PUNJAB AGRICULTURAL UNIVERSITY
LUDHIANA

PACKAGE OF PRACTICES FOR CROPS OF PUNJAB

Rabi 2012-2013

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Under the guidance of

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PUNJAB AGRICULTURAL UNIVERSITY
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The *Package of Practices for Crops of Punjab, Rabi* 2012-2013 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, oilseeds, minor and fodder crops of Punjab have been discussed and finalised in the Research & Extension Specialists Workshop held on 22-23 August, 2012. It is purposely written in the simple language and easy-to-understand style because the recommendations are intended for the use of Field Level Extension Workers and the farmers of Punjab.

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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 Appendix 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

WHEAT

Wheat is the premier cereal crop of Punjab. In 2010-2011 it was grown on 35.10 lac hectares with production of 164.72 lac tonnes and per hectare yield of 46.93 quintals (18.77 quintals per acre). Durum wheat has a great export potential.

Climatic Requirements : Wheat needs cool climate during the early stage of its growth. Warm temperature at this stage is unfavourable to tillering and also promotes several diseases. Too much of rain during the season results in heavy incidence of rusts.

Rotations : *Rice-Wheat*, Cotton-Wheat, Maize-Wheat*, Maize/Rice-Potato-Wheat, Moong/ Arhar/Mash-Wheat, Groundnut-Wheat, Early Fodder-Toria-Wheat, Green Manure-Rice-Wheat, Rice-Pea-Wheat, Soybean-Wheat*, Summer Groundnut-Potato/Toria/Pea/Late Kharif Fodder-Wheat; Maize (August)-Wheat-Bajra fodder.*

Improved Varieties :

Timely Sown Irrigated Conditions

HD 2967 : (2011)** It is a double dwarf variety with an average plant height of 101 cm. It has profuse tillering. The ears are medium dense and tapering in shape with white glumes. Its grains are amber, medium bold, hard and lustrous. It is resistant to yellow and brown rusts and susceptible to Karnal bunt and loose smut diseases. It takes about 157 days to mature. Its average yield is 21.4 quintals per acre.

PBW 621 (2011) : It is a double dwarf variety with an average plant height of 100 cm. It has profuse tillering. The ears are medium dense and tapering in shape with white glumes. Its grains are amber, medium bold, hard and lustrous. It is resistant to yellow and brown rusts and susceptible to Karnal bunt and loose smut diseases. It takes about 158 days to mature. Its average yield is 21.1 quintals per acre.

DBW 17 (2008) : It is a double dwarf variety with an average plant height of 87 cm. It has profuse tillering. Its ears are medium dense and tapering in shape with white smooth glumes. Its grains are amber, hard, medium bold and lustrous. It is susceptible to new races of yellow rust, moderately resistant to brown rust and less susceptible to Karnal bunt. It matures in about 155 days. Its` average grain yield is 20.0 quintals per acre.

PBW 550 (2007) : It is a double dwarf variety with average plant height of 86 cm. The ears are medium dense, tapering in shape and fully bearded with white smooth glumes. Its grains are bold,

* See chapter on Organic Farming. ** year of release

amber, hard and lustrous. It is resistant to brown rust, moderately resistant to yellow rust and susceptible to Karnal bunt and loose smut diseases. It matures in about 146 days. Its average yield is 20.8 quintals per acre.

PBW 502 (2004) : It is a double-dwarf variety with an average plant height of 95 cm. It tillers profusely. The ears are dense and tapering in shape. Its grains are bold, amber, hard and lustrous. It is susceptible to new races of yellow rust and resistant to brown rust, less susceptible to Karnal bunt and susceptible to loose smut diseases. It matures in about 150 days. Its average yield is 19.5 quintals per acre.

PBW 343 (1995) : It is a double-dwarf variety with an average plant height of 100 cm. It tillers profusely, has stiff straw and is resistant to lodging. The ears are dense, fully bearded with white smooth glumes. Its grains are bold, amber, hard and lustrous. It is susceptible to new races of yellow rust and resistant to brown rust and leaf blight, susceptible to Karnal bunt and loose smut diseases. It is a long duration variety and matures in about 155 days. Its average yield is 19 quintals per acre.

Caution : Cultivation of PBW 343 should be avoided in sub-montane districts of Gurdaspur, Hoshiarpur, Shaheed Bhagat Singh Nagar, Ropar and Fatehgarh Sahib.

WH 542 (1993) : It is a double-dwarf variety with an average plant height of 90 cm. It tillers profusely. The ears are dense, fully bearded with white smooth glumes. It has medium bold, hard, lustrous amber grains. It is susceptible to new races of yellow rust and resistant to brown rust but susceptible to Karnal bunt and loose smut diseases. It is a long duration variety and takes about 155 days to mature. Its average yield is 18.5 quintals per acre.

WHD 943 (Durum) (2011) : It is a double dwarf variety of durum wheat *(Wadanak)* with an average plant height of 93 cm. It tillers profusely. Its leaves are dark green and ears are dense, fully awned, tapering with white smooth glumes. Its grains are amber, hard, bold, uniform and lustrous with low incidence of yellow berry. It possesses desirable quality characteristics and suitability for pasta making. It is resistant to yellow and brown rusts and less susceptible to leaf blight. It takes about 154 days to mature. Its average yield is 19.8 quintals per acre.

PDW 291 (2005) : It is a double-dwarf variety of durum wheat (*Wadanak*) with an average plant height of 83 cm. It tillers profusely. Its leaves are dark green and ears are dense, fully awned, tapering with white smooth glumes. Its grains are amber, hard, bold, uniform and lustrous with low incidence of yellow berry. It possesses desirable quality characteristics and suitability for pasta making. It is resistant to yellow and brown rusts, loose smut and flag smut and less susceptible to powdery mildew, leaf blight and head scab diseases. It possesses field resistance to Karnal bunt disease. It has high degree of lodging resistance. It is a long duration variety and matures in about 155 days. Its average yield is 19.4 quintals per acre.

PDW 233 (1995) : It is a double-dwarf variety of durum wheat (*Wadanak*) with an average plant height of 98 cm. Its ears are medium dense and fully bearded. It has erect leaves with partially hairy white glumes. It has bold, uniform lustrous grains. It is superior in quality parameters especially carotene content and sedimentation value and has low incidence of yellow berry. It is suitable for export. It is resistant to yellow and brown rusts, Karnal bunt and loose smut diseases. It is a long duration variety, maturing in about 150 days. Its average yield is 18.2 quintals per acre.

TL 2908 (2004) : It is a single-dwarf variety of triticale with an average plant height of 113 cm. It has long fully awned drooping spikes with red glumes and awns. It is highly resistant to yellow and brown rusts,Karnal bunt, loose smut and powdery mildew diseases. Its grains are amber, medium hard and bold. It takes about 153 days to mature and its average yield is 16.4 quintals per acre. Triticale has been found suitable for poultry feed and can replace maize and wheat for this purpose. Good quality biscuits, satisfactory breads and *chapatis* can be prepared from the flour of this variety particularly if blended with wheat to the extent of 50 per cent.

Late Sown Irrigated Conditions

PBW 590 (2009) : It is a double dwarf variety with an average plant height of 80 cm. Its ears are medium dense and tapering in shape with white smooth glumes. Its grains are amber, hard, medium bold and lustrous. It is resistant to yellow and brown rusts and susceptible to Karnal bunt and loose smut diseases. It matures in about 128 days. Its average grain yield is 16.4 quintals per acre.

PBW 509 (2004) : It is a double-dwarf variety with an average plant height of 85 cm. It has dark green foliage. The ears are medium dense. Its grains are bold, amber, hard and lustrous. It is resistant to yellow and brown rusts and suceptible to Karnal bunt and loose smut diseases. It is recommended for cultivation in the Punjab state except submontaneous regions. It takes about 130 days to mature. Its average yield is 15.8 quintals per acre.

PBW 373 (1996) : It is a double-dwarf variety with an average plant height of 90 cm. It has profuse tillering, erect leaves and dark green foliage. The ears are dense, fully bearded with white smooth glumes. Its grains are bold, amber, hard and lustrous. It is susceptible to new races of yellow and brown rusts and resistant to leaf blight. It takes about 140 days to mature. Its average yield is 16.5 quintals per acre.

Timely Sown Rainfed Conditions :

PBW 644 : (2012) : It is a dwarf variety with an average plant height of 102cm. Its ears are medium dense and tapering in shape with white smooth glumes. Its grains are amber, hard, bold and lustrous. It is less susceptible to yellow rust, moderately resistant to brown rust but susceptible to Karnal bunt and loose smut diseases. It matures in about 159 days. It average grain yield is 16.4 quintals per acre.

PBW 527 (2005) : It is a double dwarf variety with an average plant height of 100 cm. It has profuse tillering. The ears are medium dense and tapering in shape with white glumes. Its grains are amber, medium bold, hard and lustrous. It is resistant to yellow and brown rusts and susceptible to Karnal bunt and loose smut diseases. It takes about 160 days to mature. Its average yield is 13.7 quintals per acre.

PBW 175 (1987) : It is a single-dwarf variety with an average plant height of 110 cm. It tillers profusely and bears narrow and dark green leaves. The glumes are white and the spikes are of medium size. It is resistant to yellow and brown rusts and Karnal bunt but susceptible to loose smut disease. Its grains are very bold, amber and hard. It yields about 12.5 quintals per acre and matures in 165 days.

Other varieties under cultivation

HD 2932 : It is a medium duration variety for wheat growing regions of southern India. It is highly susceptible to yellow rust and brown rust diseases in Punjab.

HD 2733 : It is a long duration variety for wheat growing regions of eastern India. It is highly susceptible to yellow rust disease in Punjab.

WH 711 : It is a long duration variety and is highly susceptible to yellow and brown rust diseases.

Berbet : It is a medium duration variety with poor grain appearance and is susceptible to yellow and brown rust diseases.

Soil Type : Wheat can be grown on all kinds of soil, except the highly deteriorated alkaline and water-logged soils. Durum wheat should preferably be sown on medium to fine textured soils.

Agronomic Practices :

Preparatory Tillage

(a) Normal : The preparatory tillage for wheat after paddy would be different from that after other *kharif* crops as given below :-

(i) After paddy : If the field has enough soil moisture, undertake tillage straightway, otherwise apply *rauni*. Use disc harrow (bullock or tractor drawn) once, followed by planking. Give another cultivation/ploughing with a tractor drawn cultivator/bullock drawn soil stirring plough. If the soil is heavy, give one more cultivation before planking the soil. Tractor drawn cultivator with pulverizing roller-cum-puddler or bullock drawn disc harrow-cum-puddler can also be used for preparing the dry seed bed (See Appendix III "Agricultural Engineering").

When the paddy is harvested with combine, the left-over standing straw can be mixed into surface soil without any adverse effect on yield of wheat receiving recommended NPK fertilizers. Mixing of straw improves soil properties over a long period. For proper incorporation of straw the land should be disc-harrowed twice instead of once before the other tillage operations as given above are performed. For stubble cutting in combine harvested fields, use tractor-drawn stubble shaver (See Appendix III "Agricultural Engineering").

(ii) After other crops : After *rauni* give two cultivations/ploughings with a tractor-drawn cultivator/bullock drawn stirring plough to be followed by planking. Tractor drawn cultivator with the pulverizing roller-cum-puddler can also be used for preparing the dry seedbed.

(b) Zero/Minimum Tillage : (i) Wheat can be grown without any preparatory tillage if there is no serious problem of weeds to interfere in sowing. In weed infested fields, spray half litre of Gramoxone (Paraquat) in 200 litres of water before sowing. Zero tillage/minimum tillage has many benefits such as saving in diesel and time, less environmental pollution, saving in water during first irrigation, lower weeds infestation particularly *Phalaris minor,* no yellowing of leaves after first irrigation, ensure timely sowing improved input use efficiency and less lodging. These factors contribute towards increased productivity with reduced cost of production. Use tractor drawn zero-till drill or strip-till-drill (See Appendix III "Agricultural Engineering") for sowing wheat in unprepared fields.

(ii) Use Happy Seeder machine for sowing of wheat in combine harvested paddy fields without any straw burning or removal, with following considerations.

The loose straw should be uniformly spread in the field before sowing. The optimum depth of seeding should be between 3.5 to 5.0 cm. Proper rodent control measures should be followed

Note : It is advisable that after three years of continuous sowing of wheat under zero tillage, the field should be ploughed to solve the problem of perennial weeds or rodents, If any.

Seed Rate

For securing good yield, a seed-rate of 45 kg per acre for PBW 550, 35 kg for WH 542 and 40 kg for all other varieties is recommended. The seed should be cleaned and graded thoroughly before sowing.

Seed Treatment

In termite infested soil, first treat the seed with 4ml Dursban/Ruban/Durmet 20 EC (chlorpyriphos) or 6 ml Regent 5% SC (fipronil) per kg seed, dry the seed in shade and then treat the seed of all varieties except that of WHD 943, PDW 291, PDW 233 and TL 2908 with Vitavax @2g/kg (200g/quintal) or Raxil @1g/kg (100g/quintal) or Bavistin/Agrozim/Derosal/JK Stein/Sten 50/Provax/Bencor @2.5g/kg (250 g/quintal) seed for the control of loose smut. Treat the seed with Captan or Thiram @ 3g/kg (300g/quintal) if the seed is infected with black tip and head scab. Treatment should not be done earlier than one month of sowing as it affects seed germination. Seed treatment can be done effectively with the seed treating drum.

Time of Sowing

For securing the best grain yield, wheat must be sown at the optimum time. Delayed sowing causes a gradual decline in the yield of wheat. A delay of one week in sowing reduces wheat yield by about 150 kg per acre. Sowing of long duration varieties should commence from the fourth week of October to save these from high temperature near maturity.

The following sowing time-schedule may be observed for irrigated conditions :

	Period	*Varieties*
1.	From the 4th week of October to 4th week of November	HD 2967, PBW 621, DBW 17, PBW 502, PBW 343, WH 542 and TL 2908
2.	From the 2nd week of November to 4th week of November	PBW 550
3.	From the 4th week of October to 1st week of November	WHD 943, PDW 291, and PDW 233
4.	After 4th week of November	PBW 590, PBW 509 and PBW 373

Sowing Method and Spacing

Sow with a seed-cum-fertilizer drill at a depth of 4-6 cm because it ensures uniform placement of seed and fertilizer at proper depth throughout the field. It enables the application of recommended quantities of seed and fertilizer and also cuts down the time required for sowing. Calibrate the drill accurately before use (See under Appendix III "Agricultural Engineering"). A spacing of 20-22 cm between the rows gives good yield. However, closer spacing of 15 cm gives additional yield.

For hastening the emergence of late sown wheat, sowing of soaked seed is beneficial. Soak the seed in water for 4-6 hours and spread it in a thin layer. Sow it after 24 hours making the necessary adjustments in the seed drill.

Adopt bi-directional method of sowing and get an additional yield of about 2 quintals per acre with the same seed rate and other inputs. Use half the recommended quantities of seed and fertilizer for sowing in one direction and the remaining half in the other direction. Sow the seed a bit shallow i.e. 4 cm deep in rows 20-22 cm apart. The rows in the second direction sowing will cut across the first direction sown rows at right angles. Give light planking after completing the sowing. For the best result, make sure that there is enough soil moisture at the time of sowing. Adopt chemical weed-control measures as per recommendations. The last ploughing/cultivating operation in the preparatory tillage can be dispensed with to reduce extra cost involved in double-sowing.

Growing Wheat on Raised Beds : Sowing of wheat on beds is possible with the development of a bed planter, which enables two wheat rows 20 cm apart on 37.5 cm wide bed and 30 cm wide furrow between two beds. This method gives comparable or 3-4% more yield. An adjustment in these distances is also feasible with this planter. A seed rate of 30 kg/acre under bed planted wheat gives similar yield as with 40 kg/acre under conventional (flat) planting. On equal areas basis, depth of irrigation in bed planted wheat is 5.0 cm as compared to 7.5 cm under conventional (flat) sown wheat. Bed planting helps to use the applied fertilizer better, because of chances of retaining the basal dose of applied fertilizer in the bed, where plant roots are concentrated more and second dose of N fertilizer is also drilled within beds. Whole N can be applied at sowing before preparing beds. Weed emergence on the beds is less in bed planted wheat and the control of weeds on both beds and furrows is possible through intercultivation (with tractor)/integrated control of weeds.

Fertilizer Application :

Apply fertilizer on soil test basis (See Chapter on 'Soil Testing'). In the absence of a soil test, add the following amounts of fertilizers to wheat grown on medium fertility soils :

Nutrients* (kg/acre)			Fertilizers (kg/acre)				
N	P_2O_5	K_2O**	Urea (46%)	DAP*** or (18:46%)	Superphos- or phate *(16%)*	Nitrophosphate*** (20:20%)	Muriate of potash *(60%)*
50	**25**	**12**	**110**	**55**	**155**	**125**	**20**

Note : * These nutrients can also be supplied from other fertilizers available in the market (Appendix IV). All sources of nitrogen and phosphorus available are equally efficient.

** Apply potassium to soils testing low in this nutrient and the cited dose may be doubled in the districts of Gurdaspur, Hoshiarpur, Ropar and Shaheed Bhagat Singh Nagar.

*** When 55 kg of DAP or 125 kg of Nitrophosphate is used, reduce the dose of urea at sowing by 20 kg and 55 kg, respectively.

For N, Urea or Neem coated urea can be used.

In case of non-availability of DAP and SSP in emergent situation, sulphated P fertilizer (13:33:0:15::N:P_2O_5:K_2O:S) may be applied as an alternative source of phosphorus to wheat, although it is costly.

Apply rice husk ash or bagasse ash @ 4 t/acre, along with the recommended fertilizers, for improving wheat productivity and soil health.

Time and Method of Fertilizer Application : Drill 1/2 dose of N and whole of P and K at sowing and broadcast the remaining N with the first irrigation. If nitrogen is to be applied in the form of urea, apply half of the dose just before pre-sowing irrigation (rauni) or with the final preparatory tillage, the second dose within 7 days before or upto 5 days after first irrigation. In light soils, apply 1/2 nitrogen at the time of sowing, 1/4 nitrogen immediately after first irrigation and the remaining 1/4 nitrogen after second irrigation.

Note : 1. Reduce the nitrogen dose to one-half if the field has been green manured in the preceding kharif season. Phosphorus recommended for wheat should be applied to the green manuring crop. Summer green manuring to maize increases the yield of succeeding wheat also.

2. Apply 25% less nitrogen dose to wheat sown after leguminous crops.

3. If farmyard manure has been applied, reduce the fertilizer quantity by 2 kg of nitrogen and 1 kg of phosphorus per 1 ton of farmyard manure applied. If press mud (6 t/acre) has been applied to previous rice, reduce the fertilizer N dose by one-third and fertilizer P dose by one-half.

4. When 2.5 tonnes of poultry manure/acre is applied to rice reduce the fertilizer N dose by 25% and fertilizer P dose by 50%. Apply 37.5 kg N/acre or 81 kg urea in two equal split doses and drill 75 kg single superphosphate/acre at sowing or apply 28 kg DAP and 30 kg urea/acre at sowing and 40 kg urea/acre at first irrigation.

5. Where wheat follows potato which received 10 tonnes of farmyard manure per acre, no phosphorus and only one-half of the recommended nitrogen dose need to be applied.

6. To the wheat crop sown after mid-December, apply 25% less nitrogen than that recommended for the normal sown crop.

7. To the crop sown in kallar soil, apply 25% more nitrogen than recommended.

8. Urea can also be applied as foliar spray at the late-tillering and late jointing stages if the crop shows nitrogen deficiency. For high volume spray pumps (knapsack sprayer), use 3% urea solution (3 kg in 100 litres of water). To cover the crop thoroughly, spraying may be done cross-wise and a total volume of 300 litres of water per acre should be used. In case of low volume spray (shoulder mounted power sprayer), higher concentration of urea (upto 20%) can be used.

9. Wheat is more responsive to phosphorus application than kharif crops. Hence apply phosphorus to wheat and omit its application to following kharif crop.

Use of leaf colour chart (LCC) for need based fertilizer nitrogen application :

1. Drill 55 kg di-ammonium phosphate (DAP) per acre at sowing in medium fertility soils.
2. Apply 40 kg urea per acre for timely sown and 25 kg urea per acre for late sown (after mid December) wheat with first irrigation.

3. Match leaf colour of the topmost fully exposed intact leaf from the randomly selected ten plants with LCC under shade of your body before second irrigation (about 50-55 days after sowing). The leaves selected for matching colour with LCC should be free from disease/insect incidence and other nutrient deficiencies.
4. If leaf colour greenness of six or more out of ten leaves is less than shade 4 on LCC, top dress 40 kg urea per acre for timely sown and 25 kg urea per acre for late sown wheat with second irrigation. Otherwise, if leaf greenness is equal to or more than shade 4 on LCC top dress 25 kg urea per acre for timely sown and 15 kg urea per acre for late sown wheat with second irrigation.

The leaf colour chart can be purchased from the Department of Soil Science, Punjab Agricultural University, Ludhiana.

Zinc Deficiency : Zinc deficiency generally appears in light soils under intensive cropping. If recommended dose of zinc sulphate has been applied to the *kharif* crop, its application may be omitted to the following wheat crop. Paddy responds more to zinc application, therefore zinc should be applied to paddy and its residue is sufficient to meet the requirement of the following wheat crop. However, if zinc has not been applied to paddy and zinc deficiency is expected/appears whose symptoms are a stunted and bushy crop with leaves chlorotic in the middle, which later break and keep hanging, apply 25 kg of zinc sulphate (21%) per acre which will be enough for 2-3 years. Zinc deficiency can also be corrected by foliar spray of 0.5% zinc sulphate (21% Zinc). Prepare the solution for spray by dissolving 1kg zinc sulphate and 1/2 kg unslaked lime in 200 litres of water. This solution is sufficient for spraying an acre of wheat once. Two or three sprays at 15-day intervals are needed.

Manganese Deficiency : Manganese deficiency generally appears in light soils under intensive cropping especially in rice-wheat rotation. The symptoms appear on the middle leaves as interveinal chlorosis with light greyish yellow to pinkish brown or buff coloured specks of variable size confined largely to 2/3 lower portion of the leaf. Later, the specks coalesce forming a streak or band in between the veins which remain green. In acute deficiency whole of the plant may become dry. At earing stage, the symptoms become prominant on flag leaf. In manganese deficient soils, give one spray of 0.5% manganese sulphate solution (1 kg manganese sulphate in 200 litres of water) 2-4 days before first irrigation and three sprays afterwards at weekly intervals on sunny days. However it is desirable to apply manganese on soil test basis for which facilities are available in the Micronutrient Testing Laboratories of Punjab Agricultural University at Ludhiana, Bathinda and Gurdaspur. Do not grow varieties WHD 943, PDW 291 and PDW 233 in sandy soils as these varieties are prone to manganese deficiency. Manganese sulphate should be sprayed only as its soil application is not profitable.

Sulphur Deficiency : Wheat crop suffers from sulphur deficiency when sown in sandy soils. The deficiency is more severe when the winter rains continue for a long time in the early growth period. The symptoms first appear on the younger leaves with fading of the normal green colour. This is followed in the veins. The topmost leaves become light yellow except for the tip, while the lower leaves retain green colour for a longer time. This is distinctly different from the nitrogen deficiency where the yellowing starts with the lower leaves. The plants are short in size with fewer tillers. Where phosphorus was not applied as single superphosphate, apply 100 kg of gypsum per acre before sowing to meet the sulphur requirement of the crop. If recommended dose of gypsum

was applied to groundnut, apply only 50kg/acre. Gypsum can also be applied in standing crop if deficiency of sulphur is observed.

Weed Control :

A) Cultural control of weeds

The infestation of weeds particularly *Gullidanda/Sitti* (*Phalaris minor*) in wheat can be reduced/ minimized by early sowing (last week of October/1st week of November) and by rotating wheat with Berseem, Potato based cropping system, *raya, gobhi sarson*, winter maize etc. Growth and development of *Gullidanda* can also be suppressed by sowing wheat at 15.0 cm spacings and also by selecting quick growing wheat varieties like PBW 502, PBW 343, WH 542 etc. Preparation of soil mulch after seed bed preparation also helps in eliminating first flush of *Gullidanda*.

Give first hoeing before the application of first irrigation and second hoeing after first irrigation with wheel hoe, *Kasola*, or *Khurpa* etc. Weeds of wheat can be controlled with the use of herbicides.

B) Chemical control of weeds :

(1) Control of broad leaf weeds : Broad-leaf weeds can be controlled with 2, 4-D. In fields infested with *Bathu* (*Chenopodium album*), spray 2,4-D sodium salt (80%) or 2, 4-D ethyl ester (36%) at the rate of 250g or 250 ml in 200 litres of water per acre with knapsack sprayer. Nomor, a brand formulation of 2, 4-D ethyl ester at 250 ml/acre is also equally effective against *Bathu*. To the crop sown at the normal time (October and November), apply 2, 4-D, 35 to 45 days after sowing and to late sown crop (especially sown during December), spray 2, 4-D, 45 to 55 days after sowing. Spray when the crop is at maximum tillering stage but before the jointing stage. **Overdose of 2, 4-D should be avoided and in case of variety PBW 343, spray 2, 4-D only at maximum tillering stage.** If gram, sarson or any other broad-leaf crop is sown in wheat, do not apply 2, 4-D at all. Flush the pump thoroughly with water after use and then clean it with washing soda solution (0.5%) to remove traces of 2, 4-D. Even a very small residue of 2, 4-D in the pump can damage cotton, tomato, etc. if such a contaminated pump is used for spraying these sensitive crops.

When hardy broadleaf weeds especially *Kandiali Palak* is present in wheat, use Algrip/Algrip Royal/Markgrip (metsulfuron 20WP) at 10g/acre in 100 litres of water, 30-35 days after sowing wheat crop. This herbicide provides good control of all those broad leaf weeds which can not be controlled by 2, 4-D application.

Alternatively, broadleaf weeds can be controlled with the application of Aim/Affinity (carfentrazone-ethyl 40 DF) @20 g/acre in 200 litres of water, 30 days after sowing wheat crop. This herbicide gives good control of all broadleaf weeds including new emerging hardy broadleaf weed *Button booti* (*Malva neglecta*) which can not be controlled with 2,4-D or Algrip/Algrip Royal/Markgrip

(2) Control of wild oats : (a) Wild Oat (*Avena ludoviciana*) is locally known as *Jaundhar*. It can be controlled by spraying Avadex BW 50 EC (Triallate). The following steps should be followed to attain good control of this weed.

Prepare a fine seed bed, free from clods and stubbles.

- Before sowing but after seed bed preparation, spray the field with Avadex BW at 1.0 litre/acre in 200 litres of water.
- While spraying herbicide, avoid overlapping of the spray solution, otherwise increase in the concentration of the herbicide damages the wheat seedlings.

- Immediately after spraying, incorporate the herbicide into the upper 2-3 cm layer of the soil by running a bar harrow.
- Sow wheat the same day or the next day preferably with a drill (not with *kera*) at a depth of 5-6 cm, (not shallow), otherwise wheat seedlings are damaged by the herbicide treated soil zone.
- Delay in herbicide spray after seed bed preparation gives poor control of wild oats as the emerged weed plants are not killed by the herbicide.

(b) Wild oats in wheat can also be controlled with early post- emergence application of Isoproturon.

- Apply Isoproturon 75 WP at 300g/acre by dissolving in 150 to 200 litres of water.
- Herbicide should be sprayed 20 to 25 days after sowing wheat crop but 1-2 days before first irrigation.

(c) Wild oats in wheat can be effectively controlled with the post-emergence application of Topik/ Point/Moolah/Rakshak Plus/Jay Vjay 160 g/acre or Puma Power 400 ml per acre.

- Mix any one of these herbicides in 100 litres of water and spray 30-35 days after sowing of wheat crop uniformly.

(d) Alternatively, Total 75 WG can be sprayed at 16 g/acre for the control of wild oats and broadleaf weeds in wheat.

(3) Control of *Phalaris minor* : This weed is commonly known as *Gullidanda or Sitti* and can be controlled by the use of following herbicides.

Name of herbicide		*Dose/acre*	*Time of application*
(a)	**Isoproturon (75 WP)** Arelon/Delron/Hilproturon/Ronak/Nocilon/ Wonder/Milron/Agrilon/Totalon/Agrilon/Totalon/ Carelon/Marklon/Jai-Proturon/Isoguard/Dhar/ Rakshak/Prowl/Kanak/Isotox/Isohit/Ciluron/Isocin	500g	30-35 days after sowing
(b)	**Clodinafop (15 WP)** Topik, Point/Moolah/Rakshak/ Plus/Jay Vjay/Topple	160 g	-do-
(c)	**Pinoxaden (5 EC)** Axial	400 ml	-do-
(d)	**Fenoxaprop-p-ethyl (10 EC)** Puma Power	400 ml	-do-
(e)	**Sulfosulfuron (75 WG)** Leader/SF-10/Safal	13 g	-do-
(f)	**Mesosulfuron+Iodosulfuron** (3.6 WDG) Atlantis	160 g	-do-
(g)	**Sulfosulfuron+metsulfuron (75 WG)** Total	16 g	-do-

(h)	**Fenoxaprop 8% + Metribuozin 14%** Accord Plus	500 ml	30-35 days after sowing
(i)	**Pendimethalin** Stomp (30 EC)	1 litre	Within two days after sowing.
(ii)	**Trifluralin (48 EC)** Treflan/Tremor	1 litre	-do-

The use of Topik/Point/Moolah/Rakshak Plus/Jay Vjay/Topple/Puma Power/Leader/SF-10/ Safal should be done only (as per recommended dose) in the fields where *gullidanda* is not controlled with continuous use of Isoproturon. For spray of these herbicides, use 100 litres of water/ acre with spray pump fitted with Flat Fan nozzle, but for Isoproturon it should be 200 litres/acre.

Early Post-emergence (before first irrigation) : *Phalaris minor* (*Gullidanda*) can also be controlled by spraying Isoproturon (Recommended herbicide brands) 2 to 3 days before first irrigation.

- On heavy texture soils use Isoproturon 75 WP at 500g/acre
- In case of medium texture soils Isoproturon 75 WP can be used at 400g/acre.
- Spray the herbicide by dissolving it in 200 litres of water with knap sack sprayer fitted with flat fan or use tractor mounted sprayer.
- Give light irrigation within 2 to 3 days of spraying the herbicide.

Control of Phalaris minor and other weeds in durum wheat :

- Spray Stomp 30 EC or Treflan/Tremor 48 EC at 1.0 litre/acre in 200-300 litres of water within 2 days after sowing.
- All formulations of Isoproturon can also be sprayed on durum wheat 40 to 45 days after sowing on medium-to-heavy textured soils, which are generally the typical rice soils.
- Isoproturon should not be used in durum wheat on light textured soils.
- Use of Topik/Point/Moolah/Rakshak Plus/Jay Vjay/Topple/Puma Power/Leader/SF 10/Safal is very safe for durum wheat varieties.

Precautions

1. In fields where Leader/SF-10/Safal herbicide had been used, do not sow sorghum (jowar) and maize crops in the following season.
2. Spray must be done with patience and it should be as uniform as possible.
3. For spray of Leader/SF-10/Safal/ Topik/Point/Moolah/Rakshak Plus/Jay Vjay/Puma Power, 100 litres of water per acre is sufficient.
4. PBW 343 can tolerate 2, 4-D very well provided it is sprayed at maximum tillering stage.
5. Do not use Accord Plus/Leader/SF-10/Safal where any cruciferous crop has been sown because these crops are highly sensitive to this herbicide. In such situations Isoproturon group of herbicides or Puma Power or Topik/Point/Moolah/Rakshak Plus/Jay Vjay/Topple may be used to which *raya* and *sarson* show adequate tolerance.

6. Spray on clear days. After spray the first and second irrigation should be light. Flooding or heavy irrigation reduces the effect of herbicides.
7. In case broad-leaf weeds are also problem along with *Phalaris,* mix recommended dose of Isoproturon with 2, 4-D sodium salt at 250 g/acre or 2, 4-D ethyl ester (36%) at 250 ml/acre in 200 litres of water and apply with a knapsack sprayer when the crop is at maximum tillering stage (35-45 days after sowing). Dissolve thoroughly each herbicide in some quantity of water separately and then mix both the solutions in desired quantity of water. **Prefer the use of 2, 4-D sodium salt for this combination. Mixture with 2, 4-D should not be applied when wheat is intercropped with *raya/sarson/gobhi sarson* or gram.**
8. Joint infestation of *Gulli danda*/wild oats and broadleaf weeds in wheat can be controlled with the tank mix application of Topik/Point/Moolah/Rakshak Plus/Jay Vjay/Topple and Puma Power with 2,4-D/Algrip/Algrip Royal/Markgrip. All these herbicides are applied at their full recommended rates, 30-35 days after sowing of crop.
9. Spray the recommended dose of Stomp or Treflan as pre-emergence in 200-300 litres of water per acre on a well prepared seedbed, free of clods and plant debris. Good soil moisture and high volume spray are the key to success for both the herbicides.
10. **Do not use Accord Plus on wheat variety PBW 550 as it is phytotoxic to this variety.**

Irrigation :

Sow wheat after a heavy pre-sowing irrigation (10 cm) except when it follows rice. In case wheat sowing is likely to be delayed due to the late harvest of rice, the pre-sowing irrigation for wheat can be given to standing rice 5-10 days (depending upon soil type) before its harvest except where the crop is to be harvested with combine. This practice advances the sowing of wheat by about a week. For efficient use of irrigation water, farmers are advised to make 8 plots per acre in heavy textured soils and 16 plots per acre in light textured soils.

The first irrigation should be relatively light and given after three weeks to October-sown crop and after four weeks to the crop sown later. The subsequent irrigations are also determined by the date of sowing. Observe the following irrigation time-table for wheat sown on sandy loam or heavier soils on different dates :

Dates of sowing	*Irrigation (7.5 cm)*		
	II	III	IV
	Weeks after the previous irrigation		
Up to November 21	5-6	5-6	4
November 22 to Dec. 20	5-6	3-4	2
December 21 to Jan. 15	4	3	2

Note : 1. Advance the date of the first irrigation on light soils and delay it by one week on heavy paddy soils.

2. The indicated intervals for irrigation can be varied by 2 or 3 days on either side.

3. For each cm of rain, increase the interval for the next irrigation by 5 days upto the end of January and by 2 days after this period.

4. For the early sown crop if the irrigation date falls around 15th March no further irrigation is required in medium and heavy textured soils. However in light soils another irrigation may be given. In case unusual situation arises due to sudden rise in temperature at grain filling/ formation stage, irrigate the crop immediately. Care should be taken not to irrigate the crop on windy days to avoid lodging.

5. For the crop sown after December 5, continue irrigation upto April 10.

Wheat Cultivation under Rainfed Conditions

In the districts of Hoshiarpur, Ropar, Shaheed Bhagat Singh Nagar and Gurdaspur, considerable wheat area is rainfed. The recommendations for raising wheat under such conditions are given below :

Time of Sowing : The following sowing time schedule may be observed for rainfed conditions.

	Period	*Varieties*
1.	From 4th week of October onwards	PBW 644, PBW 527 and PBW 175
2.	From 4th week of November onwards	PBW 373

Soil : Light textured soil e.g. sandy to loamy sand usually have low water retention capacity and on such soils, wheat followed by maize gives poor yield. For best results, green manure with sunhemp or cowpea (fodder) during *Kharif* or keep these soils fallow and take a crop of wheat/wheat-gram mixture with *raya* rows during *rabi*. The fertilizers recommended for wheat also hold good for the above mixed cropping.

Moisture Conservation : Success of *rabi* crops in rainfed areas mainly depends on conservation of moisture in soil profile. The practice is locally known as 'gil dabna'. It consists of ploughing and planking the field immediately after the harvest of *Kharif* crop. The field is generally ploughed in the evening and is planked early in the morning.

Termite Control : Termites cause heavy mortality of plants. So adopt relevant control measures as given under Plant Protection Measures on page 15.

Seed-Rate and Spacing : Use 40 kg of treated seed per acre to cover the risk of poor germination due to inadequate soil moisture in the seed zone and attack of white ants or mortality of seedlings due to early drought. If the soil moisture is good at the sowing time, use 35-40 kg seed and give a row-to-row spacing of 22-25 cm. Increase the row-spacing to 25-30 cm if the soil moisture is medium to-low.

Time and Method of Sowing : Sow wheat from the last week of October to the Ist week of November preferably with a seed-cum-fertilizer drill. In case the crop stand is poor, i.e. less than 50% of the optimum and the winter rains come before 15th December, re-sow the field with any of the recommended varieties.

If the seed zone moisture is inadequate, sow seed slightly deeper in moist soil layer (8-10 cm) and increase row spacing to 30 cm.

Fertilizer Application : It pays to apply fertilizer to wheat in rainfed areas provided adequate moisture has been stored in the soil profile. In the absence of a soil-test report, apply fertilizer to the medium-fertility soils at the following rates :

Soil Type	Nutrients* (kg/acre)			Fertilizer (kg/acre)			Time and method of application
	N	P_2O_5	K_2O**	Urea (46% N)	Super phos-phate (16% P_2O_5)	Muriate of potash (60% K_2O)	
Sandy loam to clay loam soils with adequate moisture stored	32	16	12	70	100	20	Drill half N and full P & K fertilizers at sowing and broad-cast remaining half N at winter rains
Loamy sand to sandy soils with low moisture stored	16	8	6	35	50	10	Drill all fertilizers at sowing

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

** Add potassium only to soils testing low in this nutrient.

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

Interculture : Give two hoeings preferably with improved wheel hand hoe to check weed growth and create soil mulch for reducing evaporation from the soil.

Harvesting and Threshing :

Harvest and thresh high yielding wheat varieties as soon as fully ripe, to avoid grain shattering. The harvesting of wheat can be started five days earlier than dead ripe stage without adverse effect on the yield or quality of the grains. Tractor-operated vertical conveyer reaper windrowers can also be used for harvesting. Use power thresher with proper safety devices to prevent accidents. For good performance, operate these machines at cylinder speed recommended for wheat and also observe safety precautions against accidents. The syndicator type (*Toka* type) can be used to thresh the wheat crop with moisture content up to 20%.

Grain combines can also be used for simultaneous harvesting and threshing of wheat. To facilitate the use of grain combine and to reduce breakdown, dismental the bunds and channels immediately after the last irrigation. Delayed harvesting results in high grain losses. Stubbles can be bruised as fine wheat straw (*turi)* by using wheat straw combine. Straw recovery is about 60%. In case the grain contains more than 10 percent moisture, it should be dried before storing, otherwise it would be spoiled by moulds and excessive heat that develops during storage. Seed-cleaners-cum-graders may also be used at this stage. For detailed information and instructions on the use of machines/implements for various operations see chapter 'Agricultural Engineering'.

Production of Pure Seed :

Procure foundation seed from the Punjab Agricultural University, the Department of Agriculture, Punjab, the Punjab State Seeds Corporation or the National Seeds Corporation Ltd.

The use of high quality and genetically pure seed is essential. The farmer can purchase certified seed either for whole area or may purchase only one bag of foundation or certified seed from the Punjab Agricultural University or the Punjab State Seeds Corporation and multiply for planting it on the larger area during the next season. The seed to be used for multiplication must be treated with any of the recommended fungicides against loose smut. Remove all off-type and diseased plants at frequent intervals. Eliminate the chances of occurrence of admixture during harvesting, threshing and storage.

Plant Protection :

(a) Pests

1. Termite : Termites damage the crop soon after sowing and near maturity. The damaged plants dry up completely and are easily pulled out. The plants damaged at later stages give rise to white ears.

Treat the seed at the rate of 4 ml Dursban/Ruban/Durmet 20 EC (chlorpyriphos) or 6 ml Regent 5% SC (fipronil) per kg seed. Dilute 160 ml of Dursban/Ruban/Durmet or 240 ml of Regent in one litre of water and spray the same on 40 kg seed spread as a thin layer on the *pucca* ground or tarpaulin or polythene.

Note : Insecticides applied against termites would also control root aphid and the Gujhia weevil. Seed treated with chlorpyriphos is less attacked by birds.

2. *A*phids : It damage the crop resulting in discolouration of leaves. Spray 40 ml of imidacloprid 200 SL or 20 g of thiamethoxam 25 WG or 12 g of Dantop (clothianidin 50 WDG) or 150 ml of Rogor 30 EC (dimethoate) or Metasystox 25 EC (oxydemeton methyl) in 80-100 litres of water per acre using knap sack sprayer or in 30 litres of water per acre with power sprayer.

a) Control aphids at earhead stage at economic threshold level of 5 aphids per earhead as recorded from 10 randomly taken ear heads in each of the 4 quarters of one acre field.

b) Since the aphids appear first on borders of the crop. Spray only the infected strip to check their further spread.

3. Army worm attacks wheat and barley during March-April. It damages leaves and earheads. Spray 200 ml Nuvan (dichlorvos) 85 SL or 1.2 kg Sevin/Hexavin (carbaryl) 50 WP or 400 ml Ekalux (quinalphos) 25 EC in 80-100 litres of water per acre with hand-operated knapsack sprayer or in 30 litres of water with a motorized knapsack sprayer.

Note : These insecticides will also control aphid and jassid.

4. Gram pod borer *(Helicoverpa armigera)* attacks wheat at maturity. It feeds on the grains in the earheads. Damage is more where wheat follows cotton. Spray 1.2 kg Sevin 50 WP (carbaryl) or 800 ml Ekalux 25 EC (quinalphos) in 100 litres of water per acre with hand operated knap sack sprayer.

5. Pink stem borer *(Sesamia inferens)* It generally attacks the wheat crop at seedling stage. The larva bore into the stem of young plant and kills the central shoot causing 'dead heart'. Spray the crop with quinalphos 25 EC @ 800 ml/acre in 100 litres of water.

6. Brown mite : Brown wheat mite is a minor insect of wheat causing discolouration of leaves. To control it use same insecticides as recommended for the control of aphids.

(b) Diseases

1. Yellowing in the seedling stage can be caused by nutrient deficiency, bad weather conditions, poor drainage, attack of *Alternaria* and *Drechslera* sp or soil infestation with cereal cyst nematode.

A general yellowing of the leaves and necrosis occurs specially starting from the tips and along the edges. Later on, necrotic area develops within the chlorotic tissue, there is stunting and general decline. In case of Zinc deficiency, the plants remain stunted and bushy; leaves become chlorotic, stocky and break in the middle. Yellowing of young leaves may be due to sulphur deficiency, whereas yellowing of older leaves could be due to nitrogen deficiency.

(i) In light soil, add 25 kg zinc sulphate per acre. One such application will be enough for 2-3 years. (See page 8).

(ii) Add muriate of potash along with N and P fertilizers to high yielding varieties, as recommended under Fertilization (See page 6-7).

(iii) Give proper irrigation to counteract the effect of frost. Avoid excessive irrigation.

(iv) If the cereal cyst nematode is present in the soil, apply Furadan 3 G @ 13 kg per acre at sowing time.

(v) Apply 100 kg gypsum per acre for correcting sulphur deficiency.(See page 8).

2. Wheat rusts : (i) ***Yellow or stripe rust*** *(Puccinia striiformis):* Yellow pustules on leaves, forming stripes.

(ii) **Brown or leaf rust** *(P. recondita):* Round, orange pustules, irregularly arranged or in clusters on leaves, less common on the leaf sheath and stalk.

Grow varieties such as HD 2967, PBW 621, PBW 550, WHD 943, PDW 291, PDW 233, PBW 590, PBW 509, TL 2908, PBW 527 and PBW 175. These varieties are resistant to wheat rusts. Spray the crop with Tilt 25EC/Shine 25EC/Bumper 25EC or Folicur 25 EC @ 200 ml or Bayleton 25 WP @ 200 g in 200 litres of water/acre as soon as the disease is noticed. Repeat the spray at 15 days interval, if need to protect the flag leaf.

3. Loose smut *(Ustilago tritici) :* The fungus destroys the ears completely, turning them into a black loose powdery mass consisting of spores and leaving behind the rachis only. (i) Grow resistant varieties such as WHD 943, PDW 291, PDW 233 and TL 2908. (ii) Soak the wheat seed in ordinary water from 8 a.m. to 12 noon on any calm and sunny day during May/June. After 4 hours soaking, spread out the moist seed in the Sun in a thin layer on cemented floor (*pucca*), on tarpaulin or sheets of cloth. Dry the grain completely and store in a dry place till sowing.

(iii) Alternatively the seed may be treated as mentioned on page 5.

4. Flag smut or leaf-smut *(Urocystis agropyri) :* Long narrow lead grey or black streaks or stripes running parallel to veins are formed on the leaves. The stripes eventually rupture and expose black sooty mass of spores. Practise shallow sowing. Rogue out the affected stools and destroy them by burning. Dress the wheat seed with Vitavax @ 2 g per kg seed or Bavistin or Agrozim or Derosal or J.K. Stein or Sten 50 or Benlate @ 2.5 g or Thiram 75% @ 3g or Raxil @1g per kg seed before sowing. Grow resistant varieties such as WHD 943, PDW 291, PDW 233 and TL 2908.

5. Ear cockle *(Mamni)* and **Yellow ear rot** *(tundu) (Anguina tritici* and *Rathyi bacter) :* Diseased plants have spreading tendency and swollen base, leaves become crinckled and twisted. Earheads contain dark-brown, hard and roundish galls (*Mamni)* instead of grains. Severely diseased plants are stunted and may die at seedling stage. Occurrence of yellow, slimy mass indicates ear rot phase which prevents grain and gall formation. Put wheat seed in ordinary water and agitate vigorously for a few minutes. Ear-cockle galls will float to the surface. These may be skimmed off with an ordinary sieve and burnt.

6. Leaf blight, glume blight and black tip : Elongated brown spots and blotches on leaves and glumes. Ears are poorly filled, grains shrivelled, discoloured and black tipped. Treat the seed with 3 g Thiram or Captaf (83%)per kg of seed.

7. Molya *(Heterodera avenae) :* Plants become stunted with yellowing of leaves, reduced tillering, absence of ears on some tillers or small ears with poorly filled grains. The root system of infected plants gets reduced in size and becomes bunchy with profuse development of thin rootlets. Cysts (shining white bodies of female nematode) are seen attached to the roots at the later stage of the crop. Expose the soil to the hot sun by cultivation during May and June. Practise rotation with non-cereals in badly infested soils. Apply Furadan 3G @13 kg per acre at sowing time.

8. Karnal bunt *(Neovossia indica) :* In the ear only a few grains are infected. The infected grains on pressing give out black powder of spore mass. This powder gives peculiar stinking smell. Grow resistant varieties namely WHD 943, PDW 291, PDW 233 and TL2908 under irrigated conditions and PBW 527 and PBW 175 under rainfed conditions. A single spray of Tilt/Folicur 25 EC @ 200 ml per acre using 200 litres of water at ear emergence stage for the control of Karnal bunt is recommended in wheat meant for seed production only.

9. Powdery mildew *(Erysiphe graminis tritici) :* The fungus develops numerous superficial white floury spots on all the above ground parts of the plant. The white colour of the floury spots changes to grey or reddish brown when cleistothecia develop. Infected plants become stunted due to reduction in the size and number of leaves. Grow resistant variety TL 2908. Spray with Karathane 40 EC @ 0.05% (100 ml in 200 litres of water) or with Tilt 25 EC 200 ml in 200 litres of water per acre.

10. Head blight or Scab *(Fusarium spp.) :* Individual spikelets or portion of earheads show premature bleaching or brown discolouration. Characteristic pinkish mycelium of the fungus may be visible on infected spikelets during humid conditions. The grain formation is either completely inhibited or the infected spikelets produce shrivelled chalky grains showing pinkish discolouration. Seed lots affected by scab should be cleaned thoroughly to eliminate shrivelled seeds. Grow tolerant varieties such as PBW 343 and WH 542. **The incidence of this disease is more on durum varieties, their cultivation in highly humid areas, particularly near rivers should be avoided.**

Field Rats and Mice : (See Chapter on Management of Rodents and Birds)

BARLEY

Barley is usually grown on soils with inadequate irrigation facilities. In 2010-2011 barley covered 12 thousand hectares with a production of 44 thousand tonnes and average yield of 36.52 quintals per hectare (14.61 quintals per acre).

Climatic Requirements : Barley requires cool weather during early growth and warm and dry weather at maturity. Being drought resistant, barley suits to areas with scanty rainfall.

Rotations : *Paddy*-Barley, *Kharif fodder-Barley, Cotton-Barley* and Bajra-*Barley*.

Improved Varieties

PL 807 (2009) : It is a six-rowed semi dwarf and still stemmed feed barley variety with medium broad and upright leaves. It is highly resistant to lodging. The ears are dense, erect and parallel with medium awns. Its grains are medium and light yellow in colour. It is fairly resistant to yellow rust, brown rust, loose smut, leaf blight and stripe disease. It takes about 137 days to mature. Its average yield is 17.2 quintals per acre. It is recommended for timely sown irrigated conditions in Punjab.

DWRUB 52 (2008) : It is a two-rowed variety having narrow and upright leaves with an average plant height of 101 cm. It tillers profusely and has less lodging due to stiff stem. The ears are dense, erect and arrow-shaped with medium awns. Its grains are bold and light yellow in colour with thin husk. It is fairly resistant to yellow rust, brown rust, loose smut, covered smut and leaf blight diseases. It takes about 140 days to mature. Its average yield is 17.3 quintals per acre. It is recommended for timely sown irrigated conditions in Punjab. **This variety is particularly suitable for brewing industry.**

VJM 201 (2005) : This is a two-rowed variety having narrow and upright leaves with an average plant height of 118 cm. It tillers profusely and has less lodging due to hard stem. The ears are dense and tapering in shape with medium white awns. Its grains are bold and white in colour with thin husk. It is fairly resistant to brown rust, loose smut, covered smut and stripe disease. It takes about 135 days to mature. Its yield is 14.8 quintals per acre. It is recommended for cultivation under timely sown irrigated conditions in Punjab. **This variety is particularly suitable for brewing industry.**

PL 419 (1995) : This is six-rowed variety with broad and upright leaves. It is short statured (80cm), stiff stemmed and lodging resistant. It is resistant to yellow rust, loose and covered smuts. It is moderately susceptible to stripe disease (*Drechslera graminea)* and aphids. It has bold seeds and thin husk. It yields 14 quintals per acre and matures in 130 days. Its cultivation is recommended under rainfed conditions throughout the Punjab State specially in *Kandi* area.

PL 426 (1994) : It is a six-rowed, semi-dwarf and stiff stemmed variety. It is highly resistant to lodging, yellow rust, loose and covered smuts. It is tolerant to stripe disease but moderately susceptible to aphids. The grains are bold and thin husked. It yields 14 quintals per acre and matures in 124 days. It is recommended for cultivation under irrigated conditions throughout the state.

PL 172 (1984) : This is a six-rowed semi-dwarf stiff stemmed and lodging resistant variety. It has purple coloured leaf sheath. It is highly resistant to yellow rust, loose smut and covered smut and has moderate resistance to aphid and *stripe disease.* This variety has uniform grains with thin husk

hence suitable for malting. It yields 17.1 quintals per acre and matures in 132 days. It is recommended for irrigated conditions throughout the State. It also gives good yield under late sown conditions.

Soil Type : Barley can be grown on well drained soils. It can do well even in salt affected soils during the early phases of the reclamation of these soils.

Agronomic Practices

Preparatory Tillage : Two to three ploughings each followed by planking will be needed.

Time and Method of Sowing : Barley gives best results when sown between October 15 and November 15. In south-western districts, where barley is usually grown rainfed, it should be sown early. There is a gradual decline in yield when sowing gets progressively delayed up to the end of December. The crop should be sown by *kera* if there is enough moisture in the soil and by *pora* if the moisture in the upper soil layer is insufficient. *Sohaga* is run after sowing by *kera* but not after sowing by *pora*. Sowing can also be done with conventional Seed-cum-fertilizer drill after calibration (See Agril. Engg.). The running of bar-harrow after *sohaga* is useful in reducing the loss of moisture from the soil surface.

Seed Rate and Spacing : A seed rate of 35 kg per acre gives a good stand under irrigated conditions. Under rainfed and late-sown conditions, seed-rate upto 45 kg per acre may be used. A spacing of 22.5 cm for the normal sown crop and 18-20 cm for the late-sown and rainfed crop is recommended.

Sowing with zero tillage : Barley can also be grown without any preparatory tillage with zero till drill after rice. In weed infested fields, weeds 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 environmental pollution and saving of irrigation water in first irrigation thus resulting in reduced cost of production. This also helps in timely sowing of crop after basmati and results in increased yield.

Seed Treatment : Before sowing, treat the seed with Vitavax or Raxil @ 1.5 g/kg of seed to control covered smut, loose smut and stripe disease in barley. Solar heat treatment as recommended for wheat can be done to control the loose smut of Barley.

Weed Control : One hoeing and weeding preferably with improved wheel hand hoe should be done after the first irrigation.

For the chemical control of broad-leaf weeds (*bathu, pitpapra* etc.) spray 2, 4-D sodium salt (80%) or 2, 4-D ethyl ester (36%) @ 250 g or ml of the commercial product in 200 litres of water per acre when the crop is fully tillered 40-45 days after sowing in case of the normal sown crop but is not yet at the jointing stage. Alternatively, apply Algrip (metsulfuron 20 WG) @ 8 g/acre by dissolving in 150 litres of water 30 days after sowing. This herbicide also controls hardy weeds like *Kandiyali Palak* and other broadleaf weeds which are not controlled by 2,4 D.

For the control of wild oats in barley use Avadex BW/isoproturon in the same way as in 'WHEAT'.

For the control of Phalaris minor in Barley use Treflan/Tremor 1.0 litre per acre as per emergence or post emergence application of Puma Power at 400 ml/acre or Topik/Point/Moollah/ Rakshak Plus/Jay Vjay at 160 g/acre 30-35 days after sowing.

Irrigation : In the south-western dry districts, two post-sowing irrigations are generally required, whereas in other districts, one irrigation from five to six weeks after sowing may be enough.

Fertilizer Application :

Variety	*Nutrients* (kg/acre)*			*Fertilizer (kg/acre)*			
	N	P_2O_5	K_2O**	Urea*** (46%)	DAP (18:46%)	Super phosphate (16 %)	Muriate of potash *(60%)*
PL 419	16	12	6	35	27	75	10
All other varieties	25	12	6	55	27	75	10

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

** Potash should be applied only if soils are low in potash.

*** Reduce the urea dose by 10 kg per acre, if the recommended amount of DAP is to be applied.

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

Time and Method of Fertilizer Application : Drill all fertilizers at sowing. In case nitrogen is to be applied in the form of urea, it should be applied just before pre-sowing irrigation (*rauni*).

Production of Pure Seed : The foundation seed should be procured from some recognised agency. The crop intended for seed production should be given special care by removing the off type and diseased plants at frequent intervals. Due attention should be paid at the time of harvesting to avoid mixture.

Harvesting : The crop should be harvested immediately after it ripens otherwise it might lodge and shatter grain because of wind storms.

Plant Protection

(a) Insect Pests

Corn leaf aphid is a very serious pest of barley. Control measures against insect pests are the same as those in the case of wheat.

(b) Diseases

1. Stripe disease *(Drechslera graminea) :* Yellow to brown stripes appear on leaves. The plants become stunted and the leaves are shredded. Treat seed as given on page 19.

2. Covered smut *(Ustilago hordei) :* The entire ear, except the awns turn into a black compact mass of spores. Give the same seed treatment as recommended (See page 19). Sow the crop late and shallow to reduce seedling infection.

3. Loose smut *(U. nuda) :* The smut sori are enclosed in a fragile membrane which soon ruptures, releasing the dark dusty spore mass which is disseminated by wind, leaves the naked rachis behind. Treat seed as given on page 19.

4. Yellow rust *(Puccinia striiformis) :* Yellow pustules appear on leaves, forming stripes. When the attack is severe, leaf-sheath, awns and glumes are also affected. Grow resistant varieties like PL 807, DWRUB 52, VJM 201, PL 426, PL 419 and PL 172.

5. Seedling blight, leaf and glume blight - (*Bipolaris sorokiniana*) **:** Infects all the parts of the plant. In earlier stages may reduce crop stand. Elongated brown spots may be chlorotic, coalescing and may extend to the whole leaves and glumes causing blight. Grow resistant varieties or those which are less affected like PL 807, PL 172 and VJM 201.

WINTER MAIZE

The cultivation of winter maize will help in diversifying the rice-wheat dominated cropping pattern in the State.

Soil Type and Choice of Field : Maize thrives on well-drained sandy loam to silty loam soils. Fertile fields, rich in organic matter should be preferred. Fields that have trees should not be selected, as the shade adversely affects the plant growth and grain yield. However, the trees on the northern side of the field provide protection from cold.

Rotations : Rice-Maize and Maize-Maize.

Improved Varieties :

Buland (2003): It is a cold tolerant single cross hybrid having medium tall plants and medium ear placement. Leaves are large broad with rough surface. The tassel is open and of medium size. Glumes are green having anthocyanin coloration at the base. Ears are thick having bold, yellow orange flint grains. It matures in 178 days and its average yield is 31.0 q/acre.

Partap 1 (1983): It has strong, thick stem and is highly resistant to lodging. The ears are medium long; thick with tight husk cover. It matures in 180 days and yields about 25.0 q/acre.

Note : Locals are highly susceptible to cold and give very poor yield during winter season.

Agronomic Practices :

Land Preparation : Give four or five ploughings followed by plankings to make seedbed free from clods and weeds. Use a mould board plough or disc harrow for the cultivation.

Seed Rate : 10 kg seed is required to sow one acre.

Seed Treatment : The seed should be treated with Bavistin or Derosal or Agrozim @ 3 g per kg of seed. Use fresh seed (*kharif* produce). Seed from *rabi* produce can also be used provided it had been stored under low temperature and low humidity conditions. Improperly stored old seed shows poor germination under cold conditions.

Time of Sowing : 25 October to 30 November

Method of sowing : Sowing should be done on the southern slope of 60 cm apart east-west ridges by dibbling seeds 3-5 cm deep about 6-7 cm above the base of ridge. Keep the plant to plant spacing of 20 cm for hybrid Buland and Composite Partap 1. Tractor drawn ridger seed drill is most suitable for ridge sowing. Ridge sowing is always better than flat sowing but advantage increases with fall in temperature in late sowings. Sowing on ridges can even be done during December and January but yield is reduced by 20-40 per cent than normal sowing.

Intercropping : To make winter maize more remunerative, it can be intercropped with pea for green pods. Grow one row of pea in between the maize rows raised on flat beds. In this intercrop system, care should be taken to give frequent irrigation during the frosty period. The weed control should be done mechanically.

Winter maize can also be grown as intercrop by sowing one row of maize between two rows of autumn planted sugarcane from 25th Oct. to 10th Nov. after giving irrigation. Additional dose of 45 kg N, 16 kg P_2O_5 and 8 kg K_2O should be applied to this crop.

Thinning : If the plant population is higher than recommended, remove the excess plant so as to have plant-to-plant distance of about 20cm. Thinning may be carried out with first hoeing or earlier.

Gap Filling : Gaps can be successfully filled by transplanting at the time of first irrigation. The plants for transplanting can be taken from the same or other field wherever stand is more than required or from nursery sown specifically for this purpose. It is desirable to use seedlings 4-6 days older than the crop when sowing has been done before mid-November and 7-10 days older when sowing has been done after mid-November.

Weed Control : Weeds can be effectively and economically controlled with herbicides. Apply Atrataf 50 WP (Atrazine) @ 500g per acre within 2-3 days of sowing in 200 litres of water. Atrataf 50 WP @ 600g/acre can also be sprayed post-emergence 30-35 days after sowing. These herbicides are very effective against *Phalaris minor (Gulli danda),* wild oats (jaundhar), *Chenopodium album (Bathu), Melilotus* spp. (Khandi) etc.

Weeds can also be controlled by giving 3 or 4 hoeings preferably with improved wheel hand hoe at one month's interval.

Note : In fields, where herbicides have been applied and need re-sowing, do not sow wheat/*raya*/ barley/oats/early cucurbits etc., as their germination is adversely affected by these herbicides. In situation like this, an early crop of maize fodder/sugarcane can be sown in February.

Earthing up : The ridge-sown crop should be earthed up in the second fortnight of January after the application of the second dose of fertilizer.

Irrigation : Irrigation requirements are the same as those of wheat crop till mid-March but additional 2 or 3 irrigations will be required afterwards. Apply first irrigation 3-4 weeks after germination. Apply subsequent irrigation at 4-5 week intervals up to mid-March and thereafter at 1-2 weeks intervals depending upon rainfall and temperature. It is desirable to apply light irrigations, as flooded crop has been observed to suffer from cold damage. The crop should not get water stress during flowering and grain development stage.

Fertilizer Application : Winter maize has been observed to be highly responsive to fertilizers. Cold damage has also been observed to be less on healthy crop. It is desirable to apply 8-10 tonnes of farmyard manure before sowing or green manure the field. Apply fertilizer on soil test basis in the interest of balanced application of nutrients. In the absence of a soil test, add the following amounts of fertilizers :

Nutrients* (kg/acre)			Fertilizers (kg/acre)			
N	P_2O_5	K_2O**	Urea (46%)	***DAP or (18:46%)	Superphos-phate *(16%)*	**Muriate of potash *60%)*
70	**24**	**12**	**155**	**55**	**150**	**20**

* 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.

*** Reduce the urea dose by 20kg per acre, if the recommended quantity of DAP is to be applied.

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

Time and Method of Fertilizer Application : Apply 1/3 N and all P and K as basal dose at the time of sowing. 1/3 N in mid-January and 1/3 N at pre-tasseling stage.

Note : If farmyard manure has been applied, reduce the amount of nutrients by 2kg of nitrogen and 1 kg of phosphorus for each tonne of farmyard manure applied. All the three doses of nitrogen should be equally reduced.

Zinc Application : In zinc deficient soils, broadcast 10 kg of zinc sulphate (21%) or 6.5 kg (33%) per acre at sowing. When zinc sulphate is to be applied after the zinc deficiency symptoms appear in the crop, apply zinc sulphate mixed with an equal quantity of dry soil along the 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 and 0.6 kg of unslaked lime with 200 litres of water to cover one acre.

Harvesting and Shelling : The crop is ready for harvesting even when stalks and leaves are somewhat green, but husks have dried. Shell ears when moisture content ranges between 15 and 20 per cent. Maize shellers operated manually or with power are available in the market.

Maize dehusker and conventional grain combines can also be used for threshing maize ears with husks to save labour involved in dehusking. The maize ears should preferably be dried 3-4 days after harvesting. However, some adjustments are necessary, details of which are given in chapter on Agricultural Engineering.

CULTIVATION OF TRANSPLANTED MAIZE : Maize can be successfully cultivated by transplanting in winter season in the fields vacated by potato, *toria* and early harvested sugarcane or as a companion crop in autumn sugarcane. The nursery sown from 10 to 20 November can be transplanted from mid-December to mid-January. For transplanting in the second fortnight of January, sow the nursery from 21 to 30 November. Do not transplant nursery older than 60 days.

To raise nursery for one acre, sow 10 kg seed in 1/10 acre by *kera* keeping a row-to-row distance of 20-22 cm. Apply farmyard manure @1.5 to 2.0 tonnes or 3.0 kg N, 2.5 kg P_2O_5 1.2 kg K_2O and 1.0 kg zinc sulphate to the seed bed before sowing nursery. Weed control may be carried out by pre-emergence application of weedicide as given for the directly sown crop or by hand hoeing. Uproot the nursery under good *wattar* with *Khurpa.* Keep the uprooted nursery under shade and transplant it as early as possible.

The seedlings may be transplanted on southern slope of east-west ridges or in flat fields. In flat fields, place seedlings in furrows and cover their roots manually. Transplanting on ridges gives relatively higher yield than in flat fields. Apply first irrigation immediately and second irrigation 8-10 days afterwards.

Weed control may be carried out by application of herbicides (atrazine or simazine) or hand hoeing. For simazine application, dose is as given for the directly sown crop. It should be applied at transplanting or after first irrigation when it is possible to walk in the field. Apply Atrataf 50 WP (atrazine) at 400g/acre in 200 litres of water at transplanting or upto 4 weeks after transplanting on heavy textured soils. The dose of this herbicide may be reduced to 200g/acre on light textured soils. If maize is transplanted in the area in which nursery was raised, the weedicide should not be applied again after transplanting.

Apply 60 kg N in three equal splits, first as a basal dose, second by the end of February and third at the pre-tasseling stage. The other cultural practices including the application of other nutrients and plant protection measures are the same as those of the direct sown crop.

BABY CORN CULTIVATION

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 vegetable and preparing pickle, *pakora* and soup. Baby corn salad and soup is a delicacy in hotels, air line and shipping companies because of crispiness and sweet flavour. Baby corn has export potential as it is very extensively consumed in developed countries. After picking baby corn ears, rest of the plant can be used for feeding cattle.

Partap 1 is the most appropriate variety for taking baby corn crop during winter season which gives on an average of 9.0 q/acre yield of dehusked ears. The sowing time for baby corn crop is same as that for grain crop viz. end October to end November. However, it can be grown through transplanting in the month of December and January. Sow the crop having row-to-row spacing of 60 cm and plant-to-plant of 10-15 cm using 20kg seed/acre. Apply 50kg N/acre in two equal splits at sowing and mid-January. 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 plants 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 required to raise crop are same as for grain crop.

Seed Production of Composite :

The seed of Partap-1 can be used by the farmers for 3-4 years without marked reduction in yield, provided the following precautions are taken to maintain genetic purity.

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 field 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 around.

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.
4. The seed of Partap-1 can be produced during Kharif season also.

Seed Production of Hybrid

The seed of hybrid Buland should be produced during kharif season only.

Plant Protection

A. Insect Pests :

There is no serious pest on *rabi* maize at present. Therefore, no pest control measures are required. Negligible incidence of following pest has been noticed.

Army worm : The larvae feed on the tender leaves of the whorl or may eat out the whole leaf including the mid-rib. Presence of faecal pellets on the whorl leaves indicates the occurrence of this pest. Attack is relatively more on the border rows adjoining wheat field in March. If necessary, control this pest by spraying 250g Sevin 50WP (carbaryl) or 35 ml Cymbush 25 EC (cypermethrin) or 40 ml Sumicidin 20 EC (fenvalerate) in 60 litres of water per acre.

B. Diseases :

Incidence of seed rots and seedling blights, common rust and post-flowering stalk rots has been observed. Their symptoms and control measures are given below :

1. Seed rot and seedling blight, *(Fusarium, Penicillium, Aspergillus spp.) :* Poor germination, unthrifty seedlings and seedling mortality. Treat the seed with Bavistin or Derosal or Agrozim @ 3g/ kg seed.

2. Common rust *(Puccinia sorghii) :* Circular to elongated brown pustules appear on both surfaces of the leaf. Pustules rupture and turn black on maturity. Grow the recommended variety. Give three sprays of Indofil M-45 @250g/100 litres of water per acre at 15 days interval. Start first spray in the first week of March.

3. Post-flowering stalk rots, *(Macrophomina phaseolina, Cephalosporium maydis, Fusarium spp.) :* All the stalk rots result in wilting of plants after flowering followed by weakening of stem. Infection with *M. phaseolina* result in black sporulation in the pith region. Grow recommended varieties.

No incidence has been observed of most of the diseases prevalent during *kharif* season, namely maydis leaf blight, brown stripe downy mildew and pre-flowering stalk rots.

Reaction to Cold : The crop takes longer time to germinate in *rabi* than in *kharif* season. The crop sown from 25 October to 10 November emerges in about 8-10 days. Later sown crop takes 12-15 days to emerge. The crop remains stunted in growth till end of January. Sometimes the leaves become pale yellow and may even partly dry. But the growing point is not damaged. As soon as the season warms up, there is a very quick recovery in growth. Therefore, follow normal package of practices in winter months.

C. Birds (see under management of Rodents & Birds)

SPRING MAIZE

Cultivation of spring maize has recently become very popular in the districts of Hoshiarpur, Nawanshahar, Jalandhar, Ropar and Gurdaspur.

Single cross hybrid varieties PMH1, PMH2 and JH3459 recommended for *kharif* season can be grown for spring season as well.

Agronomic Practices

Land Preparation : Give four or 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 Method of Sowing : The sowing may be done using 10 kg seed per acre by dibbling seed preferably 6-7 cm high on the southern side of 60 cm spaced East-West ridges for early emergence and good vigour. Keep plant to plant spacing of 20 and 15 cm for long and short duration hybrids respectively. Take special care to apply irrigation as per the need of the crop to evade high temperature stress during grain filling period.

Seed Treatment : The seed should be treated with Bavistin or Derosal or Agrozim @ 3 g per kg seed.

Time of Sowing : 20 January to 15 February. The crop sown after mid February may encounter high temperature stress causing desiccation of pollen resulting in poor seed setting.

Hoeing and thinning : Give two hoeings about 15-30 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 15-20 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 vide 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.

Fertilizers Applications : Apply the following amounts of inorganic fertilizers.

Varieties	Nutrients (kg/acre)			Fertilizers* (kg/acre)				
	N	P_2O_5	K_2O	Urea (46% N)	***DAP (18% : 46%	or Super or phosphate (16%	Niatro-Phosphate (20%)	** Muriate of Potash (60%)
PMH 1	50	24	12	110	55	150	125	20
PMH 2 JH 3459	35	12	8	75	27	75	62	15

* 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".

To all recommended varieties drill one third of nitrogen and the entire quantity of phosphorous 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.

i) 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 phosphorous, potassium, zinc and nitrogen recommended as basal dose.

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

Zinc deficiency : Follow recommendation given in case of winter maize.

Harvesting and Threshing : As mentioned in case of winter maize.

Plant Protection Measures

1. Insect Pests

Maize shoot fly : Maize shoot fly is most serious pest of spring maize and Sathi maize grown during summer season in Punjab. It attacks very young (3-4 days old) seedlings, producing deformed, twisted and dead hearted plants. For its control, apply Furadan 3 G (carbofuran) @ 5 kg/acre or Thimet 10 G (phorate) @ 4 kg/acre in the furrows at the time of sowing or treat the seed with Gaucho (imidacloprid) 600 FS @ 6.0 ml/kg seed one day before sowing.

Jassid, thrips, pyrilla, grey weevil and leaf-feeding insects

These pests cause a serious loss to the sathi crop during March to May; they also 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 : Follow recommended control measures as given in case of winter maize.

Cultivation of Maize in summer

Maize can also be sown in summer after harvesting of wheat. Punjab Sathi-1 (1994) is most suitable variety for this season. It is a heat tolerant, extra early maturing composite variety, suitable for growing during summer season as a catch crop. It matures in about 70 days. The plants are short with medium ear placement. Leaves are narrow, short, semi-erect to erect. The tassel is light and open. The silks are generally light green. The ears are short and thin with tight husk cover. The grains are small, orange flint. Its average grain yield is 9 q/acre.

It can be sown from mid March to end April by using 6 kg seed per acre. The seed should be treated with a fungicide such as Bavistin or Derosal or Agrozim @ 3 g per kg seed. Sow the seed 3-5 cm deep in lines 30-37 cm apart and thin out the plants about 15 days after sowing at the time of first hoeing keeping a plant to plant distance of 15-20 cm. Maize can also be grown without any preparatory tillage with zero till drill after conventional or zero till sown wheat. Give one or two hoeings about 15-30 days after sowing or follow chemical weed control method as described in case of spring maize. Adequate water apply is essential throughout the crop season particularly during the pre-tasselling and silking stages. Apply 55 kg urea, 27 kg of DAP or 75 kg or superphosphate or 62 kg of nitrophosphate and 15 kg of Muriate of potash per acre. Apply whole phosphorus, potassium and one half of nitrogen at sowing and the remaining one half one month later. If maize follows wheat, which had received the recommended quantities of phosphorous and potassium, omit the application of these nutrients to it. Follow other necessary precautions regarding use of fertilizers and zinc deficiency as highlighted in case of spring maize. Maize shoot fly is the most serious pest of this crop. For the control of this insect and other pests and diseases that may damage this crop follow various control measures as explained in case of spring maize.

2. PULSES

GRAM

Gram is an important *rabi* pulse crop of Punjab. It registered an area of 2.1 thousand hectares and a production of 2.7 thousand tonnes in 2010-2011. The average yield was 1300 kg per hectare (520 kg/acre).

Climatic Requirements : Gram is a winter season crop but severe cold and frost are injurious to it. It is primarily a crop of low-rainfall areas, but gives good returns in irrigated conditions as well. Excessive rains soon after sowing or at flowering and fruiting or hail-storms at ripening cause heavy loss. Sometimes there is an early onset of summer which reduces the growing period of this crop, hastens maturity and reduces the yield.

Rotations : Gram in rotation with cereal crops helps in controlling soil-borne diseases. The common rotations are *Kharif* fallow-*Gram, Kharif* fallow-*Gram+Wheat/Barley/Raya/Taramira, Chari-Gram, Bajra-Gram* and *Rice/Maize-Gram, Rice-Gram-Summer Moong.*

Improved Varieties

Desi gram (Irrigated)

PBG 5 (2003) : It has thick stem with dark green foliage. It matures in about 165 days. Its seeds are medium bold (18 g/100 seeds weight) with dark brown appearance. This variety is fairly resistant to Ascochyta blight and wilt complex (wilt, root rot and foot rot). Its average yield is 6.8 quintals per acre.

GPF 2 (1994) : The plants are semi-erect with lush green leaves and long fruiting branches with two seeds per pod. It has bold seeds and matures in about 170 days. Its average yield is 7.6 quintals per acre.

PBG 1 (1987) : The plants are tall with erect growth habit and long fruiting branches. It has high degree of resistance to Ascochyta blight and wilt complex. It takes about 160 days to mature. It has bold seeds of brownish colour. It yields about 6.4 quintals per acre.

Desi gram (Rainfed)

PDG 4 (2000) : Its plants are erect with dark green foliage. It bears long fruiting branches arising from the base. It has bold seeds and matures in about 160 days. It is fairly resistant to wilt, foot rot, root rot and blight. Its average yield is 7.8 quintals per acre.

PDG 3 (1997) : It is semi-erect with dark green leaves and long fruiting branches. It has bold seeds and matures in about 160 days. Its average yield is 7.2 quintals per acre.

Kabuli *gram*

L 552 (2011) : It is early in flowering and matures in 157 days. It is tall and erect variety. It has large pods and bold seeds (33.6 g/100 average seed weight). The seeds are creamy white in appearance with good culinary properties. Its average yield is 7.3 quintals per acre.

BG 1053 (2001) : It is early in flowering and matures in about 155 days. Its growth habit is semi-erect. This variety has bold seed (26.8g/100 seeds weight) and creamy white in appearance. It is fairly tolerant to wilt, root rot and foot rot. Its average yield is 8.0 quintals per acre.

L 550 (1974) : It is very early in flowering and matures in about 160 days. It has bushy growth habit. Its seeds are of medium size (21.3 g/100 seeds weight) and creamy white with a very attractive round shape. Its average yield is 6.0 quintals per acre.

Varieties Recommended for Various Areas/Conditions

Varieties	*Areas/Conditions for which recommended*
PBG 5, PBG1	Irrigated conditions in humid areas comprising the districts of Gurdaspur, Hoshiarpur, Ropar, Shaheed Bhagat Singh Nagar, Tarn Taran and Amritsar.
L552 GPF 2, BG 1053 and L 550	Irrigated conditions in the entire state except humid areas.
PDG 4 and PDG 3	Rainfed conditions in the entire state except humid areas.

Soil Type : Gram grows best on well drained light to medium textured soils. Saline, alkaline or waterlogged soils are not suitable for its cultivation.

Agronomic Practices

Preparatory Tillage : Gram does not require fine tilth. The soil should be opened up well, as loose and well-aerated soil restricts the wilt attack and increases the grain yield. Deep tillage upto 22.5 cm depth has been found to increase the yield. Deep tillage may be done during July and August. It eradicates the weeds, loosens the soil and promotes the seepage of rain water. It also helps the plants to develop deep roots.

Conservation of Soil Moisture Under Rainfed Situation : In fields kept fallow during *kharif* conservation of soil moisture during the rainy season ensures a successful rainfed gram crop. Adopt following measures to conserve the maximum amount of moisture in the soil:

(a) Level the field before the monsoon rains set in.

(b) Divide each field into small plots and make strong bunds so that the rain water does not run off.

(c) Do not allow weeds to grow, as they rob the soil moisture and nutrients.

(d) Open up the land with the first shower of rain with a plough. Plough deep with subsequent showers of rain. Water is readily absorbed in the cultivated soil and the loss through evaporation and drainage is also minimized. Towards the end of the monsoon season, the ploughing should invariably be followed by planking.

(e) Plough the field only once, preparatory to sowing. However, if the soil appears to be deficient in moisture, run a roller about a week before sowing. This will help in bringing moisture near the soil-surface for the germination of seed.

Time of Sowing : The optimum sowing time for *desi* gram under rainfed conditions is from October 10 to October 25. Under irrigated conditions both *desi* and *Kabuli* gram should be sown from *October 25 to November 10.* The early-sown crop suffers from wilt owing to high temperature at that time. It also makes excessive vegetative growth which results in poor seed-set. On the other hand, the late-sown crop makes poor vegetative growth, with inadequate root development which results in low yield. This can be partly compensated by increasing the seed rate.

Method of Sowing and Seed Rate : Gram should be sown by the *pora* method in rows 30 cm apart. The seed should be placed 10-12.5 cm deep, because the shallow-sown crop is more liable to be damaged by wilt. After rice particularly on heavy soils, sow two rows of gram on raised beds. Conventional seed-cum-fertilizer drill with broader flutes can be used for sowing gram (see Agril. Engg.). The optimum seed rate for *desi* and *kabuli* gram are 15-18 kg and 37 kg per acre, respectively. For variety PBG 5 use 24 kg seed per acre. Seed rate of *desi* gram should be increased to 27 kg per acre in the case of second fortnight of November sowing and to 36 kg per acre in case sowing is done in the first fortnight of December.

Seed Treatment : Treat the seed with insecticide followed by fungicide before inoculation as given below :

i) Insecticide : In termite infested soil, treat the seed before sowing with chlorpyrifos 20 EC @ 10 ml/kg seed. Dilute 180 ml of chlorpyrifos in half litre water and spray the same on 18 kg seed of *desi* gram spread as a thin layer on the pucca floor or tarpaulin or polythene. Use 370 ml of insecticide in 1 litre water for 37 kg seed of *kabuli* gram. Mix the seed properly and allow drying. Seed treatment can also be done effecively with a seed treating drum.

ii) Fungicide : Treat the seed with Captan or Captaf or Bavistan @3g or Rovral @2.5g per kg of seed.

Seed Inoculation : Inoculate the seed with *Mesorhizobium* culture/*Mesorhizobium* and Rhizobacterium cultures at the time of sowing for getting higher productivity of gram. Moisten the seed recommended for one acre with minimum amount of water. Mix thoroughly single packet of *Mesorhizobium*/both culture packets of *Mesorhizobium* and Rhizobacterium with it and dry it in shade. Sow the seed after inoculation. The inoculation of seed with *Mesorhizobium* increases the grain yield by 7% whereas application of consortium culture enhances the grain yield by 13%. *Mesorhizobium* and Rhizobacterium can be applied simultaneously with fungicide. If the seed is to be treated with insecticide, then first apply insecticide followed by fungicide and *Mesorhizobium*. *Mesorhizobium* and Rhizobacterium cultures are available with the Department of Microbiology, PAU, Ludhiana.

Weed Control : One or two hand-hoeings preferably with improved wheel hand hoe at 30 and 60 days after sowing help to keep the weeds under check.

Alternately, pre-plant application of Treflan 48 EC (trifluralin) at 1.0 litre or pre-emergence application of Stomp 30 EC (pendimethalin) at 1.0 litre per acre can be used for controlling annual

weeds from irrigated gram. In case, Treflan is to be used sow the crop by drilling and do not give planking.

Irrigation : Where irrigation facilities are available, give a heavy pre-sowing irrigation (*rauni*). It will ensure deep rooting for proper utilization of soil moisture. Afterwards, give one more irrigation between mid-December and end-January depending upon the date of sowing and the rainfall. This irrigation reduces the incidence of wilt disease. In no case, should this irrigation be given earlier than 4 weeks after sowing. If early rains are received, delay the irrigation. Excess of irrigation enhances vegetative growth and depresses grain yield. Do not irrigate the crop if it is sown after rice particularly on heavy soils. Irrigation applied on such soils causes heavy damage to the crop. Irrigation can be applied to gram sown after rice on raised beds under water stress conditions especially at pod initiation stage.

Fertilizer Application

Recommended areas/situation	*Nutrients* (kg/acre)*		*Fertilizers (kg/acre)*		*Time and method of application*
	N	P_2O_5	*Urea (46%N)*	*Super phos-phate (16% P_2O_5)*	
			Desi gram		
Irrigated and Unirrigated	6	8	13	50	Drill all fertilizers at sowing.
			Kabuli gram		
Irrigated	6	16	13	100	-do-

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

Harvesting : Harvest when the pods mature and the plants dry up. Harvest with a sickle. Do not uproot the plants and deprive the soil of the root residues.

Plant Protection

(a) Insect Pests

1. Termite : Termites attack the crop especially at seedling stage and also near maturity. The pest can be generally observed feeding on roots or near the root zone of the damaged plants. The affected plants dry up and can be pulled out easily. The incidence of pest is more in light soils.

Treat the seed before sowing with chlorpyrifos 20 EC @ 10 ml/kg seed. For details, see under seed treatment.

2. Gram caterpillar (*Helicoverpa armigera) :* The larvae damage the gram crop by feeding on leaves, flower buds, flowers, pods and grains in the pods. Spray 200 ml indoxacarb 14.5 SC or 60 ml spinosad 45 SC or 100 ml Sumicidin/Fenlik/Agrofen 20 EC (fenvalerate) or 160 ml Decis 2.8 EC (deltamethrin) or 80 ml Cymbush 25 EC (cypermethrin) in 80-100 litres of water per acre or dust 10 kg Malathion 5% dust (malathion) per acre at the start of pod formation and repeat after two weeks, if necessary.

Precaution : For consuming any part of raw gram plant, observe a waiting period of 20 days after the spray of any insecticide mentioned above.

Stored Grain Insect Pests : (See Appendix V)

(b) Diseases :

1. Blight *(Ascochyta rabiei) :* Dark-brown spots studded with dot- like bodies are produced on the stem, branches, leaflets and pods. Even the seeds in the pods are infected. On pods and leaves, the dot-like bodies are concentrically arranged. Shoot terminals are specially liable to attack. In the event of excessive rains, whole crop may be blighted and killed rapidly.

Treat the seed as given under fungicide on page 31. Give 3-5 sprays of Indofil M-45 or Captan or Captaf or Kavach (360g/acre) in 100 litres water at 15 days intervals. Give first spray immediately on appearance of the disease. Grow comparatively resistant varieties PBG 5 and PBG1. After harvest, the diseased plants should not be allowed to stand in the field but should be destroyed by burning. Use disease free seed.

2. Grey mould *(Botrytis cinerea) :* Small water soaked spots are produced on leaflets. Spots on infected leaves become dark brown. Under humid conditions, erect sporophores of the fungus are produced on flowers, leaves, growing tips, branches and pods. At the point of infection, soft rotting of the tissue occurs. Flowers and growing tips are more vulnerable. The fungus forms dark grey to black sporodochia on infected tissue.

Treat the seed as given under fungicide on page 31. Give one spray of Indofil M-45 @ 350g or Baytan 200g or Bayleton 200g in 100-120 litres of water/acre immediately on the appearance of the disease symptoms particularly in February or March.

3. Wilt *(Fusarium oxysporum f. sp. ciceri) :* Affected plants show drooping of petioles and dull green colour in the initial stage. Slowly all the leaves turn yellow and become straw coloured. The most characteristic symptom of this disease is vascular dis-colouration which is dark brown to black. Sometimes only one sided branches are affected resulting in partial wilting.

Grow wilt tolerant desi varieties like PDG4, PDG 3, GPF2, PBG 5, PBG 1 and *Kabuli* varieties BG 1053 and L552. Conserve soil moisture in rainfed areas. Plough the field with a furrow turning plough to eradicate weeds and promote water infilteration. Sow the crop as per recommendations.

4. Stem rot *(Sclerotinia sclerotium) :* The disease attacks all the above ground parts of the plant. The main stem is usually affected at the soil level. The affected parts are shredded and covered with white mycelium and black sclerotia. The whitish, fluffy fungal growth can also be seen on the soil surface. The seed should be free from sclerotia. Sow the gram crop from October 25 to November 10 to escape the disease attack. Collect and destroy the diseased debris soon after harvesting the crop. In the month of May or June, flood the field after deep ploughing and do not leave it fallow. Rotate gram with non-susceptible crops such as wheat and barley.

5. Foot rot : *(Opercullela padwickii) :* Light brown to dark-brown lesions appear on the collar region of the plants. Later, these lesions become black and affect the basal tap root. Complete girdling in the collar region takes place. Sow the crop from 25 October to 10 November. Follow crop rotation with non-susceptible crops such as wheat and barley.

LENTIL

Lentil is a protein rich pulse crop of Punjab. It occupied an area of 1.1 thousand hectares with a production of 0.74 thousand tonnes during the year 2010-2011. The average yield was 672 kg/ha (269 kg/acre).

Climate : It is hardy and can tolerate frost and severe winter. It can be grown with the moisture conserved in the soil during the rainy season.

Rotations : Rice-Lentil-Summer Moong, *Desi* Cotton-Lentil and Groundnut-Lentil.

Improved Varieties

LL 931 (2009) : Its plants are short, erect with profuse branching and bear more number of pods. It has dark green leaves, pink flowers, non-pigmented green pods and rudimentary tendrils. It matures in 146 days. It is fairly resistant to rust and possesses good tolerance to pod borer. Its seeds are medium bold with greyish brown colour and light flecks. It has good culinary properties. Its average yield is 4.8 quintals per acre.

LL 699 (2001) : The plants are short, erect with profuse branching. Its plants are dark green, bear high number of pods and are early in flowering. It matures in 145 days. It is moderately resistant to rust and blight diseases and possesses good tolerance to pod borer. It has good culinary properties. Average grain yield is 5 quintals per acre.

Soil Type : All soils, except those which are saline, alkaline or waterlogged are suitable for raising this crop.

Agronomic Practices

Preparatory Tillage : The land should be ploughed two or three times to pulverise it well. Each ploughing should be followed by planking. The field should be free from weeds and clods at the time of sowing.

Time of Sowing : The crop may be sown in the second fortnight of October in the sub-montane areas and from end of October to first week of November in other areas. Later sowings may be done under compelling circumstances but such delayed sowings invariably result in reduced yield especially in the central districts.

Seed Treatment : Treat the seed with Captan at the rate of 2g per kg seed before sowing.

Method of Sowing and Seed Rate : The crop should be sown in lines 22.5 cm apart by seed cum fertilizer drill or *pora* method. It can also be sown by broadcasting the seed following the paddy crop where the shortage of time as well as field conditions do not permit good land preparation. Under late-sown conditions, the row-spacing should be reduced to 20 cm. The optimum seed rate is 12-15 kg per acre.

Inoculation : The lentil seed should be treated before sowing with the recommended *Rhizobium* culture. 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 seed with *Rhizobium* increases the grain yield by 12-15%. *Rhizobium* and fungicide can be applied simultaneously. The culture is available with the Department of Microbiology, Punjab Agricultural University, Ludhiana.

Weed Control : One or two weedings preferably with improved wheel hand hoe 30 and 60 days after sowing are enough. Alternatively, weeds can be controlled effectively with pre-emergence application of either Stomp 30 EC 600 ml/acre or Treflan 400 ml/acre integrated with one hand hoeing at 60 days after sowing.

Irrigation : Lentil requires one or two irrigations depending upon the rains during the growing season. In case of one irrigation, apply it at 6 weeks after sowing and in case of two irrigations, apply one at 4 weeks after sowing and second at flowering or pod formation stage depending upon the prevailing weather.

Fertilizer Application : Being a leguminous crop, apply 5 kg N (11 kg of Urea) per acre. Drill 8 kg P_2O_5 (50 kg superphosphate) per acre when the seeds are inoculated with *Rhizobium* and use 16 kg P_2O_5 (100 kg superphosphate) per acre when seeds are not inoculated. Apply both the fertilizers at the time of sowing.

Harvesting : The crop should be harvested when the plants dry up and pods mature.

Plant Protection

(a) **Insect Pests :** The lentil pod-borer causes damage to the crop by feeding on leaves, flower buds, flowers, pods and grains in the pods. It can be controlled by spraying 900 g Sevin/Hexavin 50 WP (carbaryl) in 80 litres of water per acre at flower initiation. Repeat the spray after three weeks, if necessary.

Stored Grain Insect Pests: (See Appendix V)

(b) Diseases

1. Blight *(Ascochyta fabae f.* sp. *lentis) :* Dark brown spots are produced on stem, branches, leaves and pods. The lesions on the stems and branches are elongated. The characteristic symptoms of the disease are black pinhead-like pycnidial bodies of the fungus on the spots in the form of concentric rings. On tender branches spots rapidly girdle the branch and parts of the plant above the girdle, wilt and dry. Use disease free seed. Treat the seed with Captan @2g/kg seed. Destroy the diseased plant debris after harvest to reduce the inoculum of the fungus.

2. Rust *(Uromyces fabae) :* Yellowish white pycnial and aecial pustules develop on stems, branches, leaves and pods. These may appear singly or in small groups. Later on brown uredia are formed. Small pustules may coalesce to form large pustules. In later stage of the crop, dark brown to black telia are formed. In severe cases, affected plants dry up and give burnt appearance. Use clean seed free from diseased plant debris. Grow tolerant variety LL 931.

FIELD PEA

Field pea was grown on 3.2 thousand hectares during 2010-2011 and a production of 4.1 thousand tonnes. The average yield was 1278 kg per hectare (511 kg/acre). It is mainly grown in Hoshiarpur district under rainfed conditions. The crop can successfully be grown in other parts of the State under limited irrigation conditions with low inputs.

Climatic and Soil Requirements : The crop requires cool climate during its vegetative phase. However, severe cold and frost may adversely affect flowering and fruiting. Field pea can be grown on well drained sandy loam to clay loam soils.

Rotations : The crop can be grown in fallow-field pea rotation under rainfed conditions and maize-field pea, maize/rice/fodder/other *kharif* crop-field pea-summer *moong*/summer mash/ summer fodders under irrigated conditions. The crops such as summer vegetables, sugarcane and cotton can also be sown in time after field pea.

In areas of Hoshiarpur, Ropar, Shaheed Bhagat Singh Nagar and Gurdaspur where maize is grown in *Kharif* season, it is more remunerative to grow maize in rotation with field pea instead of wheat. Maize following field pea gives 2.0 to 2.5 q/acre additional yield as compared to when it follows wheat and the yield of maize further increases by 2.0 to 2.5 q/acre if it is sown after incorporation of field pea straw into the soil.

Improved Varieties

Field Pea 48 (1993) : It is an early maturing variety with erect, semi-dwarf plant type. It matures in 135 days. It has very attractive light green, bold seeds, slightly wrinkled and possess high swelling capacity. It has very good nutritional and cooking quality. It has high protein content. Due to its early maturity, it escapes heavy damage from pod borer and powdery mildew. It gives an average grain yield of 8 quintals per acre.

PG 3 (1977) : This variety has a dwarf plant type with white flowers. It is early in flowering and maturity. The grains are creamy white, slightly wrinkled and possess high swelling capacity. It has very good cooking quality. It escapes heavy damage from pod borer and powdery mildew due to early maturity. It matures in about 135 days. It yields about 7 quintals per acre.

Agronomic Practices

Preparatory Tillage : Give two or three ploughings followed by plankings to obtain a fine seed bed.

Time of Sowing : The optimum sowing time for field pea is from end-October to mid-November, however its sowing can be extended upto end of November with slight reduction in yield.

Method of Sowing and Seed Rate : The crop should be sown in rows at a spacing of 30 cm by *pora* or *kera,* using 25-30 kg seed per acre.

Seed Treatment : Treat the seed with Captan @ 2 g/kg seed before sowing.

Inoculation : The inoculation of pea seed with the specific culture (*Rhizobium leguminosarum*) ensures proper nodulation and increases grain yield by 8-10%. *Rhizobium* and fungicide can be applied simultaneously. The *Rhizobium* culture can be obtained from the Department of Microbiology, Punjab Agricultural University, Ludhiana. The method of *Rhizobium* treatment is same as mentioned in gram and lentil.

Fertilizer Application : Apply 12 kg nitrogen (26 kg Urea) and 16 kg P_2O_5 (100 kg superphosphate) per acre at the time of sowing by drilling along the rows.

Weed Control : The crop should be kept free from weeds by giving two hoeings preferably with wheel hand hoe at 3 and 6 weeks after sowing.

For efficient weed control use Stomp 30 EC (pendimethalin) 1.0 litre/acre as pre-emergence within 2-days of sowing. Dissolve herbicide in 150-200 litres of water and spray it uniformly over the entire field. Application of Stomp controls *Phalaris minor* and broadleaf weeds but not wild oats.

Irrigation : The crop should be sown after *rauni* irrigation. However, it can be sown without irrigation after paddy if sufficient moisture is available. It requires two more irrigations, first during pre-flowering around end of December and second at pod-formation stage. In certain areas the crop may need only one irrigation, depending upon the timing of rainfall during crop season. The crop can be grown rainfed in submontane areas.

Harvesting : The crop is ready for harvesting in the 3rd week of March.

Plant Protection

(a) Insect Pests

1. Pea stem fly *(Ophiomyia phaseoli)* **:** It causes serious damage in the early sown crop at the seedling stage. Avoid sowing of the crop earlier than mid-October to check its attack.

2. Pea thrips *(Thrips indicus)* **:** It causes severe damage to the young crop by sucking cell sap. Spray 400 ml Rogor 30 EC (dimethoate) in 80-100 litres of water per acre when the attack starts and repeat after 15 days, if necessary.

3. Pea leaf miner *(Chromatomyia horticola)* **:** The larvae feed by making tunnels in the leaves and cause serious damage during December-March. Spray 400 ml Rogor 30 EC (dimethoate) in 80-100 litres of water per acre when the attack starts and repeat after 15 days, if necessary.

4. Pea aphid *(Acyrthosiphon pisum)* **:** It sucks cell sap resulting in yellowing and drying of leaves. Spray 400 ml Rogor 30 EC (dimethoate) in 80-100 litres of water per acre when the attack starts and repeat after 15 days if necessary.

5. Pod borers *(Etiella zinckenella, Lampides boeticus and Helicoverpa armigera)* **:** The larvae damage the crop by feeding on flowers and pods. Spray 900 g Sevin/Hexavin 50 WP (carbaryl) in 80-100 litres of water per acre when the attack starts and repeat after 15 days, if necessary.

For control of American bollworm (*Helicoverpa armigera*) spray 2 litres Durmet 20 EC (chlorpyriphos) or 800g Asataf 75 SP (acephate) in 100 litres of water with manually operated knapsack sprayer.

Caution : Pluck the harvestable green pods before spray and observe a waiting period of 7 days after spray for replucking the pods.

Stored Grain Insect Pests : (See Appendix V)

(b) Diseases

1. Powdery mildew *(Erysiphe polygoni)* **:** White floury patches, covering large areas appear on stems, branches, leaves and pods. Spray the crop with Karathane 40 EC @ 80 ml per acre using 100 litres of water. Three sprays may be given at 10 day intervals.

2. **Wilt** *(Fusarium oxysporum f.* sp. *pisi)* **:** Rotting of roots and yellowing of the lower most leaves is followed by wilting. Treat the seed with 2 g of Captan per kg seed before sowing. Avoid sowing earlier than the recommended date in badly infested areas.

3. Rust *(Uromyces viciae-fabae)* **:** Yellowish, reddish-brown spherical raised pustules appear on leaves, stems, branches and pods from December onwards. Give first spray of 400g Indofil M-45 in 100 litres of water by the end of December. Three subsequent sprays may be given at 10-day intervals. Keep the field free from *Rewari* weed which serves as a source of inoculum.

SUMMER *MOONG*

Summer *Moong* is a popular short duration pulse crop. It occupies an estimated area of about 50.0 thousand hectares. Due to its short duration it can fit well in many cropping systems. It has a great scope in rice-wheat cropping system.

Climatic requirements : *Moong* is considered to be the hardiest of all pulse crops. It requires a hot climate. *Moong* is also suitable as a *kharif* crop.

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

Rotations

Sugarcane/Potato/Cotton/Raya-Summer *Moong*, Summer *Moong*-Maize/Rice-Raya/Wheat, Summer *Moong*-Maize-Potato, Summer *Moong*-Rice-Potato, Summer *Moong*-Raya/Wheat, Summer *Moong-Kharif Moong*-Raya/Wheat and Summer *Moong*-Rice/Maize-Gobhi Sarson.

Improved varieties

SML-832 (2010) : It has erect and determinate plant type and medium stature. It bears pods in clusters and possesses early and synchronous maturity (61 days). Pods have thick coat of blackish brown colour at maturity. Each pod contains about 10 grains. Grains are green, medium sized and very shining with good culinary properties. Its average yield is 4.6 q/acre.

SML-668 (2002) : It has erect and determinate plant type and short stature. It bears pods in clusters profusely and possesses early and synchronous maturity (60 days). Pods are long with thick coat and each pod contains 10-11 seeds. Grains are very bold and shining with good cooking quality. It is tolerant to mungbean yellow mosaic virus (MYMV) disease and thrips. Average yield is 4.5 q/acre.

Agronomic Practices

Land preparation : Give two or three ploughings to the land followed by planking to crush the clods and eradicate the weeds. Summer *moong* can be sown without any preparatory tillage after the harvest of wheat. The sowing can be done with zero-till drill if there is no wheat straw in the field. In case of combine harvested wheat crop, summer *moong* can be sown with happy seeder in the presence of wheat straw. Zero tillage saves time, energy and money.

Seed rate : Use 15 kg. seed per acre for SML 668 and 12 kg seed for SML 832 varieties.

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

Time and method of sowing : Sow the crop from 20th March to 10th April. Its sowing can be done up to 3rd week of April. However, there is a risk of pre-monsoon showers at maturity.

Sow the crop in rows 22.5 cm apart. The plant-to-plant distance should be about 7 cm and sow 4 to 6 cm deep with seed drill/*kera*/pora/*Zero-till drill/happy seeder.*

Grow summer *moong* on raised beds : Sowing of summer *moong* in medium to heavy textured soils should be done on beds spaced 67.5 cm apart (37.5 cm bed top, 30 cm furrow) by using wheat bed planter. Sow two rows per bed with row spacing of 20 cm using the same quantity of seed, fertilizers and following other cultivation practices as in flat sown summer *moong.* Irrigation is applied in furrows by taking care that beds are not over flooded. This practice not only saves the crop from damage by rain especially at emergence but also saves about 20-30 per cent irrigation water along with 10 per cent increase in yield over flat sowing.

Weed control : One or two hoeings are recommended to keep 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) @ 600ml per acre on well prepared seed-bed and then sow the crop on the same day. Alternatively spray 1.0 litre Stomp/ Stamp 30 EC (pendimethalin) or apply 600 ml Stomp/Stamp 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 : Apply 3 to 5 irrigations to the crop depending upon the climatic conditions and water holding capacity of the soil. The last irrigation should be stopped about 55 days after sowing for obtaining high yields and synchronous maturity.

Fertilizer application : Drill 5 kg of N (11 kg of Urea 46% N) along with 16 kg of P_2O_5 (100 kg of single super phosphate 16% P_2O_5) per acre at the time of sowing to summer *moong* to be sown after wheat.

Summer *moong* sown after potato in rice-potato-summer *moong* and maize-potato- summer *moong* needs no fertilizer.

Harvesting and threshing : Harvest the crop when about 80% of the pods mature. Spike tooth type power thresher for wheat can be used to thresh *moong* after proper modifications. When about 80% of the pods mature apply Gramoxone (paraquat) @ 800 ml per acre, using 150-200 litres of water for combine harvesting of the crop. This practice avoid risk due to rainfall.

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

Insect Pests

Thrips : Summer *moong* crop is severely attacked by the thrips which is very small, dark brown insect, found in flower and cause flower-drop, deformation of pods, deterioration of grain quality and ultimately high reduction in yield. Some times there may be complete failure of the crop. Spray the crop at bud initation stage with 600 ml triazophos 40 EC or 100 ml of Rogor 30 EC (dimethoate) or malathion 50 EC (malathion) or 120 ml (metasystox) 25 EC (oxydemiton methyl) in 80 to100 litres of water per acre with manually operated knapsack sprayer.

Pod borer (*Helicoverpa armigera*) **:** Pod borer has become a limiting factor in the cultivation of summer *moong* in Punjab. Larvae of the borer feed on leaves, flowers, pods and seeds in pods, thus, causing heavy loss in yield. The larvae may be pale green, yellow, brown or black in colour measuring about 3-5 cm when full grown. Larval presence can be observed from damage to plant and from dark green faeces below the plants on the soil. Spray the crop at the appearance of larvae with 60 ml spinosad 45 SC or 200 ml indoxacarb 14.5 SC or 800 g acephate 75 SP in 80 to 100 litres of water per acre with manually operated knapsack sprayer. Repeat the spray whenever necessary.

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 lay eggs in masses covered with brown hairs on the lower side of leaves. After hatching, first and second instar larvae feed gregariously and sketetonize the foliage. Later on the grown up larvae disperse and feed singly. Besides leaves they also damage buds, flowers and pods.

Cultural control :

1. Ensure timely sowing of the crop.
2. Control the weeds, particularly *itsit/chapatti* as it acts as an alternate host for the tobacco caterpillar.

Mechanical 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.

Diseases

Mungbean yellow mosaic virus : It is a viral disease transmitted by whitefly. 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 SML-668 and SML 832 of *moong* and Mash-1008, Mash-414 and Mash-218 varieties of *mash*.
3. Whitefly can be controlled by spraying 40 g Thiamethoxam 25 WG or 600 ml triazophos 40 EC using 80-100 litres of water per acre.

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.

Rhizoctronia blight : It is caused by *Rhizoctronia 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 conspicuously seen in the field. Whitish web like growth develops on leaves in humid weather. Dark brown sclerotia develop on infected tissue. Infestation on crop comes from the weeds in the field. Keeping the field weed free helps to check the disease.

SUMMER *MASH*

Summer *mash* is grown on an estimated area of about 4.0 thousand hectares in Punjab.

Climatic and soil requirements : Short duration summer *mash* varieties (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-alkline or waterlogged soils. Its cultivation improves soil fertility.

Rotations : Summer *mash* can be grown after sugarcane/toria/raya/potato under irrigated conditions.

Improved varieties

Mash-1008 (2004) : It has erect, compact and determinate plant type. It is a short statured (25 cm) variety. It matures in about 72 days. Pod bearing is profuse and each pod contains 6-7 seeds. It is fairly tolerant to yellow mosaic virus and leaf crinkle virus. Average grain yield is about 4.5 quintal per acre. Grains are bold, blackish in colour, contain about 24 per cent protein and possess good culinary properties.

Mash-414 (1994) : It has erect, compact and determinate plant type with short stature (30 cm). It is a short duration variety and ripens in about 72 days. Pod bearing is profuse and each pod contains 6-7 seeds. Average grain yield is about 4.2 quintal per acre. Grains are bold, blackish in colour, contain about 23 per cent protein and possess good culinary properties.

Mash-218 (1988) : It has erect, compact and determinate plant type with short stature (30 cm). It is a short duration variety and ripens in about 75 days. Pod bearing is profuse and each pod contains 6 seeds. Average grain yield is about 4 quintal per acre. Grains are bold, dull black, contain about 23 per cent protein and possess good culinary properties.

Agronomic Practices

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

Seed rate : Use 20 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 from 15 March to 1st week of April at a row spacing of 22.5 cm. The plant-to-plant distance should be about 4-5 cm and sow 4 to 6 cm deep with seed drill/kera/pora.

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 requires 3 to 4 irrigations. The last irrigations should be stopped about 60 days after sowing for obtaining high yields and synchronous maturity.

Fertilizer application : Drill at sowing 5 kg N (11 kg of Urea 46% N) along with 10 kg of P_2O_5 (60 kg of single superphosphate 16% P_2O_5) per acre.

Harvesting : The crop should be harvested when 80 per cent of the pods mature. The matured crop should not be uprooted.

Plant Protection Measures : (See under summer *moong*).

3. OILSEEDS

RAPESEED AND MUSTARD

Rapeseed and mustard comprise *toria (Brassica rapa), taramira (Eruca sativa), raya (B. juncea), gobhi sarson (B. napus)* and *African sarson (B. carinata).* Varying levels of self and cross-pollination occur in different *Brassica* species. *Toria* and *taramira* are predominantly cross pollinated whereas *raya, gobhi sarson* and *African sarson* are broadly self pollinated. In trade, *toria, gobhi sarson* and *taramira* are categorised as rapeseed while *raya* and *African sarson* are categorised as mustard. Rapeseed and mustard were grown on 31 thousand hectares with a production of 41 thousand tonnes during 2010-2011 in the State. The average yield was 13.08 q/ha (5.23 q per acre). *Toria, gobhi sarson* and *African sarson* are sown exclusively under irrigated conditions whereas *raya* can be grown under both irrigated and rainfed conditions. *Taramira* is grown as rainfed crop only.

Climatic Requirements : The rapeseed and mustard crops grow well in areas having 25 to 40 cm of rainfall. *Taramira* is preferred in low-rainfall areas, whereas *raya, gobhi sarson, African sarson and toria* are grown in medium and high-rainfall areas.

Soil Type : The rapeseed and mustard grow best on well-drained, light-to-medium-textured soils. Whereas *raya, gobhi sarson* and *African sarson* may be grown on all soil types, *toria* should be grown preferably on loamy soils. *Taramira* does well on sandy and loamy-sand soils.

Rotations : Under irrigated conditions, the common rotations are:

Toria : Summer *moong*-*Toria*-Wheat; *kharif* Fodder-*Toria*-Wheat; *kharif* Fodder-*Toria*-Sunflower/ Potato (spring); *kharif* Fodder-*Toria*+*Gobhi Sarson*-*Summer Moong; Kharif* Fodder-*Toria*-Winter Maize (transplanted); *Kharif* Fodder-*Toria*-Sugarcane-Sugarcane ratoon; Paddy-*Toria*-Sunflower.

Raya : Early Fodder/Maize/*Bajra*-Raya-Summer *Moong; Cotton-Raya.*

Gobhi Sarson : Rice-*Gobhi Sarson*-Summer *Moong; Kharif* Fodder-*Toria*+*Gobhi Sarson*-*Summer Moong;* Cotton-*Gobhi Sarson* (transplanted);

African Sarson : Maize/Rice/Maize/Cotton/Groundnut/*Moong/Arhar-African Sarson; Bajra/* Sesamum/Guara-*African Sarson.*

Improved Varieties

Toria

TL 17 (2011) : This variety is more suitable for multiple cropping systems due to its early maturity than PBT 37. It matures in 90 days. It has profuse branching and pod bearing capacity. Its average yield is 5.2 q/acre. Its seeds contain 42.0 oil content.

PBT 37 (1994) : It is an early maturing variety suitable for toria-wheat rotation. It matures in 91 days. It has long main shoot laiden with pods and has profuse branching habit. Its seeds are dark

brown in colour and bold in size. Its average yield is 5.4 q/acre and its seeds contain 41.7% oil content.

TL 15 (1978): This variety takes about 88 days to mature. Because of its early maturity it is suitable in *toria*-wheat rotation. It yields 4.5 q/acre. Its oil content is 41 per cent.

Raya

RLC1 (2007) : It is the first mustard variety with low erucic acid (<2%) in the oil. Such an oil is considered healthy for human consumption. This variety is recommended for cultivation in South Western districts (Bathinda, Faridkot, Ferozepur, Muktsar and Mansa) of the state under timely sown and irrigated conditions. It is a tall variety with profuse branching and pod bearing. Its average yield is 6.62 q/acre and oil content is 37.8 per cent. It matures in 152 days.

PBR 210 (2002) : This variety is recommended for general cultivation in South Western region (Bathinda, Faridkot, Ferozepur, Mukatsar and Mansa) of Punjab under timely sown and irrigated conditions. This variety is medium tall with profuse branching and very high number of pods per plant. It has medium to large green leaves and thick stem. This variety is tolerant to white rust. Its average seed yield is 6 q/acre with 38% of oil content. It matures in 150 days.

PBR 97 (1997) : This variety is recommended for sowing under rainfed conditions in the State. It is 160 cm in height, has profuse branching and long main shoot with dense pods. The grains are medium bold with oil content of 39.8 per cent. On an average it yields 5.2 q/acre. It matures in 136 days.

PBR 91 (1994) : This variety is recommended for cultivation in South-Western region (Bathinda, Faridkot, Ferozepur, Mukatsar and Mansa) of Punjab under timely sown irrigated conditions. The variety is 170 cm in height with profuse branching habit. It has broad, thick, dark green leaves. Its seeds are bold and dark brown in colour having 37.6 per cent oil. It matures in 145 days. It has higher degree of resistance to white rust and is on a par with other varieties for reaction to *Alternaria* blight and insect-pests. Its average yield is 8.1 q/acre.

RLM 619 (1983) : This variety is recommended for general cultivation in the State under irrigated as well as rainfed conditions. It possesses bold seeds and has oil content of 43%. It has comparatively greater resistance to white rust, *Alternaria* blight and downy mildew. Its average yield is 8 q/acre. It is very suitable for sowing after cotton in cotton belt of the Punjab State. It matures in 143 days.

Gobhi Sarson

PGSH 51 (1994) : It is a tall, high yielding hybrid of *gobhi sarson.* It has pale green and serrated leaves and is profusely branched with intense pod bearing. Its yield is 7.9 q/acre. The seed oil content of this hybrid is 44.5 per cent. It has superior oil and seed-cake quality. It is recommended for irrigated, timely sown, high fertility conditions in *gobhi sarson* growing area. It matures in 162 days.

GSL 2 (1994) : This is the first ever atrazine herbicide resistant variety of *gobhi sarson* suitable for atrazine based weed management. It is recommended for cultivation under timely sown and irrigated conditions in Punjab. Its leaves are dark green and plants have comparatively close canopy.

It has tall plants with stiff stem and as such does not lodge. It takes about 160 days to mature. On an average it yields 6.8 q/acre. Its oil content is 44.5 per cent with superior oil quality.

GSL 1 (1985): This variety is recommended for general cultivation in the state. Its leaves are thick, smooth and sweet in taste and give quality *saag.* Its initial growth is slow and plants remain in vegetative phase till early February. As such, the crop escapes frost injury. Plants are stout and do not lodge easily. It takes about 160 days for maturity. Its yield is 6.7 q/acre. The seed possesses 44.5 per cent oil of good quality.

Gobhi sarson (Canola type)

Canola is an internationally accepted nomenclature for *Brassica* varieties having <2% erucic acid in oil and <30 micro moles glucosinolates/g defatted meal. The oil from canola variety is healthy oil for human consumption. The defatted meal from such varieties is specially suited as animal feed.

GSC 6 (2007) : This variety is recommended for cultivation in the state for timely sowing under irrigated conditions. Its growth habit is similar to GSC 5. It has lustrous bold seeds (4.1 g/1000 seeds). Its average yield is 6.07 q/acre, with oil content of 39.1 per cent. It matures in 145 days.

GSC 5 (2004) : This is a short statured and early maturing (147 days) variety recommended for general cultivation throughout the state. Its average seed yield is 5.43 q/acre. The seeds are brownish black, lustrous with 38.7 per cent oil content. Bolting in about 35 days old crop is a distinctive feature of this variety. Significant vegetative growth takes place after initial flowering.

Hyola PAC 401 (2004) : This hybrid is recommended for general cultivation in Punjab. It is medium statured and matures in 150 days. Its seeds are brownish black and lustrous. The 1000 seed weight is 3.5 g. It contains 42 per cent oil. The average seed yield is 6.74 q/acre.

African Sarson

PC5 (1995) : This variety is recommended for cultivation under irrigated conditions in South-West districts of Punjab. It is a tall growing variety having waxy leaves with low serration. It matures in 168 days. It is free from white rust and is resistant to *Alternaria* blight and tolerant to mustard aphid. On an average its yield is 8.0 q/acre. Its seeds are brown with 37.3 per cent oil. It is highly resistant to pod shattering. Crude fibre content of the variety is low and hence oil recovery is high.

Taramira

TMLC 2 (1990) : This variety is recommended for cultivation in Bathinda, Sangrur, Ferozepur and Kandi areas of Hoshiarpur, Gurdaspur, Ropar and Shaheed Bhagat Singh Nagar districts. It has longer main shoot length, more number of pods on main shoot and more seeds per pod. It gives an average seed yield of 2.9 q/acre with 36.6 per cent oil content. It matures in 150 days.

Agronomic Practices

Preparatory Tillage : A fine seedbed is required to ensure good germination. In irrigated areas, the first ploughing is done with a medium furrow-turning plough, followed by two to four ploughings with a *desi* plough or cultivator. Planking is done after every ploughing. In rainfed areas, one or two ploughings with *desi* plough or a cultivator each followed by planking are sufficient. *Toria* in particular requires a fairly moist seedbed for good germination, but too moist seedbed impairs its germination.

Seed Rate and Spacing : When sown pure, 1.5 kg seed per acre is used for rapeseed-mustard. These crops are sown in rows 30 cm apart and 4-5 cm deep. Plant to plant distance of 10 to 15 cm is kept except in case of *taramira,* in which it is 15 cm. *Gobhi sarson* should be sown in rows, 45 cm apart with plant to plant distance of 10 cm.

Time of Sowing : The time of sowing for crops sown pure is given below :

Period	*Crop/Variety*	*Remarks*
First fortnight of Sept.- Mid September	Toria : TL 17 TL 15 & PBT 37 Toria+ *Gobhi sarson*	Pure crop, short duration. Intercropping
Oct. 10 to Oct. 30	*Gobhi Sarson :* PGSH 51 GSL 2 and GSL 1, GSC 5, GSC 6 and Hyola (PAC 401).	Pure crop (direct seeding)
Whole October	African Sarson : PC 5 Taramira : TMLC 2	Pure crop (direct seeding)
Mid Oct. to Mid Nov.	Raya : PBR 91, PBR 97, RLM 619, PBR 210 and RLC 1.	For higher yield, early sowing should be preferred.
Mid. Oct. to End Nov.	Raya : RLM 619/ African Sarson : PC 5	Does well in late sown . conditions
Nov. to Mid Dec.	*Gobhi Sarson :* GSL1, PGSH 51 and Hyola PAC-401	Transplanting
	African Sarson : PC 5	Transplanting

When sown mixed with some other crop(s), the time of sowing of rapeseed and mustard is governed by the sowing of the main crop. In case the soil moisture is inadequate, the seed is mixed with moist soil and kept overnight before sowing. Seed mixed with soil increases the bulk and thus its uniform distribution in the field is facilitated.

Toria+*Gobhi Sarson* Intercropping : To get higher oilseed production, toria and *gobhi sarson* can be sown simultaneously 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. While toria will be harvested around mid-December, *gobhi sarson* will continue in the field till March. Average yield of both the crops is 12 q/acre (4q *Toria+8q Gobhi sarson).*

Method of Sowing : These crops are sown with a drill or a pora attached to a plough. Thinning is done three weeks after sowing to maintain plant to plant distance as per requirement depending on the crops. Manually operated oil seed drill can be used effectively for sowing these crops at the recommended seed rate and plant spacing. It ensures uniform placement of seeds at a uniform depth and row spacing is maintained with the help of markers provided in the machine. At 3 mm exposure length of flutted roller, desired seed rate of about 1.5 kg/acre can be achieved. For varying the seed rate, exposure length of the flutted roller is adjusted. The flutted roller used in this case is a combination of smaller flute and wider flute rollers.

Raya should be sown bi-directionally (in two directions) with 30 cm wide rows in the north-south direction and 45 cm wide rows in the east-west direction with plant-to-plant spacing of 10 to 15 cm in both the directions. Nine hundred grams of seed will be used in narrow rows and 600 g in the wide rows. The fertilizers, at the sowing time, should be drilled in the same ratio i.e. 45 kg superphosphate and 27 kg urea under the north-south and 30 kg superphosphate and 18 kg urea under the east-west rows. Second dose of nitrogen should be uniformly broadcast with first irrigation.

Sowing with Zero Tillage : Raya can also be successfully cultivated without preparatory tillage with zero till drill after the rice harvesting. In weed infested fields, weeds can be controlled by spraying half litre of Gramoxone (Paraquat) in 200 litres of water before sowing. Zero tillage has the benefits of reduced cost of production associated with saving of water in first irrigation and reduced environmental pollution. This also helps in timely sowing of crop after basmati and results in increased yield.

Sowing with Dual Seed Drill : Tractor drawn Dual seed drill for oil seeds (small seeds) and wheat can be used for sowing of different varieties of Raya and *Gobhi Sarson* and wheat in the well prepared field as per recommended seed rate. Roller with fine flutes will be used for sowing small oil seeds with exposure length of 3-4 mm and wide flutes roller are used for sowing of wheat. The operational speed of tractor drawn dual seed drill should be 3-4 km/hr.

Nursery Raising : Sowing the nursery of *gobhi sarson* should be undertaken about 60 days for GSL 1, 40 days for hybrid *gobhi sarson* PGSH 51, 35-45 days for Hyola PAC-401 and 45 days for *African sarson* PC 5 ahead of the transplanting period. About eight marlas (200 sq. metre) of nursery is sufficient for transplanting one acre. A fine seedbed with adequate soil moisture is necessary for getting good stand of nursery. Apply 4.5 kg urea and 4 kg of single superphosphate with last ploughing and level it. Broadcast uniformly 400 g seed of GSL 1 or PGSH 51 or Hyola PAC 401 and 600 g of PC 5 and mix it with the help of *trangli (*toothed rake). Give a light irrigation to the nursery bed after about 10 days of germination to be followed by one or two more irrigations when needed.

Transplanting of *Gobhi Sarson/African Sarson* : A successful crop of *gobhi sarson/ African sarson* can be raised by transplanting. This technique should be preferred where sowing is likely to be delayed to November-mid-December. For higher yield, transplanting should be done in November.

After applying pre-sowing irrigation, prepare the field well. Draw furrows 45 cm apart for *gobhi sarson* and 30 cm for *African sarson* and place one seedling at a distance of 10-15 cm. Close the furrows and irrigate the field immediately.

Bed planting : Transplanting of *gobhi sarson* can also be done on raised beds for higher yield (10-15%) and saving (20-25%) of irrigation water. During field preparation, broadcast half N and full P before last cultivation. Prepare beds with already recommended wheat bed planter. Transplant two rows of *gobhi sarson* seedlings on top portion of the beds by keeping row to row spacing of 30 cm and plant to plant spacing of 15 cm. Irrigate the furrows immediately after transplanting. Broadcast the remaining half N after first irrigation at 3-4 weeks after transplanting and reshape the furrows with the same bed planter. **While reshaping detach the bed planker from the bed planter.**

Fertilizer Application : Apply fertilizers on soil test basis (See Chapter on 'Soil Testing'). In the absence of a soil test, add the following quantity of fertilizers on medium fertility soils. However, on loamy sand soils, apply 60 kg N/acre to *gobhi sarson.*

Crops	**Nutrients (kg/acre)*			*Fertilizers (kg/acre)*		
	N	*P_2O_5*	*K_2O***	*Urea (46%)*	*Super-Phosphate (16%)*	*Muriate of Potash (60%)*
Irrigated Conditions						
Toria	25	8	—	55	50	-
Raya, Gobhi sarson and African *sarson*	40	12	6	90	75	10
Rainfed Conditions						
Raya	15	8	—	33	50	—
Taramira	12	—	—	26	—	—

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

** Apply potassium to soils testing low in this nutrient.

(i) Apply 10 kg zinc sulphate (21%) per acre to *raya* in soils testing low in zinc.

(ii) *To Toria+gobhi sarson* sown together in mid September, apply 55 kg N and 12 kg P_2O_5/acre. Drill 25 kg N and full dose of P_2O_5 at sowing and remaining 30 kg N with irrigation after harvesting *toria.*

(iii) If nitrogen is to be applied in the form of urea it should be applied just before pre-sowing irrigation (*rauni*).

(iv) Apply 25% less nitrogen to direct seeded African sarson (PC 5) and transplanted *gobhi sarson* (GSL1) under delayed sowing up to mid December, than recommended.

(v) Prefer phosphorus from single superphosphate. If this fertilizer is not available, apply gypsum @ 50 kg per acre particularly in sulphur-deficient soils along with other nitrogenous and phosphatic fertilizers at sowing.

(vi) When gypsum is not available in the market then in sulphur deficient soils sulphated P fertilizer (13:33:0:15:N:P_2O_5:K_2O:S) may be applied as an alternate source of sulphur to raya.

Time and Method of Fertilizer Application : Under irrigated conditions, in toria drill the fertilizer (both N and P_2O_5) just before sowing. In raya, *gobhi sarson* and *African sarson* drill 1/2 N and full phosphorus and potash before sowing and the remaining 1/2 N with first irrigation. Under rainfed conditions, drill the fertilizers before sowing to raya and taramira.

Weed Control: One hoeing to *toria* after the third week of sowing and one or two hoeings preferably with improved wheel hand hoe to *raya, gobhi sarson, African sarson* and *taramira* are adequate. Weeds can also be controlled with selective herbicides as given below :

Crop	*Herbicide recommended*	*Dose/acre*	*Time of Application*
1. Toria	Trifluralin (Treflan 48 EC)*	400 ml	Pre-plant incorporation
2. *Raya*	Isoproturon (75 WP) or	400 g	Pre-emergence within 2 days of sowing or post-emergence 25-30 days after sowing.
	Trifluralin (Treflan 48 EC)	625 ml or 400 ml + one hoeing 50 days after sowing	Pre-plant incorporation
3. *Gobhi Sarson* (GSL1, GSL 2, PGSH 51) and African Sarson (PC 5) (Seeded)	Isoproturon (75 WP) or	300g	Post-emergene before first irrigation
	Fluchloralin (Basalin 45 EC) or	650 ml	Pre-plant incorporation
	Trifluralin (Treflan 48 EC)	625 ml	-do-
Transplanted	Isoproturon (75 WP)	300 g	Immediately after transplanting but before irrigation.
Gobhi Sarson (GSL-2)	Atrazine (Atrataf 50 WP)	320 g	Pre-emergence or post-emergence Seeded 20-25 days after sowing but 2-3 days before first irrigation.

* Highly effective against *itsit/chapatti.*

Precautions :

- Use 200 litres of water per acre for spraying the herbicides.
- Use of Isoproturon causes initial toxicity to *raya* and *gobhi Sarson* (seeded) but the crop recovers afterwards.
- The herbicides give effective control of annual grass and broad leaf weeds.
- Incorporation of herbicides can be avoided if sowing of the crop is done on the same day after spraying.

Irrigation : Raya and *gobhi sarson* sown after heavy pre-sowing irrigaton (10-12 cm), should be irrigated 3 to 4 weeks after sowing to promote deeper rooting and for better utilization of applied fertilizer.

In *raya,* if necessary, second irrigation at flowering stage may be given. If the crop is threatened by frost damage, the second irrigation may be given earlier.

In *gobhi sarson,* second irrigation may be given at the end of December or begining of January. The third and the last irrigation be given during second fortnight of February. The crop should not be applied any irrigation, thereafter, as it lodges.

Toria should be sown with heavy *rauni* and if need arises, one irrigation should be given at the time of flower initiation.

Production of Pure Seed : All the rapeseed mustard forms must be sown in isolation for seed multiplication. Special care regarding isolation/mechanical mixing must be taken for canola and low erucic acid varieties. In case of self-sterile forms such as *toria* and *taramira,* take seed from healthy and pyramidal plants, which are profusely branching near the base and grow in isolation. For maintaining the purity of largely self-fertile forms such as mustard, pull out the off-type plants before flowering and again just before harvesting.

Harvesting and Threshing : The crop is ready for harvest when pods turn yellow. Timely sown *toria* is harvested in Ist week of December; *raya and taramira* in March and *gobhi sarson* in first fortnight of April. Owing to grain shattering in *raya* and *gobhi sarson* care should be taken to harvest it at the proper time. The harvested crop should be stacked for 7-10 days before threshing (Appendix III).

Seed Production of Hybrids : Fresh hybrid seed has to be produced every year. The hybrid seed of PGSH 51 is produced by crossing female parent TCMS-PR 05 (A-line) with a pollinator parent TFR 91 (R line). Following steps are involved in the production of its hybrid seed at farmers fields :

(i) Obtain fresh seed of female (A) and pollinator (R) parent from the Punjab Agricultural University every year.

(ii) The quantity of seed required for sowing one acre of seed plot is about 750 g of A line and 350 g of R line.

(iii) Select an isolated field which is located at least 1500 metres from another *gobhi sarson* field. It must be ensured that no crop of *gobhi sarson* had been sown in the selected field for at least three previous years.

(iv) Ratio of pollinator and female lines should be kept at 2:4 i.e. after every two rows of pollinator parent, four rows of female parent should be sown. Distance between lines should be 30 cm. It is also recommended to sow a strip of pollinator parent on all sides of seed production block to augment the pollen supply.

(v) Normal cultural practices (except for line spacing) as recommended in *gobhi sarson* are to be followed for seed production.

(vi) The pollinator parent, TFR 91 of the hybrid is about 7 days earlier than the female parent, TCMS-PR 05. To achieve synchronization, the detopping of main shoot of pollinator parent is recommended. Extra dose of urea @5kg/acre applied between the pollinator rows after second irrigation helps in delaying flowering and increasing plant height of pollinator.

(vii) The off type plants if any, in A and R lines should be removed before flowering. Roguing of pollen shedders/male contaminants from A lines is recommended till the majority of plants have flowered. Roguing should be done during early hours of the day.

(viii) For increased pollination and seed setting on female lines, honey bee colonies may be placed near the seed production plots. In the event of low bee population, shaking of pollinator rows with sticks will help in pollen dispersal.

(ix) The R line should be harvested immediately after pod setting is complete to avoid contamination of hybrid seed due to shattering.

(x) The seed set on "A" line is hybrid seed which should be harvested, threshed and graded separately.

Plant Protection

(a) Insect Pests

1. Painted bug *(Bagrada hilaris) :* It is serious on the germinating crop in October and again on mature crop in March-April. The nymphs and adults suck the sap from the foliage and pods which subsequenty dry up.

Control : (i) Give first irrigation 3-4 weeks after sowing as it reduces the painted bug population significantly. (ii) Spray 400 ml Malathion 50 EC (malathion) Ekalux 25 EC (quinalphos) in 60-80 litres of water per acre.

2. Mustard sawfly *(Athalia lugens proxima):* The larvae attack the young crop, bite holes into the leaves and may eat all the leaves in case of heavy attack. It can be controlled by spraying insecticides as recommended against painted bug.

3. Mustard aphid *(Lipaphis erysimi):* The green plant lice become innumerable, covering the inflorescence and pods. They suck the plant sap in huge quantities and as a result, the plants remain stunted, pods shrivel up and seeds do not develop. The following pest management programme is recommended for its effective and economic control.

(a) Sow the crop early wherever possible, preferably upto 3rd week of October.

(b) Apply recommended dose of fertilizers.

(c) Apply insecticides on the basis of need by following any of the economic threshold values given below. For determining aphid infestation, observe 12-16 widely scattered plants from an acre twice a week starting from first week of January. Spray, when pest population reaches, 50-60 aphids/10 cm terminal portion of the central shoot. OR

When an average of 0.5 to 1.0 cm terminal portion of central shoot is covered by aphids.

OR

When plants infested by aphids reach 40-50% (observe 100 plants/acre).

Use any of the following insecticides and repeat application whenever the above mentioned economic threshold values are noticed.

I. Foliar sprays : Use 80-125 litres of spray fluid per acre depending upon the stage of crops.

(i)	Actara 25 WG (thiamethoxam)	@ 40 g
(ii)	Metasystox 25 EC (oxydemeton methyl)	
(iii)	Rogor 30 EC (dimethoate)	
(iv)	Ekalux 25 EC (quinalphos)	
(v)	Malathion 50 EC (malathion)	
(vi)	Dursban/Coroban 20 EC (chlorpyriphos)	@ 600 ml

II. Granular insecticides : Apply 4 kg Thimet/Phorolik 10 G (phorate) or 13 kg Furadan 3 G (carbofuran) by broadcasting followed by light irrigation.

4. Leaf miner *(Chromatomyia horticola):* Larvae feed by making mines into the leaves and cause heavy damage. The systemic insecticides (Metasystox 25 EC or Rogor 30 EC or granular insecticides) recommended for control of mustard aphid should be used for controlling the leaf-miner.

5. Hairy caterpillar *(Spilosoma obliqua)* and cabbage caterpillar *(Pieris brassicae)* **:** The caterpillars feed on leaves, young shoots and green pods. When young, they feed gregariously but the grown-up caterpillars migrate from one field to the other.

When in the gregarious stage, they can be easily controlled by picking and destroying the infested leaves. Grown-up caterpillars should be controlled with Malathion 5% dust @ 15 kg per acre or by spraying with 200 ml of Nuvan 85 SL (dichlorvos) in 80-125 litres of water per acre with manually operated knap sack sprayer.

6. Green peach aphid *(Myzus persicae):* The green peach aphid attacks *taramira* from December to March with peak activity during February. After the appearance of inflorescence, the aphid congregates on terminal buds and feeds there. As a result there is flower shedding, poor pod formation and shrivelling of grains. For its control, sow the crop in first week of October and spray 200 ml Rogor 30 EC (dimethoate) or 250 ml Metasystox 25 EC (oxydemeton methyl) in 100 litres of water per acre in 3rd week of February when aphid starts congregating on top flower buds. Only one spray is needed.

Precautions : (i) Generally the mustard aphid becomes serious around mid-January, hence greater vigilance is needed from first week of January for monitoring its population at regular intervals for deciding the need and time of control measures to be followed.

(ii) Spray in the afternoon when the pollinators are less active.

(iii) The crop meant for *Saag* purposes should be treated with Malathion only. Observe a *waiting period of one week* after spraying to pluck *saag.*

(b) *Diseases :*

1. *Alternaria* blight *(Alternaria brassicae) :* Brown to blackish spots with concentric rings appear on leaves, pods and stems. In case of severe attack, the upper parts of the stem and pod wither. Destroy diseased debris from the previous crop. Spray the crop with Blitox or Indofil M-45 @ 250 g in 100 litres of water per acre at 75 days old crop followed by second spray of Score 25 EC @ 100 ml and third spray of Blitox or Indofil M-45 @ 250 g in 100 litres of water per acre at 15 days interval.

2. Downy mildew *(Peronospora brassicae) :* Small light green lesions appear on the lower side of the leaves, which later enlarge, become more greyish, dry up, shrivel and tear easily. All aerial parts of the plants are attacked. The disease is severe on foliage and seed bearing parts. Greater deformity occurs in the stem. Destroy diseased debris from the previous crop. Spray the crop three to four times at 15 days interval with 250g of Blitox or Indofil M-45 in 100 litres of water per acre starting at about 75 days old crop.

3. White rust *(Albugo candida):* Prominent white creamy-yellow, scattered pustules appear on the under surface of the leaves. The swelling of affected parts often occurs. Flowers get malformed and become sterile. Petals become green and stamens are transformed into leaf-like structures which become thick and club shaped. All parts are attacked, except roots. Adopt same control measures as for downy mildew.

4. Phyllody *(MLO):* Plant parts are malformed. Numerous shoots arise and the plants become bushy or broom shaped. Floral parts are transformed into leafy structures. Avoid early sowing. Rogue out the affected plants.

LINSEED

Linseed cultivation is mainly confined to Gurdaspur, Hoshiarpur and Ropar districts adjoining the main linseed growing area of Himachal Pradesh. During 2008-2009, Linseed was grown on 0.1 thousand hectares with a production of 0.1 thousand tonnes in Punjab State. Its average yield was 8.0 q per hectare (3.2 q/acre). The low yield can be stepped up by adopting the recommended package of practices.

Climatic Requirements : It does well in high rainfall areas.

Rotations : Rice-Linseed.

Improved Variety

LC 2063 (2007) : It is a high yielding variety which is recommended for cultivation in the linseed growing areas of the state. It is a tall variety with profuse branching and blue flowers. It matures in about 158 days. It has lustrous brown bold seeds with 38.4 per cent oil content. Its average yield is 4.89 q/acre. It is on a par with LC 2023 for tolerance to prevailing diseases in the state.

LC 2023 (1998) : It is recommended for rainfed and irrigated conditions.It is a tall variety having blue flowers and profuse capsule bearing. It has brown medium sized seeds. It matures in 158 and 163 days under rainfed & irrigated conditions respectively. It is tolerant to wilt, rust, *Alternaria* blight and moderately resistant to powdery mildew. Its seed contains 37.4 per cent oil. Its yield is about 4.5 q/acre.

Soil Type : A well-drained, loamy to clay soil is suitable.

Agronomic Practices

Preparatory Tillage : The land should be prepared by giving two or three ploughings, depending on the intensity of weeds.

Sowing Time and Method of Sowing : Linseed is sown in the first fortnight of October with drill or pora at a depth of 4 to 5 cm in rows 23 cm apart. Plant spacing in the row is 7 to 10 cm.

Sowing with Zero Tillage : Linseed can also be raised without any tillage operation with zero till drill after rice. In weed infested fields, weeds can be controlled by spraying 500 ml of Gramoxone (Paraquat) in 200 litres of water before sowing. Zero tillage has the benefits such as saving in diesel and time, reduced environmental pollution and saving of irrigation water in first irrigation which contribute towards reduced cost of production.

Seed Rate : When sown in prepared seedbed, 15 kg seed per acre is required.

Fertilizer Application : Apply 25 kg of N (55 kg of urea) and 16 kg P_2O_5 (100 kg superphosphate) per acre at sowing. Prefer phosphorus from single superphosphate.

Weed Control : Two hoeings preferably with improved wheel hand hoe should be done, three and six weeks after sowing respectively. Weeds can also be controlled by herbicides. Spray Isoproturon 75 WP @ 500g/acre in 200 litres of water either as pre-emergence within two days of sowing or post-emergence before or after first irrigation.

Production of Pure Seed : The off-type plants should be removed at the time of flowering and again at harvesting. The flowers of LC 2063 and LC 2023 are blue.

Harvesting: The crop is ready for harvest in April.

Plant Protection

(a) Insect Pests :

The **Lucerne caterpillar** may cause damage by feeding on the leaves. Spray the crop with 450g of Sevin/Hexavin 50 WP (carbaryl) or 400 ml of Malathion 50 EC (Malathion) in 80-100 litres of water per acre.

(b) Diseases :

1. Rust *(Melampsora lini) :* Pink lesions or spots appear on the surface of leaves, stems and pods. Grow resistant varieties. Dust the crop with sulphur @7 kg per acre or spray it with Indofil Z-78 (Zineb 75%) @ 500 g in 250 litres of water.

2. Wilt *(Fusarium oxysporum) :* Young seedlings die when attacked. Full grown plants show yellowing of leaves and later wilt and die. Grow tolerant varieties like *LC 2023* and *LC 2063.*

3. Powdery Mildew *(Erysiphe cichoracearum) :* A greyish white powdery growth on the youngest growing tips is the first visible symptom of this disease. In case of severe infection, the fungus attacks branches, leaves and flowers. It causes heavy loss owing to the defoliation of infected plants which leads to the shrivelling of grains. Dust the crop with sulphur @ 7 kg per acre once before flowering.

SAFFLOWER

Safflower commonly known as "Khusambha" contains 24-36 per cent oil having 94 per cent unsaturated fatty acids. Its oil has gained much significance in the edible oilseeds due to the presence of Linoleic acid (74%) which is considered good for cardiac patients. The reddish dye (carthamin) extracted from its florets was previously used in textile dyeing, but more recently this dye has gained importance in food and pharmaceutical industry. The cake obtained from decorticated seed is used as cattle feed. Being a deep rooted and drought resistant crop, safflower offers good scope of cultivation in rainfed submontaneous (Kandi) area of Punjab.

Climatic Requirements : It requires cool and dry climate and it can be grown successfully under rainfed conditions.

Soil Type : Safflower can be grown on a wide variety of soils, but it thrives best on well drained sandy loam to loamy soils, rich in organic matter and retentive of soil moisture.

Rotation : Safflower follows *Kharif* crops such as maize, moong, mash, sesamum, fodder etc.

Agronomic Practices

Preparatory Tillage : Prepare a fine seedbed free from clods. Each ploughing should be followed by planking.

Seed Rate and Seed Treatment : To sow one acre 6 kg healthy and disease free seeds are sufficient. Overnight soaking of seed in water will ensure better germination.

Time and Method of Sowing : Best time of sowing safflower is last week of October to first week of November. Under dryland conditions depth of sowing plays an important role. The seed should be placed at a depth of 5-7 cm in rows 45 cm apart. The plant to plant spacing should be maintained 15 cm.

Fertilizer Application : Apply 16 kg N (35 kg urea) per acre. Use phosphorus only to the soils testing low in this nutrient. Drill all the fertilizers at the time of sowing.

Weed Control : One or two hand hoeings preferably with improved hand hoe will help to keep weeds under check. If sufficient moisture is there at the time of sowing, weeds can also be controlled with pre-emergence application of Stomp 30 EC (pendimethalin) @ 1.0 litre/acre. Spray the herbicide uniformly within 24 hours of the sowing by using 200 litres of water per acre.

Irrigation : Where irrigation facilities are available and soil moisture is low at the time of sowing, a heavy pre-sowing irrigation will prove beneficial. Afterward if possible give one irrigation at branching stage to get higher yield.

Harvesting : Crop is ready for harvesting when flowers turn yellowish brown in the mid of May.

Threshing : Threshing can be done successfully with the help of wheat thresher. On an average it yields 5-6 quintals of seed per acre.

Plant Protection

(a) Insect pests :

Two species of aphid attack safflower crop from January to March.

1. Green peach aphid *(Myzus persicae) :* It feeds on the central whorl and the plants show stunted growth and burnt appearance.

2. Safflower aphid *(Uroleucon compositae) :* Feeds on leaves, tender shoot and stem of the plant. The infested plants become weak, remain stunted and sometimes dried up.

For the control of aphid, spray 100ml of Rogor 30 EC (dimethoate) or Monocil 36 SL (monocrotophos) or 250 ml Coroban 20 EC (chlorpyriphos) in 100 litres of water per acre and repeat the spray after 15 days, if necessary.

(b) Diseases

Wilt and head rot *(Sclerotinia sclerotiorum)* : Plants become yellowish, turn brown and ultimately die. Large black sclerotia of the fungus are formed on the crown, inside the stem, floral heads and adjoining roots. Shredding of the stem takes place. For its effective control destroy the crop debris. Take the seeds from healthy crop. Do not pile up soil around stem during rains. In heavily infested soils grow non-host crops.

SUNFLOWER

Sunflower is an important oil seed crop of Punjab. The spring season is most suited for assured crop and high yields. Availability of honey bees during this season in abundance, also helps in good seed setting. The seeds of sunflower hybrids are black in colour with 100 seed weight of 5 g to 6.5 g. Seeds contain 40-43 per cent, high quality oil which is very well suited for the manufacture of edible refined oil and vanaspati. Its oil can also be used for soap making and a number of allied products. During 2010-2011 season, sunflower was grown on 21.6 thousand hectares with a production of 37.8 thousand tonnes. Average yield was 16.6 q/ha (6.66 q/acre).

Soil Type : It requires well drained, medium texture soil. Avoid salt affected soils.

Rotations : Rice/Maize-Potato-Sunflower; Rice-*Toria*-Sunflower, Cotton-Sunflower;Sugarcane-Sugarcane ratoon-Sunflower and *Kharif* fodder-*Toria*-Sunlfower. Basmati-Sunflower is more productive and remunerative as compared to prevalent Basmati-Wheat crop sequence.

Hybrids :

PSH 996 (2012) : It is a medium tall hybrid with an average plant height of 141cm. It matures in 96 days. The average seed yield of this hybrid is 7.8 q/acre. The seeds are black and bold with 100 seed weight of 6.8 g. The oil content of this hybrid is 35.8%. This hybrid is also suitable for growing under late sown conditions.

PSH 569 (2008) : It is a medium tall hybrid with an average plant height of 162 cm. It matures in about 98 days. The average seed yield is 7.44 q/acre. The seeds are bold with 100 seed weight of 6.8 g. The seeds contain 36.3 per cent oil content. This hybrid is also suitable for growing under late sown conditions.

PSFH 118 (2002) : It is a medium tall, short duration hybrid with an average plant height of 155 cm. It matures in about 98 days. This hybrid fits well in the late sown conditions. The average yield of this hybrid is 7.6 q/acre . The seeds of this hybrid contain about 40.5 per cent oil.

SH 3322 (1997) : It is a medium tall hybrid with an average plant height of 160 cm. It takes 120 days to mature. Its average yield is 8.3 q/acre. It contains 43.0 per cent oil.

GKSFH 2002 (1994) : It is a medium tall hybrid with an average plant height of 160 cm. It matures in about 115 days. Its average yield is 7.5 q/acre. It contains 42.5 per cent oil.

Jawalamukhi (1993) : It is a medium tall hybrid with an average plant height of 170 cm. It takes about 120 days to mature. Its average yield is 7.3 q/acre. It contains 42.0 per cent oil.

Other varieties under cultivation

1. **Pioneer 64 A 57 :** Not tested by the Punjab Agricultural University.
2. **Syngenta 207 :** Not tested by the Punjab Agricultural University.
3. **DK 3849 :** It is a medium duration and tall hybrid. It has high seed and oil yield.
4. **NSFH-36 :** It is tall, medium maturing hybrid having high oil content. However, it's seed size is small.

Agronomic Practices

Land Preparation : Two or three ploughings, followed by planking, are necessary to get a fine seed bed for sunflower.

Time and Method of Sowing : To realize high seed yield and to save irrigation water, the sowing of sunflower should be done by the end of January. However, if the planting is delayed till first week of February, hybrid PSH 569 should be preferred. However, for further delay in the month of February adopt transplanting because direct seeding causes substantial reduction in seed yield. Delayed sowing of crop in the second fortnight of February or in the month of March by direct seeding reduces seed setting and results in increased quantity of unfilled seeds due to rise in temperature at the time of pollination. Delayed sowing also increases the incidence of pests and diseases. Sow the seed 4-5 cm deep, in rows 60 cm apart with plant-to-plant spacing of 30 cm. Row crop planter (inclined plate) can be conveniently used for flat or ridge sowing of sunflower seeds (See Agril. Engg.). Carry out thinning a fortnight after germination, if needed. Earlier sown crop performs well when planted on southern side of East-West ridges. Place the seed about 6-8 cm below the ridge top. Apply irrigation to ridge sown crop 2-3 days after sowing. Take care that water level in the ridges remains well below the seed placement line. The crop sown on ridges does not lodge and it also helps to save the water during hot summer months.

Nursery Raising and Transplanting

When sowing is likely to be delayed to second fortnight of February, the crop should be raised by transplanting the nursery for getting higher yield and early maturity than that of seeded crop. About 30 sq.m. of nursery is sufficient for transplanting one acre. Nursery should be raised by sowing 1.5 kg seed 30 days before transplanting in well prepared seed-bed after mixing 0.5 kg urea and 1.5 kg single superphosphate. Cover the seed-bed with a thin layer of well decomposed FYM. Give a light irrigation and cover the seed-bed with transparent polythene sheet in the form of a tunnel by giving support with sticks. Remove the polythene sheet gradually after seedling emergence. Irrigate the nursery before uprooting. Transplant one seedling at 4-leaf stage at a distance of 30 cm in rows 60 cm apart and irrigate the field.

Intercropping : 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 super phosphate)/acre. Full phosphorus and half nitrogen be applied at planting and remaining half nitrogen at 40 days after planting.

Seed Rate : Use 2 kg seed/acre.

Seed Treatment : Seed should be treated with Thiram @ 2 g/kg of seed before sowing.

Fertilizer Application : In general use 24 kg N (50 kg urea) per acre along with 12 kg P_2O_5 (75 kg superphosphate) at sowing. In coarse textured soils apply 24 kg N/acre to sunflower in two splits i.e. 1/2 at sowing and 1/2, 30 days after sowing. Also drill 12 kg K_2O (20 kg Muriate of Potash) on soils testing low in K. In Hoshiarpur and Shaheed Bhagat Singh Nagar Districts apply 24 kg K_2O (40 kg Muriate of Potash) per acre. Prefer single superphosphate for phosphorus application as it also contains sulphur.

However, sunflower grown after potato receiving 20 tonnes FYM/acre requires 12 kg N (25 kg urea) per acre.

Sunflower following toria should be applied with 10 tonnes of farmyard manure along with the recommended fertilizers.

Irrigation : Sunflower generally requires 6-9 irrigations depending upon the soil type, rain and weather prevalent. Apply the first irrigation about a month after sowing in case of flat sowing and reduce the intervals to 2 weeks during March and to 8-10 days during hot summer months of April-May. Stop irrigations about 12-14 days before harvest. The crop stages such as 50% flowering, soft and hard dough stages are very critical for irrigation. The irrigation missed at soft dough stage, 50% flowering as well as hard dough stages reduce seed yield by 25 and 21 per cent, respectively. Avoid moisture stress to the crop at these critical stages.

Earthing up : To overcome the problem of lodging, earthing up should be done in case of both flat and ridge sown crops. It may be done when the crop is 60-70 cm tall but before flowering.

Weed Control : The first hoeing should be done 2-3 weeks after the emergence followed by second hoeing three weeks thereafter. Mechanical cultivation is possible in this crop before the plants grow 60-70 cm tall. An improved three tine wheel hand-hoe can be used for hoeing. Weeds can also be controlled with selective herbicides. Spray 1 litre of Stomp 30 EC (Pendimethalin) dissolved in 150-200 litres of water per acre as pre-emergence within 2-3 days after sowing.

Harvesting and Threshing : The crop is ready for harvesting when heads turn yellowish-brown at lower surface near the stalk and the discs start drying up. At this stage, the seed gives blackish look and are fully ripe. The harvested sunflower heads can be threshed immediately after harvesting by a sunflower thresher when the heads are relatively moist. However, the performance of the sunflower thresher is better when the crop is dry. After threshing seed should be dried thoroughly before storing, otherwise they are liable to get affected by fungus.

Seed Production of Hybrids : The seed of HYBRIDS should be procured FRESH EVERY YEAR. The parents of the hybrid are as under :

Hybrid	*Female Line (A)*	*Pollinator Line (R)*
PSH 996	*CMS 11 A*	*P 93 R*
PSH 569	*CMS 234 A*	*P 69 R*
PSFH 118	*CMS 10 A*	*P 61 R*

The female line and the pollinator line of any hybrid are commonly termed as *A* line and *R* line, respectively.

To produce the hybrid seed, *A* and *R* lines are planted in an isolated field with no sunflower crop in 400 metres around. The seed crop should not be planted on land on which sunflower was grown in the previous year. The quantity of seed required for sowing one acre of seed plot is 1.5 kg of the female *A* line and 0.5 kg of pollinator *R* line. The ratios of *A* and *R* lines should be kept 3:1, i.e., after every three rows of *A* line, one row of *R* line should be sown. However, the first two border rows on either side may be sown with *R* line to supply enough pollen. The *R* line is a multi head line. In addition to the main head there are auxillary heads also which help in the supply of pollen for a longer time.

The off type plants if any, in the A and R lines should be removed before flowering. Pollen shedders if any, in A line should be removed just at the initiation of flowering. Roguing of pollen shedders is to be continued till the majority of plants flowered. Remove all late flowering plants. To improve the pollination and better seed setting in the female parent, honey bee colonies may be placed near the seed plots. To further increase the quantity of hybrid seed, hand pollination can be done. This can be achieved by following procedure :

i) Collect the pollen from the pollinator R plants in the dry plastic or metallic container by shaking the heads.

ii) Apply the pollen gently to the flowers of female A line by using soft brush or cotton/silk pad.

The R line should be harvested first and ensure that no plant from R line is left in the field. The seed set on A line is the hybrid seed which should be harvested and threshed separately. The seed should be dried to the maximum moisture content of 9.0%. The packing of seed should be done in moisture proof bags. The seed is to be stored in pucca stores which are moisture free. Under such conditions the seed remains viable for about 10 months and thereafter it losses germinability and cannot be used for next sowing. The seed of sunflower remains dormant for about 45 days after harvesting the crop and thus cannot be used for sowing during this period. The germination of seed must be got tested before sowing and it should be used for sowing only if the germination is 70 per cent or more. On an average 250 kg hybrid seed per acre is obtained.

Plant Protection

(a) Insect Pests

1. Cutworms (*Agrotis spp.) :* The insect may be serious during March-April in fields where sunflower follows potato. Caterpillars cut the seedlings at the ground level.

(i) Sow the crop on ridges to avoid cutworm damage in the germinating seedlings. (ii) Where flat sowing is practised, apply 2 litres of Dursban/Radar 20 EC (chlorpyriphos) per acre before sowing. The insecticide should be mixed in 10 kg fine soil and broadcast uniformly in the field after last ploughing but before planking.

2. Tobacco caterpillar (*Spodoptera litura)* **and *Bihar hairy-caterpillar*** *(Spilosoma obliqua):* These are serious during April-May and defoliate the plants. Young larvae feed gregariously but the grown-up caterpillars spread throughout the field and migrate from one field to the other.

To control these pests, egg masses and young larvae feeding gregariously should be collected along with leaves and destroyed. Grown-up caterpillars should be controlled by spraying 200 ml Nuvan 85 SL (dichlorvos) in 100 litres of water per acre. Repeat after two weeks, if necessary.

Precautions : It will also control *Cabbage semi looper (Thysanoplusia orichalcea)* jassid and other sucking pests in case they appear on the crop.

3. The Head borer or American bollworm *(Helicoverpa armigera) :* It is a serious pest of sunflower and causes heavy damage by feeding on the tissues and developing grains in the head capsule.

Spray 1 kg of Sevin 50 WP *(carbaryl)* or 800 g of Asataf 75 SP *(acephate)* or 1 litre of Dursban 20 EC *(chlorpyriphos)* in 100 litres of water per acre at the initiation of starbud stage. Repeat after two weeks, if necessary.

Precautions : Spraying should be done either in early morning or late in evening when the bees activity is minimum.

(b) Diseases

1. Stem rot *(Sclerotium rolfsii, Sclerotinia sclerotiorum) :* The pathogens attack basal part of the stem. However, when *S. sclerotiorum* is predominant, it can cover the entire plant parts, including the head as evident by the white cottony growth. The sclerotia of this pathogen, almost of the size of sunflower seed, are produced in abundance which are visible in the pith of rotten stem and infected head. The affected tissue turns black and shredded. Treat the seed with Thiram @ 2g/kg seed.

2. Root rot or Charcoal rot *(Macrophomina phaseolina):* Infection at early stages kills the seedlings rapidly. At later stages, it causes premature ripening, small sized heads, poor filling and reduction in yield. Avoid moisture stress to the crop.

3. Head rot *(Rhizopus oryzae, R. stolonifer, Sclerotinia sclerotiorum):* The symptoms are visible on any part of the receptacle, usually starting from the stalk. Severely affected heads show shredding of the tissue and incomplete filling. The rot may be partial or complete. Seeds formed in affected heads are highly shrivelled causing considerable reduction in yield and oil content. Spray the crop twice with 250g Indofil M-45 in 100 litres of water per acre at 15 days interval starting at about 60 day old crop.

(c) Birds

(Seed chapter on Management of Rodents & Birds)

4. MEDICINAL, SPICE AND AROMATIC CROPS

CELERY

Celery, commonly known as *Karnauli,* is grown, mostly in districts of Amritsar and Gurdaspur. The seed and its products are exported.

Climatic Requirements : It requires mild cool climate for luxuriant growth in the early stages and warm dry weather at maturity.

Rotations : Cauliflower/Potato (early)-Celery, Paddy-Pea (early)-Celery, Paddy-Celery, Paddy-Potato-Celery, Basmati rice-Celery-Bajra fodder and Maize (August)-Celery-Bajra fodder.

Variety

Local : It is a herbaceous plant with an average height of 115 cm. Its growth is slow in initial stages and it starts branching in the month of February. The white flowers appear in the month of March. The fruits are dark brown in colour possessing characteristic odour and aromatic pungent taste. It matures in 165-170 days after transplanting.

Soil Type : All soils, except the saline, alkali and waterlogged ones are suitable. It, however, thrives best on loamy soils rich in organic matter and retentive of soil moisture.

Agronomic Practices

Preparatory Tillage : The land should be thoroughly levelled and seedbed prepared by giving 4 or 5 ploughings, each followed by a planking.

Seed Rate : 400 g per acre.

Time and Method of Nursery Raising

(i) Time of Nursery Sowing : September 15 to October 15.

***(*ii) Nursery Raising :** Mix 15 cartloads per acre of well-rotten farmyard manure or compost into the soil and give 4 or 5 ploughings to obtain fine tilth. Prepare seedbeds measuring 8mx1.25 m or any other convenient size. Eight such seedbeds, will give required seedlings for transplanting in an acre. A shallow channel should be provided around the beds to facilitate irrigations. To each bed apply 150 g mixture of calcium ammonium nitrate and single superphosphate in equal proportions and mix it well with the surface soil. Sow 50g of clean seed on each bed. Cover the seed with a mixture of farmyard manure and soil. Apply water with a sprinkler immediately after sowing. The seed germinates after 12-15 days. About a fortnight after the germination of seed, apply 100g

calcium ammonium nitrate to each bed. If seedling size is not normal, apply another dose of 100g calcium ammonium nitrate per bed after about a month. The seedlings will be ready for transplanting in about 60-70 days. Irrigate the nursery regularly and keep it free from weeds.

(iii) Uprooting of Seedlings : Apply light irrigation to the seedbeds a day before uprooting the seedlings.

(iv) Time and Method of Transplanting : 60 to 70 days old seedlings should be transplanted from November 15 to end December at a spacing of 45 x 25 cm.

Weed Control : Two or three hoeings preferably with improved wheel hand hoe are enough to keep the crop free from weeds.

Irrigation : Light and frequent irrigations should be applied.

Fertilizer Application : For medium fertility soils, the following fertilizers may be applied.

**Nutrients (kg/acre)*		*Fertilizers (kg/acre)*		
N	*P_2O_5*	*Urea or (46%)*	***DAP (18:46)*	*Superphosphate (16%P_2O_5)*
40	16	90	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 13 kg.

Time and Method of Fertilizer Application : Add 1/2 N and full amount of P_2O_5 at transplanting and apply 1/4 N 45 days after transplanting and 1/4 N 75 days after transplanting.

Harvesting and Threshing : The crop should be harvested when seeds in most of the umbels turn light brown in colour. Delay in harvesting results in loss through seed-shedding. Since the seed is very small and light, therefore, winnowing and sieving should be avoided, when wind velocity is high.

Yield : 5-6 q/acre seed.

Insect Pests : Aphids sometimes appear as pest. They suck cell-sap from the leaves and thus, adversely affect the crop growth. Spray 400 ml Malathion 50 EC per acre and repeat after 15 days, if necessary.

Hints to minimize shattering losses

1. Use seedlings of the same age and size group.
2. Harvest the crop at right stage.
3. Harvest the crop early in the morning hours.
4. Transport the harvested crop immediately to threshing floor.

CORIANDER

Coriander is mostly grown for its green leaves. Its cultivation for seed is also picking up due to high economic returns.

Climatic Requirements : It requires cool climate in early stages and warm dry weather at maturity.

Rotation : Maize-Potato-Coriander, Summer Maize-Maize-Coriander and Rice-Coriander.

Variety

Local : It is a herbaceous plant with an average height of 60cm. The stem is erect and hollow. It bears white flowers. The fruits are light green to yellowish in colour which dehisce into two parts. It matures in 175-180 days after sowing.

Soil Type : Coriander can be sown on a wide variety of soil but it performs best in well-drained sandy loam to loamy soils.

Agronomic Practices

Preparatory Tillage : Prepare a fine seedbed by giving two or three ploughings, each followed by planking.

Seed Rate : 8-10 kg/acre.

Seed Preparation : Use healthy and disease free capsules (seeds). Rub the capsules gently to break them into 2 to 4 parts. Unrubbed capsules give very poor germination. Treat the seed with Thiram @ 2.5g per kg of seed.

Time and Method of Sowing : Optimum period of sowing is from the last week of October to the first week of November. The sowing can however be continued up to last week of December. Sow by *pora* method in rows 30 cm apart.

Weed Control : The slow growth of coriander in the initial stages poses a serious weed problem. Give two weedings, preferably with improved wheel hand hoe, the first about 4 weeks after sowing and the second 5-6 weeks thereafter.

Irrigation : Give four or five irrigations depending upon the rainfall. The first irrigation may be given about 3 weeks after sowing. Subsequent irrigations may be given when required taking care that there is no moisture stress at flowering and seed development stages.

Fertilizer Application : Apply 30 kg N (65 kg urea) per acre in two splits, half at sowing and the remaining half at flower initiation. There is no need of applying phosphorus to soils testing medium to high in this nutrient.

Harvesting and Threshing : The crop is ready for harvesting by the end of April. Harvest when the capsules are mature but green. The green coloured fetch a price premium over the brown coloured over-ripe capsules.

Remove the harvested produce to a *pucca* threshing floor, allow it to dry and then thresh. Dry the capsules fully before storage.

Yield : 2.5 to 3 quintals of seed per acre.

Plant Protection

(a) Insects :

Cabbage semilooper and **aphid** sometimes appear as pests.

(b) Diseases :

Stem gall : The disease forms tumor like swellings on leaf veins, petioles, peduncles, stems and capsules. The fruits in the umbels may become enlarged. Remove and burn the diseased plants.

Treat the seed, as given under *Seed-Preparation.*

FENNEL

Fennel is commonly known as *saunf.* Its seeds possess medicinal value and are used as spice in pickles, candies etc. The seed contains 1-2% essential oil which finds its use in the food, flavour, perfume and pharmaceutical industries.

Climatic Requirements : Fennel requires cool and dry climate. Rainfall at maturity spoils the colour and reduce the germination of the seeds.

Soil Type : Well drained sandy loam to loamy soil is best suited for its cultivation.

Rotations : Fennel can follow any *kharif* crop such as paddy, maize, *moong/mash and kharif* fodder.

Variety

Local : It is herbaceous plant with an average height of 150 cm. The stem is hollow and cylindrical having dull green leaves. The plant is slow in growth upto the end of January after which it starts branching. Yellow flowers appear in the month of March. The fruit is oblong, smooth, greenish grey in colour with prominent ridges. It mature in 185-190 days after sowing.

Agronomic Practices

Preparatory Tillage : Give two or three ploughings each followed by planking to prepare a fine seedbed.

Seed Rate : Four kg per acre.

Time of Sowing : The best time of sowing is second fortnight of October. The yield decreases with the delay in sowing.

Method of Sowing : Sow the seed 3-4 cm deep by *kera* in rows 45 cm apart.

Fertilizer Application : Apply 20 kg nitrogen (80 kg CAN) in 2 or 3 splits depending upon the texture of the soil. Apply phosphorus only to the soil testing low in this nutrient.

Irrigation : Give a pre-sowing irrigation. Apply the first irrigation 10-15 days after sowing to ensure proper seedling-emergence and subsequent irrigation when needed, taking care that there is no moisture stress at flowering and milk-stages. In the month of March and April, apply light irrigations and on calm days to avoid lodging.

Weed Control : Hoe once or twice preferably with improved wheel hand hoe depending upon the intensity of the weeds.

Plant Protection

No serious disease or insect-pest have been noticed in this crop so far. However, the pests like aphid, thrips and cabbage semi-looper appear occasionally on this crop.

Harvesting and Threshing : The crop is ready for harvest by the end of April to the Ist week of May. Harvest when the umbel changes its colour from green to light yellow. For getting quality grains for table purpose, harvest the crop at dough stage in early April. This produce is, however poor in germination and should not therefore, be used for seed.

Dry the harvested produce preferably under shade to obtain produce of green colour which fetches premium in the market.

Yield : A yield of 4 to 5 quintals of seed per acre can be obtained.

Marketing : The marketing of bulk quantities of fennel can pose problems.

DILL SEED

Dill seed (*Anethum graveolens L)* commonly known as *sowa/soe* is well known for its medicinal properties due to the presence of an essential oil called dill oil. Dill oil is used in food, flavour and perfume industries. It has a good demand in the national as well as in the international markets.

Climatic Requirements : It requires cool and dry climate. Rainfall at the time of maturity can cause seed-shedding.

Soil Type : Well drained sandy loam to loamy soil is best suited for its cultivation.

Rotations : Dill seed can follow *kharif* crops such as paddy, maize, mash, *moong,* fodder etc.

Variety

Local : Dill seed is a herbaceous plant which is slow in growth in the initial stages and finally attains an average height of 160 cm. It starts branching in the end of February. It has light yellow flowers. The fruit is long, oval to elliptical in shape with prominent ribs. The plant matures in 185-190 days after sowing.

Agronomic Practices

Preparatory Tillage : Prepare a fine seedbed by giving two or three ploughings each followed by planking.

Seed Rate, Time and Method of Sowing : Two kg seed is sufficient to sow an acre. The best time of sowing is the second fortnight of October. Delayed sowing causes reduction in yield. Sow the seed 3-4 cm deep by *kera* in rows 45 cm apart.

Fertilizer Application : Apply 35 kg nitrogen (75 kg Urea) in 2 or 3 splits depending upon the texture of the soil. Apply phosphorus only to the soil testing low in this nutrient.

Irrigation : Give a pre-sowing irrigation. Apply first irrigaton 10-15 days after sowing to ensure proper seedling emergence. Subsequent irrigations should be given to ensure proper moisture throughout the growth period, taking care that there is no moisture stress at flowering stage. In the months of March and April, apply light irrigations and on calm days to avoid lodging.

Weed Control : Give one or two hoeings depending upon the intensity of weeds preferably with improved wheel hand hoe. The first hoeing may be done 30-40 days after sowing and overcrowded seedlings may be thinned at this stage.

Harvesting and Threshing : The crop is ready for harvest by the first week of May. Harvest the crop, when the umbel changes its colour from green to light-yellow. Harvest in the morning and transport to the threshing floor immediately to prevent seed shedding.

Yield : An average yield of 3 to 4 quintals of seed per acre can be obtained.

HONEY PLANT

Honey plant is an important medicinal crop grown for seeds which are a commercial source of xanthotoxin (0.4%). Some of the pharmaceutical companies and export houses purchase the seed of this crop for export.

Climatic Requirements : It requires cool and dry climate and can successfully be grown under the Punjab conditions. High velocity winds at maturity cause seed shedding.

Soil Type : It can be grown on a wide variety of soils but performs best in well drained sandy loam to loamy soils.

Rotations : Honey plant can follow *kharif* crops such as paddy, maize, *moong, mash* and fodder.

Variety

Local : It is a herbaceous plant with dark green leaves. In the initial stages,the plants are spreading in nature but later grow upwards to an average height of 150 cm. The plants start branching in February. Each branch ends into an umbel. White flowers appear in March. The flowers contain lot of nectar and attract honey-bees. The plant matures in 180-185 days after transplanting.

Nursery Raising : The best time of sowing nursery is the whole month of September. For transplanting an acre, 400g seed is sufficient.

Mix 15 cartloads of well-rotten farmyard manure or compost per acre into the soil. Prepare beds measuring 8mx1.25m or of any other convenient size. Eight such beds will provide seedlings for transplanting in an acre. A shallow channel should be provided around the beds to facilitate drainage and irrigation. To each bed, apply 80g urea and 150g single superphosphate and mix well with the surface soil. Sow 50g clean seed on each bed. Cover the seed with a mixture of Farmyard manure and soil. Apply water with a sprinkler immediately after sowing. About fortnight after the emergence of seedlings, apply 55g urea to each bed. If seedling growth is not normal, apply another dose of 55g urea per bed after about a month. The seedlings will be ready for transplanting in 60-70 days. Irrigate the nursery regularly and keep it free from weeds. Apply light irrigation to the seedbeds a day before uprooting the seedlings.

Time and Method of Transplanting : 60 to 70 days old seedling should be transplanted during November at a row spacing of 60 cm and plant-to-plant distance of 30 cm.

Fertilizer Application : Apply 25 kg nitrogen (55 kg urea) in 2 or 3 splits depending upon the texture of soil. Apply phosphorus only to the soil testing low in this nutrient.

Weed Control : Two or three hoeings preferably with improved wheel hand hoe, are enough to keep the crop free from weeds.

Irrigation : Apply light and frequent irrigations in the initial stages for proper establishment of the seedlings. Ensure adequate moisture throughout the growth period particularly at the time of branching and flowering stages.

Harvesting and Threshing : The crop is ready for harvest by the first week of May. Harvest when the umbels change colour from green to light yellow. The delay in harvesting causes shattering. The crop should be harvested in the morning hours and transported to the threshing floor immediately to prevent seed shedding.

Yield : An average seed yield of 4 to 5 quintals per acre can be obtained.

Marketing : The marketing of honey plant can pose a problem. Before sowing, ensure disposal by having a contract with a pharmaceutical industry or export house.

FENUGREEK

Fenugreek *(Trigonella foenum-graecum L.)* commonly called as *metha*, is an annual herbaceous plant belonging to family Leguminosae. Fenugreek is used as a condiment. Its seed adds nutritive value as well as flavour to food. It is an important constituent to curry-powder. Its tender pods and shoots are used as vegetable.

Improved Variety

ML-150 (1995) : Its plants are erect with dark green leaves. It is moderately resistant to powdery mildew and stem rot diseases. It bears large number of pods. It has bright, yellow and bold seeds. Its average grain yield is 6.5 q/acre. It can also be grown for fodder purpose.

Climatic Requirements : It is a cold-season crop and is fairly tolerant to frost and low temperature injury. It does well under irrigated conditions but can be grown as rainfed crop in the areas of moderate rainfall.

Soil Type : It can be grown on all types of soils except water logged alkaline and saline ones. However, it thrives best on well drained loamy soils.

Rotations : Fenugreek can follow *Kharif* crops such as paddy, maize, *moong, mash,* fodder etc.

Agronomic Practices : To get fine seedbed, 2 or 3 ploughings followed by planking are necessary. The field should be free from stubbles and weeds.

Time and Method of Sowing : The best time of sowing is last week of October to first week of November. Sow 12 kg seed per acre 3-4 cm deep in lines 22.5 cm apart.

Fertilizer Application : Apply 5 kg nitrogen (11 kg urea) and 8 kg P_2O_5 (50 kg single superphosphate) per acre at the time of sowing.

Irrigation : Give a pre-sowing irrigation for better and quick germination. Three or four irrigations are enough to raise the crop.

Weed Control : In order to keep the crop free from weeds, one or two hoeings may be given.

Harvesting : The crop is ready for harvesting in April. Harvest the crop when colour of the pods changes from green to light yellow. Delay in harvesting results in shattering of seeds. It yields 5-6 quintals of seed per acre.

Insect Pest : Aphid appears as a pest and adversely affect the crop growth. It can be controlled by spraying 250 ml Malathion 50 EC or 150 ml of Rogor 30 EC or Metasystox 25 EC in 80-100 litres of water.

Diseases

The crop is some times affected by **powdery mildew, downy mildew and rust.** Powdery mildew can be controlled by spraying Karathane 40 EC @ 0.05-0.1% or wettable sulphur @0.25%. Rust and downy mildew can be controlled by spraying Indofil M-45 @0.25%. If necessary sprays may be repeated at 10-day intervals.

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.

Mentha Arvensis Selection (MAS-1) : The stem is hairy, green and having erect growth. The leaves are petiolated with serrated margin. It grows to a height of about 50 cm in 120 days. It contains 0.71 per cent essential oil, on fresh weight basis, having 80.3 to 82.7 per cent total menthol.

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% Carbendazim 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. 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. 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 (30 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 (46%)*	***DAP (18% : 46%)*	*or*	*Super-phosphate (16%)*
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 (oxyflourfen) 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

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.

Jasid 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.

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 Carbendazim 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.

5. FODDERS

Fodder production in Punjab has to be substantially increased if the current population of 7.31 million cattle and buffaloes (6.04 million adult unit) is to be provided sufficient feed of good quality. The area under fodder crops in the State is approximately 0.85 million hectares (3.26 million hectares in *rabi* season) and the annual production is about 62.8 million tonnes of green fodder. At present, fodder supply of 28.5 kg/ animal/day is far from satisfactory. On the basis of 40 kg green fodder per adult animal per day, approximately 82.1 million tonnes of fodder will be required. Since no extra area is likely to become available for fodders in the State, therefore, production per unit of land per unit of time must be increased through multiple and relay cropping, extra agronomic inputs like seeds, fertilizers and irrigation.

The feeding cost for milk production can be considerably reduced by substituting high-quality fodders for concentrates. An all-berseem or an all-lucerne ration is adequate for milch animals yielding upto 7 litres of milk daily. Efforts should be made to feed mixture of legumes and non-legumes such as berseem or lucerne with oats and silage of maize, sorghum etc.

In order to maximize production of *rabi* fodders and to obtain optimum fodder quality, the package of practices described below should be followed. Rabi fodders except oats are rich in protein.

BERSEEM

Berseem gives a highly nutritious and palatable fodder in repeated cuttings from November to mid-June. It is grown on 2.10 lac hectares with production of 200.3 lac ton and fodder yield of 95 ton/ ha.

Climatic Requirements : Berseem needs mild temperature for germination and establishment. Its growth is checked during intensely cold or frosty weather.

Improved Varieties

BL-42 (2003) : It is a quick-growing variety which produces more number of tillers per unit area. It is tolerant to stem-rot disease. It has superior nutritional quality. It supplies green fodder upto first week of June and yields about 440 q/acre of green fodder and has high seed yield.

BL-10 (1983) : It is a longer duration variety and supplies green fodder upto mid June. Its seed is small. It is moderately tolerant to stem rot disease. Its nutritive value and voluntary intake are high. It yields about 410 quintals per acre green fodder. Its seed crop matures in the last week of June.

BL-1 (1977): It is quick growing and produces more tillers. It is a medium duration variety and is capable of supplying green fodder upto last week of May. It yields about 380 quintals of green fodder per acre. The seed crop matures in the first week of June. Its seeds are bright yellow, bold and attractive.

Soil Type : It grows well on medium to heavy soils and withstands alkalinity.

Agronomic Practices

Preparatory Tillage : A good crop is raised on land which had been properly levelled and is free from weeds. Prepare a good seedbed with three ploughings, each followed by a planking.

Time of Sowing : The last week of September to first week of October is the best time of sowing.

Inoculation : The inoculation of berseem with the proper *Rhizobium* culture will increase the forage yield. *Rhizobium trifolii* culture is available in the Deptt. of Microbiology, PAU, Ludhiana.

Prepare half litre of 10 per cent *gur* solution. Mix one packet of *Rhizobium* culture with it. Add the mixture to 8-10 kg of berseem seed and rub the mixture thoroughly as to give a fine covering of the bacterial suspension to every seed. Dry the seed in shade and broadcast it in standing water on the same day, preferably in the evening because the direct sun light kills the bacteria.

Seed Rate and Method of Sowing : Eight to ten kg seed, depending upon the viability should be broadcast in standing water when the weather is calm. In case of high wind, the seed should be broadcasted evenly in dry land followed immediately by raking and irrigation. The seed should be free from seeds of chicory (*Kashni)* and other weeds. To ensure this, put the berseem seed into water and sieve or decant the floating weed seed.

For obtaining a high yield of good-quality fodder, mix 750g of mustard seed with the full seed-rate of berseem. Alternatively mix berseem with oats, using half the recommended seed-rate of oats. In this case the oats seed is broadcast and mixed with the soil with a cultivator. The field is irrigated immediately and the berseem seed is broadcasted evenly as usual, in standing water.

Berseem+ryegrass when grown together make a very compatible mixture. To obtain high yield of good quality fodder, add 2-3 kg seed of ryegrass per acre with full seed rate of berseem or mix 1kg ryegrass seed per acre with the recommended seed rate of berseem+oats or berseem+sarson mixture. Mix some moist soil with ryegrass seed and broadcast evenly. Then broadcast berseem seed, rake the field and irrigate immediately.

Fertilizer Application : Apply six tonnes of farmyard manure alongwith 20 kg phosphorus (125 kg superphosphate) per acre at sowing time. Where farmyard manure has not been added, apply 10 kg nitrogen (22 kg Urea) and 30 kg phosphorus (185 kg superphosphate) per acre. The application of phosphorus in the form of superphosphate adds sulphur. Where ryegrass has been mixed in berseem, apply 10 kg N (22 kg Urea) per acre after each cutting.

Manganese Deficiency : Manganese deficiency generally appears in coarse textured soils especially where berseem follows rice. The symptoms appear more prominently when the crop reaches the cutting stage. In the early stages of deficiency, the mid-stem leaves of berseem show grey to yellow mottling. Tip and about 1/3 area from the base remains green. Later this mottling spreads on the entire leaf and colour changes from pinkish to brown which coalesce to form necrotic lesions. Where the deficiency is noticed, spray the crop twice or thrice with 0.5% manganese sulphate solution (1 kg manganese sulphate in 200 litres of water per acre) at weekly intervals on sunny days. Spray the crop after two weeks of cutting.

Weed Control : *Poa annua* commonly known as *Bueen* is a serious weed in berseem in certain situations and it offers severe competition to berseem during the early period of growth. It considerably reduces the fodder yield. This weed can be effectively controlled by spraying Basalin (fluchloralin) 45 EC at the rate of 400 ml in 200 litres of water per acre on a well prepared seedbed just before sowing of berseem. Under situations where itsit (*Trianthema portulacastrum*) is a problem, sow berseem mixed with raya which is fast growing crop and exerts tremendous smothering effect on this weed. Where the problem of this weed is serious, delay the sowing to the second week of October, as during this period, the incidence of the weed is drastically reduced due to the fall in temperature.

Irrigation : The first irrigation is important and should be applied early to get a good crop stand. The first irrigation may be given within 3-5 days in light soils and 6-8 days in heavy soils after sowing. Afterwards it may be applied within 8-10 days during summer and 10-15 days during winter depending upon soil type and weather.

Harvesting : First cutting is ready in about 50 days after sowing and subsequent cuttings at 40 days intervals during winter and 30 days intervals in spring, making 4-6 cuttings in all. Harvesting of berseem can be done with scythe that saves 60% of labour.

Seed Production : The seed yield of berseem mainly depends upon the time of last cut for green fodder and leaving it for seed production. The decision varies with the variety, type of soil and climate. The last cutting should be taken relatively early in low humidity and late in high humidity areas. The optimum time of leaving the crop for seed production is the first fortnight of April for BL-1 and second fortnight of April for BL-10 varieties of berseem. Variety BL 42 should be left for seed production by 10th of April. Shaftal, *kashni* and other weeds should be completely removed from the seed crop. Irrigate the crop frequently during the formation and ripening of the seed.

The seed crop of berseem can also be sown as late as the first fortnight of January. This late sown crop should also be left for seed production as mentioned above after taking two cuttings. The management practices of the late sown crop are the same as in normal sown crop. The average seed yield is about 2 quintals per acre.

A successful crop of berseem for seed production can be sown in end November after the harvest of basmati rice. It provides three cuttings of green fodder before leaving the crop for seed production.

Plant Protection

(a) Insect Pests :

1. Black ants : These ants take away the seed when it is just germinating. Locate the nests of the black ants and destroy them.

2. Bihar hairy caterpillar (Bhabu Kuta) : It is polyphagous and sporadic pest. It attacks berseem crop twice a season. In September-October larvae devour the young crop to the ground level and the farmers have to resow it. Again it feeds voraciously on foliage of plants and causes severe losses in March-April . Weeds like *Gutpatna, Bathu, Jangli Palak* and wild castor are the

alternate host plants on which the pest feeds in gregarious phase and later on migrates to berseem. Destroy these weeds growing adjoining to berseem fields before its sowing.

3. Surface grasshopper : Particularly *Oxya* spp. are sporadic pests and feed voraciously on berseem during May-June . More than 90% of the population of *Oxya* migrate from other crops to berseem during this period.Spray the crop with 500 ml of Malathion 50 EC in 80-100 litres of water per acre.

Caution : Use only Malathion on berseem meant for fodder and do not feed it to cattle for seven days after spraying.

4. Gram caterpillar : *(Helicoverpa armigera)* It attacks the seed crop very seriously.

Control :- (i) Spray 50ml of Chlorantraniliprole 18.5 SL or 200 ml of indoxacarb 15.8 EC or 60ml Tracer (spinosad 48 SC)/acre with the help of a manually operated knapsack sprayer using 80-100 litres of water at the initiation of flowers. Repeat after 10 days if necessary. Spray in evening when the insect pollinators are scanty in the field. (ii) Avoid raising of berseem seed crop adjoining to tomato, gram, late sown wheat, *sathi* moong, *sathe* mash and sunflower on which the pest multiplies and later shifts to berseem. If it is not possible, the pest should be controlled properly on these crops grown in the vicinity of berseem in order to check its migration to berseem fields.

5. Cabbage semilooper : It is a polyphagous pest and its larvae which are green in colour cause severe damage to berseem in March-April. Larvae make round holes in the leaves and defoliate the plants.

Control : During March-April, harvest the berseem crop at regular interval (30 days) to avoid lodging which creates favourable conditions for pest survival and multiplication and also hinders the activity of predatory birds which play key role to control the pest.

(b) Diseases

1. Stem rot (*Sclerotinia sclerotiorum*) : The fungus which is present in the seed or in the soil attacks the basal portion of the stem and causes it to rot. It produces white cottony mycellium which begins to grow on the dead organic matter on the surface of the soil. The white mycellium can very easily be spotted in the field around the wilted patches of the berseem crop. The seed should be taken from disease free crop so that there are no sclerotia of the fungus present in the seed. The field affected by the pathogen should be heavily flooded during summer months so that hard, black sclerotia, present in the soil may be destroyed. Cut the crop and expose the soil to the sun. Give one spray of Bavistin/Derosal/Agrozim/J.K. Stein @400g in 200 litres of water per acre immediately after the first cutting. Do not sow berseem in badly infested fields for 3-4 years.

Important hints to check reddening of leaves

1. Do not grow berseem where tubewell water is not fit for irrigation.
2. Treat berseem seed with *Rhizobium* culture before sowing.
3. Use only well rotten farm yard manure.
4. Control insect pests with recommended insecticides.

SHAFTAL

Shaftal commonly known as *Chhattala* or *Bhukal* is highly nutritious leguminous fodder. Being succulent, it is relished by all kinds of animals.

Climatic and Soil Requirements: Shaftal needs mild temperature for gemination and growth. It grows well on medium to heavy fertility soils.

Improved Variety

Shaftal 69 (1994) : Its plants are leafy having long stalk. Its leaflets are roundish in shape and flowers are light pink in colour. It is highly resistant to stem-rot disease and is thus particularly suitable for disease infested fields. It supplies green fodder upto mid May. Its seeds are small in size, immature seeds are greenish and mature seeds are dark yellow in colour. The average green fodder yield is 390 quintals per acre.

Agronomic Practices

Preparatory Tillage : Plough the field once with disc harrow and twice with cultivator followed by planking to secure a fine seed bed.

Sowing Time : The optimum time of sowing is the last week of September to the first week of October.

Seed Rate and Sowing : Broadcast 4-5 kg seed of shaftal in one acre in standing water. It can also be sown by broadcasting the seed in dry soil followed by raking and irrigation. To obtain high yield of good quality fodder from the first cutting, mix 500 g of mustard seed with full seed rate of shaftal or broadcast 12 kg oats seed per acre and mix it in the soil with cultivator. Shaftal+ryegrass when grown together makes a very compatible mixture. To obtain high yield of good quality fodder, add 2 kg of ryegrass per acre with full seed rate of shaftal. Alternatively mix 1 kg ryegrass seed per acre with recommended seed rate of shaftal+oats or shaftal+sarson mixture. Mix some moist soil with ryegrass seed and broadcast evenly. Then broadcast shaftal seed, rake the field and irrigate immediately.

Fertilizer Application : Apply 5 kg nitrogen (11 kg urea) and 20 kg phosphorus (125 kg single superphosphate) per acre at the time of sowing. Where ryegrass has been mixed in shaftal apply 5 kg N (11 kg Urea) per acre after each cutting.

Irrigation : Apply first irrigation within 3-5 days after sowing in light soils and 6-8 days after sowing in heavy soils. Afterwards irrigate at 8-10 days interval in summer and 10-15 days during winter depending upon weather.

Harvesting : The first cutting is ready in about 55 days after sowing and subsequent cuttings may be taken at an interval of about 30 days.

Feeding : As sole feeding of this protein rich (21.0%) legume can cause scouring in animals, therefore, wheat straw should be mixed in equal parts (1:1) on dry matter basis for feeding to the growing as well as milch animals.

Seed Production : Take last cutting of fodder in the first fortnight of March. Weeds should be completely rogued out from the seed crop. The seed crop of shaftal can also be sown as late as first

fortnight of January. This late sown crop after taking one cutting of fodder should be left for seed production in the first fortnight of March. The average seed yield of shaftal is about 2-3 quintals per acre.

Plant Protection

(a) Insect Pests :

1. Defoliators : In some years, ***Bihar hairy caterpillar (Bhabu Kuta)*** appears and infests this crop in October and subsequently in March-April. Shaftal is among the preferred hosts of ***Cabbage-semi looper.*** Its larvae make round holes in the leaves at early stage. However its severe attack in March-April defoliates the fodder crop. Control of Bihar hairy catterpillar and Cabbage semilooper on shaftal is the same as given under berseem. Shaftal is also attacked by some minor pests such as ***Lucerne-weevil*** (December to March); ***Aphid*** (February to March) ***Leaf miner*** (March-April). The infestation by these pests is of very low magnitude to cause any economic loss.

2. Gram caterpillar *: (Helicoverpa armigera).* It has emerged as a major pest of shaftal seed crop. It should be controlled by application of insecticides as given in berseem seed crop.

(b) Diseases

1. Downy mildew *(Peronospora trifoli-repentis):*The disease starts appearing in the month of January under cool, humid conditions. Leaves at the top of plants show greyish-cottony growth on the underside. Corresponding upper surface becomes yellowish and necrotic. Leaves of severely diseased plants are twisted and dry ultimately. Stem growth is retarded.

2. Rust *(Uromyces trifolii):* The disease starts appearing in February as small red brown pustules which may appear on all the green parts. Severely rusted leaves dry and many leaves fall. The growth of the crop is reduced. Seed from infected crop become light in weight. Generally this disease is in more severe form on seed crop.

The following steps may be followed for keeping these diseases under check :

(i) Always use seed from a healthy crop. (ii) Avoid application of high dose of nitrogen/organic matter as it increases lodging of the crop thus making it more susceptible to both the diseases. (iii) Delayed cutting may be avoided to reduce the inoculum which may cause infection to the subsequent cuttings. (iv) Avoid frequent irrigations.

LUCERNE

Lucerne is a perennial leguminous crop. It remains green almost throughout the year and is relished by all kinds of livestock. It is a valuable crop for soil improvement.

Climatic Requirements : It does well on irrigated soil of arid and semi-arid tract.

Improved Variety

LL Composite 5 (1982) : It is a tall, erect and fast growing annual variety.It has broad dark green leaves with purple flowers. It has bold seeds. It is highly resistant to downy mildew. It gives eight cuttings upto first week of July and yields 280 quintals per acre.

Soil Type : Deep and well-drained loamy soils are the best for this crop. It cannot withstand alkaline and waterlogged conditions.

Agronomic Practices

Preparatory Tillage: Plough the field once with a disc harrow and three times with a cultivator, followed each time by planking to secure a fine seedbed.

Sowing and Seed Rate: Middle of October is the best time for sowing lucerne. Sow 6-8 kg of seed per acre in rows 30 cm apart with *pora* or drill at a depth of 2 to 4 cm in proper soil moisture condition *(Wattar)*. The seed should be free from cuscuta *(Amarbel)* and other weed seeds.

For obtaining high yield, especially from the first cutting of the annual lucerne crop, broadcast 15 kg oats seed per acre and mix it with soil with a cultivator before sowing lucerne. Alternatively, broadcast 750 g per acre of mustard seed alongwith the full seed rate of lucerne.

Inoculation : The inoculation of lucerne with the proper *Rhizobium* culture will increase the forage yield as well as improve the fodder quality. *Rhizobium meliloti* culture is available in the Deptt. of Microbiology, PAU, Ludhiana. The method of inoculation is the same as in berseem.

Fertilizer Application : Ten kg of N (22 kg Urea) and 32 kg of P_2O_5 (200 kg of superphosphate) per acre should be applied at sowing. Drill 16 kg of P_2O_5 (100 kg of superphosphate) per acre along the rows every year in November to perennial crop.

Weed Control : To the planted crop, give the first hoeing about 1-month after sowing and the second after the rainy season. To the ratoon crop, carry out the weeding, when necessary.

Irrigation : Give the first irrigation about a month after sowing and the subsequent irrigations after 15-30 days, depending upon the weather. During the rainy season, do not allow water to stagnate in the crop.

Harvesting : The planted crop takes about 75 days to become ready for the first cutting. The subsequent cuttings may be taken at an interval of 30-40 days.

Seed Production : In case of the established crop, take the last cutting of fodder in mid March. Stop irrigation after full blossoming to arrest further vegetative growth and thus ensure good seed yield. The seed crop should be sown in rows 45 to 60 cm apart. The harvesting of the mature crop should not be delayed, as it may result in the shedding of pods. Harvest when two third of the pods dry up. On an average it yields 75-100 kg of seed per acre.

Plant Protection

Insect Pests

1. Lucerne caterpillar, jassid and lucerne weevil : These insects attack the crop. (i) Spray the crop with 450 g of Sevin/Hexavin 50 WP or 400 ml of Malathion 50 EC in 80-100 litres of water per acre. (ii) Adults of lucerne weevil aestivate from April to October under the scales of Eucalyptus trees and attack the crop sown near these trees. Remove the scales alongwith adults, in a gunny bag and burn them. (iii) If the crop is infested with lucerne weevil larvae, harvest the crop with least disturbance to the plants and collect it in *pallies* so that larvae are removed with the fodder from the fields.

2. Alfalfa aphid is some times serious in this crop. Spray 250 ml of Malathion 50 EC in 80-100 litres of water per acre.

3. Gram caterpillar (*Helicoverpa armigera*) : Same as given against this insect in berseem.

Precaution : Wait for two weeks after spray to harvest the fodder.

OATS

Oats is an important *rabi* fodder grown under restricted irrigation facilities. In nutritive value, oats is next to berseem. It is grown on 0.9 lac heactares with production of 33.6 lac ton and fodder yield of 35 ton/ha.

Climatic Requirements : Oats makes best growth in cool and moist weather. High temperature at blossoming increases the proportion of empty spikelets and reduces the seed yield.

Soil Type : Oats can be grown on all types of soils, except the alkaline or water logged ones.

Improved Varieties

OL-9 (1987) : It is recommended for the irrigated areas of Punjab. It is tall, erect growing leafy variety suitable for single/two cuttings. Seeds are medium in size. It gives 230 quintals of green fodder per acre. Its seed yield is 7 quintals per acre.

Kent (1986) : It is recommended for the irrigated areas of Punjab. It is tall, erect growing variety suitable for single/two cuttings. Seeds are bold. It gives 210 quintals of green fodder per acre. It produces 8 quintals of seed per acre.

Agronomic Practices

Preparatory Tillage : Plough the land three times to make it free from weeds.

Time of Sowing : The optimum time of sowing is from second week to last week of October.

Seed Rate and Sowing : Twenty five kg of seed should be sown per acre by the *kera* method or with *pora* in rows 20 cm apart. However, 10-15% higher fodder yield can be obtained through bi-directional method of sowing using the same seed rate. The seed should be treated with Vitavax @ one g per kg of seed to ensure freedom from smut. In oats + raya mixture, sow oats as given above and broadcast 1.0 kg raya/acre followed by planking. This mixture gives good quality higher fodder yield from first cut at 55-65 days after sowing during lean period. The second cut of oats can be taken either for fodder or seed.

Sowing with Zero Tillage : Oats can also be sown for seed and green fodder production without seed bed preparation with zero till drill after the harvesting of rice. In weed infested fields, weeds 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 environmental pollution and saving of irrigation water in first irrigation thus resulting in reduced cost of production. This also helps in timely sowing of crop after basmati.

Fertilizer Application : Apply 15 kg of N (33 kg Urea) and 8 kg P_2O_5 (50 kg Superphosphate) per acre at sowing and 15 kg N (33 kg Urea) 30-40 days afterwards.

Irrigation and Weed Control : Three to four irrigations including the pre-sowing irrigation are sufficient. Interculture is generally not necessary, but the growth of weeds must be checked in the early stages of the crop by weeding, if necessary.

Harvesting : The harvesting of oats should be done from boot to milk stage.

Seed Production : Seed crop should be sown in the second fortnight of November and it gives about 8 quintals seed per acre. However, the crop sown before 15th November may be left for seed after taking fodder at 65-70 days after sowing. In this case apply an additional dose of 8 kg N per acre after sprouting. This crop gives about 6 quintals of seed besides 100 quintals per acre of additional green fodder.

Plant Protection

Insect Pests

Oat aphid *(Rhopalosiphum padi)* **:** Oat aphid appears on oats during January to March. It sucks sap from the plants and lowers down the quality of fodder. Coccinellid beetles, syrphid fly and heavy rainfall keep check on its multiplication.

Caution : Do not spray any insecticide on fodder crop as it is hazardous to animals and also kills the predators of the aphid.

Diseases

1. Loose smut *(Ustilago avenae) :* The individual flowers of the oats panicle are replaced by spore masses. Treat the seed before sowing with one g of Vitavax per kg of seed.

2. Covered smut *(U. kolleri) :* The smut destroys the kernels completely and replaces them with black masses of spores which remain closed within the affected spikelets till harvested. Rogue out and destroy the smutted ears. Treat the seed before sowing with Vitavax @one g per kg of seed.

RYEGRASS

It is a multicut non-legume fodder and gives about five to six cuttings in *rabi* season. It is highly nutritious palatable and easily digestible fodder crop.

Climatic and Soil Requirements : Ryegrass needs mild temperature for germination and growth. It grows well on medium to heavy fertility soils.

Improved Variety

Punjab Ryegrass No.1 (1991) : It is quick growing variety and its first cutting is ready in about 55 days after sowing and subsequent cuttings can be taken after an interval of about 30-35 days. It has soft stem and leaves which are relished by the animals. Its average green fodder yield is 325 quintals per acre in five-six cuttings from November to May.

Agronomic Practices

Preparatory Tillage : A good crop is raised on lands which had been properly levelled. Prepare a good seed bed with 3-4 ploughings each followed by planking.

Time of Sowing : The optimum time of sowing is the last week of September to the first week of October. The seed crop can be sown up to November.

Seed Rate and Sowing : Sow 4 kg of seed per acre by broadcast method. Mix the seed with moist soil for even broadcasting in dry land followed immediately by raking and irrigation.

Fertilizer Application : Apply 15-20 tonnes of farmyard manure at the time of land preparation. Apply 15 kg of N (33 kg Urea) per acre at sowing time and 15 kg N (33 kg Urea) about 30 days afterwards. In subsequent cuttings 30 kg N/acre (66 kg Urea) should be applied immediately after cutting.

Irrigation : First irrigation should be applied immediately after sowing and second irrigation after about five days of sowing. Afterwards, irrigate the crop at an interval of about 10 days depending upon the prevailing weather conditions.

Harvesting : The first cutting is ready in about 55 days after sowing. Subsequent cuttings are ready at about a month interval.

Seed Production : The crop sown for fodder is left for seed producton in the middle of March. Irrigate the crop frequently during the formation and ripening of the seed. However, care should be taken that the seed crop does not lodge. Seed crop can also be sown separately at the seed rate of 2-3 kg/acre in rows 50 cm apart. The harvesting of the mature crop should not be delayed as it may result in shattering of seed. The seed crop matures in the first week of June.It produces 2-3 quintals of seed per acre.

Caution : Ryegrass is very sensitive to weedicides. So no weedcide should be sprayed.

SENJI

Senji (Sweet clover) is an important forage legume suitable for cultivation under restricted moisture supply and can thrive under a wide range of climatic and soil conditions.

Improved Varieties

Senji Safed 76 (1977) : It gives about 128 quintals of green fodder per acre. Its flowers are white.

YSL-106 (1983) : It is a yellow-flowered and quick growing early season variety and yields about 128 quintals of green fodder per acre.

Agronomic Practices

Preparatory Tillage : One ploughing, followed by planking is enough. It is sown in the standing crops of cotton and maize without any ploughing.

Sowing and Seed Rate : *YSL-106* is sown from end of September to the end of October. In standing crops of cotton and maize, sowing may be done in the 2nd or 3rd week of September. The optimum sowing time for *Senji -76* is the second fortnight of November. Fifteen kg of husked seed is enough for one acre, but it should be dehusked before sowing by giving a light beating. *Senji* is sown by broadcasting followed by irrigation.

Fertilizer Application : Apply 25 kg of P_2O_5 (155 kg super-phosphate) per acre at sowing.

Irrigation : In all, 2 or 3 irrigations are enough.

Harvesting : Fodder crop is harvested, when it is in full blossom.

Seed Production : No cutting should be taken from seed crop which matures by the end of March to yield about three quintals of seed per acre.

Plant Protection : To control weevil and black aphid, adopt the same control measures as given under lucerne.

NUTRITIVE VALUE OF FODDERS

Fodder	*Crude protein on dry-matter basis (%)*	*Total digestible nutrients on dry matter basis (%)*
Berseem	18.0	60.5
Shaftal	21.0	58.5
Lucerne	22.0	59.5
Senji	18.0	62.0
Oats	9.5	64.0
Ryegrass	16.0	63.5

SILAGE MAKING

Most of the fodder crops can be preserved as hay or silage. It is essential that in making silage, the material is thoroughly chopped to a preferable length i.e. between 5 to 8 cm. The material should be fairly dry with average dry matter content not less than 35 per cent. All material should be thoroughly compressed to remove air and sealed after covering.

There are several methods of making silage. The most common method is to put the chopped fodder in a silo trench or a pit. Silage can be made on hard-ground or a floor, which is free from danger of water accumulation or soaking. The compressed material can be covered with a plastic sheet or a polythene sheet and sealed by putting soil and dung mixture along its edges. The complete sealing of the edges is extremely essential for good preservation. The elimination of air pockets is also necessary, because the process of preservation is carried out by anaerobic bacteria. A well preserved material has *p*H of 4.5 and is low in losses of nitrogen. A good quality silage retains the nutritional value of original crop and has a high lactic acid and a low butyric acid content. Important points for preparing a high quality silage are given below :

1. *Silo-trench.*- Prepare silo trench of 10mx3mx1.5 m near the cattle shed. About 350-400 quintals of green fodder can be packed in this trench which will supply silage for a herd of five cows or buffaloes for 4 months at 40 kg/head/day.
2. Forage crops should be harvested at their optimum stage of digestibility e.g. oats at milk stage and Napier bajra hybrid when at 1 metre height.
3. Chop the harvested crop and pack it into the silo trench. A crop with 30-35% dry matter ferments into a high quality silage. If moisture content is too high, let the crop wilt in the field for 1-2 days.
4. Press the chopped crop in the trench and let it remain one metre above ground level.
5. Cover it with a layer of 10-15 cm *Kadbi* straw or wheat *bhusa.* Cover with mud and finally mud plaster so that silo trench is completely air tight. Alternatively, a plastic sheet may be used to cover the packed forage and its edges sealed with clay and dung mixture.
6. Keep an occasional watch and if there is any crack or hole, plug it immediately. Silage will be ready within 45 days.
7. Open the silo-pit from one side only and take out 40 kg of silage per animal per day for feeding. The remaining silage, kept covered, stays good till used.

HAY-MAKING

The drying and storing of high-quality forage offers many advantages. It assures the supply of high digestible feed with high protein and calorific values all the year round. It reduces the amount of concentrates that must be fed to cattle. The storage losses are less than those in silage. It reduces the labour involved in handling and transporting green forage, because the chopped green forage has 80-90% water, whereas the hay has less than 15%. It makes movement to the market as well as to the feed manger easier. Hay-making admits of harvesting and storing all crops at the optimum stage with regard to nutrient contents. The labour and botheration of cutting green forage daily is eliminated. Even the intensity of cropping can be increased and more cuttings can be taken from the multiple-cut crops.

In making-hay from high-quality forage, the biggest hazards is the loss of leaves in handling. With the loss of leaves, a large fraction of proteins in the crop is lost particularly in case of legumes such as berseem, cowpeas and *guara.* This problem is not so bad in case of non-legumes, such as maize, sorghum and napier x bajra hybrid.

A simple method of making hay with minimum loss of leaves is described below. It can be easily adopted by the farmers without extra investment in equipment.

1. Cut berseem or lucerne in the pre-blossom stage in order to ensure conservation of protein and available energy to a great extent.
2. Chop the forage while still moist (fresh or wilted) with a chaff-cutter. Chopping need not be too fine. The best length of the cut is about 5 to 8 cm.
3. Spread the wet chopped forage in the sun on a smooth hard surface in a thin layer not exceeding 12 to 15 cm in depth. The usual threshing floors, roof tops, etc. can be used as drying floors.
4. Stir the drying forage every 2-3 hours during the day to speed up the drying process under exposure to the sun and the air.
5. When thoroughly dry (usually) after 3-4 days, depending on the frequency of stirring, the intensity of the sun and the movement of the air, gather the mixture of dried stems and leaves to store or market. When hay balers become available, the chopped and dried forage can be baled. Baling will reduce the storage space and facilitate the transport of the forage to the market.
6. The chopped and dried forage can be stored at the village farm in the same way as wheat *bhusa* is done in thatched or mud-covered stacks or in buildings normally used for storing wheat *bhusa* or rice straw.

Hay making is profitable when the production of fodder is in excess of consumption. Good-quality dried forage (hay) is as nutritious as the green forage (if available) during the period from June to December when high protein forage is scarce. It fetches higher price and helps to increase milk production. Hay is priced on the basis of dry matter in the corresponding green forage. For instance, 10 kg of hay containing 85 per cent dry matter would be worth as much as 35-40 kg of green forage containing 15% dry matter of the same crop.

6. SELENIUM TOXICITY AND ITS CONTROL

Selenium (Se) is an essential element for animal health. Critical level of Se in the fodder is 0.05 mg/kg fodder for the animals and becomes toxic when present more than 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 stiff 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. 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.
7. Follow maize-wheat instead of rice-wheat rotation.
8. Ensure that grass, grains and fodder produced at the toxic sites should not be consumed at all either by human-beings or animals.

7. SOIL TESTING

Soil testing is a protective tool against irrational use of nutrients, which not only increases the profit level, but also improves the soil environment. In soil testing, organic carbon content and the amount of available nutrients present in the soil are determined. The soils are classified into different categories such as low, medium and high in respect of available nutrients and fertilizer recommendations are made for each category separately. The general fertilizer recommendations, which are given in the package of practices, pertain to normal soils of medium category (Table 1.)

Table 1. Fertilizer recommendations (kg/acre) for medium category soils

Crop	*For Nitrogen*	*For Phosphorus*		*For Potassium***
	Urea (46% N)	*Single Super Phosphate (16% P_2O_5)*	*DAP* (18% N and 46% P_2O_5)*	*Muriate of Potash (60% K_2O)*
Wheat	110	155	55	20
Barley (PL 419)	35	75	25	10
Barley (PL 172, PL 426, VJM 201)	55	75	27	10
Winter Maize	155	150	55	20
Gram (*Desi*)	15	50	20	--
Gram (*Kabuli*)	15	100	35	--
Raya (irrigated)	90	75	27	--
Raya (rainfed)	55	50	20	--
Toria	55	50	20	--
Sunflower	50	75	25	20
Berseem	20	185	65	20

* For every 50 kg DAP reduce the dose of urea by 20 kg;

** Recommended only in potassium-deficient soils

Nitrogen : Organic carbon (OC) content of soil is taken as an index of nitrogen (N) availability and is thus used to make fertilizer recommendations for nitrogen. Based on organic carbon content soils are categorized as low (less than 0.4% OC), medium (0.40-0.75% OC) and high (more than 0.75% OC). Soils low in organic carbon are poor in supplying nitrogen, therefore, apply 25 per cent higher dose of fertilizer over the general recommended dose, which is for medium organic carbon soils. On the other hand, in high organic carbon soils apply 25 per cent less fertilizer as compared to medium soils.

Phosphorus : Based on available phosphorus (P) content, soils are rated as low (less than 5 kg P/acre), medium (5-9 kg P/acre), high (9-20 kg P/acre) and very high (more than 20 kg P/acre).

For soils testing low in phosphorus, apply 25 per cent more fertilizer over the recommended dose, whereas in high P soils reduce it by the same amount. In soils testing very high in available phosphorus, omit phosphorus fertilizer application for 2-3 years and then again get the soil tested.

In addition to soil phosphorus status, organic carbon content also influences the amount of fertilizer phosphorus required (Table 2). Therefore, recommended fertilizer dose should be adjusted keeping in mind both the soil organic carbon and available phosphorus content as shown in Table 2.

If the soil organic carbon content is 0.4 to 0.6 per cent, reduce the phosphatic fertilizer dose by one forth in medium P soils, by half in high P soils and omit its application in very high P soils.

If organic carbon content of the soil is more than 0.6 per cent and available phosphorus is 5-9 kg/acre, apply half the recommended dose of fertilizer. However, if the soil phosphorus status is more than 9 kg/acre, omit the application of phosphatic fertilizers.

In all other categories of soil viz. soil with less than 5 kg P/acre irrespective of organic carbon content and soils with less than 0.4 per cent organic carbon irrespective of soil P status, apply the recommended dose of phosphatic fertilizer.

Potassium : The soils are broadly divided into two categories 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 potassium. Since the farmers mostly omit potassium application, it is important that soil testing for potassium must be done so that its deficiency does not limit crop yields. Soils in Gurdaspur, Hoshiarpur, Nawanshahr, Jalandhar and Ropar districts generally show K deficiency.

Table 2. Recommendations for fertilizer phosphorus based on available phosphorus and organic carbon content in soils

Soil organic	*Available Phosphorus (kg/acre)*			
carbon(%)	*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

Micronutrients : With the intensification of agriculture, cultivation of fertilizer responsive high yielding varieties and the use of high analysis NPK fertilizers, micronutrient deficiencies are becoming yield limiting factors in many crops. Deficiencies of zinc, iron and manganese have been noticed in our state. The Punjab Agricultural University is now providing soil test for micronutriests also. The soils are categorized as deficient or adequate in respect of different micronutrients based on their critical values.

In zinc-deficient soils (zinc content less than 0.6 kg/acre), soil application of 10-25 kg zinc sulphate per acre is recommended depending on the crop in question. In a cropping sequence, the application of zinc sulphate should preferably be made to kharif crop for getting maximum benefit.

Manganese deficiency generally appears in wheat or berseem following rice in sandy soils. In manganese deficient soils (manganese content below 3.5 kg/acre), spray the wheat crop with 0.5% manganese sulphate solution 2-4 days prior to first irrigation followed by 3 subsequent sprays at weekly interval. In berseem, where the deficiency is noticed, spray the crop 2 or 3 times with 0.5% manganese sulphate solution at weekly interval starting with 2 weeks after 1st *cutting.*

Salt affected soils : Apart from the nutrient content, soil texture, soil reaction, and salinity or alkalinity level also affect the efficiency of applied fertilizers.

In alkali soils (pH more than 9.3) along with gypsum application, other management practices need to be followed for proper reclamation of the soil. In these soils, 25 per cent additional fertilizer nitrogen over the normal soils is recommended. 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 milli mhos/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 in saline soils.

Keeping in view the resources available with the farmer 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% reduced fertilizer dose where soil status is high.

Collection of soil sample

For 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.

8. 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 flouride. It is, therefore, important that the underground tubewell waters must be got tested from a soil 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 which may be tackled by following the guidelines given below :

(1) Ensure adequate drainage : In areas receiving poor quality irrigation waters, leachig of excess salts and water from the root zone has to be ensured so as to maintain a favourable salt and water balance. In poorly drained soils and in soils having hard pan, long term irrigation with poor quality waters results in the build up of salts more rapidly than that under well drained soils. 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 preferably be laser levelled. Proper levelling 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, 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 soil salinity and sodicity among different crops and their varieties. It is always desirable 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 applying pre-sowing irrigations with canal 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 preferably should 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 ameliorated 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 estimlated from a soil and water testing laboratory. For each me/l of RSC above 2.5 me/l, the quantity of gypsum (70% purity) works out to 1.50 q/acre for four irrigations of 7.5 cm each. Gypsum calculated for 4 irrigations should be applied with the first irrigation. If the soil has already deteriorated, gypsum should be applied on soil test basis. After mixing gypusm 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 Dhaincha green manure or wheat straw @ 2.5 tonnes/acre/year for reducing harmful effects of sodic irrigation water.

(7) Use poor and good quality 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 canal water. The poor and good quality waters can be used 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 the later stages as crops can tolerate higher salinity/sodicity levels.

(8) 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 and water samples tested at regular intervals. This will help them in keeping a check on soil deterioration.

(9) Use of village pond water for irrigation : Water in village ponds contain 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, the pond water should be got tested from Soil and Water Testing Laboratory and may be used for irrigation as per the recommendation.

9. 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 beaks 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 : In the first phase, the Protection of Plant Varieties and Farmers Rights Authority has started the registration of varieties of the following 14 crops; Rice, Bread, Wheat, Maize, Sorghum, Peral millet, Field Pea, Chickpea, Pigeon pea, Green gram, Black gram, Lentil, Kidney bean, Cotton and Jute.

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

10. 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 System

Organic 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).

Organic 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, pressmud, sludge and compost enriched with rock phosphate* can be used in raising the organic wheat. The dose 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 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, Vermicompost and Non edible cake, each supplying 1/3 of the total nitrogen requirement. Apply 1.7 t/acre FYM (1 per cent nitrogen), 1.1 t/acre vermicompost (1.5 per cent nitrogen) 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 *(Coccynella septumpunctata)* becomes active on the appearance of the aphid.

**Method of Preparing Phospho-compost*

Rice-Straw is collected from fields and brought to the composting point conveniently near the tubewells on the farm because of 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 at day 80-90 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.

Maize/Soybean-Wheat System

The soil, seed rate, spacing etc. requirements are comparable with conventional farming while fertilizers and other chemicals should not be used.

Organic 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 rate/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.

Organic 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 rate/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.

Organic 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 proved highly productive when its nutrition need was fulfilled by applying 1/3 each of FYM, vermicompost and non-edible cake under organic farming. The yield improved when potato was intercropped with radish and onion with coriander which enabled to harvest the comparable yield with the chemical farming even in the first year. The nutritional requirement was calculated keeping in view the package recommendations. The conversion from chemical or organic was made on the basis of nitrogen content in each source. The organic sources used were FYM (1 per cent), vermicompost (1.5 per cent) and non-edible cake (2.5 per cent). The quantity of organic manures to be applied to organic maize system for getting 50 kg N/acre is 16.7 q FYM; 11.1 q vermicompost and 6.7 q non-edible cake/acre. For potato (75 kg N/acre) the corresponding quantity of FYM, vermicompost and non-edible cake was 25.0, 16.7 and 10.0 q/acre; and for onion (40 kg N/acre) was 13.3, 8.9 and 5.3 q/acre respectively. Therefore, 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)

Organic 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 per cent nitrogen), 1.1 t/acre Vermicompost (1.5 per cent nitrogen) 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.

Organic 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 per cent nitrogen), 1.1 t/acre vermicompost (1.5 per cent nitrogen) 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.

Organic 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.

Organic 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.

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

11. MULTIPLE CROPPING

Multiple Cropping is a system in which more than two crops are grown one after another on the same piece of land in quick succession during a year. The success of this system depends upon the selection of suitable crop/varieties, availability of labour, farm machinery, irrigation, fertilizers, pesticides, finance etc, in addition to the technical know-how. Timely cultural operations, alertness and managerial capacity of the farmers 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 dead ripe stage.

Some of the important multiple cropping systems are :

1. Green manure (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. Bury 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, practice 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 and after picking of pods, burying of its straw 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 of April. These fodder crops will vacate field for timely sowing of the succeeding maize/rice crop and provide green fodder during the lean period in summer in the months of June. A fodder crop of 45-55 days generally provide 80-100 q/acre of green fodder.

3. Green manure-Maize-Wheat : Sow a green manure crop of dhaincha/sunhemp/cowpea with recommended practices in the last week of April and bury 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. Green manured maize crop does not require any application of organic manure (FYM etc.)

4. Maize/Rice-Potato-Wheat : Grow a short duration variety of maize/rice (PR 115) in mid 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 grow late sown wheat variety (PBW 373) with 50% recommended N/acre without P and K.

5. Maize/Rice-Potato-Summer Moong : As summer moong sown after harvesting of wheat is liable to be caught 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 to third week of March. In these cropping sequences maize/rice can be planted in early June to vacate the field for timely sowing of potato crop in the 2nd fortnight of September. Further, the summer moong after potato does not require any fertilizer application if the preceding potato crop received recommended level of NPK and FYM.

6. Rice-Potato/Toria-Sunflower : Transplant short duration variety of rice (PR 115) in early 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, sunflower can be sown in the early January on southern slope of East-West drawn ridges. Apply 12 kg N/acre to sunflower grown after potato, if the potato crop received recommended level of NPK alongwith 20 tonnes of FYM per acre. Sunflower crop will vacate the field in mid May for timely transplanting of rice.

7. Maize-Potato/Toria-Sunflower : In this system maize can 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 (PSFH 118, SH-88, DK 3890, PAC-302) can be grown successfully in early January on southern slope of East-West drawn ridges. Apply 12 kg N per acre to sunflower grown 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. Summer Groundnut-Potato/Toria/Pea/late Kharif fodder- Wheat : In Summer groudnut-wheat system, a crop of potato/toria/pea/late kharif maize fodder can be raised successfully. For this sow summer groudnut variety SG 84 during end of April to first week of May after the harvest of wheat. Further as summer groundnut crop vacates the field in early September, thereafter, an additional crop of potato or early Pea (*Ageta*-6 or Arkel) or Toria (TL 15) or late sown maize fodder can be taken during the second fortnight of September. Toria/Pea/late sown fodder and potato vacates the field during December when late sown wheat (PBW 373) can be sown. Such groundnut based cropping systems have been found more 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 the first week of October and Onion (Punjab Naroya) from 10-15 January for the high yield realization. The soil fertility in relation to organic carbon, available N, P and K also improve over time.

10. Summer 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 (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 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 substantial 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 that 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 and 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 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 Moongbean : These systems produced more yield and economic returns than the maize-wheat and rice-wheat system. Therefore, the maize/rice should be sown in the first fort night of June, *Gobhi Sarson* from 10-30 October and summer moonbean in the first fortnight of April. The summer moongbean can be sown without tillage after applying pre-sowing irrigation.

16. Rice-gram-summer moongbean : 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.

Fodder cropping systems

17. 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.

18. 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 1st 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 betwen milkripe and dough stage of grain development.

The above multiple cropping systems are highly remunerative and also provide more employment hours.

12. 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 pour 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 clodinafop, fenoxaprop-p-ethyl, phenoxy, metsulfuron groups (recommended for wheat 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. However, other herbicides belonging to

isoproturon, sulfosulfuron, mesosulfuron + iodosulfuron etc. groups can be sprayed with less or more quantity of water as these herbicides enter the weed plants both through roots and foliage and they should be sprayed on a moist field.

During *rabi* season, some herbicides are applied as pre-plant or pre-emergence and these require 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 wheat 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 sleeve 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 EC (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 Parthenium (congress grass/carrot grass)

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 600g/acre (Excel Mera). Parthenium plants are more susceptible to these herbicides when sprayed at their active growing stage but before flowering.

13. MANAGEMENT OF RODENTS AND BIRDS

(A) Management of Rodents

Rats and mice are the most serious pests of crops and must be controlled. By virtue of their extremely adaptable nature, highly intelligent patterns of behaviours and tremendous potential to multiply, they maintain their large population which cause extensive damage in crop fields. They live in burrows, possess acute senses of smell and taste and are very selective in food choice. Such characteristics make their control difficult which requires specialized methods quite different from insects and bird pests.

Species and Distribution : 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 and the soft-furred field rat are most predominant in wheat, paddy, sugarcane growing regions and bet areas, the Indian gerbil and the mouse in sandy soils and rainfed regions, soft-furred field rat in alkaline soils and the Indian bush rat and the gerbil in kandi region.

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 to wheat is 2.9% at seedling and 4.5% at ripening stage and to pea is 1.1% at seedling and 5.9% at ripening. In winter maize they cause 10.7% damage at the seedling stage only. The rat damage in wheat crop near sugarcane fields, waste land, canals, roads and in *bet* areas may reach upto 25% and therefore, control operations must be intensified in such areas.

Methods of Control : The performance of different control methods vary in different situations and at different stages of the crop. The best control success can only be achieved if these methods are adopted properly at appropriate timings.

A. Mechanical Control :

(i) During irrigation of vacant harvested fields, rats coming out of flooded burrows should be killed with sticks.

(ii) Trapping : Use double chambered multi-catch trap with tunnel-type entrance (as developed by PAU) 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 the traps by wrapping paper around them.

To enhance trapping do pre-baiting by placing 10-15 g of the plain bait 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 (6x6cm) in the trap tunnel. Trap the rat for 3 consecutive days.

Important : Kill the trapped rats by drowning in water and the interval between two trappings at the same location should not be less than 30 days.

Baiting Techniques

B. Chemical Control

1. Poison bait preparation : 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 g of sunflower/groundnut oil and mix it thoroughly with 25 g of zinc phosphide.

Caution : *Never add water in zinc phosphide bait and always use freshly prepared bait. Minimum interval between two baitings of zinc phosphide must be 2 months.*

(ii) 0.005% Bromadiolone bait : Mix 20 g of 0.25% Bromadiolone powder, 20 g of oil and 20 g of powdered sugar in 1 kg of any cereal flour.

Bait Placement and Timings

(1) Baiting in November-December : 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 10g of zinc phosphide or bromadiolone bait 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.

(2) Baiting in mid-February to early-March : This period is critical for the control of rodents in the crops as acceptance of bait is poor due to extreme cold conditions before this period and abundant food in the form of ripening crops after this. For successful control adopt the following schedule :

Prebaiting : Prebaiting 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 g of zinc phosphide or bromadiolone bait at 40 baiting points per acre on dry sites inside the crop throughout the field covering runways and activity sites of rats.

3) Baiting in zero tilled wheat fields : Rodent infestation and damage is more in zero tilled as compared to conventionally tilled wheat fields. Poison baiting in burrows in zero tilled fields before sowing of wheat (late October and early November) and poison baiting on pieces of paper during crop period (Mid February-early March) should be done to protect the crop from rodent damage.

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 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 inhaling of poison through mouth and nose. Wash exposed skin and hands after mixing.
3. Household utensils should never be used for preparation of the 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 accidental ingestion induce vomiting by inserting fingers in the throat and rush to a doctor. Vitamin K is the antidote for bromadiolone which 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.

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.

E. Integrated Approach :

No single method is 100% effective in controlling rats and mice. Left over population reproduce reaching the original size in a short time. Therefore, adopt an integrated approach by carrying out different methods at different stages of the crop. Before sowing the Rabi crops, rats must be killed during irrigation and apply chemical measures at appropriate timings in the crops as given above. The left over rats after zinc phosphide baiting should be tackled with bromadiolone. Due to bait shyness, zinc phosphide can not be used in follow up baiting but bromadiolone can be used.

F. 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 anti-rat campaigns, to cover maximum possible area, both cultivated and uncultivated, should be organized.

(B) 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 of 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.

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 logging 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 at Communication Centre, 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 crop 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 intergrated pest mangement. For covering larger area use of amplifier and addition of speaker as per requirements can be done.

Conservation of Useful Birds : Predatory birds like owls, falcons, hawks, eagles, kites etc. eat a large number of rats and mice. A single owl normally eats 4-5 rats a day. Insect eating birds like drongos, 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 ones. A single pair of house sparrows feed insects to their young ones 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.

14. 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) f 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.

15. FISH FARMING

PACKAGE OF PRACTICE FOR FRESH WATER FISH FARMING

Fish farming is one of the most important allied agricultural occupations in Punjab. Because of relatively easy farming method and high economic returns, fish farming is becoming popular day by day. Raising fish on scientific lines gives a net return of approximately Rs. 40, 000 per acre per year (on the basis of prevailing market prices). Besides, it has a great potential for utilizing wasteland (such as low-lying, water-logged-areas, flood land, etc.) and many wastes and by-products originating from agriculture and animal husbandry.

1. Culturable Fishes

Mixed or composit culture of six species is recommended. These six species include three Indian major carps viz. catla, rohu, and mrigal and three exotic carps viz. common carp, grass carp, and silver carp.

2. Site for Construction of Fish Pond

The soil should retain water. Clay or clay loam soils are preferred. In case of light soils, the water retaining capacity can be increased by puddling. There must be a permanent source of water for filling up the pond and to compensate for the losses due to evaporation and seepage. It may be tubewell or canal water. In case canal water is to be used, a galvanized iron screen, to prevent the entry of unwanted organisms including predatory (mulley, singhara, dolla) and weed (Sheesha, Puthi, Kangi) fishes, must be provided at the inlet.

3. Design and Construction of a New Pond

To be economically viable, the pond should be between one and five acres in size. The depth of the pond should be 6-7 feet. The pond should have even bottom and gentle slope to facilitate netting. The pond should have controlled inlet and outlet for an easy supply and draining out the water. The most desirable time for digging out of a fish pond is mid February for the maximum utilization of the growth period (mid March to late November). The digging can be carried out with the help of a tractor or bulldozer. To meet the requirements of the fish seed for restocking in one-acre pond, a small nursery pond of 500m^2 (One kanal) should be maintained.

4. Eradication of Aquatic Weeds from an Old Pond

To prevant the growth of aquatic weeds in old ponds, its water level should be strictly maintained between 5 and 6 feet. However to eradicate aquatic weeds following methods are used :

a) Physical methods : The weeds can be removed by draining the pond and by manual clearing of weeds with the help of a bottom raker made of barbed wire.

b) Biological methods : Duck weeds *(Spirodella, Wolfia, Lemna), Hydrilla,* and *Vallisnaria* can be controlled with the introduction of grass carp. Silver carp can check the growth of dense algal blooms.

5. Eradication of Fish Enemies from an Old Pond

The problem of fish enemies including predatory and weed fishes is encountered in old village ponds. For the eradication of these enemies, following methods are recommended :

a) Repeated netting : All enemies which include predatory and weed fishes, tortoises, snakes etc. except bottom dwellers like dolla, singhi (which burrow into a mud) can be removed by this method. Nylon net should be used to trap snakes which should be killed after carefully taking them out of the net.

b) Poisoning : Some safe poisons recommended for use in fish ponds are :

i) Bleaching powder @ 140 kg per acre, and ii) a combination of urea and bleaching powder (apply urea @ 40 kg per acre and next day, apply bleaching powder @ 70 kg per acre).

The fish killed with any of these poisons is safe for human consumption. The ponds treated with any of these poisons can be stocked with fish only after 7 days of the application, when the effect of poision is over.

6. Maintenance of Water depth

The water depth, both in old and newly constructed fish ponds, should be maintained between 5-6 feet throughout the year.

7. Water Quality

Dissolved oxygen and pH are two critical parameters which effect survival and growth of fish. Dissolved oxygen should remain more than 5 mg/l and pH between 7 and 9. If the pH of water is below 7.0, apply finely ground quick lime @ 80-100 kg/acre (in liquid form) so as to bring pH to the favourable range. Salinity of water should not exceed 2 ppt.

8. Manuring and Fertilization

In old ponds, the rate of manuring depends upon the water-quality and plankton production. To ensure adequate supply of plankton production (fish food organisms), the new ponds should be manured with any of the organic manures and inorganic fertilizers given in table 1.

Table 1. Different organic manures and inorganic fertilizers recommended for use in new fish ponds.

Manure	Rate per acre	Initial dose *(kg)*	Subsequent dose* *(kg)*
Organic Manure			
Farm yard manure	8,000 kg/year	2,000	120/week
Poultry manure	4,000 kg/year	1,000	60/week
Farm yard manure (3 parts) and poultry manure (1 part)	7,200 kg/year	1,800	112/week
Biogas slurry (semi-solid)	20 litres/day	--	--
Inorganic Fertilizers			
Single super phosphate	240 kg/year	80	15/month
Urea	40 kg/year	40	--

* Subsequent dose of organic manure is given after a fortnight of the initial dose and that of the inorganic fertilizers after one month of the initial dose.

The initial dose of the organic manure and the inorganic fertilizers is to be given 15 days before the stocking of the fish. Inorganic fertilizers should be sprayed on water surface after dissolving them in water. If there is a foul smell or the development of thick algal blooms, the use of manures/fertilizers should be temporarily suspended till the situation improves.

9. Stocking of Fish

Stock the pond with fish fry (3 to 5 cm in length) @ 4000/acre in the ratio of :

Catla 20%, rohu 30%, mrigal 10%, common carp 20%, grass carp 10% and silver carp 10%

OR

Catla 25%, rohu 35%, mrigal 20%, common carp 20%

The seed of the fish can be obtained from different seed produciton units of the State Fisheries Department.

10. Supplementary Feeding

Feed the fish with supplementary diet containing approximately 25% protein. The feed can be prepared by using deoiled rice or wheat bran 44%, deoiled mustard or any other cake 44%, fish meal/meat meal/soya meal 10%, mineral mixutre/bone meal 1.5% and common salt 0.5%. Soak the feed in water for 3 to 4 hours and then mix properly to make doughs which can be given in trays, baskets or in perforated plastic bags kept 2 to 3 feet below water surface. The schedule of feeding is given in table 2.

Table 2. Schedule of feeding fish during the growth period (mid March to late November; water temperature above 20^0C).

	Average Body Weight (g)							
	up to *50*	50-*100*	100-*200*	200-*300*	300-*400*	400-*500*	500-*600*	600-*700*
Feed (kg/1000 fish/day)	0.1	0.3	1.2	1.3	4.5	8.9	10.4	11.5

During winter (December to early March), a maintenance ration of 0.5 kg/1000 fish/day should be provided.

11. Periodic Harvesting and Restocking

The first harvesting is done after one year of stocking when the fish attain marketable size (above 500g). Harvesting can be done either partially or completely. Harvested fish should be replaced with the same number of the seed of the same species.

12. Fish Health Management

To prevent occurrence of fish disesaes, it is desirable to treat fish seed with potassium permagnate ($KMnO_4$) solution (100 mg/litre) before stocking (given a quick dip). Fish health should be regularly monitored by the examination of fish at fortnightly intervals. A brief account of some of the common diseases of culturable fishes, their symptoms and treatments is given in table 3.

Table 3. Some common fish diseases, their symptoms and treatments.

S. No.	*Name fo disease*	*Caused by*	*Symptoms*	*Treatment*
1.	Tail and fin rot	Bacterium (*Pseudomonas* spp.)	The appearance of a faint white line on the margin of fin. Subsequently,spreading over the entire fin and finally damaging it.	Treat the fish with 0.05% solution of copper sulphate for 1-2 minutes in a tub.
2.	Haemorrhagic septicemia.	Bacterium (*Aeromonas hydrophila.*	External leisons, ulcerations, abdominal dropsy.	Treat the fish with 100 mg/litre $KMnO_4$ sol. or give terramycine in feed @ 75-80 mg/kg body weight for 10-15 days.
3.	Gill-rot	Fungi. (*Brachiomyces* spp.)	The filaments of the gills become greyish white and finally drop off. The fish gasps at surface of the water and dies of suffocation.	i. Add fresh water to the pond and prevent the entry of sewage water, if any. ii. Apply quick lime to the pond @ 40 kg/acre. iii. Discontinue manuring and supplementry feeding. iv. Give bath to the infected fish for 5-10 minutes in 3-5% common salt solution or in 5 mg/1 of $KMnO_4$.
4.	EUS (Epizootic Ulcerative syndrome	Multiple infection caused by bacteria virus & fungi	Ulcers on the body, erosions of the skin and fins leading to death of the fish.	Treat the pond with quick lime @ 240 kg/ acre/week for three consecutive weeks and stop feeding and manuring till fish cures.
5.	Argulosis	Crustacean (Argulus spp.	Stunted growth, loose scales, spots and clotted blood on the skin.	Add fresh water continuously. Treat the pond with three successive applications of 1.0 litre malathion (50 EC) with a gap of fifteen days. In case of severe infestation, the pond should be drained and dried up.

Appendix- I

Minimum Support Prices of Different Crops, 2007-08 to 2011-12

S.No.	Crop	2007-08	2008-09	2009-10	2010-11	2011-12
1	Paddy Common	645 (p)	850 (v)	1000	1000	1080
	Paddy (F)/ Grade 'A'	675(p)	880(v)	1030	1030	1110
2	Jowar Hybrid	600	840	840	880	980
3	Bajra	600	840	840	880	980
4	Maize	620	840	840	880	980
5	Arhar	1550(b)	2000	2300	3000	3200
6	Moong	1700(b)	2520	2760	3170	3500
7	Mash/ Urad	1700 (b)	2520	2520	2900	3300
8	Groundnut	1550	2100	2100	2300	2700
9	Sunflower Seed	1510	2215	2215	2350	2800
10	**Soybean**					
	Black	910	1350	1350	1400	1650
	Yellow	1050	1390	1390	1440	1690
11	Sesamum	1580	2750	2850	2900	3400
12	**Cotton**					
	F 414/H 777/J 34 (Raj.)	1800	2500	2500	2500	2800
	H-4 /S-6	2030	3000	3000	3000	3300
13	Wheat	750(a)	1000	1080	1100	1120(c)
14	Barley	565	650	680	750	780
15	Gram	1445	1600	1730	1760	2100
16	Lentil (Massar)	1545	1700	1870	1870	2250
17	Rapeseed / Mustard	1715	1800	1830	1830	1850
18	Safflower	1565	1650	1650	1680	1800
19	Toria	1680	1800	1830	1830	1850
20	Sugarcane (SMP)	81.18	81.18	129.84	139.12	145.00

p : Additional incentive bonus of Rs. 100/- per quintal for paddy for 2007-08
b : An additional incentive bonus of Rs. 40/- per quintal for 2007-08 season
a : And additional incentive bonus of Rs. 100/- per quintal during Rabi marketing season 2007-08
v : Bonus of Rs. 50/- per quintal
c : Incentive bonus of Rs. 50/- per quintal for wheat procurement during 2011-12
SMP : Statutory Minimum Price

Appendix - I-A

District-wise Area, Yield and Production of Various Crops for Rabi 2010-2011

	Wheat			*Barley*			*Taramira*			*Sarson*		
District	*A*	*Y*	*P*	*A*	*Y*	*P*	*A*	*Y*	*P*	*A*	*Y*	*P*
Amritsar	189	4283	810	–	–	–	–	–	–	1	1054	2
Barnala	115	4976	572	1	3013	3	–	–	–	1	1285	1
Bathinda	253	4609	1166	2	3193	7	–	–	–	2	1376	3
Faridkot	117	4810	563	–	–	–	–	–	–	–	–	–
Fatehgarh Sahib	85	4903	417	–	–	–	–	–	–	–	–	–
Ferozepur	397	4660	1850	3	3668	11	–	–	–	5	1713	9
Gurdaspur	226	4065	919	–	–	–	–	–	–	3	931	3
Hoshiarpur	154	4294	661	–	–	–	2	1225	3	4	1225	5
Jalandhar	169	4690	793	–	–	–	–	–	–	1	1234	1
Kapurthala	108	4442	480	–	–	–	–	–	–	1	1225	1
Ludhiana	257	4964	1276	1	4053	4	–	–	–	1	1395	2
Mansa	170	4884	830	1	3273	3	–	–	–	2	1592	3
Moga	177	5014	887	–	–	–	–	–	–	1	1269	1
Mohali	53	4276	227	–	–	–	–	–	–	1	1093	1
Mukatsar	192	4985	957	1	4043	4	–	–	–	1	1804	2
Patiala	236	4836	1141	1	4091	4	–	–	–	1	1137	1
Ropar	65	3900	253	–	–	–	1	911	1	2	911	1
Sangrur	287	5128	1472	2	3979	8	–	–	–	1	1310	1
Shaheed Bhagat Singh Nagar	74	4708	348	–	–	–	–	–	–	1	1278	1
Tarn Taran	186	4571	850	–	–	–	–	–	–	–	–	–
Punjab	3510	4693	16472	12	3652	44	3	1120	4	28	1328	37

Source : Director, Department of Agriculture Punjab, Chandigarh

A = Area '000' ha, Y = Yield in kg/ha and P = Production in '000' tonnes

	Rabi oilseed			Mattar (Peas)			Sunflower			Gram			Massar (Lentil)		
District	*A*	*Y*	*P*	*A*	*Y*	*P*	*A*	*Y*	*P*	*A*	*Y*	*P*	*A*	*Y*	*P*
Amritsar	1	1054	1	4	1150	5	2	1715	3	–	–	–	–	–	–
Barnala	1	1285	1	–	–	–	–	–	–	0.1	1078	0.1	–	–	–
Bathinda	2	1376	3	–	–	–	–	–	–	0.3	1402	0.4	–	–	–
Faridkot	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ferozepur	5	1713	9	–	–	–	–	–	–	1.1	1324	1.5	–	–	–
Fatehgarh Sahib	–	–	–	–	–	–	20	1764	35	–	–	–	–	–	–
Gurdaspur	3	931	3	2	1093	2	–	–	–	0.1	1091	0.1	2	463	0.93
Hoshiarpur	6	1225	8	2	1060	2	5	1947	10	0.1	985	0.1	3	618	1.85
Jalandhar	1	1234	1	1	890	1	45	1509	68	–	–	–	–	–	–
Kapurthala	1	1225	1	1	1200	1	26	1430	37	–	–	–	–	–	–
Ludhiana	1	1395	2	3	1450	4	13	1664*	22	–	–	–	–	–	–
Mansa	2	1592	3	–	–	–	–	–	–	0.1	1219	0.1	–	–	–
Moga	1	1269	1	–	–	–	–	–	–	–	–	–	–	–	–
Mohali	1	1093	1	–	–	–	9	1824	16	–	–	–	3	789	2.37
Mukatsar	1	1804	2	–	–	–	–	–	–	0.1	1783	0.2	–	–	–
Patiala	1	1137	1	14	1278*	18	6	1632	10	–	–	–	1	672*	0.67
Ropar	2	911	2	–	–	–	–	–	–	0.2	1185	0.2	1	900	0.90
Sangrur	1	1310	1	3	1700	5	1	1664*	2	–	–	–	–	–	–
Shaheed Bhagat Singh Nagar	1	1278	1	–	–	–	19	2097	40	–	–	–	–	–	–
Tarn Taran	–	–	–	2	1278*	3	–	–	–	–	–	–	1	672*	0.67
Punjab	31	1308	41	32	1278	41	146	1664	243	2.1	1300	2.7	11	672	7.39

Source : Director, Department of Agriculture Punjab, Chandigarh

A = Area '000' ha, Y = Yield in kg/ha and P = Production in '000' tonnes

Appendix - II

Field Standards for Foundation and Certified Seeds

Crop	*ısolation (in metre)*		*Pollen shedders*		*Off type*		*Inseparable other crop plants/earheads*		*Objectionable weed plants/ earheads*		*Plants/earheads affected by seed born disease*		*Remarks*
	F	*C*	*F*	*C*	*F*	*C*	*F*	*C*	*F*	*C*	*F*	*C*	
Wheat	3	3	-	-	0.05	0.20	0.01*	0.05*	-	-	0.10	0.50	Loose smut
Barley	3	3	-	-	0.05	0.20	0.01**	0.05**	-	-	0.10	0.50	Loose smut
Gram	10	5	-	-	0.10	0.20	-	-	-	-	-	-	
Lentil	10	5	-	-	0.10	0.20	-	-	-	-	-	-	
Field Pea	10	5	-	-	0.10	0.20	-	-	-	-	-	-	
Rapeseed and Mustard	100	50	-	-	0.10	0.50	-	-	0.05#	0.10#			
Linseed	50	25	-	-	0.05	0.10	-	-	-	-	-	-	
Barseem	400	100	-	-	0.20	1.00	-	-	None***	0.05***	-	-	
Sunflower hybrids	600	400	0.5	1.0	0.20	0.50	-	-	None ##	None##	0.05	0.50	Downy Mildew

Standards in percentages unless indicated otherwise F : Foundation C : Certified

*(Barley, Oats, Gram & Triticale) ** (Oats, Wheat, Gram & Triticale) *** Objectionable Weed; Chicory (Kasni)

(Mexican Prickly poppy, Satyanasi ## (Wild *Helianthus spp.*)

Appendix - II-A

Seed Certification Standards for Foundation and Certified Seeds

Crop	*Pure Seed (Minimum)*		*Inert matter (Maximum)*		*Other Crop seeds (Maximum)*		*Weed Seeds (Maximum)*		*Objectionable weed seeds*		*Diseased seeds*		*Germination percentage (Minimum)*		*Moisture ordinary container F & C*
	F	*C*	*F*	*C*	*F**	*C**	*F**	*C**	*F**	*C**	*F*	*C*	*F*	*C*	
Wheat	98.0	98.0	2.0	2.0	10/kg	20/kg	10/kg	20/kg	2/kg (Hiran khuri, Gullidanda)	5/kg*	None** 0.05***	None** 0.25***	85	85	12.0
Barley	98.0	98.0	2.0	2.0	10/kg	20/kg	10/kg	20/kg	-	-	-	-	85	85	12.0
Gram	98.0	98.0	2.0	2.0	5/kg	10/kg	5/kg	10/kg	-	-	-	-	75	75	9.0
Lentil	98.0	98.0	2.0	2.0	5/kg	10/kg	10/kg	20/kg	-	-	-	-	75	75	9.0
Field Pea	98.0	98.0	2.0	2.0	None	5/kg	None	None	-	-	-	-	75	75	9.0
Rapeseed and Mustard	97.0	97.0	3.0	3.0	10/kg	20/kg	10/kg	20/kg	5/kg	10/kg	-	-	85	85	8.0
Linseed	98.0	98.0	2.0	2.0	10/kg	20/kg	5/kg	10/kg	-	-	-	-	80	80	9.0
Barseem	98.0	98.0	2.0	2.0	10/kg	20/kg	10/kg	20/kg	5/kg	10/kg	-	-	80	80	10.0
Sunflower Hybrids	98.0	98.0	2.0	2.0	None	None	5/kg	10/kg	None	None	None	None	70	70	9.0

Standards in percentage unless indicated otherwise.

F : Foundation C : Certified * Wild morning glory (Hiran Khuri) Gulli Danda and ** Ear Cockle and Tundu Karnal Bunt

*** Orobanche cumana disease --Huskless seeds in Sunflower F & C (maximum) 2.0% in both the cases.

APPENDIX - III

AGRICULTURAL ENGINEERING

Recommendations for Implements/Machines

Seed-cum-Fertilizer Drill :

In selecting a seed-cum-fertilizer drill, the following points should be considered :

(i) It must have provision for varying line-to-line distance.

(ii) The machine must have 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 furrow openers must deliver the same quantity of seed and fertilizer.

(v) A good agitator in the fertilizer box is desirable to avoid bridging.

(vi) There should be provision for disengaging the seed and fertilizer distribution system.

For proper selection of seed-cum-fertilizer drills, the Test Reports issued by the **Farm Machinery Testing Centre** of the Punjab Agricultural University must be considered.

Seed Drill Calibration Procedure

1. Lift the machine to about one foot on tractor hitch after putting seed in the seed hopper.
2. Put small open mouth containers below each furrow opener or put plastic bag on each seed tube to collect seed.
3. Find out the effective width of the machine by multiplying number of rows to row-spacing in inches. For example if a 9 row drill has 8" row spacing its effective width will be 9 x 8 = 72".
4. Measure the circumference of the ground wheel in inches by putting a measuring tape around it. Tape should not be put around the lugs of the wheel but at the plane surface that touches the ground.
5. Then the ground wheel be rotated through number of revolutions as given in table below in forward direction.

Table : No. of revolutions for different sizes of seed drills having different circumference.

Row spacing	*No. of rows*	*Wheel circumference in inches*				
		50"	*57"*	*63"*	*69"*	*75"*
6"	9	20.5	18.5	17.0	15.0	14.0
	11	17.0	15.0	13.5	12.5	11.5
	13	14.5	13.0	11.5	10.5	9.5
7"	9	17.5	15.5	14.0	13.0	11.5
	11	14.5	13.0	12.0	10.5	9.5
	13	12.5	11.0	10.0	9.0	8.0
8"	9	16.0	14.0	12.5	11.5	10.5
	11	13.0	11.5	10.5	9.5	8.5
	13	10.5	9.5	8.5	8.0	7.0
9"	9	13.5	12.5	11.0	10.0	9.0
	11	11.0	10.0	9.0	8.0	7.5
	13	9.5	8.5	7.5	7.0	6.5

6. The seed collected in different rows should be compared individually for uniform dropping in different rows. Then all the collected seed should be pooled and weighted.
7. This quantity of seeds (in g) be divided by 10. It will give the seed rate in Kg/acre. For example, if quantity of seed so collected is 400 g then the desired seed rate is 40 kg/acre.
8. Seed rate could be adjusted further if the setting is not correct.

Safety Precautions During Threshing

1. Don't wear loose clothes, wrist watch etc. 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 kept 90 cm covered upto a minimum of 45 cm and inclined to a 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. A person is advised not to work on a thresher for more than 10 hours a day.
5. Do not indulge in talking or any other distraction while working on the thresher.
6. Avoid feeding ear heads (ghundian) as it may lead to serious hand injuries. Wet crop should also not be fed as it is bound to lead to fire accident. Take special care while feeding the damaged or short stalked crop.
7. The exhaust pipe of the tractor should be fixed vertically upward and not under the tractor.
8. The main switch of the electrical motor should be within the reach of the operators to switch off the current at the time of emergency. At the same time it should be ensured that layout of electrical wiring should not hinder the operational movement of workers.

9. Do not cross over the belt or move near it.
10. Keep a fire control equipment and first aid box for use in the event of need.

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.

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

Markfed also provide financial assistance to only farmer members of their affiliated societies. Markfed provide monetary relief at the rate of Rs. 50,000/- in case of loss of life and Rs. 25,000/- in case of disability.

Application Procedure for Monetary Help

In Mandi Board, victim or the nearest successor has to submit prescribed application within 30 days of accident or with a justification in case of delay. The performa includes personal detail of the victim, details of accident and level of injury. This performa is to be verified by the Sarpanch and 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, Patwari and Tehsildar. 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. Application procedure of Markfed is on same guidelines as in case of Mandi Board.

Tips to Save Diesel

1. Badly maintained tractor wastes upto 25 per cent of the diesel used.
2. Leakage of diesel is a direct wastage.
3. Wrong gear selection can increase fuel consumption upto 30 per cent and reduce output upto 50 per cent.
4. A smoky tractor wastes diesel upto 20 per cent.
5. Unfiltered air wears out cylinder bore 45 times faster and piston rings 115 times faster than normal which results in loss of power and wastage of diesel.
6. Avoid unnecessary slippage of tractor wheels with the help of water ballast and/or cast iron weights in case of sandy soils and use cage wheel in wet land condition to avoid slippage.
7. Relug worn out tyres.
8. Operate the tractor at the correct throttle setting to give the recommended p.t.o. speed for operating pumping set or thresher.
9. Keep the correct inflation pressure in tyres.
10. Operate tractor at 70-90^{o}C engine temperature.

GUIDELINES FOR PROPER UPTAKE AND MAINTENANCE OF FARM MACHINERY

1. Remove the fertilizer and chemical from hoppers and tanks of sowing machines and plant-protection equipment respectively to prevent rusting and clogging of opening and allied components of metering and dispensing devices.
2. Clean and wash the soil and dirt from your equipment and check all nuts, bolts, washers, pins, grease nipples and cups after each day's work.
3. Lubricate all bearings, joint and pivot points with grease or oil of the recommended grade after each day's work or as recommended by the manufacturers.
4. Check the cutting edges of the soil-working tools and blades of harvesting equipment, sharpen them for smooth working and coat them with grease or mobile oil to avoid rusting.
5. Check the oil level of the gear box and top up if necessary.
6. If machine has belt-drive, one must check the belt tension and tight the belt if necessary.
7. Clean the chains thoroughly; wash them with oil and coat the links with grease or use engine oil to prevent them from rusting.
8. In the off-season keep your machine under covered shed to project against sun, rain and dust, otherwise its life will be shortened. Paint your equipment if it has come off.
9. For all equipment with tyres, place logs or bricks under the axle or frame to remove the load from the tyres.

SELECTION, INSTALATION AND OPERATION OF FARM PUMPS

1. Irrigation Pumps :

Four types of pumps are used for irrigation in Punjab. They are centrifugal pumps, propeller pumps, turbine pumps and submersible pumps. Centrifugal pumps are widely used in pumping water. They are simple in construction, easy to operate, low in intial cost and produce a constant steady discharge. Generally they are used to lift water for a total head of 4 meters to 60 meters. Propeller pump is used for low head (generally less than 4 meters). It is used for lifting water from water course, drain, pond, 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, then submersible pump or turbine pump is used. Both turbine pumps as well as submersible pumps have high initial cost, difficult to install and difficult to repair as compard to centrifugal pumps.

(a) Selection : Total head and discharge expected from the pump to irrigate a particular area is calculated and then the pump is selected which has the best efficiency at the above head and discharge conditions. Reputed pump manufacturers furnish the characteristic, curves or catalogues

giving summary of important characteristics of their pumps. Pumps made by different manufacturers may vary considerably in their prices, adaptibility and efficiency. The pumps have efficiencies from 50 to 70 per cent. Good pumps with the highest possible efficiency should, therefore, be chosen. Regarding efficiency, ISI and Punjab quality mark pump can be relied upon.

While purchasing the pump, the farmer should have the following information :

(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) Discharge required.

(vi) Type of Prime-mover (engine or motor). In case of electric motor, the hours of electric supply.

(vii) Location of tubewell in the farm.

(viii) Type of drive (Belt drive, direct coupled, monoblock).

(ix) Water conveyance system (lined or unlined or underground pipeline).

(x) Ground water quality in the area.

(b) Instructions for Efficient Use of Pumps :

1. The centrifungal pump should be installed at 1 to 2 m above the water level.
2. Select a proper pump by consulting the different performance tables or charts from the dealer.
3. Use large radius bends.
4. Keep the height of delivery pipe at the minimum possible height above the ground level.
5. (a) use proper material of joint *dori.*

   (b) Fix joint *dori* in such a way that it leaks about 15-20 drops per minute.

   (c) Put the joint *dori* in pieces equal to circumference of pump shaft. The ends of each piece should be staggered.
6. Servicing and annual overhauling of the pump set should be done as per manufacturer's instructions.
7. To avoid leakage in joints, tighten the joints properly using good quality gaskets.
8. The pump must be run at the recommended revolutions.
9. Use proper quality of driving belts, in case of belt driven pumps.
10. Use proper size of suction and delivery pipes according to discharge.
11. Use good quality reflax valve whose flap should open fully.
12. Foundation should be pucca, levelled and with bolts embedded in it.
13. Align the motor and pump pulley accurately.

(c) Gas Problem in Tubewell Pits :

In some areas, accummulation 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 off means that below that point there is carbon dioxide gas. This can be removed by using the following measures :

1. One can use an exhaust fan lowered up to bottom of the pit and keep the exhaust fan on the ground surface and attach a PVC pipe up to bottom of it.
2. One can use an empty juite bag or bucket or umbrella and move it up and down in the pit to remove the gas.
3. If the pump is loaded 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.

(d) 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.

Furrow method of irrigation is suitable for sunflower crop in 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. The recommended plot sizes (*Kiara*) under different field conditions for flooding method of irrigation are as given below.

For light, medium and heavy soils, the recommended slopes are 0.4, 0.3 and 0.15 per cent respectively i.e., the difference in levels at the two ends of an acre field should be 9.6, 7.2 and 3.6 inches respectively. Further, for tubewell delivery size of 3"-4" (7.5-10 litres per sec) and 6" (20 litres per sec), the number of border strips (*Kiara*) per acre should be 16, 10, 8 and 10, 5, 4 respectively for light, medium and heavy soils. For Mogha discharge of 30 litres per sec the number of border strips (*Kiara*) per acre should be 7, 4, 3 respectively for light, medium and heavy soils.

Recommendations for Implements

General recommendations in respect of implements and machines used for rabi crops are given in table below :

Farm Equipment/Implements Recommended for Various Operations for Rabi Crops

Sr. No.	*Operation*	*Implement*	*Source of Power*	*Capacity/ output*	*Remarks/Comments*
1	*2*	*3*	*4*	*5*	*6*
1.	**Seeding & fertilizer application**	**Dual Seed Drill**	**Tractor**	**2.5-3.5 ha/day**	**Single machine can sow oil seed (small seeds) and wheat for saving the cost of sowing.**
2.	**Stubble management**				
	a. Paddy	Stubble Shaver	Tractor	3-5 ha/day	Saves one disking operation
	b. Wheat	Wheat-straw combine	-do-	2.5-3.0 ha/day	Stubbles can be bruised as wheat straw (TURI)
3.	**Ploughing**	Mould-board plough	Bullocks	0.3 to 0.5 ha/day	Used to open up unploughed land.
			Tractor	1.6-2.5 ha/day	
4.	**Harrowing**	Disc-Harrow	Tractor	2.5-3.5 ha/day	Used to break clods, chop weeds and pulverising soil
		Bar-harrow (Spike Tooth)	Tractor	3 to 3.5 ha/day	Breakes soil crust and uproots early weeds
		Cultivator	Tractor	2.5-5 ha/day	Loosen the soil for better aeration and pulverisation
		Cultivator with pulverising roller	Tractor	2.5-5 ha/day	For better pulverisation and fuel saving
5.	**Seeding and Fertilizer application**	Seed-cum-Fertilizer Drill	Tractor	4-6 ha/day	For uniform seed and fertilizer distributions in rows
		Strip-till-Drill	Tractor	2.5-3.5 ha/day	Wheat can be sown in unprepared field after harvest ing paddy
		Zero-till-Drill	Tractor	4.0-4.5 ha/day	Wheat can be sown in unprepared field after harvest ing paddy
		Happy seeder	Tractor	2.0-2.5 ha/day	Wheat can be directly drilled into unprepared combine harvested paddy field without residue removal or burning.
		Row crop planter (Inclined plate)	Tractor	3-4 ha/day	Sunflower and maize seed can be planted on ridges or flat field using ridger/flat type planters.
		Duel seed drill	Tractor	4-5 ha/day	Oilseeds and wheat can be sown.

1	2	3	4	5	6
5.	**Inter-culture**	Kasola-hoe	Manual	0.15-0.20 ha/day	
		V-Blade hoe	-do-	-do-	
		Wheel hand hoe	-do-	0.3-0.5 ha/day	
6.	**Harvesting**				
	a) Wheat stacking	Vertical Conveyor Reaper	Tractor	3-4 ha/day	Eight persons are required for crop collection and
	b) Barseem	Scythe	Manual	0.15-0.20 ha/day	Saves 60% labour in comparison to sickle
7.	**Threshing**				
	a) Wheat	Spike Tooth Thresher	5-20 hp motor/Tractor	0.8-7.5 q/h	
		Syndicator/Toka Thresher	-do-	1.5-12 q/h	Can handle wet crop also.
		Harambha Thresher	15-20 hp motor/Tractor	12-15 q/h	-- do --
	b) Sunflower	Sunflower Thresher	7.5-15 hp motor or Tractor	4-10 qls/h	Sunflower heads are fed for threshing.
	c) Maize	Rasp bar thresher/combine	20 hp motor or combine	20-30 q/h	Threshing can be done with husk
		Maize sheller	5-20 hp motor	5-10 q/h	
		Maize dehusker cum thresher	5-20 hp motor	15-25 q/h	Maize with husk can be threshed
	d) Raya	Spike tooth thresher	5-20 hp motor/tractor	1-5 q/h	i) Retain only two spikes in each row in a spiral manner. ii) Increase concave clearance to 25 mm. iii) Use concave having bar to bar spacing of 6 mm. iv) Reduce speed of threshing drum to 3/4th by replacing pulley. v) Use sieve having holes of 3 mm diameter and bottom screen with blank sheet.
8.	**Combining**	Tractor mounted/	Tractor	0.4-0.5 ha/h	
		Self-propelled combine	110-125 HP	1.0-1.2 ha/h	

APPENDIX - IV

FERTILIZERS SOURCES FOR THE SUPPLY OF NITROGEN, PHOSPHORUS, POTASH AND OTHER NUTRIENTS

(A) Nutrient Content of Different Fertilizers (percent)

Fertilizers	*N*	*P_2O_5*	*K_2O*	*Others*
Ammonium Sulphate	20.5	—	—	—
Ammonium Chloride	25	—	—	—
Urea	46	—	—	—
Superphosphate	—	16	—	—
Diammonium Phosphate	18	46	—	—
Urea Ammonium Phosphate	28	28	—	—
Nitrophosphate	20	20	—	—
Sulphated Phosphorus	13	33	0	15 (S)
Sulphate of Potash	—	—	48	—
Muriate of Potash	—	—	60	—
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 (oven dry)	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	
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
Sulphated Phosphate	3.4 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) contains both nitrogen and phosphorus. One kg of Phosphorus (P_2O_5) added through these fertilizers also supplies one kg of nitrogen (N) in the case of Urea-Ammonium Phosphate and Nitrophosphate and 0.4 kg N in the case of Diammonium Phosphate. This must be taken into account while using these three 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.

APPENDIX - V

STORED GRAIN INSECT PESTS

Stored Grain Insect Pests : Twenty species of insects infest grains in the Punjab. **Khapra beetle** (*Trogoderma granarium*), **lesser grain borer** (*Rhizopertha dominica*), **rice weevil** (*Sitophillus oryzae*) and **flour beetle** or **susri** (*Tribolium castaneum, T. confusum*) are serious pests of wheat, jowar, rice, barley and maize. ***Grain moth*** (*Sitotroga cerealella*) attacks wheat, maize, jowar, oats, barley which loose nutritive value and germination capacity besides loss of weight.

Preventive measures : Store new grains in clean godown or receptacles. Plug all cracks, crevices and holes in the godowns thoroughly. Disinfest old gunny bags by dipping them into emulsion prepared by mixing 6 ml Sumicidin 20 EC (fenvalerate) or 5 ml Cymbush 25 EC (cypermethrin) in 10 litres of water for 10 minutes and dry them in shade before filling with grains or use new gunny bags. Disinfect empty godowns or receptacles by spraying 0.5% malathion emulsion, i.e. 100 ml of Cythion 50 EC (Malathion premium grade) in 10 litres of water on the floor, walls and ceiling, or fumigate the godowns, using 25 tablets of aluminium phosphide per 100 cu m of empty space before storing the grains. Exposure period should be 7 days. Mix malathion 5% dust at the rate of 250 g with one quintal of grains meant for seed only or treat the grains meant for seed with 25 ml Cythion 50 EC (malathion) or 2 ml Sumicidin 20 EC (fenvalerate) or 1.5 ml Cymbush or Markcyper 25 EC (cypermethrin) or 14 ml Decis 2.8 EC (deltamethrin) per quintal seed. Before treatment dilute the insecticide in 1/2 litre of water and spray with knapsack sprayer on the grains spread in a thin layer on *pucca* floor or polythene sheet. After treatment, the grains should be mixed thoroughly and then put into the containers.

Curative measures : Fumigate with any one of the following :

Phostoxin or Delicia or Celphos (aluminium phosphide) one tablet of 3 g per tonne or 25 tablets per 100 cu m space in air tight conditions for seven days.

Precautions : (1) Where there is infestation of khapra, the fumigation of godowns with aluminium phosphide is essential by using double the recommended dose.

(2) Dry the grains properly before storing.

(3) The metal bins should be cleaned and placed in the sun for 2-3 days.

(4) Grains stored in metal bins may also get infested if not treated with recommended insecticides. Control this infestation with a fumigant.

(5) The fumigants should be used only in air tight stores or under a tarpaulin in the open by especially trained persons because these chemicals are deadly poisonous.

(6) Aluminium phosphide must not be used in living quarters. Its use in godowns next to the living rooms may also prove hazardous.

Grains Storage Bins of the Punjab Agricultural Univesity

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 throughly 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.

Storage of Wheat

(a) For Home Consumption : Improved storage structures of various capacities of 1.5, 3.5, 10 and 15 quintals capacity are available. For outdoor use, drawings of PAU metal bins of 15-tonnes capacity with perforated floor-bottom, rooms storage structure of 8-tonnes capacity and flat storage structures of 100 tonnes capacity are available. The air-tight bin is so constructed that it does not allow entry of any outside insect and rodent and the insects present in the grains do not get favourable atmosphere to develop. It is also economical portable and simple to fabricate.

For lifting and using the PAU metal bins, 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 seprated.

(iii) Do not mix new grains with old stock as the later may be infested with insect.

(iv) Never store infested grains, in grains with high moisture content. Dry the grains in 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. Use recommended fumigants 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 first 30 days and thereafter open it fornightly. 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.

Information about the storage structure can be had from the Department of Processing and Food Engineering, PAU.

APPENDIX - 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 pesticide cartons, but bury them deep.
15. The worker should not smoke, chew, eat or drink in the spraying area.
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. 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.

APPENDIX - VII

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. phostoxin etc)	No specific antidote, induce vomiting with 5% sodium bicarbonate. Give activated 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 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	**Dimercaprol (BAL)** 3-4 mg/kg body weight. Comes as 3 ml, given deep
Copper sulphate (Blitox etc.)	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% metalaxyl+64% mancozeb)	No specific antidote for metalaxyl. Antidote for mancozeb as given above 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, Anilfos Padigard 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. **2-PAM :** 1-2 g intravenous 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 @ 1/2g/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.**

APPENDIX - VIII

FIRST AID MEASURES

A) Cut Injury

(i) The first aid treatment of cut injury depends upon the extent of injury. But in first aid one should clean the wound with antiseptic lotion.

(ii) If it is bleeding profusely tight bandage without ointment is to be given.

(iii) The injured part should be kept raised or elevated.

(iv) If there is any associated fracture, a proper split or support should be given. But the patient, should be brought to the hospital at the earliest possible.

B) Snake Bite Preventions

In snake infested regions long trousers, high shoes or leggings and gloves should be worn. Most important is to look where one steps while walking.

First Aid

Re-assurance and complete rest to the victim to retard the absorption of venom. A wide tournaquet (or any piece of cloth) should be placed a few centimeters above the site of bite. It should be tight to an extent that a finger should pass below it with difficulty. Suction of venom should be done by giving a 1 cm linear and 1/2 cm deep incision at the mark of the fangs after applying an antiseptic lotion. Suction should preferably be done with rubber bulb, breast pump or with mouth after ensuring that there is no oral lesion. It should be continued for about an hour. If done promptly 50% of the venom can be removed.

C) Electric Injuries-Preventions

Education of electric hazards to everybody.

Proper installation of electric appliances, grounding of telephone lines, radio and television arials, use of rubber gloves and dry shoes when working with electric circuits.

First Aid

Prompt switching off the current, if possible. Immediate removal of the victim from the contact with the current without directly touching him. Rescurer should use a rubber sheet, a leather belt, a wooden pole or any other non conductive material to detach him.

Honey Bee and Wasp Bites

1. Cooling of the part with ice pads.
2. Removal of stings.
3. Cleaning with soap and water.
4. Local and systemic anti allergics to be given.
5. Perfumes and bright colours attract these insects and should be avoided.
6. Sensitive person can have severe anaphyllatic shock with even a single bite.
7. Every such patient must get the medical aid from a doctor.

APPENDIX - IX

PROFORMA FOR REFERRING SAMPLE TO PLANT CLINIC, PAU, LUDHIANA FOR DIAGNOSIS OF DISORDERS

1.	Name and address of the farmers	:	_____
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/Tubewell/Rainfed
18.	Irrigations applied	:	1/2/3/4/5/More than 5
19.	Industrial plant in adjoining area	:	Yes/No
	If yes,	:	Distance in meters_____
20.	Name the Input used	:	_____ Dose_____Timings_____
21.	Diagnosis by field funtionary (Extension Scientist)	:	_____
	To be sent to	:	Director Extension Education Punjab Agricultural University, Ludhiana (Signature and Address of Extension Scientist)

APPENDIX - X

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	**1551 (Toll Free)**
Krishi Vigyan Kendras	
Bathinda	0164-2215619
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	01763-221217
Sri Mukatsar Sahib (Goneana)	01633-210046
Moga	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 (FS,N&E)	2400376, 240
Addl. Director of Research (Horticulture)	2400439
Addl. Director of Research (Crop improvement)	379
Director (Seed)	0161-2400898
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
Nawanshahar (Ballowal Sanukhri)	01885-241601