20 bee-frame strength) queenless colony and royal jelly be extracted after 72 h of larval grafting either manually with a wooden spatula, aspirator, syringe or with PAU royal jelly extractor.

Annexure - I

(Rupees per quintal)

Minimum Support Prices of Different Crops, 2008-09 to 2013-14

S.No.	Crop	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
1	Paddy Common	850*	1000	1000	1080	1250	1310
	Paddy (F)/ Grade 'A'	880*	1030	1030	1110	1280	1345
2	Jowar Hybrid	840	840	880	980	1500	1500
3.	Jowar Maldandi	860	860	900	1000	1520	1520
4.	Bajra	840	840	880	980	1175	1250
5.	Ragi	915	915	965	1050	1500	1500
6.	Maize	840	840	880	980	1175	1310
7.	Tur (Arhar)	2000	2300	3000	3200	3850	4300
8.	Moong	2520	2760	3170	3500	4400	4500
9.	Mash (Urad)	2520	2520	2900	3300	4300	4300
10.	Groundnut	2100	2100	2300	2700	3700	4000
11.	Sunflower Seed	2215	2215	2350	2800	3700	3700
12.	Soybean Black	1350	1350	1400	1650	2200	2500
13.	Soybean Yellow	1390	1390	1440	1690	2240	2560
14.	Sesamum	2750	2850	2900	3400	4200	4500
15.	Nigerseed	2405	2405	2450	2900	3500	3500
16.	Cotton (Medium Staple)	2500	2500	2500	2800	3600	3700
17.	Cotton (Long staple)	3000	3000	3000	3300	3900	4000
18.	Wheat	1000	1080	1100	1120*	1285	1350
19.	Barley	650	680	750	780	980	980
20.	Gram	1600	1730	1760	2100	2800	3000
21.	Lentil (Massar)	1700	1870	1870	2250	2800	2900
22.	Rapeseed / Mustard	1800	1830	1830	1850	2500	3000
23.	Safflower	1650	1650	1680	1800	2500	2800
24.	Copra (Milling)	3660	4450	4450	4525	5100	5250
25.	Copra (Ball)	3910	4700	4700	4775	5350	5500

Bonus of Rs. 50/- per quintal

Annexure I-A
District Wise Final Estimates of Area, Yield and Production for Kharif, 2012-13

Districts	Rice			Maize			Bajra			Total Kharif Crops	
	A	Y	P	A	Y	P	A	Y	P	A	P
Amritsar	183	2941	538	1	2555	3	-	-	-	184	541
Baranala	106	4626	490	-	-	-	-	-	-	106	490
Bathinda	107	4282	458	-	-	-	-	-	-	107	450
Faridkot	102	4357	444	-	-	-	-	-	-	102	444
Fatehgarh Sahib	86	4462	384	-	-	-	-	-	-	86	384
Ferozepur	267	3960	1057	-	-	-	1	790	0.79	268	1057
Gurdaspur	201	3071	617	11	2656	29	-	-	-	212	646
Hoshiarpur	70	3604	252	61	4060	248	-	-	-	131	500
Jalandhar	165	3790	625	8	3311	27	-	-	-	173	652
Kapurthala	117	3802	445	2	4683	9	-	-	-	119	454
Ludhiana	257	4548	1169	2	2675	5	-	-	-	259	1174
Mansa	78	4118	321	-	-	-	1	1000	1	79	322
Moga	176	4511	794	-	-	-	-	-	-	176	794
Mohali	31	3760	117	6	2983	18	-	-	-	37	135
Muktsar	118	3992	471	-	-	-	-	-	-	118	471
Patiala	233	3956	922	1	4149	4	1	895	0.895	235	927
Ropar	38	3816	145	23	3221	74	-	-	-	61	219
Sangrur	276	4705	1299	-	-	-	-	-	-	276	1299
SBS Nagar	56	4132	231	13	4178	54	-	-	-	69	285
Tarn Taran	178	3345	595	1	3680	4	-	-	-	179	599
State	**2845**	**3998**	**11374**	**129**	**3680**	**475**	**3**	**895**	**2.685**	2977	11852

A = Area 000 ha Y = Yield kg/ha P = Production 000 tonnes

Source : Director Agriculture, Punjab

District Wise Final Estimates of Area, Yield and Production for Kharif, 2012-13

Districts	Moong			Mash			Arhar			Total Kharif Pulses	
	A	Y	P	A	Y	P	A	Y	P	A	P
Amritsar	-	-	-	2	466	0.9	2	894*	1.79	4	1.9
Barnala	3	933	3	-	-	-	1	863	0.86	4	3.9
Bathinda	4	781	3	-	-	-	-	-	-	4	3
Faridkot	4	815	3	-	-	-	-	-	-	4	3
Fatehgarh Sahib	-	-	-	-	-	-	-	-	-	-	-
Ferozepur	9	952	9	-	-	-	-	-	-	9	9
Gurdaspur	-	-	-	16	417	6.7	-	-	-	16	6.7
Hoshiarpur	-	-	-	2	573	1.2	1	894*	0.89	3	2.1
Jalandhar	-	-	-	-	-	-	6	1011	6.07	6	6.1
Kapurthala	-	-	-	-	-	-	-	-	-	-	-
Ludhiana	-	-	-	-	-	-	9	847	7.62	15	10.6
Mansa	3	675	2	-	-	-	-	-	-	3	2
Moga	3	925	3	-	-	-	2	819	1.64	5	4.6
Mohali	-	-	-	2	750	1.5	3	861	2.58	5	4.1
Muktsar	4	1211	5	-	-	-	-	-	-	4	5
Patiala	-	-	-	-	-	-	-	-	-	-	-
Ropar	-	-	-	-	-	-	-	-	-	-	-
Sangrur	3	971	3	-	-	-	4	894*	3.58	7	6.6
SBS Nagar	-	-	-	-	-	-	-	-	-	-	-
Tarn Taran	12	918	11	-	-	-	3	894*	2.68	15	13.7
State	**51**	**877**	**45**	**22**	**466**	**10.3**	**31**	**894**	**27.71**	**104**	**83**

A = Area 000 ha Y = Yield kg/ha P = Production 000 tonnes

Source : Director Agriculture, Punjab

District Wise Final Estimates of Area, Yield and Production for Kharif, 2012-13

Districts	Cotton Desi			Cotton American			Total cotton		
	A	Y	P	A	Y	P	A	Y	P
Amritsar	-	-	-	-	-	-	-	-	-
Barnala	1	510	3	8	617	29	9	605	32
Bathinda	2	475	6	149	656	575	151	654	581
Faridkot	1	512	3	14	518	43	15	518	46
Fatehgarh Sahib	-	-	-	-	-	-	-	-	-
Ferozepur	2	419	5	111	443	289	113	443	294
Gurdaspur	-	-	-	-	-	-	-	-	-
Hoshiarpur	-	-	-	-	-	-	-	-	-
Jalandhar	-	-	-	-	-	-	-	-	-
Kapurthala	-	-	-	-	-	-	-	-	-
Ludhiana	-	-	-	1	369	2	1	369	2
Mansa	1	393	2	89	602	315	90	599	317
Moga	-	-	-	2	722	9	2	722	9
Mohali	-	-	-	-	-	-	-	-	-
Muktsar	-	-	-	88	577	299	88	577	299
Patiala	-	-	-	1	577	3	1	577	3
Ropar	-	-	-	-	-	-	-	-	-
Sangrur	2	459	5	9	732	39	11	682	44
SBS Nagar	-	-	-	-	-	-	-	-	-
Tarn Taran	-	-	-	-	-	-	-	-	-
State	**9**	**458**	**24**	**472**	**577**	**1603**	**481**	**575**	**1627**

A = Area 000 ha Y = Yield kg/ha P = Production 000 tonnes

Source : Director Agriculture, Punjab

District Wise Final Estimates of Area, Yield and Production for Kharif, 2012-13

Districts	Sesasum			Groundnut			Total kharif oilseeds	
	A	Y	P	A	Y	P	A	P
Amritsar	12	294	3.53	-	-	-	12	3.5
Barnala	-	-	-	-	-	-	-	-
Bathinda	-	-	-	-	-	-	-	-
Faridkot	-	-	-	1	770	1	1	1
Fatehgarh Sahib	-	-	-	-	-	-	-	-
Ferozepur	6	457	2.74	-	-	-	6	2.7
Gurdaspur	9	222	2.00	-	-	-	9	2
Hoshiarpur	6	363	2.18	16	1800	29	22	31.2
Jalandhar	3	396	1.19	-	-	-	3	1.2
Kapurthala	-	-	-	-	-	-	-	-
Ludhiana	-	-	-	-	-	-	-	-
Mansa	-	-	-	-	-	-	-	-
Moga	-	-	-	-	-	-	-	-
Mohali	-	-	-	-	-	-	-	- -
Muktsar	-	-	-	-	-	-	-	-
Patiala	-	-	-	-	-	-	-	-
Ropar	1	317	0.32	-	-	-	1	0.3
Sangrur	1	317	0.32	-	-	-	1	0.3
SBS Nagar	-	-	-	-	-	-	-	-
Tarn Taran	14	323*	4.52	-	-	-	14	4.5
State	**51**	**323**	**16.5**	**17**	**1739**	**30**	**68**	**46.5**

A = Area 000 ha Y = Yield kg/ha P = Production 000 tonnes

* Average yield of state

Source : Director Agriculture, Punjab

District Wise Final Estimates of Area, Yield and Production for Kharif, 2012-13

Districts	Sugarcane			Sugarcane (Gur)			Guar Seed		
	A	Y	P	A	Y	P	A	Y	P
Amritsar	4	70679	282.7	4	5836	23	-	-	-
Barnala	1	70040	70.0	1	5784	6	3	111	3
Bathinda	0	0	0	0	0	0	43	880	38
Faridkot	0	0	0	0	0	0	2	815	2
Fatehgarh Sahib	3	85958	257.9	3	7098	21	-	-	-
Ferozepur	2	80855	161.7	2	6677	14	117	857	100
Gurdaspur	25	72699	1817.5	25	6003	150	-	-	-
Hoshiarpur	19	69540	1321.3	19	5742	109	-	-	-
Jalandhar	10	65053	650.5	10	5372	54	-	-	-
Kapurthala	3	64552	193.7	3	5330	16	-	-	-
Ludhiana	2	67734	135.5	2	5593	11	1	911	10
Mansa	0	0	0	0	0	0	28	1000	28
Moga	0	0	0	0	0	0	-	-	-
Mohali	1	57440	57.4	1	4741	5	-	-	-
Muktsar	0	0	0	0	0	0	18	1150	21
Patiala	2	92198	184.4	2	7613	15	-	-	-
Ropar	3	75787	227.4	3	6258	19	1	1078	1
Sangrur	2	80238	160.5	2	6626	13	1	1078	1
SBS Nagar	5	65437	327.2	5	5403	27	1	1100	1
Tarn Taran	1	71312	71.3	1	5888	6	-	-	-
State	**83**	**71312**	**5918.9**	**83**	**5888**	**489**	**214**	**911**	**195**

A = Area 000 ha Y = Yield kg/ha P = Production 000 tonnes

Source : Director Agriculture, Punjab

Annexure I-B
Seed Standards for Foundation and Certified Seed

Crops	*Pure seed (Minimum) (%) (Per Kg)*		*Inert matter (Maximum) (%)*		*Other crop Seed (Max.) (Per Kg)*		*Weed seeds (Maximum) (Per Kg)*		*Objectionable Weed Seeds (Maximum)*		*Germination (Minimum) (%)*		*Moisture (Ordinary (%)*	
	F	*C*	*F*	*C*	*F*	*C*	*F*	*C*	*F*	*C*	*F*	*C*	*F*	*C*
Rice	98.0	98.0	2.0	2.0	10	20	10	20	2	5	80	80	13.0	13.0
Maize														
(i) Hybrids	–	98.0	–	2.0	–	10	–	None	–	–	–	90	–	12.0
(ii) Composite and open pollinated varities	98.0	98.0	2.0	2.0	5	10	None	None	–	–	90	90	12.0	12.0
Bajra (Hybs. & Vtys.)	98.0	98.0	2.0	2.0	10	20	10	20	–	–	75	75	12.0	12.0
Mash	98.0	98.0	2.0	2.0	5	10	5	10	–	–	75	75	9.0	9.0
Moong	98.0	98.0	2.0	2.0	5	10	5	10	–	–	75	75	9.0	9.0
Arhar	98.0	98.0	2.0	2.0	5	10	5	10	–	–	75	75	9.0	9.0
Soybean	98.0	98.0	2.0	2.0	None	10	5	10	–	–	70	70	12.0	12.0
Cotton (Hybs. & Vtys.)	98.0	98.0	2.0	2.0	5	10	5	10	–	–	65	65	10.0	10.0
Groundnut	796.0	96.0	4.0	4.0	None	None	None	None	–	–	70	70	9.0	9.0
Sesamum	97.0	97.0	3.0	3.0	10	20	10	20	–	–	80	80	9.0	9.0
Sunfloweer (Hybs. & Vtys.)	98.0	98.0	2.0	2.0	None	None	5	10	–	–	70	70	9.0	9.0

Standards in percentage unless indicated otherwise.

F : Foundation

C : Certified.

ANNEXURE I–C
Field Standards for the Production of Foundation and Certified Seeds

Sr. No.	Crop	Isolation (in metre)		Pollen shedders		Off type Plants/Earheads		Objectional weed		Plants/Earheads affected by seed borne diseases		Remarks
		F	C	F	C	F	C	F	C	F	C	
1	Rice	3	3	-	-	0.05	0.2	0.01	0.02	-	-	Wild rice or red rice
2	Maize Varieties	400	200	1.0	1.0	0.1	-	-	-	-	-	With same colour and texture
	hybrids	-	300	0.5	1.0	-	-	-	-	-	-	With different kernel colour
		-	200	-	-	-	-	-	-	-	-	With same kernel colour
3	Bajra(hybrid)	1000	200	0.05	0.1	0.01	0.05	-	-	0.05	0.1	Grain ear and grain smut
4	Bajra (Composite)	400	200	-	-	0.05	0.1	-	-	0.05	0.1	
5	Mash	10	5	-	-	0.1	0.2	-	-	-	-	At final inspection
6	Moong	10	5	-	-	0.1	0.2	-	-	0.1	0.2	For disease
7	Arhar	200	100	-	-	0.1	0.2	-	-	-	-	Permitted at final inspection
8	Soybean	3	3	-	-	0.1	0.2	-	-	-	-	At final inspection
9	Cotton	50	30	-	-	0.1	0.2	-	-	-	-	Same species, permitted at flowering
		5	5	-	-	-	-	-	-	-	-	Different species, permitted at flowering
10	Groundnut	3	3	-	-	0.1	0.2	-	-	-	-	-
11	Sesamum	100	50	-	-	0.1	0.2	-	-	0.5*	1.0*	-
12	Sunflower (hybrid)	600	400	0.05	1.0	0.2	0.5	-	-	-	-	-

Standards are in percentage unless indicated otherwise

F: Foundation C: Certified

* Cercospora leaf spot disease

ANNEXURE - II

STORED GRAIN INSECTS

Pests and Symptoms of attack	*Recommendations*	*Caution/limitation*
Twenty species of insects infest grains in the Punjab. *Khapra beetle* (*Trogoderma granarium*), l*esser grain-borer* (*Rhizopertha domonica*) *rice weevil* (*Sitophilus oryzae)* and *flour beetles* (*Tribolium* and *T. aconfusum*) are serious pests of wheat *jowar,* rice barley and maize. *Mung dhora (Calosobruchus analis*), *gram dhora (C. chinensis)* and *cowpea dhora (C. maculatus*) attack different pulses. *Grain moth* (*Sitotroga cerealella* attacks wheat, maize, jowar, oats, barley grains which lose nutritive value and germinating capacity, besides loss in weight.	*Preventive measures* (1) Dry the grains properly before storage. (2)Plug all cracks, crevices and holes in the godowns thoroughly. (3)Store new grains in the clean godowns or receptacles. (4) Disinfect old gunny bags by dipping them into 0.0125% fenvalerate/cypermethrin (6ml Sumicidin 20EC/5 ml Cymbush 25 EC in 10 litres of water for 10 minutes) and drying them in shade before filling with grains or use new gunny bags. (5) Disinfect empty godowns or receptacles by spraying 0.05% malathion emulsion (100 ml Malathion 50 EC in 10 litres of water) on the floor, walls and ceiling or fumigate the godowns using 25 tablets of aluminium phosphide /100 cum of empty space before storing the grains. Exposure 7 days. (6)Mix Malathion 5% dust @ 250 g/quintal grains meant for seed only. Or Treat the grains meant for seed with 25ml Cythion 50EC (malathion premium grade) Or 2 ml Sumicidin 20 EC (fenvalerate) or 1.5 ml Cymbush 25 EC or 1.5 ml Markcyper 25 EC (Cypermethrin) Or 14 ml Decis 2.8 EC (deltamethrin) per quintal seed by diluting in 1/2 litre of water, with knap-sack sprayer. Before treatment, the grains should be spread in thin layer on pucca floor Or polythene seet. After treatment the grains should be mixed thoroughly and then put into the containers.	-Before storing, the metal bins should be cleaned and placed in the sun for 2-3 days. -Grains stored in metal bin also get infested if not treated with any insecticide. Control this infestation by giving fumigation.

1	2	3
	7. Against *dhora*, cover the pulses stored in bulk with 7 cm layer of sand or sawdust or dung ash.	-Where there is infestation of *Khapra* use double the dose of aluminium phosphide.
	Curative measures 1. Phostoxin or Delicia or Celphos (aluminium phosphide) one tablet of 3 g/tonne or 25 tablets/100 cum space. Exposure 7 days.	-The fumigant should be only used in air-tight stores or under tarpaulins in the open by specially trained persons because these fumigants are deadly poisonous.

Grain Storage Bins of the Punjab Agricultural University

The storage bins are easy to manufacture and rat-proof, portable and economical over a long period. Besides, they facilitate fumigation in case the grain in them gets infested.

For filling and using the PAU grain bins, the following storage practices are recommended.

1. Clean the bin throoughly and do not allow, the left-over of the previously stored grain remain in the bin. Inspect the covers to ensure that the gaskets are intact.
2. Clean and sort the grain of all impurities. Broken kernels and other impurities attract insects and hence, should be separated.

ANNEXURE - III

AGRICULTURAL ENGINEERING

SECTION–A

Recommendations for Implements/Machines

General recommendations in respect of implements and machines used in agriculture are given below :

1. The selection of the implements or machinery should be made on the basis of size and draft requirements which should match with the power available on the farm.
2. Design, field capacity, materials, availability of spare parts and cost of operation per hour or per acre are important criteria to be considered in order to arrive at the decision to own a machine or any implement.
3. Implements and machines including tractor involve a lot of investment. Periodic maintenance before and after the use of machinery is therefore, very necessary. In most cases, owner's manuals will provide safe guide-lines. On following these guidelines, machinery is expected to give un-interrupted service throughout its life.
4. The seed-*cum*-fertilizer drill and the tractor mounted sprayer should be calibrated before they are used. The method of calibration of a seed-*cum*-fertilizer drill is given on page 179-180.
5. Safety rules must be followed and adhered to strictly while operating tractors and high-speed agricultural machinery to avoid the loss of life and property.

Details of implements and machines recommended are furnished in Table1.

Table No. 1 : Agricultural Engineering

Sr. No.	*Operation*	*Name of the implement/ machine*	*Size*	*Power required*	*Capacity (acre/day)*	*Remarks*
1	*2*	*3*	*4*	*5*	*6*	*7*
1.	Levelling	Float-cum-scoop	105 cm	A pair of bullocks	5	The capacities will depend on the soil type and the extent of undula tion in the field.
		Float	172 cm		15	
		Leveller	230 cm		17.5	
		Super-leveller	300 cm	Tractor 35 hp & above	25	
		Laser land leveller	180 cm	Tractor 50 hp and above	4-6	
2.	Seed-bed preparation	Mould board plough	15-20 cm	A pair of bullocks	0.75-1.0	
		Ditto	30 cm (2 bottom)	Tractor 20 hp & above	3.75-5.0	1 ha = 2.47 acres 1 day = 8 hr.
		Ditto	30-35 (3 bottom)	Tractor 30 hp & above	5-6	
		Spike-tooth or bar-harrow	0.75 to 1 m	A pair of bullocks	2.5-4.0	
		Disc-harrow	0.75 to 0.9 m	Ditto	1.0-2.5	
		Offset disc harrow				
		(a) Trailing type	0.9 m	10-15 hp	5-7.5	For medium soil and when the tractor does not have three point hitch.
			1.35 m	23-30 hp	10-11	
			1.8 m	Above 40 hp	12-15	
		(b) Mounted type	0.9 m	10-20 hp	5-7	For standard 3-point hitch or any tractor.
			1.35 m	20-30 hp	10-12	
			1.8 m	Above 40 hp	12-15	-Ditto-
		Cultivator	7 to 11 tined	25-45 hp	8-15	
3.	Puddling	*Straight-angular blade puddler*	83 cm	1 pair of bullocks	2.5	Puddling of rice fields.
		-Ditto-	2.5 m	Tractor 30 hp	12.5	
		Paddy-disc-harrow	1.8 m	Tractor 30 hp	10-12	
		Cultivator with rotary puddling attachment	9 tine	-Ditto-	8-10	
		Disc-harrow-cum-puddler	1.08 m	1 pair of bullocks	2	The operator can also sit on the seat provided.
4.	Transplanting	Paddy transplanter	1.0 m	Manually operated	0.6-0.8	Machine uses only mat type nursery. Two persons are

1	2	3	4	5	6	7
						required for machine operation including nursery uprootting and transporation.
5.	Sowing	Seed-cum-fertilizer planter	Single-row	A pair of bullocks	2.5	maize, groundnut, cotton, soybean), gram and peas.
		-Ditto-	Four rows	Tractor 35 hp & above	6	-Ditto-
		-Ditto-	Two rows	Tractor 35 hp & above	6	For hybrid maize and cotton.
		Seed-cum-fertilizer drill	2 or 3 rows	A pair of bullocks	2.5	For hybrid maize and cotton.
		-Ditto-	7-9 rows	Tractor 35 hp & above	10-15	
		Tractor drawn Sugarcane planter	2 rows	Tractor 30-45 hp	4	Use setts of 20" length.
		Bullock drawn ridger	Single row	A pair of bullocks	2.5	
		Tractor drawn ridger	Two rows	Tractor 35 hp & above		
		Ridger planter	-do-	-do-	5-6	For sowing cotton on ridges applies fungicide and
		Sugarcane cutter planter	Two rows, (row spacing 60-90cm adjustable	35 hp and above	2-3	Machine cuts sugarcane sets, insecticides automatically
		Sugarcane trench digger	Paired two row spacing (30cm)	-do-	2-3	Machine makes trenches and a bed for paired row sugarcane planting
6.	Inter-culture	Adjustable hand-hoe	9-34 cm	Manually operated	0.2-04	For small plots.
		Wheel hoe	24-38 cm	Manually operated	0.5-0.8	For small plots
		Cultivator (horse-hoe) or expanding tine	30-63 cm	A pair of bullocks	1-2.5	Adjustable width
		Paddy weeder	10-15 cm	Manually operated	0.3	For paddy crop only
7.	Spraying and dusting	Knapsack sprayer with low-volume nozzle	16 litre	Manually operated	1.5	For maize
					1.5	For cotton
		Foot sprayer with two way delivery attachment		Foot-operated	2.5	For maize
					2.5	For cotton
		Shoulder mounted power-sprayer-cum-duster		1.5 hp engine	4.5	For maize and cotton
		Tractor-mounted power sprayer	6.5 m	20 hp Tractor	30	Multipurpose
		Tractor-mounted sprayer	9 m	30-35 hp Tractor	30-40	Multipurpose
		Self-propelled high clearance sprayer	10.8 m	20 h.p. diesel engine	30-40	It can be used for even sprays without any damage to crop.
8.	Harvesting	Groundnut-digger shaker	1.22 m	30 hp Tractor-operated	5	For digging, shaking and winnowing of groundnut.
		Vertical conveying reaper	1.9 m	35 hp Tractor-operated	40-50	For harvesting paddy 7 or 8 persons required for machine operation including the crop collection and transporation.
9.	Threshing, Grading etc.	Japanese-type pedal Thresher		Maually operated	2.5-3.0 q/h	For small farmers and hilly region.

1	2	3	4	5	6	7
		\Regular power-thresher and winnower		Engine-operated 3.5 hp	300-400 kg/hr. (paddy)	In the case of bajra, the threshing of heads is done only.
		Power-operated thresher		20-30 hp	400-600 kg/h (bajra)	
		Paddy-huller		2 men	200 kg/day	For hulling rice.
		Groundnut thresher		25 hp Tractor	220-293 kg/ha	For threshing groundnut crop.
		Groundnut-decorticator		Manually operated	200 kg/day	For shelling groundnut pods.
		Groundnut-decorticator		Power operated 5-6 hp	1 q/hr.	-Ditto-
		Maize-sheller		Manually operated	120 kg/hr.	For shelling maize cobs.
		Maize-sheller		Power-operated 7.6 hp	2.6 q/hr	-Ditto-
		Multicrop thresher	Feeding width 370 mm	5 hp electric motor or equivalent	Wheat : 2 q/hr. Paddy : 4 q/hr.	Three persons are required for machine operation and trans-
			Feeding width : 560 mm	10-15 hp electric motor or tractor of about 30 hp	Wheat : 4 q/hr. Paddy : 8 q/hr.	portation of the crop.
		Combine (for maize shelling	-	30-35 hp Tractor	20-25 q/hr.	(i) Adjustment needed
		Moong Thresher	-	7.5 hp or above	2.5 q/hr electric motor or equivalent diesel engine/hactor	Spike tooth type power thresher for wheat can be used with following modifications : i) Keep only one spike on each row in spiral manner and remove additional spikes. ii) Increase concave clearance to 25 mm by reducing the spike length. iii) Operate the thresher at a cylinder peripheral speed of 19-21 m/s. This can be achieved by increasing the existing pulley size on thresher by a factor of 1.1 to 1.2.
10.	Removal of sticks	Cotton stalk uprooter	Two row (135 cm)	45 hp & above	1.25 to 1.50 acre/hr	For uprooting of cotton sticks

SECTION—B

Selection, Installation and Operation of Farm machinery

1. Irrigation Pumps.—Four types of pumps are used for irrigation in Punjab. They are : centrifugal pump, propeller pump, vertical turbine pump and submersible pump. Centrifugal pumps are most widely used in pumping water. They are simple in construction, easy to operate, low in initial cost and produces a constant and steady discharge. Generally, they are used to lift water for a total head of 4 metres to 60 metres. Propeller pump is used for low head (generally less than 4 metres). It is used for lifting water from water course, drain, pond or river etc. It is also relatively simple in fabrication, care and repair. When the depth of water table is more than the practical reach of centrifugal pump or the water table is fluctuating, turbine pump or submersible pumps are recommended. They have high initial cost, difficult to instal and repair as compared to centrifugal pump.

1.1. Selection.—Total head and discharge expected from the pump to irrigate a particular area is calculated and then that pump is selected which has the peak efficiency at the above head and discharge conditions. Reputed pump manufacturers furnish the characteristic operational curves or catalogues giving summary of the important characteristics of their pumps. Pumps made by different manufacturers may vary considerably in their prices, adaptability and efficiency. The pumps have efficiencies ranging from 50 to 70 per cent. Good pumps with the highest possible efficiency should, therefore, be chosen. Regarding efficiency, ISI and Punjab quality mark pumps can be relied upon.

1.1.1. While purchasing the pump from a manufacturer or dealer, the farmer should have the following information to select the most suitable pump :

(i) Source of water supply (open well, tubewell, canal etc.)

(ii) Water table depth in the area.

(iii) Crops to be sown.

(iv) Total area under crops.

(v) Type of prime mover (engine or motor). In case of electric motor, the hours of electric supply.

(vi) Location of tubewell on the farm.

(vii) Type of drive (Belt driven, direct coupled, monoblock).

(viii) Water conveyance system ; lined or unlined or underground pipe line.

(ix) Ground water quality in the area.

1.1.2 Instructions for efficient use of pumps :

(i) The centrifugal pump should be installed at 1-2 m above the water level in the tubewell bore.

(ii) Select a proper pump by consulting the different design-tables or charts from the dealer.

(iii) Use large radius bends.

(iv) Keep the height of delivery pipe at the minimum possible height above the ground level.

(a) Use proper material of joint dori.

(b) Fix joint *dori* in such a way that it leaks about 20 drops per minute.

(c) Put the joint *dori* in pieces equal to circumference of pump shaft. The ends of each piece should be staggered.

1.1.3 Servicing and annual overhauling of the pump set should be done as per manufacturer's instructions.

1.1.4 To avoid leakage in joints, tighten the joints properly using good quality gaskets.

1.1.5 The pump must be run at the recommended revolutions.

1.1.6. Use proper quality of driving belts, in case of belt driven pumps.

1.1.7 Use proper size of suction and delivery pipes according to discharge.

1.1.8 Use good quality reflex value whose flap should open fully.

1.1.9 Foundation should be pucca, levelled and with bolts embedded in it.

1.1.10 Align the motor and pump pulley accurately.

1.2. Gas problem in Tubewell Pits

In some areas accumulation of gas (mainly carbon dioxide gas) has been found in the lower portion of the tubewell pit. When one goes into the pit for repair of pump, he feels difficulty in respiration and becomes unconscious after a few minutes. If one experiences such conditions, he should immediately come out of the pit. For testing the gas, one can burn a kerosene lamp and slowly lower it in the pit. Wherever, it blows out, it means that below that point there is carbon dioxide gas. This can be removed by using the following measures :

(a) One can use an electric table fan lowered up to bottom of pit or keep the exhaust fan on the ground surface and attach a PVC pipe up to bottom of pit.

(b) One can use an empty jute bag or bucket or umbrella and move it up and down in the pit to remove the gas.

3. If the pump is rotated by belt, run the pump idle for 15 minutes and the gas is pushed out. After using these measures, one should re-test the gas accumulation with the kerosene lamp before going down in the pit for repairs, etc.

1.3. Efficient use of irrigation water

Methods of irrigation are Flooding (*Kiara*), Furrow. Sprinkler and Drip method. Flooding (*Kiara*) method is most commonly used by the farmers for irrigating cereal crops. For proper utilisation of

irrigation water, It is necessary that most water applied in the field should be stored in the root zone of the crop. This depends upon soil type, field slope, field size, discharge and crop. To have better use of applied water, irrigation method should be properly selected.

At present, irrigation application efficiency is 30 to 40% which can be increased to 60 to 70% by adopting proper method of irrigation.

The recommended plot sizes (*Kiara*) under different field conditions for flooding method of irrigation are given in Table 1.

Furrow method of irrigation is suitable for crops like cotton, maize, soybean, sunflower and sugarcane etc. on all types of soils. Sprinkler method can be used on sand dunes, light soils and where water is scarce. However, the system has high initial cost. Drip method is suitable for row crops like cotton, sugarcane on light soils, poor quality water and undulating lands but the initial cost is quite high.

Table 1. Recommended plot sizes (*Kiara*) under different soil types, slopes and discharges in one acre length.

Soil type	Average slope	Number of border strips (Kiara) for different discharges (litres per sec)					
	(percent)	Tubewell delivery size			Mogha discharge		
		3"-4"	*5"*	*6"*			
		7.5-10	*15*	*20*	*30*	*45*	*60*
Light	0.3	17-18	14-15	12-13	9-10	6-7	4-5
	0.4	15-16	13-14	10-11	7-8	5-6	--
	0.5	13-14	11-12	9-10	6-7	4-5	--
Medium	0.2	12-13	9-10	6-7	4-5	--	--
	0.3	10-11	7-8	5-6	--	--	--
	0.4	8-9	6-7	4-5	--	--	--
Heavy	0.05	9-10	6-7	4-5	--	--	--
	0.15	7-8	5-6	--	--	--	--
	0.25	6-7	4-5	--	--	--	--

In case of paddy, the field should be levelled and one acre should be divided into 2 equal parts.

Laser land leveling : Laser land leveling is one such important technology for using water efficiently as it reduces irrigation time and enhances productivity not only of water but also of other non-water farm inputs. Laser leveler is trailed type equipment used for achieving precise fine leveling with desired grade. This two meter wide automatic leveling operation can be successfully operated with 50 or above horse powered tractor. It has four basic units' viz. Laser emitter/transmitting unit,

laser receiving unit with soil bucket having double actuating hydraulic valve and level control box. The laser beam signal with 360^0 laser reference up to a command radius of 300-400 m for auto-guidance of the receiving unit. This unit actuates the hydraulic control for moving up/down the leveling bucket for the desired cut/fill operation. Prior to operating the machine the area requiring fine leveling has to be surveyed using a grade rod. Then based on the survey observations a mean grade is found. The bucket blade is then placed at the average grade and synchronized with the control unit. After this the operator operates the machine and the necessary cuts and fills are automatically controlled by the machine to achieve the desired grade in the field. The capacity of the machine depends upon the amount of soil cut and fill required in the field and field geometry. It has been observed that the field efficiency of the machine is more for regular sized fields. It generally takes 1.5-2.5 h/acre if the mean cut and fill is with-in 8 to 10 cm. At present the machine cost is around 4 lac.

Since the initial cost of the Laser leveler is quite high so this type of service should be available on custom hiring through Govt. agencies, cooperative societies and custom operators/Contractors for making this service available to all categories of farmers. This technology will prove a boon to farmer community and for state agriculture and will motivate other farmers for adopting proper water management measures to use water more efficiently and judiciously, thus saving the depleting natural resource (water).

Seed-*cum*-Fertilizer Drill

In selecting a seed-*cum*-fertilizer drill, the following points should be considered.

(i) In case the machine is meant to sow several crops, it must have provision for varying line-to-line distance. Separate calibrating charts (scales) should be provided for each crop and fertilizer.

(ii) The machine must have a provision to control the depth of seed placement.

(iii) The metering system of the drill should not damage the seeds which pass through the system.

(iv) All openers must deliver the same quantity of seed and fertilizer and this should not vary with the operation of machine. Often the setting gets disturbed even after a couple of hours of running.

(v) A good agitator in the fertilizer box is desirable to avoid bridging.

(vi) The seed and fertilizer boxes, should be large so that too frequent refilling is not required.

(vii) There should be a provision for disconnecting the seed and fertilizer dropping system while transporting the machine or during turning. Provision for easy transportation is also essential.

(viii) Detailed information on several seed-cum-fertilizer drills is furnished in the Test Report issued by the Farm Machinery Testing Centre of the University. These reports are available from the Senior Testing Engineer, Department of Farm Power and Machinery, Punjab Agricultural University, Ludhiana.

The farmers should study these test reports before making a choice, and buy only such a machine whose manufacturer is able to supply a Test-Report from an impartial agency.

2.1 How to Calibrate

Calibration means such a setting of the metering mechanism that ensures the dropping of the right quantity of seed and fertilizer in the field. The drills are already calibrated by the manufacturers, but the calibration may become defective during transportation. Further, the same calibration may not be found appropriate for all varieties of seed. The method of calibration is given below :

1. Jaeck-up the seed-cum-fertilizer drill and check the free rotation of the driving wheel and the grain and fertilizer feed-shafts.
2. Place the container or bag under each seed tube.
3. Measure the circumference of the wheel. The circumference gives the distance covered in one revolution of the wheel.
4. Find out the size of the drill by multiplying the number of furrow-openers by the distance between the furrow openers.
5. Find out the number of revolutions required to sow one acre area as follows :

$$\text{Number of revolutions} = \frac{\text{Area of an acre (4000 sq. m. or 43560 sq. ft.)}}{\text{size of drill (m/ft) X circumference of wheel (m/ft)}}$$

Multiply this figure by 9/10 to take care of the wheel-slippage in the field.

6. Mark a point on the rim of the wheel. Rotate the wheel by 1/10th of the number of revolutions required to sow one acre as obtained in step 5 above. Collect the seed quantity from each container separately and weigh.
7. For getting seedrate per acre, multiply by 10.
8. If the quantity collected from each container is not uniform, then check for a defect in the seed-dropping mechanism.
9. Adjust the shift-lever on the feed box for grain rate accordingly, *i.e.* if the seed rate seems to be less than the actual quantity required per acre, then move the indicator a little to the higher side and *vice-versa.*
10. Repeat this process twice to get the correct setting of the seed rate.
11. Calibrate in the same manner for fertilizer rate.

Quantity and Number of Seeds Dropped in Five Revolutions of Wheel

(For each seed tube of seed-cum-fertilizer drill)

Distance between rows	*Size of Wheel*			
	45 cm/18"	*60 cm/24"*	*75 cm/30"*	*90 cm/36"*
20 cm/8"	15-18 grams	20-22 grams	25-28 grams	32-34 grams
	330-400 No.	440-490 No.	550-625 No.	715-760 No.
22 cm/9"	18-20 grams	24-26 grams	30-33 grams	37-39 grams
	400-440 No.	535-580 No.	670-735 No.	825-870 No.

3. Combine Harvester

Some farmers own combines while some other get this facility on custom hire basis from the other agencies. There have been reports that in several instances the combine did a poor job, resulting in considerable loss of grain. To facilitate the proper operation of the combine and to reduce its breakdowns, the irrigation *bunds* and channels should be dismantled immediately after the last irrigation. The combine should be worked in crops with relatively high moisture content at harvest. The loss of grains as loose grains or ear heads can occur at the following points in a combine.

(i) *At the cutter bar.*—These losses can be seen on the ground if all the discharge from behind the machine is collected in a bag and then the machine performance is observed for some distance. These can be avoided or reduced by setting the proper height of cutter-bar-reel and forward speed.

(ii) *Behind the Machine.*—These losses will be either in the form of unthreshed-heads or loose grains. Too many unthreshed heads mean that the cylinder-speed and the cylinder-concave clearance are not properly adjusted. Too many loose grains may be due to many chocked sieves or excessive air blasts or both. Proper machine adjustment including running at speed according to the plant density can reduce such losses.

(iii) *Grain Delivery.*—Unclean grain or broken grain or both will result from excessive cylinder speed or improper sieve-chaffer setting or improper forward speed.

Combine is very sensitive to adjustments which are required to be made at turning or according to the varying plant density, crop conditions (lodged etc.) and ground level (*bunds*) etc.

To get a rough estimate of losses, measure one metre square area and collect the grain and loose material fallen on it behind a combine. Separate the grains and weigh in grams. Multiply this by 10 to get the loss in kilograms per hectare. Alternatively, estimate the loss by counting the number of grains collected from one square metre area. One hundred grains per sq. metre mean about 40 kg per hectare for wheat.

Tips for efficient use of combine for paddy harvesting :

1. Paddy should be harvested between 9.00 A.M. to 9.00 P.M. due to fog/dew and excessive moisture in air.
2. Self-propelled combine should be operated between 2.5 to 4.5 km/hr whereas tractor operated combine should be operated below 2.5 km/hr depending upon the field condition. Further in case of lodged crop the maximum speeds are 3.5 and 1.5 km/hr for self-propelled and tractor operated combines respectively.
3. Paddy should be harvested below 22% moisture.
4. Replace cutter bar blades if it has become blunt.
5. Reduce air-blast if grain damage as thrower losses is above 1%. If still, the problem persists, open chaff sieve further.

6. If grain breakage is more than 2% in the grain tank then reduce cylinder speed or increase concave clearance at the rear.
7. If the amount of un-threshed grain in the thrower loss is more than 1% then reduce the cylinder concave clearance.
8. If combine gets over-loaded, then reduce the forward speed or cut the crop little higher.
9. If crop is wet, i.e. more than 22 percent grain moisture then it should not be harvested otherwise it can cause fire.

3.1 Guidelines for adjusting the combine for maize threshing with husk.

1. The drive to the cutter bar should be disconnected and the reel should be removed for easier feeding of the maize ears. This can be done very easily by removing a belt and opening only a few nuts and bolts. Arrangements should be made to put the maize ears at a distance from the auger and allow these ears to flow by gravity directly to the auger. This will make the feeding proper and safe. The feeding platform should be lifted about one foot above ground for proper feeding.
2. Raspbar cylinder used for threshing wheat should be used for threshing maize. The speed of cylinder should be kept between 500 to 600 rpm as compared to about 900 rpms for wheat. This could be achieved by mounting a 12 inches pulley on the cylinder shaft and 6 inches pulley on the drive shaft (stripping beater shaft).
3. Cylinder-concave clearance should be maximum (approx. one inch) for maize threshing. This could be achieved by setting concaveshaft on one of the last three notches.
4. The sieve in the cleaning shoe should be replaced by the large hole size sieve (approx. 1/2 inch) generally provided with the combine by manufacturers.
5. If the combine does not have a grain tank, the grains should directly by taken from the chaffer to avoid possible grain damage. However, if a grain tank is provided, no such change is necessary.
6. There should be least two convas screens on the straw/rack/walkers. One screen is normally provided at 1/3rd distance in the first portion. The second screen should be provided at 1/3rd distance from the rear. This is necessary to avoid grain losses.

4.1 Effective Utilization of Threshers

Presently, about 3,00,000 threshers are being used for threshing of wheat crop in the Punjab. In order to utilize these threshers efficiently and economically, the following points are to be kept in mind:

(i) The farmer's decision on owning a particular type of thresher should be based upon :
   (a) Output of threshed crop in quintals per horse-power/hour.
   (b) Speed of the threshing cylinder in rpm recommended by the manufacturer.
   (c) Power required to operate the thresher.

This information should be gathered from the manufacturer and check with the test report from the Farm Machinery Testing Centre, Department of Farm Power and Machinery PAU, Ludhiana, if available.

(ii) With the above-mentioned information in hand, the farmer will be able to use his thresher economically and efficiently provided the following guidelines are observed :

(a) The thresher should be kept in level position.

(b) The power required by the thresher should match with that of the power source which should not be overloaded.

(c) It should be operated at the recommended rpm with due adjustment made in the thresher for the crop variety, moisture content and cleanliness of the grain.

Safety Precautions During Threshing

1. Don't wear loose clothes, particularly dhoti, dupatta and loose sleeve shirts, wrist watch, steel bangel (Kara) while working on a thresher.
2. Never operate thresher under the influence of intoxicants like opium, liquor etc.
3. For safety, the minimum length of the feeding chute should be 90 cm, covered upto a minimum of 45 cm and inclined to the horizontal at an angle of 5 to 10 degrees. The angle of the covered portion with the base length of feeding chute should be kept equal to 5 degrees.
4. No worker should work on a thresher for more than 8 hours a day. Fatigue and drowsiness during operation can lead to serious accidents like hand-chopping.
5. Do not indulge in talking or any other discussion while working on the thresher.
6. Avoid feeding earheads (*ghundian*) without stalks as it may lead to serious hand injuries. Similarly wet crop should also not be fed as it is bound to lead to fire accidents. Take special care while feeding the damaged or short stalked crop.
7. Employ only skilled and trained workers for feeding the crop in the threshing drum.
8. Do not smoke or light a fire near the threshing yard.
9. The exhaust pipe of the tractor should be fixed vertically upward and not under the tractor. There should be no stock of straw within 7 metres of the tractor.
10. The main switch of the electrical motors should be within the reach of the operator to switch off the current at the time of emergency.
11. Do not cross over the flat belt or move near it.
12. Keep the heap of sand or powdered soil or fire extinguisher at hand near the threshing floor to extinguish fire in case it breaks out.
13. Keep a first aid box handy for use in the event of need.
14. The farmers must buy only those threshers which the fitted with safe feeding chute as per BIS specifications.

Safely Precautions During Tractor-Trolley use

i) Purchase tractor with driver's safety structure to make operator safe during roll back of tractor.

ii) Use Triangular Reflector (Slow Moving Vehicle Emblem) on tractors, trolleys, carts etc.

iii) Do not load trolleys to oversize (width) while transporting wheat straw (*turi*), cotton sticks etc. Use proper lighting system and reflectors (mirror) while transporting above said bulky materials.

iv) Tractor used for trailer should also be weight blasted at the front axle to make it stable to check rearward rolling.

v) When tractor-trailer moving up the slope, do not disengage the gear otherwise trailer may pull back tractor during gear change.

vi) Be careful while crossing un-manned railway crossing.

Safety Precautions During Chaff Cutting

i) Purchase chaff-cutter with safety features like flywheel lock and cover on blade, fly wheel, gearbox, shafts, pulleys and belts etc.

ii) Feeding chute of chaff cutter should be 90 cm long and 45 cm cover on top with a warning roller in it.

iii) A reversal gear mechanism should be provided and located near the worker to stop or reverse the speed in emergency.

iv) The chaff cutter should be installed with firm foundation, in shade with sufficient space and lighting arrangement.

Safety Precautions to Avoid Fire Accidents

i) To avoid fire accident the silencer of tractor or engine should be up in vertical direction.

ii) Threshing and collection of crop should be away from high-tension electric wires. The wires should be high enough so that the combine harvester with hood may pass safely.

iii) The arrangement of water (tubewell or canal) or heap of sand should be available near the site to control fire.

iv) Do not burn wheat straw to vacate field and use straw combines to make turi (dry fodder).

Monetary Compensation for Accident Victims

Punjab State Marketing Board (Mandi Board) provide financial help to all the farmers, their family members and labourers while :

i) Working on agricultural implements or arising out of use of said implements in the field.

ii) Digging of well or electrocution while operating tubewell on the farm.

iii) Using pesticides or due to snake bite in the field.

iv) Use of implements in the notified market committees in Punjab.

v) While transporting agricultural produce

Mandi Board Rates of Monetary aid to Accident Victims.

S.N	*Type of injury*	*Rate of monetary aid (Rs.)*
1.	Loss of life	2,00,000
2.	Loss of two limbs i.e. hands, arms, legs, feet etc.	60,000
3.	Loss of one limb i.e. hand, arm, leg, foot etc.	40,000
4.	Loss of four fingers i.e. equivalent to amputation of one body part.	40,000
5.	Loss of finger/finger parts equivalent to amputation of complete finger	10,000
6.	Disability (more than 25% of body parts)	50,000-1,00,000

Application Procedure for Monetary Help

The victim or the nearest successor must inform the officials of Mandi Board within 30 days of accidents. The prescribed application with due verifications can be submitted afterwards at the earliest. The performa includes personal detail of victim, details of accident and level of injury. This performa is to be verified by the Sarpanch or two members of village Panchayat or by the Municipal Commissioner in case of jurisdiction of municipal committee. He/She has to submit a police report of the accident and also a verification report by the Sub-Divisional Magistrate. Regarding medical treatment and loss, verification is accepted only from registered or qualified doctor. The victim has to submit an affidavit mentioning that monetary relief is not being sought from any other agency.

Turmeric washing and Polishing Machine

Turmeric rhizomes can be mechanically washed as well as polished in a, portable, electric power (1 hp) operated, rotary drum type turmeric washing and polishing machine. The rotating drum, made of stainless steel is provided with an electronic device to regulate precisely the rotational speed of the drum. The machine operated at 40 rmp for 5 minutes can wash 2.5-3.0 quintals per hour of turmeric rhizomes. The same machine can be used to polish 1 qph of turmeric by increasing abrasiveness using three detachable abrasive screens along the inner side of the drum. The desirable olive yellow colour of turmeric having smooth surface and negligible microbial infestation can be achieved by polishing turmeric at 40 rpm for 20 minutes. Only one person is required to operate the machine. For more information Department of Processing and Food Engineering of Punjab Agricultural University can be contacted.

SECTION—C

STORAGE

1. Storage of Wheat

(*a*) ***Home consumption.***—Improved storage structures of various capacities are now available. For indoor use, PAU metal bins of 1.6, 3.5, 7.5, 10 and 15 quintal capacity are available. For outdoor use, metalbins of 15-tonne capacity with perforated floor-bottom, rooms storage structures of 8-tonne capacity and flat storage structure of 100 tonnes capacity are available. The air-tight bin is so constructed that it does not allow entry of any outside insects and rodents and the insects present in the grain do not get favourable atmosphere to develop. It is also economical, portable and simple to fabricate.

For filling and using the PAU metal bin, the following storage practices are recommended :

(i) Clean the bin thoroughly and do not allow the left-overs of the previously-stored grains to remain in the bin. Inspect the covers to ensure that the gaskets are intact.

(ii) Clean and sort the grains of all impurities. Broken kernels and other impurities lead to insect attraction and, hence, should be separated.

(iii) Do not mix the new grains with old stock as the latter may be infested with insects.

(iv) Never store infested grains, or grains with high moisture content. Dry the grains out in the sun, cool it and fill in the bin later in the evening. The moisture content of the grains should not be higher than 9 per cent. The use of fumigants are recommended to kill the initial infestation in the stock, if any.

(v) Fill-in the bin to full capacity.

(vi) Do not open the bin for the first 30 days and thereafter open it fortnightly. The cover should be replaced immediately after use.

(vii) Inspect the grains frequently. Any suitable fumigant should be used in case any insect-pest infection is detected.

(b) Commercial Purposes.—For storing wheat for commercial purposes, the farmers should make use of the facilities provided by the following agencies.

(i) State Warehousing Corporation in the State and its regional offices.

(ii) Central Warehousing Corporation and its regional offices.

ANNEXURE - IV

Fertilizer Sources of Nitrogen, Phosphorus, Potassium and other Nutrients

(*A*) *Nutrient contents of different fertilizers (Percent)*

Fertilizer	*N*	P_2O_5	K_2O	*Other*
Ammonium Sulphate	20.5	..	..	
Ammonium Chloride	25.0	..	..	
Calcium Ammonium Nitrate	25.0	..	..	
Urea	46.0	..	..	
Superphosphate (single)	..	16.0	..	
Diammonium Phosphate	18.0	46.0	..	
Urea-ammonium Phosphate	28.0	28.0	..	
Nitrophosphate	20.0	20.0		
Sulphated phosphate	13	33	..	15(S)
Sulphate of Potash	..	..	48.0	
Muriate of Potash	..	..	60.0	
Potassium Nitrate	13	..	45	
Manganese Sulphate	..	..	..	30 (Mn)
Zinc Sulphate (Heptahydrate)	..	..	..	21 (Zn)
Zinc Sulphate (Monohydrate)	..	..	..	33 (Zn)
Ferrous Sulphate	..	..	..	19 (Fe)
Copper Sulphate	..	..	..	24 (Cu)
Gypsum	..	..	..	16 (S)
FYM/Vermicompost	0.5 -1.5	1.2 - 1.8	1.2 - 2.0	Sufficient

(*B*) *Quantity of the fertilizer to give 1 kg of nutrient*

For 1 kg of N

Calcium ammonium nitrate	4 kg
Ammonium chloride	4 kg
Ammonium sulphate	5 kg
Urea	2.2 kg

For 1 kg of P_2O_5

Superphosphate	6.2 kg
Diammonium phosphate	2.2 kg
Urea-ammonium-phosphate	3.6 kg
Nitrophosphate	5.0 kg

For 1 kg of K_2O

Muriate of Potash	1.7 kg

Note : Urea-ammonium phosphate (28-28), nitrophosphate (20-20) and diammonium phosphate (18-46) contain both nitrogen and phosphorus. By adding one kg of phosphorus (P_2O_5) through these fertilizers, one kg nitrogen (N) from urea-ammonium phosphate and nitrophosphate and 400 g of N from diammonium phosphate is also added. This point must be taken into account while using these fertilizers.

Well rotten FYM contains 40-50 % moisture. Each ton of such FYM supplies N, P and K equivalent to 4 kg Urea, 10 kg Superphosphate and 6 kg muriate of Potash. So reduce the fertilizer dose accordingly.

ANNEXURE - V

ANTIDOTES FOR PESTICIDES FOR HUMAN BEINGS

SIGNS AND SYMPTOMS OF TOXICITY

Inhalation	Usually appear within 1/2 hour of exposure, maximum after 6 hours. Nausea and vomiting, running nose, feeling of chest tightness, excessive salivation, difficulty in respiration, frothing from mouth, headache, giddiness, vertigo.
Oral intake	Nausea and vomiting, abdominal cramps, diarrhoea, muscle twitching, confusion and disorientation, salivation and frothing, profused sweating, diminished vision, pin-point pupils, respiratory difficulty, convulsions, coma, death.

I. INSECTICIDES

Organochlorines (lindane etc.)	No specific antidote. For convulsions : **Diazepam** 10 mg intravenous (I/V). Could be repeated upto 30-40 mg. After that it should be mixed with drip. **Phenobarbitone** 100-300 mg in drip.
Organophosphates (monocrotophos, chlorpyriphos, methyl parathion acephate,triazophos malathion, quinlphos, dimethoate etc)	**Atropine** : 2-4 mg intravenous as a test dose. If no effect double dose may be given every 10 minutes till atropinization. Maintain upto 24-48 hours. minutes **2-PAM**: 1- 2 g I/V as 5% solution in dextrose to be given in 5-7 minutes or 150 ml of saline drip every 30 minute. If required it may be repeated every hour if the muscle weakness and fasiculation persists. To be continued every 6 - 8 hours for 1 - 2 days or 5% solution as infusion @ 1/2 g/hr. **2 - PAMCL** : dose same as above. **Atropine + 2PAM :** should be given together as 2 PAM acts as synergist to atropine
Carbamates (Carbaryl carbofuran etc.)	**Atropine** : 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours. **Warning : Do not use oxime or morphine.**
Pyrethroids (cypermethrin, fenvalerate, deltamethrin etc).	Only symptomatic treatment, antihistamine are of value, if large amounts are ingested to cause nervous infestation, pentabarbitone (0.7g/day) should be used. For diarrohoea treat by **atropine.**
Cartap hydrochloride (Padan, Caldan etc)	**Dimercaprol (BAL)** 3-4 mg/kg body weight. (Comes as 3 ml, 10% solution alongwith benzyl benzoate in arachis oil). Given deep intra muscular every 4 hours for 2 days and then twice for another 10 days.
Aluminium phosphide (celphos.	No specific antidote, induce vomiting with 5% sodium bicarbonate. Give acti vated charcoal slurry with sorbitol 50-100 g orally, **diazepam** 5-10 mg I/V slowly over 2-3 minutes. **Phenobarbitone** 600-1200 mg.diluted in 60 ml

phostoxin etc)	noral saline. Maximum dose 1-2 g.**Dimercaprol (BAL). Dopamine** 4-6 ug/ kg/min I/V. Magnesium sulphate 3g I/V bolus followed by 6 g in 12 hours for 5-7 days. Administering 5% glucose I/V can minimize liver and kidney damage. **Warning :** Do not give water or water based drinks
Naturalyte (Spinosad)	No specific antidote. Treat symptomatically
Oxadiazine (Indoxacarb)	No specific antidote. Treat sympotmatically
Phenyl Parazole (fipronil)	No specific antidote. Treat symptomatically

II FUNGICIDES

Carbendazim (Bavistin, Agrozim, Parazim, Derosal etc.)	**Atropine :** 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours.
Streptocycline	Injection of **adrenalin, antihistamine** and **cartisone** in case of acute anaphylactic shock, high or low blood pressure, profuse respiration and urticaria.
Copper oxychloride Copper sulphate (Blitox etc.)	**Dimercaprol (BAL)** 3-4 mg/kg body weight. Comes as 3 ml, given deep intramuscular every 4 hours for 2 days and then twice for another 10 days.
Edifenphos (Hinosan)	**Atropine:** 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minutes till atropinization.
Iprobenphos (Kitazin)	Maintain upto 24-48 hours. **2-PAM** : 1-2g I/V as 5% solution in dextrose to be given in 5-7 minutes or 150 ml of saline drip every 30 minutes. If required it may be repeated every hour if the muscle weakness and fasiculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2 g/hr.
Methoxy ethyl mercuric chloride (MEMC), Agallol, Ceresan etc.	Activated charcoal, egg white or 5% sodium bicarbon-ate solution (gastric lavage). High colonic irritation : 5% **sodium formaldehyde sulfoxylate** (fresh 100 - 200 ml) intravenous. For f aster treatment **sodium citrate,** oral 1 - 4 g every 4 hours. For spasms 100 ml (10%) **calcium gluconate** intravenous.
Mancozeb, Thiram, Zineb	**Ascorbic acid** (vitamin C) intravenous @ 0.2 g/min.
Ridomil MZ (8% mancozeb)	No specific antidote for metalaxyl. Antidote for mancozeb as given above metalaxyl+64% may be recommended as this combination contains 64% mancozeb .

Triadimifon	No specific antidote, gastric lavage with 5% sodium (Bayleton) bicarbonate.
Dinocap	No specific antidote. Gastric lavage with Karathane) 5% sodium bicarbonate and medicinal charcoal suspension. Then give 15-30 g sodium sulphate in half litre of water.
Carboxin (Vitavax)	Treat symptomatically
Captan (Captaf)	If ingested, induce vomiting by administering a spoon-ful of salt in hot water.
Chlorothalonil (Kavach)	Treat symptomatically
Propiconazole (Tilt)	Treat symptomatically
Wettable sulphur (Sultaf)	If chemical has gotten into the victim's eyes, flush eyes with plenty of water for atleast 5 minutes

III. HERBICIDES

Anilophos (Arozin, Libra, Anilguard,	**Atropine :** 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours. **2-PAM :** 1-2 g intravenous as 5% solution in dextrose to be given in 5-7 minutes or 150 ml of Anilfos Padigard etc.) saline drip every 30 minutes. If required it may be repeated every hour if the muscle weakness and fasiculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2g/hr. **2-PAMCL**: dose same as above. Gastric lavage with 5% **sodium bicarbonate.**
2,4-D	**Ingestion :** Gastric lavage with activated charcoal slurry. For muscle and cardiac irritability give **Lidocaine** 50-100 mg intravenous, followed by 1-4 mg/minas needed. Alkalize urine by sodium bicarbonate 10-15 g daily intravenously.
Glyphosate	**Ingestion :** immediately dilute by swallowing milk (Roundup) or water.
Isoproturon (Arelon, Delron Milron etc.)	Flush eyes with soap. Wash skin with soap and water.
Paraquat (Grammoxone)	Induce vomiting unless unconscious. Give gastric lavage with one litre of 30% aqueous suspension with Fuller's earth together with sodium sulphate. Repeat administration until Fuller's earth is seen in stool.

IV. RODENTICIDES

Zinc phosphide (Ratol, Zinc-Tox etc.)	As under aluminium phosphide
Coumatetralyl (Racumin)	Vitamin 'K' under medical supervision
Bromadiolone	Vitamin 'K' under medical supervision.

Some common trade names of antidotes

Diazepam :	Calmpose, Lori, Paciquil, Tenil, Valium
Phenobarbitone :	Gardenal
Dimercaprol :	Inj. BAL (Knoll Pharma)
PAM :	Neopam, Pam, Pamplus, Pam-A-Korea

Atropinisation includes :

1. Drying up of secretions i.e. dry mouth, no frothing, loss of sweating.
2. Tachycardia : Pulse should be maintained at about 110/minute
3. Dilated pupils
4. Hyperthermia

SOURCES OF INFORMATION :

(a) Farm Chemicals Handbook, 1994

(b) Health hazards of Pesticides and its management (1996) Voluntary Health Association of India

(c) Essentials of Forensic Medicine and Toxicology (1999) by Narayan Reddy

(d) National Poison Information Centre, AIIMS, New Delhi

Caution : Antidotes are to be used in case of poisoning only, for which a physician must be consulted immediately.

Disclaimer : The information given is only advisory. Actual selection of antidote, dose and manner of administration is to be decided by the qualified physician. **Punjab Agricultural University, Ludhiana accepts no legal responsibility.**

ANNEXURE - VI

GENERAL RECOMMENDATIONS REGARDING SAFE USE OF PESTICIDES

1. Read the label carefully and follow the manufacturer's instructions.
2. Keep pesticides in labelled containers only.
3. Store pesticides in a safe and locked place, out of the reach of children, irresponsible persons and pets.
4. Never store pesticides near foodstuffs or medicines.
5. In the handling of pesticides, the necessary protective clothings and devices must be used.
6. Do not tear open the pesticides bags, but cut them with knife.
7. The preparation of spray solutions from concentrated pesticides should be done in drums using long sticks to protect the operation from splashings and to permit stirring from a standing position.
8. Wash hands thoroughly with soda and water (*i*) every time the sprayer/duster is filled with pesticides, (*ii*) before eating, drinking or smoking and (*iii*) at the end of the day's work.
9. Water contaminated, as a result of washing the equipment and drums, must be disposed off by scattering it over barren land.
10. Do not blow, suck or apply your mouth to any sprinkler, nozzle or other spraying equipment.
11. Operators should not work for more than 8 hours a day. Those engaged in handling dangerous pesticides should be checked by a physician periodically.
12. The sprayer should use cotton clothes, trousers and full sleeve shirt, rubber boots, gloves and goggles. They should be washed and changed as frequently as possible.
13. Do not use the empty containers of pesticides for any purpose. Destroy them by making holes and bury them afterwards.
14. Do not burn weedcide cartons, but bury them deep.
15. The worker should not smoke, chew, eat or drink while spraying.
16. A worker suffering from cold or cough should not be engaged for spraying.
17. Spray should always be done in direction of the blowing wind to avoid skin exposure and inhalation.

FIRST-AID PRECAUTIONS

In case of pesticide poisoning, call a physician immediately. Awaiting the physician's arrival apply the FIRST-AID.

1. Swallowed Poisons

(a) Remove poison from the patient's stomach immediately by inducing vomitting. Give one teaspoonful (15 g) common salt in a glass of warm water (emetic) and repeat until the vomit fluid is clear. Gentle stroking or touching the throat with a finger or

placing the blunt end of a spoon will help induce vomitting when the stomach is full of fluid.

(b) If the patient is already vomitting, do not give common salt in warm water but give a large amount of warm and follow specific directions as suggested. Do not induce vomitting if the patient is in a coma.

2. Inhaled poisons

(a) Carry the patient (do not let him walk) to fresh air immediately.

(b) Open all doors and windows.

(c) Loosen all tight clothing.

(d) Apply artificial respiration if breathing has stopped or is irregular. Avoid vigorous application of pressure to the chest.

(e) Cover the patient with a blanket.

(f) Keep the patient as quiet as possible.

(g) If the patient is convulsing, keep him in bed in some dark room.

(h) Avoid any jarring noise.

(i) Do not give alcohol in any form.

3. Skin Contamination

(a) Drench the skin with water (giving shower with a hose or pump).

(b) Apply a stream of water to the skin while removing the clothing.

(c) Cleanse the skin thoroughly with water.

(d) Rapid washing is most important for reducing the extent of injury.

4. Prevention of Collapse

(a) Cover the patient with a light blanket.

(b) Do not use a hot-water bottle.

(c) Raise the feet of the patient on the bed.

(d) Apply elastic bands to arms and legs.

(e) Give strong tea or coffee.

(f) Give hypodermic injection of stimulants, such as caffeine, and epinerphrine.

(g) Give fluid administration of dextrose, 5 per cent intravenously.

(h) Give blood or plasma transfusion.

(i) Do not exhaust the patient by too much or too vigorous treatment.

5. Eye Contamination

(a) Hold eyelids open.

(b) Wash the eyes gently with stream of running water immediately.A delay of even a few seconds greatly increases the extent of injury.

(c) Continue washing until the physician arrives.

(d) Do not use chemicals. They may increase the extent of the injury.

ANNEXURE - VII

Proforma for referring sample to Plant Clinic, PAU, Ludhiana for diagnosis of disorders

1. Name and address of the farmer : _____
2. Crop : _____Variety _____ Age of the crop_____
3. Problem noticed (Approx. date) : _____
4. Sowing date : _____
5. Area (under the crop) : _____(acres)
6. Source of seed : _____
7. Is this problem related to weather ? : Yes / No
8. If yes, type of Weather : Rain/High temp./Storm/Frost/Hot dry Spell/ Wet condition / Hail / Any other (Specify)
9. Suspected disorder : Insect damage / Disease / Nutritional / Input Phytotoxicity / Any other
10. Symptoms : Holes/Excreta/Rotting/Blight/Yellowing/Wilting/Mottling/Mosaic / Root swelling/ Distortion/Any other
11. Extent of spread : Less than 25% / 25-50% / 50-75% /More than 75%
12. Spread pattern : Whole Crop / Patches / Isolated plants
13. Crop rotation : Wheat-Rice / Wheat-Cotton / Any other (Specify)
14. Soil type : Sandy / Loamy sand / Clay /Loam
15. Soil/Water analysis report : Copy attached/Not attached
16. Drainage system : Good / Moderate /Poor
17. Source of irrigation : Canal / Tubewel l/ Rainfed
18. Irrigation applied : 1 / 2 / 3 / 4 / 5 / More than 5
19. Industrial plant in adjoining area : Yes/No
    If yes, : DistanceinMts.....
20. Name the Inputs used : .....
    Dose_____ Timings _____
21. Diagnosis by field functionary (Extension Scientist) : .....

To be sent to : **Director Extension Education**
Punjab Agricultural University, Ludhiana.

(Signature and Address of Extension Scientist)

ANNEXURE - VIII

Important Telephone Numbers for the Convenience of the Farmers

PUNJAB AGRICULTURAL UNIVERSITY, LUDHIANA

0161-2401960 to 2401979

Director of Extension Education	**214**
Addl. Director of Extension Education	418
Addl. Director of Communication	373
Associate Director, Extension Education	369
Farmers' Help Line	
Plant Clinic	417
Seed Shop	419
Farm Power & Machinery	446
Farm Management	461
Horticulture	458
Vegetable Crops	452
Agronomy	401
Soils	506
Plant Pathology	505
Plant Breeding, Genetics & Biotechnology	435
Entomology	504
Kairon Kisan Ghar	368
Kisan Call Centre	**1800-180-1551 (Toll Free)**
Krishi Vigyan Kendras	
Bathinda	0164-2212159
Ferozepur	01632-246517
Hoshiarpur (Bahowal)	01884-243647
Faridkot	01639-253142
Gurdaspur	01874-220743
Sangrur (Kheri)	01672-245320
Kapurthala	01822-233056
Saheed Bhagat Singh Nagar (Langroya)	01823-250652
Patiala (Rauni)	0175-2225473
Roop Nagar	01881-220460
Amritsar (Usman)	0183-2505672
Fatehgarh Sahib (Shamsher Nagar)	01763-221217
Sri Mukatsar Sahib (Goneana)	01633-210046
Moga (Budh Singh Wala)	01636-235495
Ludhiana (Samrala)	01628-261597
Jalandhar (Noormahal)	01826-292053
Mansa	01652-235590
Farm Advisory Services	
Amritsar	0183-2501989
Bathinda	0164-2212684
Ferozepur	01632-242136

Faridkot	01639-250143
Gurdaspur	01874-220828
Hoshiarpur	01884-222392
Jalandhar	0181-2225768
Kapurthala	01822-232543
Patiala	0175-2200646
Roop Nagar	01881-222257
Sangrur	01672-234298
S.B.S. Nagar, Mohali	0172-2775348
Director of Research	0161-2401221
Addl. Director of Research (NR & PHM)	0161-2407309
Addl. Director of Research (FSN&E)	0161-2400376, 240
Addl. Director of Research (Horticulture)	2400439
Addl. Director of Research (Crop improvement)	379
Director (Seed)	0161-2400898, 438
Director (Farm)	253
Plant Breeding	224
Cotton Section	334
Maize Section	437
Oilseed Section	433
Pulse Section	413
Fodder Section	443
Agronomy, Agromet. and Forestry	308
Entomology	320
Plant Pathology	319
Soils	317
Seed Sci. & Technology	243
Floriculture	440
Microbiology	330
Fodder	443
Extension Education	321
Regional Research Stations	
Abohar	01634-225326
Bathinda	0164-2212159
	0164-2215619
Patiala (Bahadurgarh)	0175-2381473
Faridkot	01639-251244
Gurdaspur	01874-220825
Hoshiarpur (Gangian)	01883-85073
Kapurthala	01822-255094
	01822-255095
Naraingarh (Amloh)	01765-30126
Patiala (Rauni)	0175-2225473
Amritsar (Usman)	01852-246437
Shaheed Bhagat Singh Nagar (Ballowal Sanukhri)	01885-241601
Sangrur (Kheri)	01672-85020
Ladowal Farm (Ludhiana)	0161-2801566