PACKAGE OF PRACTICES FOR CROPS OF PUNJAB

Rabi 2025-26

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PUNJAB AGRICULTURAL UNIVERSITY
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The Package of Practices for Crops of Punjab, *Rabi* 2025-26 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, sugar, medicinal, spice, aromatic and fodder crops of Punjab have been discussed and finalised in the Research and Extension Specialists Workshop held on August 21-22, 2025. 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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IMPORTANT NOTICE

The information on performance of recommended technologies given in this book holds good only when used under optimal conditions. The performance of the technologies may vary with many reasons including weather conditions, soil health, quality and availability of irrigation water, management level, negligence, mishandling of recommendations etc. The Punjab Agricultural University, Ludhiana accepts no legal responsibility in this regard.

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IMPORTANT NOTE

The chemicals bearing star (*), recommended for the control of weeds, insect-pests and diseases, belong to green chemistry with short persistence.

NEW RECOMMENDATIONS

CROP VARIETIES

- **PBW 872 (Wheat):** This variety is recommended for cultivation under timely sown irrigated conditions. It matures in 152 days and its average grain yield is 24.4 quintals per acre.
- **PL 942 (Barley):** It is a two-rowed malt barley variety suitable for the brewing industry. It matures in 146 days and its average grain yield is 20.1 quintals per acre.
- **Punjab Cheena 1 (Proso millet):** It is a short-duration variety with a maturity period of 66 days. Its average grain yield is 3.2 quintals per acre.
- **Punjab Kangni 1 (Foxtail millet):** It is a short-duration variety with a maturity period of 76 days. Its average grain yield is 5.1 quintals per acre.

PRODUCTION TECHNIQUES

- **Wheat:** It can be sown directly with Super Seeder under flat/ridge/bed planted maize residue conditions. Maize residue incorporation improves wheat productivity and soil health.
- After final boll picking, *in-situ* cotton residues incorporation and wheat sowing can be done simultaneously using Super Seeder.
- In medium textured soils, to prevent crop lodging and its adverse effect on quality, apply 25% less nitrogenous fertilizers and reduce one irrigation to wheat variety PBW 1 *Chapati*.
- In paddy straw managed fields, apply 55 kg DAP per acre to wheat.
- **Millets:** The crop production technology for the cultivation of proso and foxtail millet is recommended.
- **Summer *moong*:** Under dry conditions, summer *moong* can be sown in wheat straw with Happy Seeder/Smart Seeder, followed by immediate irrigation. Under optimum moisture conditions, it can be sown directly using a Smart Seeder/Super Seeder.

- **Sunflower:** Inoculate per acre seed with 250 g biofertilizer (*Bacillus aerius* SLE1 and *Pseudomonas putida* SRB1) for higher seed and oil yield.
- **Ryegrass:** A seed rate of 3.0 kg seed per acre is recommended to obtain higher fodder yield and quality.
- **Organic farming (*Gobhi sarson*):** Apply 6 tonnes per acre of FYM at the time of sowing. Inoculate per acre of seed with 250 g of biofertilizer (*Bacillus* sp.) for higher seed and oil yield.
- **Natural farming:** Production technology for summer *moong* cultivation under natural farming is recommended.
- **Integrated Farming System:** Goat farming (9 does+1 buck) component has been included in the PAU-IFS model.

PROTECTION TECHNIQUES

- **Gram:** Adopt Bio-intensive Integrated Pest Management (BIPM) module for the management of gram caterpillar.
- **Summer *mash*:** Spray 300 mL per acre of Imazethapyr 10 SL at 15-20 days after sowing for the control of grassy, broadleaf weeds and sedges.
- ***Toria, Raya, Gobhi sarson* and African *sarson*:** Spray 350 mL per acre of Pendimethalin 38.7 CS within 2 days of sowing for effective weed control.

FARM MACHINERY

- GNSS- based auto steering system (for precise steering control in tractors) and Tractor-operated PAU Turf Manager (for cutting and collecting grass) are recommended.
- **PAU manually operated seeder:** It is recommended for sowing of crops like peas, radish, turnip, spinach, gram, fenugreek, okra, mustard, millets etc.

Details of above recommendations are provided under different chapters in this book

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.	Captafol	The use of captafol as foliar spray is banned. It shall be used as seed dresser.
3.	Cypermethrin	Cypermethrin 3% Smoke Generator is to be used only through Pest Control Operators and not allowed to be used by General Public.
4.	Dazomet	The use of Dazomet is not permitted on tea.
5.	DDT	Restricted for use in public health only.
6.	Fenitrothion	The use of fenitrothion is banned on Agriculture except for locust control in scheduled deseart area and public health
7.	Methyl bromide	Restriction for its sale and use is similar to that of Aluminium phosphide.
8.	Monocrotophos	Banned for use in vegetables.
9.	Trifluralin	Restricted for use in wheat only.

b. Pesticides banned for use in agriculture in India			
1.	Aldicarb	15.	Endrin
2.	Aldrin	16.	Ethyl Mercury Chloride
3.	Benomyl	17.	Ethyl Parathion
4.	Benzene Hexachloride	18.	Ethylene Dibromide
5.	Calcium Cyanide	19.	Fenarimol
6.	Carbaryl	20.	Fenthion
7.	Chlorbenzilate	21.	Heptachlor
8.	Chlordane	22.	Lindane (Gamma-HCH)
9.	Chlorofenvinphos	23.	Linuron
10.	Copper Acetoarsenite	24.	Maleic Hydrazide
11.	DDT	25.	Menazon
12.	Diazinon	26.	Methoxy Ethyl Mercury Chloride
13.	Dibromochloropropane (DBCB)	27.	Methyl Parathion
14.	Dieldrin	28.	Metoxuron

29.	Nicotine Sulphate	36.	Sodium Methane Arsonate
30.	Nitrofen	37.	Tetradifon
31.	Paraquat Dimethyl Sulphate	38.	Thiometon
32.	Pentachlorophenol (PCP)	39.	Toxaphene
33.	Pentochloro Nitrobenzene (PCNB)	40.	Trichloro acetic acid (TCA)
34.	Phenyl Mercury Acetate (PMA)	41.	Tridemorph
35.	Sodium Cyanide		

c. Pesticide formulations banned for use			
1.	Carbofuran 50% SP	3.	Methomyl 12.5% L
2.	Methomyl 24% L	4.	Phosphamidan 85% L

CAUTION

Chemicals used to control insects, diseases and weeds are poisons for human beings. Farmers are cautioned to use these poisons carefully to avoid any effect on human health.

- 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.
- It should, however, be ensured that the actual amount of pesticides 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.

1. CEREAL CROPS

WHEAT

Wheat is a major cereal crop of Punjab. It was grown on an area of 35.16 lakh hectares during 2023-24 with production of 181.76 lakh tonnes and average yield of 51.70 quintals per hectare (20.92 quintals per acre).

Climatic Requirements: Wheat is a cool season crop. In Punjab, higher productivity can be expected if maximum temperature remains within 15-22 & 21-28°C and minimum temperature remains within 4-11 & 7-13°C during vegetative & grain development stages, respectively. The higher temperature during vegetative stage results in poor tillering and early heading. The higher temperature during grain filling stage leads to premature ripening and reduction in grain weight.

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

Rotations: Rice-Wheat, Rice-Wheat-Summer *Moong/Mash*, 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, Summer *moong*/Green manure-Direct Seeded Rice (DSR)/Direct Seeded Basmati Rice (DSBR)-Wheat.

Improved Varieties

A. Timely Sown Irrigated Conditions

PBW 872 (2025)*: This variety has been recommended for cultivation under timely sown irrigated conditions. Its average plant height is 100 cm and matures in about 152 days. It is moderately resistant to yellow and brown rust. It possesses bold and lustrous grains with an average grain yield of 24.4 quintals per acre. This variety is suitable for growing under poplar plantation.

PBW 826 (2022): This variety has been recommended for cultivation under timely sown irrigated conditions. Its average plant height is 100 cm and matures in about 148 days. It is moderately resistant to yellow rust and brown rust. It possesses lustrous bold grains. Its average grain yield is 24.0 quintals per acre.

PBW 869 (2021): This variety has been recommended for sowing with Happy Seeder/Super Seeder in *in-situ* rice residue managed fields. Its average plant height is 101 cm and matures in about 158 days. It is resistant to brown rust and moderately resistant to yellow rust. Its average yield is 23.2 quintals per acre. It possesses bold grains and longer coleoptile. Use 45 kg seed per acre.

PBW 824 (2021): Its average plant height is 104 cm and matures in about 156 days. It is resistant to brown rust and moderately resistant to yellow rust. Its average yield is 23.3 quintals per acre.

* year of release

PBW 803 (2021): This variety has been recommended for cultivation in South-Western region of Punjab (Bathinda, Faridkot, Fazilka, Ferozepur, Mansa and Sri Muktsar Sahib). Its average plant height is 100 cm and matures in about 151 days. It is resistant to brown rust and moderately resistant to yellow rust. Its average yield is 22.7 quintals per acre.

***Sunehri* (PBW 766) (2020):** Its average plant height is 106 cm and matures in about 155 days. It is moderately resistant to yellow rust and resistant to brown rust. Its average grain yield is 23.1 quintals per acre.

- **Grow recommended varieties and do not depend upon a single variety.**
- **Select varieties according to the time of sowing.**
- **Prefer PBW 872, PBW 725 and PBW 677 for cultivation under poplar plantation.**
- **Avoid cultivation of DBW 222 in sub-mountaneous area.**

DBW 222 (2020): This bread wheat variety has been recommended for cultivation in the Punjab state except sub-mountainous regions. Its average plant height is 103 cm and matures in about 152 days. It is moderately susceptible to yellow rust and resistant to brown rust. Its average grain yield is 22.3 quintals per acre.

DBW 187 (2020): Its average plant height is 104 cm and matures in about 153 days. It is moderately resistant to yellow rust and resistant to brown rust. Its average grain yield is 22.6 quintals per acre.

HD 3226 (2020): Its average plant height is 106 cm and matures in about 155 days. It is resistant to yellow and brown rust. It possesses good grain quality characteristics. Its average grain yield is 21.9 quintals per acre.

***Unnat* PBW 343 (2017):** It is an improved version of PBW 343 and has an average plant height of 100 cm. It is resistant to brown rust and moderately resistant to yellow rust. It matures in about 155 days. Its average grain yield is 23.2 quintals per acre.

***Unnat* PBW 550 (2017):** It is an improved version of PBW 550, has average plant height of 86 cm. It is resistant to yellow and brown rust. It matures in about 145 days. It has bold grains and its average grain yield is 23.0 quintals per acre. Use 45 kg seed per acre and sow this variety during 2nd to 4th week of November.

PBW 725 (2015): Its average plant height is 105 cm and matures in about 154 days. It is resistant to yellow and brown rust. Its average grain yield is 22.9 quintals per acre. This variety is suitable for growing under poplar plantation.

PBW 677 (2015): Average plant height of this variety is 107 cm and matures in about 157 days. It is moderately resistant to yellow and brown rust. Its average grain yield is 22.4 quintals per acre. This variety is suitable for growing under poplar plantation.

HD 3086 (2015): The average plant height of this variety is 96 cm and matures in about 148 days. It is susceptible to new races of yellow rust and moderately susceptible to brown rust. Its average grain yield is 23.0 quintals per acre.

B. Timely Sown irrigated condition (special purpose varieties)

PBW Biscuit 1 (2024): This is a premium special quality wheat variety suitable for making cookies and biscuits as its spread factor is 9.8/10 and has medium soft

grain texture. Its average plant height is 100 cm and matures in about 157 days. It is resistant to yellow and brown rust. Its average grain yield is 21.1 quintals per acre.

PBW Zinc 2 (2023): It possesses higher grain zinc concentration which is good for human health. Its average plant height is 100 cm and is resistant to yellow and brown rust. Its ears are medium dense with red glumes. It matures in about 154 days. Its average grain yield is 23.0 quintals per acre.

PBW RS1 (2023): This is a premium special quality wheat variety having high proportion of resistant starch in the grains. Its average plant height is 87 cm and matures in about 146 days. It is resistant to yellow rust and moderately resistant to brown rust. Its average grain yield is 17.1 quintals per acre. Consumption of the high resistant starch products do not cause spike in blood sugar levels, rather it acts as the dietary fibre and thus have low glycemic index. **Sow this variety during 2nd to 4th week of November.**

PBW 1 *Chapati* (2020): This a premium quality bread wheat variety having excellent *chapati* making properties. *Chapati* made from it is whitish in color, sweet in taste and remains soft even after hours of cooking with good palatability and texture. Its average plant height is 103 cm and matures in about 154 days. It is moderately resistant to yellow rust and resistant to brown rust. Its average grain yield is 17.2 quintals per acre. In medium textured soils, to prevent crop lodging and its adverse effect on quality, apply 25% less nitrogenous fertilizers and reduce one irrigation to wheat variety PBW 1 *Chapati*.

PBW 1 Zn (2017): It possesses higher grain zinc concentration which is good for human health. Its average plant height is 103 cm and is resistant to brown rust and moderately resistant to yellow rust. It matures in about 151 days. Its average grain yield is 22.5 quintals per acre.

WHD 943 (2011): It is *durum* wheat (*Wadanak*) with an average plant height of 93 cm and matures in about 154 days. It has 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 possesses field resistance to Karnal bunt disease. Its average yield is 19.8 quintals per acre.

PDW 291 (2005): It is also *durum* wheat (*Wadanak*) with an average plant height of 83 cm and matures in about 155 days. It has low incidence of yellow berry and possesses suitable 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. Its average yield is 19.4 quintals per acre.

C. Late Sown Irrigated Conditions

PBW 771 (2020): Its average plant height is 80 cm and matures in about 133 days. It is moderately resistant to yellow rust and resistant to brown rust. Its average grain yield is 19.0 quintals per acre.

PBW 757 (2020): This bread wheat variety has been recommended for cultivation in the Punjab state under irrigated very late sown conditions (January sowing). Its

average plant height is 82 cm and matures in about 114 days. It is resistant to yellow rust and brown rust diseases. Its average grain yield is 15.8 quintals per acre.

PBW 752 (2019): Its average plant height is 89 cm and matures in about 130 days. Its ears are medium dense with red glumes. It is resistant to yellow and brown rust. Its average grain yield is 19.2 quintals per acre.

Agronomic Practices for Irrigated Conditions

Field Preparation

Preparatory tillage: For normal sowing of wheat after paddy and other *kharif* crops prepare the field as under:

(i) After paddy:

a. Paddy straw retained: When paddy is harvested with combine, the left over straw can be managed using following techniques:

- The left over straw can also be chopped by using paddy straw chopper cum spreader into small pieces and the chopped straw can be mixed into the soil by tillage operations without any adverse effect on yield of wheat (See Appendix VIII).
- Wheat can also be sown in the combine (fitted with PAU Super SMS) harvested fields with 'Happy Seeder'/'Super Seeder'/'PAU Smart Seeder'/PAU Surface Seeder in the standing paddy stubbles (See Appendix VIII).

Incorporation of paddy straw or its retention through Happy Seeder for more than three years helps in increasing the wheat productivity and improves soil health. **From fourth year onwards, 20 kg urea can be saved per acre. In fields where organic carbon content of soil comes under high category, after continuous retention/ incorporation of paddy straw, drill 27 kg DAP per acre at sowing.**

b. Paddy straw removed: The left over straw can be cut by using stubble shaver and collected after 2 to 3 days (sun drying) by using straw baler. Straw baler collects the straw and compresses it in the form of bales. In such fields and in manual harvested paddy fields, if the field has enough soil moisture, undertake tillage straightway, otherwise apply pre sowing irrigation (*rauni*). Use disc harrow once, followed by planking. Give another cultivation/ploughing with a cultivator. If the soil is heavy, give one more cultivation before planking the soil. Tractor drawn cultivator with pulverizing roller-cum-puddler can also be used for preparing the dry seed bed (See Appendix III "Agricultural Engineering").

- **Harvest paddy with combine harvester fitted with PAU Super SMS.**
- **Do not burn paddy straw.**
- **In standing paddy stubbles use Happy Seeder/ Super Seeder/PAU Smart Seeder/Surface seeding-cum-mulching for wheat sowing.**
- **Treat the seed as per recommendations.**

(ii) After maize

Maize residue incorporation : Wheat can be sown directly with Super seeder under flat/ridge/bed planted maize residue condition for higher productivity and better soil health.

(iii) After Cotton

Sowing of wheat after cotton crop through Super seeder: After final boll picking, *in-situ* residue incorporation of cotton plants should be done along with sowing of wheat through Super seeder in one go. It improves wheat productivity and soil health

(iv) After other crops: After pre-sowing irrigation (*rauni*), give two cultivations/ploughings followed by planking. Tractor drawn cultivator with pulverizing roller-cum-puddler can also be used for preparing the dry seedbed.

Time of Sowing: For securing the best grain yield, wheat must be sown at the optimum time. First fortnight of November is the optimum sowing time of wheat crop. However, sowing of long duration varieties can be commenced from the fourth week of October to save these from high temperature near maturity. Delayed sowing causes a gradual decline in the yield of wheat. A delay of one week from optimum sowing reduces wheat yield by about 150 kg per acre. The following sowing period for different varieties may be observed:

Sowing Period	Area/Conditions/Purpose	Varieties
From 4th week of October to 4th week of November	Entire state	PBW 872, PBW 826, PBW 824, *Sunehri* (PBW 766), DBW 187, HD 3226, *Unnat* PBW 343, PBW 725, PBW 677 and HD 3086
	Entire state except sub mountainous districts	DBW 222
	South Western districts of Punjab	PBW 803
	Entire state/ For sowing with happy seeder and super seeder	PBW 869
	Entire state/ Product specific	PBW Biscuit 1, PBW Zinc 2, PBW 1 *Chapati* and PBW 1 Zn
From 2nd week of November to 4th week of November	Entire state	PBW RS1 and *Unnat* PBW 550
From 4th week of October to 1st week of November	Entire state/ Product specific (Durum varieties)	WHD 943 and PDW 291
From 4th week of November to 4th week of December	Entire state	PBW 771 and PBW 752
For first fortnight of January	Entire state	PBW 757

Seed Rate: For conventional sowing, use seed rate of 45 kg per acre for PBW 869 and *Unnat* PBW 550 and 40 kg for all other varieties. In case of sowing with Happy

seeder, use 50 kg seed per acre for *Unnat* PBW 550 and 45 kg for all other varieties. The seed should be cleaned and graded thoroughly before sowing.

Seed Treatment:

a. For Termite: In termite infested soil, treat the seed with 1 g Cruiser 70 WS (thiamethoxam) or 2 mL Neonix 20 FS (imidacloprid+hexaconazole) or 4 mL Dursban/ Ruban/Durmet 20 EC (chlorpyriphos) per kg seed and dry it in shade. Seed treated with Neonix also control smuts of wheat.

b. For Loose Smut: Treat 40 kg seed with 13 mL Raxil Easy/Orius 6 FS (tebuconazole) by dissolving in 400 mL water or 120 g Vitavax Power 75 WS (carboxin+tetramethyl thiurum disulphide) or 80 g Vitavax 75 WP (carboxin) or 40 g Tebuseed/Seedex/Exzole 2 DS (tebuconazole) per 40 kg seed.

c. For Flag Smut: Treat 40 kg seed with 13 mL Orius 6 FS (tebuconazole) by dissolving in 400 mL water or 120 g Vitavax Power 75 WS (carboxin+tetramethyl thiurum disulphide) or 80 g Vitavax 75 WP (carboxin) or 40 g Tebuseed/Seedex/Exzole 2 DS (tebuconazole) per 40 kg seed.

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.

d. Seed Inoculation: Consortium biofertilizer should be applied after a gap of at least 6 hours of pesticide treatment to wheat seeds. For application, inoculate recommended quantity of seed for one acre with 500 g consortium biofertilizer and one litre of water on pucca floor. Let it dry in shade and sow immediately. The use of bio-fertilizers increases grain yield as well as maintains/improves soil health. These bio-fertilizers are available with the Punjab Agricultural University, Ludhiana Seed Shop at Gate No. 1 and *Krishi Vigyan Kendra*/Farm Advisory Service Centres in different districts.

Sowing Method and Spacing

i. **Conventional Sowing**: Sow wheat with a seed-cum-fertilizer drill at a depth of 4-6 cm. A spacing of 15-20 cm between the rows gives good yield. Under late sown conditions, row spacing should be 15 cm. Calibrate the drill accurately before use. For spray of pre-emergence herbicide alongwith sowing, use **Lucky Seed Drill**. (See under Appendix III “Agricultural Engineering”).

   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.

ii. **Bi-directional Sowing**: In this method use half the recommended quantities of seed and fertilizer for sowing in one direction and the remaining half in the other direction (across the first direction). Sow the seed a bit shallow i.e. 4 cm deep in rows 20 cm apart. The last ploughing in the preparatory tillage can be dispensed to reduce extra cost involved in double-sowing.

iii. **Raised Bed Sowing**: With the help of bed planter, using 30 kg seed per acre, two rows of wheat can be sown 20 cm apart on 37.5 cm wide bed with a 30 cm wide furrow between two beds. Bed planting ensures efficient use of water and fertilizers

along with reduced weed emergence. Mechanical weed control and application of second dose of urea is possible through intercultivation operation (with tractor). Entire dose of nitrogen can be applied at sowing before preparing beds. Bed planting is beneficial under medium to heavy textured and water logged soils.

iv. **Zero Tillage Sowing**: Wheat can be sown without any preparatory tillage. In weed infested fields, spray 500 mL Gramoxone 24 SL (paraquat) in 200 litres of water per acre before sowing to control weeds. 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, ensures timely sowing, improved input use efficiency and less lodging. Use tractor drawn zero till drill or strip till drill (See Appendix III "Agricultural Engineering") for sowing wheat in unprepared fields. It is advisable that after three years of continuous sowing of wheat under zero tillage, the field should be ploughed to tackle the problem of perennial weeds or rodents, if any. For control of rodents in zero tilled fields, see chapter 12, 'Management of rodents and birds'.

v. **Happy Seeder or Super Seeder or PAU Smart Seeder Sowing**: Use 'Happy Seeder' or 'Super Seeder' or 'PAU Smart seeder' machine for sowing of wheat in combine harvested paddy fields without straw burning or removal. To ensure good moisture at wheat sowing, give last irrigation to paddy crop two weeks before harvesting. Sow the crop by keeping depth between 1.5 to 2.0 inch as under:

   a. **Ordinary Happy Seeder**: The loose straw should be uniformly spread in the field before sowing either manually or harvest paddy with combine harvester fitted with the PAU-Super SMS.

   b. **PAU Happy Seeder**: This machine has been upgraded by attaching a press wheel assembly with normal happy seeder. This machine can be used for sowing of wheat in combine harvested paddy fields after cutting and spreading of standing stubbles with PAU Straw Cutter-cum-Spreader. This happy seeder uniformly place and press the chopped paddy straw in inter row area as a mulch, which facilitate better germination, emergence and vigorous initial crop establishment. Do sowing with Happy Seeder with 8 inch row spacing for better weed control and higher yield.

   c. **Super Seeder**: Harvest paddy with combine harvester fitted with the PAU Super SMS for sowing wheat with Super Seeder. Wheat seeds can be directly drilled into combine harvested paddy fields without any straw burning or removal and also in cotton stalks left after final boll picking. Super seeder can also be used for *in-situ* incorporation of wheat residue.

   d. **PAU Smart Seeder**: Harvest paddy with combine harvester fitted with the PAU Super SMS for sowing wheat with PAU Smart Seeder.

Note: **In happy seeder sown wheat fields**: Follow proper rodent control measures (see chapter 12) and apply recommended dose of urea immediately before first and second irrigations. In case of sowing with Happy seeder, use 5 kg higher seed per acre than that recommended for conventional sowing.

Drill 55 kg of DAP per acre at sowing with Happy Seeder or Super Seeder or PAU Smart Seeder. Prefer PBW 869 for sowing. For more information, see Appendix VIII.

vi. **Sowing of wheat in standing rice/basmati rice**: Medium to heavy textured soils which are high in pH and irrigated with higher residual sodium carbonate (RSC) water leads to poor infiltration rate. Under these conditions, harvesting of rice/basmati rice gets delayed and this further delays the sowing of succeeding wheat crop which decreases its productivity. In such conditions, sowing of wheat can be done in standing rice/basmati rice. For this purpose, broadcast 55-60 kg per acre of wheat seed in standing rice/basmati rice just before or immediately after the last irrigation during 10-25 October. Ensure sufficient moisture content in the field before sowing of wheat. Sow long duration wheat varieties recommended for timely sowing under conventional system. Ensure uniform distribution of seed in the field. Harvest the rice/basmati rice either manually or with combine fitted with PAU super SMS. If combine without SMS is used then distribute the lumps of loose straw for proper germination and establishment of the wheat crop. Apply full dose of recommended phosphorus and half nitrogen with first irrigation and remaining half of nitrogen at second irrigation. In case the rain occurs, apply 2nd split of nitrogen immediately after the rain. In any case, the 2nd split of nitrogen application must be completed within 50–55 days after sowing of wheat. Rest of the package is as per conventional sown wheat.

vii. **Surface seeding-cum-mulching:** It is a low-cost and easy technique for *in-situ* paddy residue management for timely sown wheat. It does not require much costly machinery, provides complete mulching and weed infestation is also less. In this method, wheat seed and basal fertilizer are uniformly broadcasted in a combine harvested paddy field. It is followed by one pass of cutter-cum-spreader which cut the whole paddy straw (at 4-5 inch above soil surface). It is followed by irrigation to initiate germination of wheat. For sowing one acre, 45 kg wheat seed (treated with recommended pesticides) and 55 kg DAP as basal fertilizer are used.

Use 'PAU Surface Seeder' for sowing of wheat. It consists of seed & fertilizer box attachment, with fluted roller metering system, mounted on to a cutter-cum-spreader. It is a low cost machine which sow wheat seed and apply basal fertilizer in a combine harvested paddy field and cut the whole straw simultaneously. It is followed by irrigation. Alternatively, combine harvester fitted with seeding attachment which sow wheat and apply basal fertilizer at the time of paddy harvest, can be used. It is followed by a single operation of cutter-cum-spreader and irrigation. Alternatively, if the above cited machines not available, wheat seed and basal fertilizer can be broadcast manually after combine harvesting followed by cutter-cum-spreader and irrigation.

Rice field with smaller plot size without excessive soil moisture at the time of rice harvest are two pre-requisites for surface seeding. Hence, it must be ensured that the field is levelled and divided into smaller plots before rice sowing/transplanting. The cut-off irrigation before rice harvesting should be done at proper time as per recommendation of 15 days and 10 days before harvesting of transplanted and direct seeded rice, respectively.

Fertilizer Application

Follow i**ntegrated use of organic, bio and chemical fertilizers** for higher crop productivity and maintenance of soil health as under:

I) Organic Manures

i. **Farmyard manure (FYM)**: Apply good quality farmyard manure before sowing and reduce the fertilizer quantity by 2 kg of N and 1 kg of P per tonne of farmyard manure. Similarly, where wheat follows potato which received 10 tonnes of farmyard manure per acre, no phosphorus and only one-half of the recommended nitrogen dose i.e 25 kg N (55 kg urea per acre) need to be applied.

ii. **Poultry manure/gobar gas plant slurry/press mud**: If 2.5 tonne per acre of poultry manure or 2.4 tonne of gobar gas plant slurry after drying was applied to rice, reduce the fertilizer N dose in wheat by 25% and fertilizer P dose by 50%. Apply 37 kg N per acre i.e. 80 kg urea in two equal split doses (at first and second irrigation) and drill 75 kg single superphosphate/acre at sowing or apply 28 kg DAP at sowing and 35 kg urea/acre each at first and second irrigation. If pressmud (6 t/acre) has been applied to preceding rice crop, apply 75 kg urea in two equal split doses and drill 28 kg DAP or 75 kg SSP per acre at sowing.

iii. **After leguminous crops**: Apply 80 kg urea per acre in two equal splits.

iv. **Rice husk ash/Bagasse ash**: Apply 4 tonne per acre of rice husk ash or bagasse ash to wheat before last ploughing and reduce the dose of phosphorus to one-half i.e. 12 kg P_2O_5 (28 kg DAP or 75 kg SSP per acre). In addition to saving phosphorus, it improves wheat productivity and soil health.

v. **Prali char**: Apply 2 tonne per acre prali char to wheat before last ploughing and save 35 kg urea per acre. It increases the yield and improves soil health.

II) Bio-fertilizers

Inoculate the seed with bio fertilizers before sowing as per recommendations. (See seed inoculation).

III) Chemical Fertilizers

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 fertile soils:

Nutrients (kg/acre)			Fertilizers (kg/acre)				
N	P_2O_5	K_2O	Neem coated urea	DAP*	or Superphosphate	or Nitrophosphate*	Muriate of potash
50	25	#	110	55	155	125	#

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

\# Apply 12 kg K_2O (20 kg muriate of potash) per acre to soils testing low in potassium and apply 24 kg K_2O (40 kg muriate of potash) per acre at the time of sowing in the Gurdaspur, Hoshiarpur, Rupnagar and Shaheed Bhagat Singh Nagar districts.

* When 125 kg of Nitrophosphate is used, decrease quantity of urea by 50 kg per acre.

- **Use integrated nutrient management approach through organic, bio and chemical fertilizers.**
- **Apply 90 kg urea and 55 kg DAP per acre in medium fertility soils.**
- **Apply potassium to deficient soils only.**
- **Use PAU-LCC or Green Seeker for need based urea application.**
- **Correct the maganese, zinc and sulphur deficiency in deficient soils.**
- **To mitigate the effect of high temperature at grain filling stage, spray potassium nitrate or salicylic acid as per recommendation.**

Time and Method of Fertilizer Application: Drill whole of P (55 kg DAP or 155 kg SSP) and K (20 kg MOP, if required as per soil test) at sowing. No urea is required at sowing if DAP is used as source of phosphorus. If phosphorus is to be applied through SSP, apply 20 kg urea per acre at sowing. Broadcast 45 kg urea for timely sown crop and 35 kg per acre for wheat crop sown after mid December each with first and second irrigation. If second irrigation is delayed due to rains, the urea should be broadcasted at 55 days after sowing. But, if water stagnates near second irrigation, do not broadcast second dose of urea in soil. Instead, give two sprays (criss-cross) of 7.5% urea solution (15 kg urea in 200 litre water per acre) at 42 and 54 days after sowing.

Fertilizers for wheat sown with different rice straw management practices: Drill 55 kg of DAP per acre at sowing. Broadcast 45 kg urea per acre before first and second irrigation. In case of Super seeder, urea can be applied either before or after irrigation. Where wheat has been sown with Happy Seeder continuously for 3 years, reduce 20 kg urea per acre from fourth year onwards. In fields where organic carbon content of soil comes under high category, after continuous retention/incorporation of paddy straw, drill 27 kg DAP per acre at sowing.

Need Based Fertilizer Nitrogen Application with 'PAU-Leaf Colour Chart' (PAU-LCC) or Green Seeker Optical Sensor

- In medium fertility soils, drill 55 kg DAP at sowing.
- At first irrigation, apply 40 kg urea per acre for timely sown and 25 kg urea per acre for late sown (after mid December) wheat. Before second irrigation proceed as under:

i. PAU LCC Method

- Before second irrigation (about 50-55 days after sowing), match colour of the topmost fully exposed intact leaf of ten representative plants with PAU-LCC under shade of your body.
- At second irrigation, apply urea based on leaf greenness of 6 or more leaves out of 10 leaves as per following table:

Leaf Colour as per PAU-LCC	More than LCC shade 5.0	LCC shade 4.5 to 5.0	LCC shade 4.0 to 4.5	Less than LCC shade 4.0
Urea dose (kg/acre)	15	30	40	55

PAU-LCC is highly beneficial for achieving potential yield with optimum fertilizer nitrogen application in conventionally sown wheat as well as wheat sown with different rice straw management options.

ii. Green Seeker Optical Sensor Method

- The over fertilizer nitrogen reference plot of at least 30 sq metre area shall be established for the same variety with same date of sowing by applying 55 kg DAP + 45 kg urea per acre at sowing and 65 kg urea per acre at first irrigation.
- Before 2nd irrigation (about 50-55 days after sowing), record reading using Green Seeker optical sensor by keeping it at a distance of 75 cm above the crop canopy of the test field and over fertilized reference plot.
- Feed the readings of green seeker for both the plots and age of crop in the 'PAU-Urea Guide' app to know the amount of urea to be applied.

Note: PAU-LCC/Green Seeker based N application should be ensured at 55 days after sowing even if second irrigation is delayed due to rainfall. But, if water stagnates near second irrigation, do not broadcast second dose of urea in soil. Instead, give two sprays (criss-cross) at 42 and 54 days after sowing. Spray 7.5% urea solution (15 kg urea in 200 litre water per acre) if leaf greenness is equal to or darker than PAU-LCC shade 5.5 or 10% urea solution (20 kg urea in 200 litre water per acre) if leaf greenness is less than PAU-LCC shade 5.5.

For the use of LCC and Green seeker, the field should be free from diseases/ insect attack and deficiency of other nutrients.

The PAU-LCC is available at PAU, Ludhiana Book Sale Counter at Gate No. 1, and its *Krishi Vigyan Kendras*/Farm Advisory Service Centres in different districts of Punjab.

Important tips for use of fertilizers

- To the crop sown in kallar soil, apply 25% more nitrogen than recommended.
- To the crop sown after mid December, apply 25% less nitrogen than recommended.
- If full dose of urea has already been applied in soil and crop still shows nitrogen deficiency, spray 3% urea solution (9 kg urea in 300 litre water per acre). Spray cross wise to thoroughly cover the crop.
- Wheat is more responsive to phosphorus application than *kharif* crops. Hence apply phosphorus to wheat and omit its application to following *kharif* crop.
- 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) or ammonium phosphate (12:40:0:10:1:: N:P_2O_5:K_2O:S:Zn) may be applied as an alternative source of phosphorus to wheat, although it is costly.

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 (See Plate No. 1, Page No. 177). In acute deficiency whole of the plant may die. At earing stage, the symptoms become prominant on flag leaf.

In manganese deficient soils, give one spray of 0.5% manganese sulphate solution (1.0 kg manganese sulphate in 200 litres of water), 2-4 days before first irrigation and three sprays afterwards at weekly intervals on sunny days. Do not grow durum varieties in sandy soils as these varieties are prone to manganese deficiency. **Manganese sulphate should be sprayed only as its soil application is not profitable.**

Zinc Deficiency: If recommended dose of zinc sulphate has been applied to the *kharif* crop, its application may be omitted to the following wheat crop. Zinc deficiency symptoms in wheat are 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.

Enriching zinc content in wheat grain: The zinc content in wheat grain (for nutritional quality improvement) can be increased by giving one or two sprays of 0.5% zinc sulphate heptahydrate (21%) solution from anthesis to early grain development stages in the evening hours.

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. 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.

In sulphur deficient soils, where phosphorus has been applied through DAP instead of single superphosphate, apply 100 kg of gypsum or 18 kg bentonite-sulphur (90%) per acre before sowing to meet the sulphur requirement of the wheat. If recommended dose of gypsum was applied to groundnut, apply only 50 kg per acre. Gypsum can also be applied in standing crop if deficiency of sulphur is observed.

Weed Control

Weeds can be controlled by two hand hoeings, one before first irrigation and second after first irrigation with wheel hand hoe, kasola or khurpa etc. Alternatively, weeds can be controlled by the following ways:

A. Control of grass weeds

i. Control of *Phalaris minor* (*Gulli danda*)

1. Cultural methods: Sow quick growing wheat varieties from last week of October to first week of November in narrow rows at 15 cm spacing. In fields having severe infestation of this weed, replace wheat with alternate crops like berseem, potato, raya and gobhi sarson for 2 to 3 years. Preparation of soil mulch at sowing helps in eliminating the first flush of *gulli danda*.

2. Herbicides: *Gulli danda* can be controlled with use of any of herbicides listed below. The herbicides can be applied within two days of sowing or before first irrigation or after first irrigation.

<table>
<tr><th>Brands (Herbicide)</th><th>Dose per acre</th><th>Time of spray and amount of water</th></tr>
<tr><td colspan="3">a. Pre-emergence</td></tr>
<tr><td>Stomp/Dost/Penda/Markpendi/Pendin/Bunker/ Zakiyama 30 EC (pendimethalin)</td><td>1.5 litre</td><td rowspan="4">In fields to be sown with Happy Seeder, mix any of four herbicides with basal dose of Urea and broadcast just before sowing.
In fields to be sown with any other method, spray any of four herbicides within two days of sowing using 200 litres of water.</td></tr>
<tr><td>Awkira/Momiji 85 WG (pyroxasulfone)</td><td>60 g</td></tr>
<tr><td>Platform 385 SE (pendimethalin + metribuzin)
• It also controls broadleaf weeds</td><td>1.0 litre</td></tr>
<tr><td>Daksh Plus 48 EC (pendimethalin + metribuzin)
• It also controls broadleaf weeds</td><td>900 mL</td></tr>
<tr><td colspan="3">• Good soil moisture for pre-emergence spray is desirable
• ‘Lucky Seed Drill’ can be used for spray of pre-emergence herbicide along with sowing of wheat. (See Appendix- III)</td></tr>
<tr><td colspan="3">b. Post-emergence (Before first irrigation)</td></tr>
<tr><th>Brands (Herbicide)</th><th>Dose per acre</th><th>Time of spray and amount of water</th></tr>
<tr><td>Arelon/Delron/Hilproturon/ Ronak /Nocilon/ Wonder/ Milron/Agrilon/ Totalon/ Agrilon/ Shivron/Carelon/ Marklon/Jai-roturon/ Isoguard/ Dhar/ Rakshak/ Prowl/Kanak/ Isotox/ Isohit/ Ciluron/Isocin 75 WP (isoproturon)
• Don’t use isoproturon group of herbicides in areas where there is problem of resistance</td><td>300 g in light textured; 400 g in medium textured and 500 g in heavy textured soils</td><td rowspan="2">When crop is 20 days old and weeds are in 2-3 leaf stages, spray 2-3 days before first irrigation, using 150 litres of water</td></tr>
<tr><td>Leader/SF-10/Safal/ Marksulfo 75 WG (sulfosulfuron*)
• Do not use sulfosulfuron group of herbicides if any broadleaf crop is sown in wheat and where jowar/ maize to be sown after wheat</td><td>13 g</td></tr>
</table>

c. Post-emergence (After first irrigation)		
Isoproturon 75 WP: (All the above formulations of isoproturon mention in 'b'.)	500 g for all types of soil	30-35 days of sowing, using 150 litre of water
Topik/Point/Moolah/Topple/Rakshak Plus/Jay Vijay/ Markclodina/ Columbus 15 WP (clodinafop)	160 g	
Axial 5 EC (pinoxaden*)	400 mL	
Leader/SF-10/Safal/ Marksulfo 75 WG (sulfosulfuron*) • Do not use sulfosulfuron group of herbicides if any broadleaf crop is sown in wheat and where sorghum/ maize to be sown after wheat	13 g	

ii. Control of wild oats (*Jangli Javi*): All the post-emergence herbicides recommended for the control of *gulli danda* also provide effective control of wild oats.

B. Control of broadleaf weeds only:

Broadleaf weeds can be controlled with use of any of below listed herbicides:-

Brands (Herbicide)	Dose per acre	Time of spray and amount of water
2, 4-D sodium salt 80 WP or 2, 4-D ethyl ester 38 EC • Use in fields having *bathu, billi booti, jangli hallon, pitpapra, jangli senji, maina, maini, jangli palak*	250 g 250 mL	In timely sown at 35-45 days after sowing and in late sown (in Dec) at 45-55 days after sowing, using 150 litre of water
Algrip/Algrip Royal/Markgrip/Makoto 20 WP (metsulfuron*) • Use in fields having *kandiali palak*	10 g	30-35 days of sowing, using 150 litre of water
Aim/Affinity 40 DF (carfentrazone-ethyl*) • Use in fields having *button booti*	20 g	25-30 days of sowing, using 200 litre of water
Lanfida 50 DF (metsulfuron + carfentrazone*) • Use in fields having *makoh, kandiali palak, rari/rewari, hirankhuri*	20 g	25-30 days of sowing, using 150 litre of water
• **Do not use these herbicides, if any broadleaf crop such as *raya, gobhi sarson*, gram is sown in wheat.**		

C. Control of both grass and broadleaf weeds:

Grass and broadleaf weeds can simultaneously be controlled with use of any of below listed herbicides:-

Brands (Herbicide)	Dose per acre	Time of spray and amount of water
Total/ Markpower 75 WG (sulfosulfuron + metsulfuron*) • Do not use where sorghum/maize to be sown after wheat	16 g	30-35 days of sowing, using150 litre of water
Atlantis 3.6 WDG (mesosulfuron + iodosulfuron)	160 g	
Shagun 21-11 (metribuzin+clodinafop) • Preferably use where there is a problem of multiple herbicide resistance in *gulli danda* • Do not use on PBW RS1 and *Unnat* PBW 550 • Do not use on light textured soils	200 g	
ACM-9/EMEK (metribuzin+clodinafop) • Preferably use where there is a problem of multiple herbicide resistance in *gulli danda* • Do not use on PBW RS1 and *Unnat* PBW 550 • Do not use on light textured soils	240 g	
Tank mix of Topik/Point/Moolah/Rakshak Plus/ Jay Vijay/ Topple/Markclodina/ Columbus with 2,4-D/ Algrip/Algrip Royal/Markgrip/Makoto	Recommended doses as per *gulli danda* and broadleaf weeds alone	35-45 days of sowing in 150 litre of water
Tank- mix of isoproturon formulations and 2,4-D sodium salt or ethyl ester • **Only in areas where *gulli danda* has not evolved resistance to isoproturon**		
• **Do not use above listed herbicides/tank mix, if any broadleaf crop like raya, gobhi sarson, gram is sown in wheat.**		

D. Integrated weed management: Sowing wheat with happy seeder, in standing rice stubbles, significantly reduces weed pressure and soil weed seed bank, particularly of *gulli danda*. Integration of happy seeder with herbicides and hand pulling of escaped weed plants improves weed control and deplete soil seed bank further.

E. Weed control in durum wheat: All the above mentioned pre and post-emergence herbicides at recommended dose and time can be used for weed control in *durum* wheat, except Total/Markpower/Atlantis/Shagun 21-11/ACM-9/EMEK. Apply 500 g of isoproturon group of herbicides at 40-45 days after sowing in medium to heavy textured soils and do not use isoproturon on light textured soils.

Useful hints

- Spray should be as uniform as possible and on clear days.
- After spray, irrigation should be light as heavy irrigation reduces the efficacy of herbicides.
- After spray, flush the spray pump thoroughly with water and then with washing soda solution (0.5%) to remove traces of herbicides, as contaminated spray pump may be phytotoxic when used for spray on other crops.

- If *raya, sarson or gobhi sarson* is sown in wheat, use isoproturon, clodinafop or fenoxaprop group of herbicides at recommended doses.
- In areas where there is problem of resistance in *gulli danda*, do not use isoproturon group of herbicides.
- Use flat fan or flood jet nozzle for pre-emergence herbicides and flat fan nozzle for post emergence herbicides.
- Change the herbicide group every year to prevent the development of resistance in weeds.
- Some weed plants may escape after the application of herbicides. These plants should be uprooted before they produce seeds. This practice will reduce the weed problem in next crop of wheat.

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 late harvesting 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 (kiaras) 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)		
	Weeks after the previous irrigation		
	Second	Third	Fourth
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:

- Advance the date of the first irrigation on light soils and delay it by one week on heavy paddy soils.
- The indicated intervals for irrigation can be varied by 2 or 3 days on either side.
- 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.
- Depending upon the rainfall, irrigate the timely sown crop upto the end of March to avoid the harmful effect of unusual rise in temperature at grain filling/formation stage. Care should be taken not to irrigate the crop on windy days to avoid lodging.
- For the crop sown after December 5, continue irrigation upto April 10.
- **For sub-surface drip irrigation in wheat, see chapter on Multiple Cropping under maize-wheat-summer moong and cotton-wheat cropping system.**

Mitigation of effect of high temperature at grain filling and enhancing yield: Apply two sprays of 2% Potassium nitrate (13:0:45) by dissolving 4 kg potassium nitrate in 200 litres of water at boot leaf and anthesis stages or two sprays of salicylic acid by dissolving 15 gram salicylic acid in 450 mL of ethyl alcohol using 200 litres of water per acre at boot leaf and early milk stages to mitigate the effect of high temperature at grain filling and enhance the wheat yield.

Production of Quality Seed

The farmer can produce quality seed from foundation or certified seed for next season. The seed to be used for multiplication must be treated with recommended fungicides against loose smut. Remove all off-type and diseased plants at frequent intervals. **A single spray of 200 mL of Tilt 25 EC with 200 litre of water per acre is recommended to obtain Karnal bunt free seed.** Eliminate the chances of occurrence of admixture during harvesting, threshing and storage.

Harvesting and Threshing

Harvest and thresh wheat as soon as fully ripe, to avoid grain shattering. Delayed harvesting results in high grain losses. Combine harvesters are generally being used for simultaneous harvesting and threshing of wheat. Stubbles can be bruised as fine wheat straw (*turi*) by using wheat straw combine. Straw recovery is about 60%. Wheat can be harvested manually or by tractor-operated vertical conveyer reaper windrowers. For threshing, use power thresher fitted with proper safety devices to prevent accidents. For good performance, operate these machines at recommended cylinder speed 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 per cent. For detailed information and instructions on the use of machines/ implements for various operations, see Appendix III 'Agricultural Engineering'.

Storage

In case the grain contains more than 10 per cent 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 if the produce is to be used as seed. See Appendix V for the control of stored grain insect pests.

Plant Protection

(a) Insect Pests

1. 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 by diluting 40 g Cruiser 70 WS (thiamethoxam) or 160 mL Dursban/Ruban/Durmet 20 EC (chlorpyriphos) or 80 mL Neonix 20 FS (imidacloprid+hexaconazole) 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. Seed treated with Neonix also control smuts of wheat. Seed treated with insecticide is less attacked by birds. Generally, termites cause more damage in sandy soil and irrigating the affected fields result in some control of termite damage. In case of severe infestation,

broadcast 7 kg Mortel 0.3 G (fipronil) or 1.2 litre Dursban 20 EC (chlorpyriphos) per acre mixed with 20 kg of moist sand before first irrigation.

2. Aphids damage the crop resulting in discolouration of leaves (See Plate No. 2, Page No. 177). In case aphid infestation exceeds economic threshold level of 5 aphids per earheads (recorded from 10 randomly selected ear heads in each of the 4 quarters of one acre field), give two sprays of 2 litre PAU homemade neem extract at weekly interval or single spray of 20 g Actara/Taiyo 25 WG (thiamethoxam) in 80-100 litres of water per acre using knap sack sprayer or in 30 litres of water per acre with power sprayer.

- Insecticides should be applied only if the aphid attack appears on earhead stage.
- Since the aphids appear first on borders of the crop, spray only the infested strip to check their further spread.

Method of preparation of neem extract: Boil 4.0 kg terminal parts of the shoots of neem trees including leaves, green branches and fruits in 10 litres of water for 30 minutes. Then, filter this material through muslin cloth and use the filtrate for spraying at the recommended dose.

3. Army worm attack usually wheat during March-April, however it is also observed in the month of December in fields having large loads of paddy straw. It damages leaves and earheads. Spray 40 mL Coragen 18.5 SC (chlorantraniliprole*) or 400 mL Ekalux (quinalphos) in 80-100 litres of water per acre with hand-operated knapsack sprayer or in 30 litres of water with motorized sprayer. For better effectiveness of the insecticide, spraying should be done in the evening when armyworm larvae are more active. These insecticides will also control aphids. Alternatively, broadcast 7 kg Mortel/Regent 0.3 G (fipronil) or 1 litre Dursban 20 EC (chlorpyriphos) mixed with 20 kg of moist sand in one acre before first irrigation.

4. Pink stem borer (*Sesamia inferens*) 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'. If the severe damage of pink stem borer is observed in previous rice crop, avoid sowing of wheat in the month of October. Prefer to irrigate the fields during day time to maximize predation of insects by birds. In case of severe infestation, broadcast 7 kg Mortel/Regent 0.3 G (fipronil) or 1 litre Dursban 20 EC (chlorpyriphos) mixed with 20 kg of moist sand in one acre before first irrigation. Alternatively, spray 50 mL Coragen 18.5 SC (chlorantraniliprole) in 80-100 litre of water per acre.

5. 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 800 mL Ekalux 25 EC (quinalphos) in 100 litres of water per acre with hand operated knap sack sprayer.

6. Brown mite is a minor insect of wheat causing discolouration of leaves. It is of very small size and attack is more observed on rainfed wheat.

(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 especially 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.

- **Grow yellow rust resistant wheat varieties especially in disease prone sub mountainous areas of the state.**
- **Regularly monitor the fields from second week of December onward for yellow rust.**
- **Control initial appearance of yellow rust in patches to check its further spread.**
- **To produce Karnal bunt free seed, spray Tilt 25 EC at ear emergence.**

- In light soil, add 25 kg zinc sulphate per acre. One such application will be enough for 2-3 years.
- Spray 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.
- Give proper irrigation to counteract the effect of frost. Avoid excessive irrigation.
- For control of cereal cyst nematode present in the soil, apply 13 kg per acre Furadan 3 G at sowing time.
- Apply 100 kg gypsum per acre for correcting sulphur deficiency.

2. Wheat rusts: Generally, wheat crop is infested by following rusts

(i) Yellow or stripe rust (*Puccinia striiformis* f.sp.*tritici*): Yellow powdery pustules appear on leaves, forming stripes (See Plate No. 3, Page No. 177). The disease appears first in the sub-mountaineous areas of the state. Minimum temperature in the range of 7-13°C coupled with 85-100% relative humidity during night and maximum temperature in the range of 15-24°C during day are congenial for infection, development and spread of disease. Frequent rains along with wind during February-March may further enhance the disease severity and spread.

Intergrated management of yellow rust:

- Grow rust resistant (PBW Biscuit 1, PBW Zinc 2, PBW RS1, PBW 725, *Unnat* PBW 550, PBW 752, WHD 943, PDW 291 and PBW 660) varieties.
- Don't grow unrecommended varieties especially in sub-mountainous zone.
- Do not sow the crop in the month of October particularly in the disease prone sub-mountainous areas.
- Monitor the crop from 2nd week of December onward particularly after irrigation or rain to locate the initial foci of infection.
- Spray the crop with 300 g Taqat 75 WP (captan + hexaconazole) or Caviet 25 WG (tebuconazole) or 120 g Nativo 75 WG (trifloxystrobin + tebuconazole) or 200

mL Ampact Extra 25.5 SC (azoxystrobin + cyproconazole) or 200mL Opera 18.3 SE (pyraclostrobin + epoxiconazole) or 200 mL Custodia 320 SC (azoxystrobin + tebuconazole) or 200 mL Tilt 25 EC/Shine 25EC/Bumper 25 EC/ Stilt 25 EC/ Compass 25 EC/Markzole 25 EC (propiconazole) in 200 litres of water per acre as soon as the disease is noticed.

- Initially only spot application surrounding infected area should be done.
- Regularly monitor the crop and repeat the spray as per need.

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

- Grow rust resistant (PBW Biscuit 1, PBW Zinc 2, PBW 824, PBW 869, PBW 803, DBW 222, DBW 187, PBW 725, *Unnat* PBW 343, *Unnat* PBW 550, PBW 1 Zn, HD 3226, PBW 771, PBW 757, WHD 943, PDW 291 and PBW 660) varieties.
- Spray the crop with 200 mL Tilt 25 EC/Shine 25 EC/Bumper 25 EC/Stilt 25 EC/ Compass 25 EC/Markzole 25 EC (propiconazole) in 200 litres of water per acre as soon as the disease is noticed.

3. 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 and PDW 291. A single spray of 200 mL Tilt 25 EC (propiconazole) 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.

4. Powdery mildew (*Blumeria 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. Spray with 300 g Taqat 75 WP (captan + hexaconazole) or 120 g Nativo 75 WG (trifloxystrobin + tebuconazole) in 200 litres of water per acre.

5. Loose smut (*Ustilago segetum tritici***):** The fungus destroys the ears completely, turning them into a black loose powdery mass consisting of spores and leaving behind the rachis only.

- Grow resistant varieties such as WHD 943 and PDW 291.
- 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 seed completely and store in a dry place till sowing.
- Alternatively, the seed may be treated with fungicides as per recommendations.

6. 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. Rougue out the affected stools and destroy them by burning. Treat the seed with recommended fungicides. Varieties WHD 943 and PDW 291 are resistant to this disease.

7. 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. **The incidence of this disease is more on durum varieties, their cultivation in highly humid areas, particularly near rivers should be avoided.**

8. Leaf blight, glume blight and black tip of grains: Elongated brown spots and blotches appear on leaves and glumes. Ears are poorly filled, grains shrivelled, discoloured and black tipped. Use disease free seed.

9. Ear cockle (*Mamni*) **and Yellow ear rot** (*tundu*) (*Anguina tritici* and *Rathayi bacter tritici*): Diseased plants have spreading tendency and swollen base, leaves become crinkled 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 few minutes. Ear-cockle galls will float to the surface. These may be skimmed off with an ordinary sieve and burnt.

10. 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 13 kg Furadan 3G (carbofuron) per acre at sowing time.

(c) Rodents and Birds: See Chapter - Management of Rodents and Birds.

Agronomic Practices for Rainfed Conditions

In Hoshiarpur, Ropar, Sahibzada Ajit Singh Nagar (SAS Nagar), Shaheed Bhagat Singh Nagar (SBS Nagar), Gurdaspur and Pathankot some area under wheat is rainfed. The recommendations for raising wheat under such conditions are given below:

Soil: Light textured soil (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.

Improved varieties for rainfed conditions

PBW 660 (2014): Its plant height is 100 cm and matures in 162 days. It has an excellent *chapati* quality. It is resistant to yellow and brown rust. Its average grain yield is 17.1 quintals per acre.

Seed Rate: Use 40 kg seed per acre.

Seed Treatment: Termites cause heavy mortality of plants. Treat the seed with recommended pesticides as given under Plant Protection Measures to cover the risk of termite attack.

Time of Sowing: Sow wheat from the last week of October to the Ist week of November

Method of Sowing: Sow crop preferably with a seed-cum-fertilizer drill. In case the crop stand is poor, i.e. less than 50 per cent of the optimum and the winter rains come before 15th December, re-sow the field.

If the soil moisture is good so the crop at a row-to-row spacing of 22-25 cm. 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)		
	N	P_2O_5	K_2O	Urea	Super phosphate	Muriate of potash
Sandy loam to clay loam soils with adequate moisture stored	32	16	#	70	100	#
Loamy sand to sandy soils with low moisture stored	16	8	##	35	50	##

Apply 12 kg K_2O (20 kg muriate of potash) per acre to soils testing low in potassium with adequate moisture stored.

Apply 8 kg K_2O (10 kg muriate of potash) per acre to soils testing low in potassium with low moisture stored.

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

Time and method of application: In sandy loam to clay loam soils drill half N and full P & K fertilizers at sowing and broadcast remaining half N at winter rains. However, in loamy sand to sandy soils drill all fertilizers at sowing.

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, Threshing, Storage and Plant Protection: As mentioned in case of Agronomic Practices for Irrigated Conditions.

Varieties notified at National (Zonal) level for the North-Western Plains Zone of India, including Punjab during last five years

Agronomic conditions/ Segment	Varieties
Restricted irrigation	HD 3369 (2022)*, HI 1653 (2022), HI 1654 (2022), DBW 296 (2021), HUW 838 (2021), NIAW 3170 (2020), HI 1628 (2020)
High input early sown	WH 1402 (2024), PBW 872 (2022), DBW 370 (2022), DBW 371 (2022), DBW 372 (2022), DBW 327 (2021), DBW 332 (2021), DBW 303 (2021), DBW 187 (2021), WH 1270 (2021)
Very late sown (1-15 January)	HD 3298 (2021), HI 1621 (2020), HD 3271 (2020)
Marker-Assisted selection	HD 3406 (2022)
Irrigated timely sown	HD 3386 (2024), PBW 826 (2022), DBW 187 (2020), DBW 222 (2020)
Late sown	JKW 261 (2021), PBW 771 (2020)

* year of notification

BARLEY

In 2023-24, barley was grown on 5.1 thousand hectares in Punjab with a production of 19.1 thousand tonnes and average yield of 37.37 quintals per hectare (15.12 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.

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.

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

Improved Varieties (irrigated conditions)

PL 942 (2025): It is a two-row malt barley variety suitable for brewing industry. Its average plant height is 101 cm and matures in about 146 days. It possesses lustrous bold grains. It possesses desirable grain and malt quality traits such as protein, starch, diastatic power, β glucan, free amino nitrogen and malt extract. It is moderately resistant to stripe and leaf rust diseases. Its average grain yield is 20.1 quintals per acre.

DWRB 123 (2019): It is a **two rowed malt barley variety** which matures in 141 days. It is medium tall variety with 101 cm height. It is a bold seeded variety with 11% protein content. It is resistant to major pathotypes of yellow rust, moderately resistant to brown rust and tolerant to leaf blight disease. Its average grain yield is 19.4 quintals per acre. **This variety is particularly suitable for brewing industry.**

PL 891 (2019): It is a **two rowed hulless food barley variety.** It contains 4 % β-glucan content and 12% protein content. β-glucan is helpful in preventing heart

diseases and type-II diabetes. It matures in 144 days. It is medium tall variety with 102 cm height. It is resistant to major pathotypes of yellow rust, brown rust and leaf blight disease. Its average grain yield is 16.8 quintals per acre. It is a bold seeded variety so use 50 kg seed per acre. Hulless barley can be consumed as whole grain cereal, barley flakes, barley flour, etc. Barley sattu can be used as energy drinks.

PL 807 (2009): It is a **six-rowed and feed barley variety** which matures in 137 days. It is fairly resistant to yellow rust, brown rust and leaf blight. Its average grain yield is 17.2 quintals per acre.

DWRUB 52 (2008): It is a **two-rowed and malt barley variety** which matures in about 140 days. It is fairly resistant to yellow rust, brown rust and leaf blight diseases. Its average grain yield is 17.3 quintals per acre. **This variety is particularly suitable for brewing industry.**

PL 426 (1994): It is a **six-rowed and feed barley variety** which matures in 124 days. It is resistant to lodging and yellow rust. It is moderately susceptible to stripe disease and aphids. Its average grain yield is 14.0 quintals per acre.

Agronomic Practices

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

Time of Sowing: Barley gives best results when sown between October 15 to November 15. There is a gradual decline in yield when sowing is progressively delayed up to the end of December.

Seed Rate: Use 35 kg seed per acre under timely sown irrigated conditions. For rainfed and late sown conditions, use 45 kg seed per acre. However, for variety PL 891, use 50 kg seed per acre.

Seed Treatment: Before sowing, treat the seed with 1.5 g Vitavax 75 WP (carboxin) per kg of seed to control covered smut and loose smut in barley. Solar heat treatment as recommended for wheat can be done to control the loose smut of Barley.

Method of Sowing: In rainfed areas, 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 Appendix III). Barley can also be grown without any preparatory tillage with zero till drill after rice. A spacing of 22.5 cm for the normal sown crop and 18-20 cm for the late-sown crop is recommended.

Fertilizer Application

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

Nutrients (kg/acre)			Fertilizer (kg/acre)			
N	P_2O_5	K_2O	Urea	DAP*	or Superphosphate	Muriate of potash
25	12	#	55	27	75	#

Apply 6 kg K_2O (10 kg muriate of potash) per acre to soils testing low in this nutrient.

* Apply 45 kg urea per acre, if the recommended dose of DAP is to be applied.

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*).

Zinc Deficiency: Zinc deficiency symptoms are stunted and bushy crop. Apply 10 kg per acre of zinc sulphate (21%) at the time of sowing in zinc deficient soils.

Enriching zinc content in grains: The zinc content in grain (for nutritional quality improvement) can be increased by giving two sprays of 0.5% zinc sulphate (21%) solution in the evening hours at earing and milk stages. Prepare the solution for spray by dissolving 1kg zinc sulphate and 1/2 kg unslaked lime in 200 litres of water.

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

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.

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

1. Aphids are the major insect pest of barley. The natural predators (*Coccinella septempunctata*) become active on the appearance of the aphids.

(b) Diseases

1. Stripe disease (*Drechslera graminea*): Yellow to brown stripes appear on leaves. The plants become stunted and the leaves are shredded. Use disease free seed.

2. Loose smut (*Ustilago nuda*): The smut sori are enclosed in a fragile membrane which soon ruptures, releasing the dark dusty spore mass which is disseminated by wind, leaving the naked rachis behind. Treat seed as per recommendations given in wheat.

3. Covered smut (*U. hordei*): The entire ear, except the awns turn into a black compact mass of spores. Treat the seed as per recommendations. Sow the crop late and shallow to reduce seedling infection.

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 recommended varieties.

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. Prefer resistant varieties.

Varieties notified at National (Zonal) level for the North-Western Plains Zone of India, including Punjab during last five years

Agronomic condition/ Segment	Varieties
Food Barley - hulless under timely sown irrigated conditions	PL 891 (2020*)
Feed Barley - timely sown under irrigated conditions	DWRB 137 (2021)
Malt Barley - timely sown under irrigated conditions	DWRB 182 (2021), DWRB 160 (2020)

* year of notification

SPRING MAIZE

Cultivation of spring maize is very popular in the districts of Hoshiarpur, Kapurthala, Shaheed Bhagat Singh Nagar, Jalandhar and Ropar.

Rotations: Maize-vegetable pea/potato-spring maize

Improved Varieties

P 1844 (2019): This hybrid is suitable for spring season cultivation in Punjab. It has tall plants and medium broad leaves. Tassel is open and heavy. Ears are long having orange flint grains with yellow caps. It matures in about 120 days. Its average yield is 32.0 quintals per acre.

PMH 10 (2015): Plants of this single cross hybrid are medium tall with medium ear placement. Leaves are broad. Tassels are medium in size, semi-open with green anthers. Silks are pink in colour. Ears are medium long, conico-cylindrical with attractive orange flint grains. It matures in about 120 days. Its average yield is 31.5 quintals per acre.

DKC 9108 (2015): Plants are medium tall with low ear placement. Leaves are broad and erect. Tassels are semi-open. Anthers and silks are green. Ears are medium long and cylindrical. Grain are dull yellow, semi-dent with caps. It matures in about 122 days having average grain yield of 32.0 quintals per acre.

PMH 8 (2014): This hybrid has medium tall plants with medium ear placement. Leaves are medium broad and curved. The tassel is open with strongly curved branches. The glumes, anthers and silks are green. Pollen shedding and silk emergence are synchronous. It has medium sized, conico-cylinderical ears with attractive yellow orange flint grains with slight yellow capping. It matures in about 117 days. Its average yield is 31.0 quintals per acre.

PMH 7 (2013): This single cross hybrid has medium tall plants with medium ear placement. Leaves are medium broad and curved. The tassel is open with strongly

curved branches. Anthers are green. Silks are green at emergence. Pollen shedding and silk emergence are synchronous. Ears are medium sized and conico-cylindrical with orange flint grains. It matures in 115 days and its average yield is 30.0 quintals per acre.

PMH 1 (2005): It has tall plants with well developed root system. The stem has purple coloration and is zig-zag and sturdy. The leaves are medium broad. Tassel is open and medium in size. Ears are medium long with yellow orange flint grains. Its average yield is 27.6 quintals per acre and matures in 118 days.

- **Treat the seed to control maize shoot fly.**
- **Pollen desiccation may occur due to high temperature in late sown crop.**
- **Preferably sow the crop on southern slope of east-west ridges/beds by dibbling.**
- **Spray of Atrataf 50 WP upto 10 days of sowing effectively manage the weeds.**
- **Ensure adequate water supply during tasseling, silking and grain filling stage.**

Avoid cultivation of unrecommended Varieties

P31Y45: This hybrid has medium tall plants with medium ear placement and susceptible to post flowering stalk rots.

Agronomic Practices

Land Preparation: Give 4-5 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. Biomass incorporator (a modified mould-board plough equipped with a clod crusher) can also be utilized for simultaneous pulverization (see Agricultural Engineering, Appendix III). 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.

Time of Sowing: Sow the crop during 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.

Seed Rate and Treatment: Use 10 kg seed per acre. For the control of maize shoot fly, treat the seed with 6 mL Gaucho 600 FS (imidacloprid) per kg seed. The treated seed should be sown within 14 days.

Method of Sowing: The sowing should be done by dibbling seed preferably 6-7 cm high on the southern side of 60 cm spaced East-West ridges or 67.5 cm spaced beds for early emergence and good vigour. Keep plant to plant spacing of 20 cm in case of ridge planting and 18 cm in case of bed planting. For bed preparation the wheat bed planter should be used and it saves the irrigation water.

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

Fertilizer Application

Apply 6 tonnes of good quality farmyard manure per acre to the maize crop year after year and omit the application of phosphorous, potassium, zinc and nitrogen recommended as basal dose. Application of nitrogen fertilizer more than recommended dose is no substitute for FYM.

Apply fertilizer on soil test basis. In the absence of a soil test, apply the following amounts of inorganic fertilizers.

Varieties	Nutrients (kg/acre)			Fertilizers (kg/acre)				
	N	P_2O_5	K_2O	Urea	DAP*	or Super phosphate	or Nitro-Phosphate*	Muriate of Potash
P 1844, PMH 10, DKC 9108, PMH 8, PMH 1	50	24	#	110	55	150	125	#
PMH 7	35	12	##	75	27	75	62	##

\# Apply 12 kg K_2O (20 kg muriate of potash) per acre to soils testing low in this nutrient.

Apply 8 kg K_2O (15 kg muriate of potash) per acre to soils testing low in this nutrient.

* Apply 90 kg urea per acre, if 55 kg DAP is used. Similarly, apply 65 kg urea per acre if 27 kg DAP is used for respective varieties. Apply 60/50 kg urea per acre if 125/62 kg nitrophosphate is used respectively for different 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.

Zinc Deficiency: In deficient field its symptoms appear within two weeks of seedling emergence. A broad band of white or very light-yellow tissue, with reddish veins appears on each side of the midrib, beginning at the base of the second or third leaf from the top of the plant. The symptoms later extends in stripes towards the tip parallel to the midrib. The mild deficiency disappears by the mid-season, but the silking and taselling are delayed.

In zinc deficient soils, broadcast 10 kg of zinc sulphate heptahydrate (21%) or 6.5 kg zinc sulphate monohydrate (33%) per acre at sowing mixed with an equal quantity of dry soil. On the appearance of deficiency symptoms, apply above mentioned quantity of zinc sulphate along with equal quantity of soil along rows, hoe it into the soil and then irrigate the field. When symptoms are observed late in the season and interculture is not possible, spray zinc sulphate-lime mixture prepared by mixing 1200 g of zinc sulphate heptahydrate (21%) and 600 g of unslaked lime or 750 g zinc sulphate monohydrate (33%) and 375 g of unslaked lime in 200 litres of water to cover one acre.

Weed Control: Two hand hoeings preferably with improved wheel hand hoe at monthly intervals help to keep the weeds under check. Alternatively, spray 800 g per

acre Atrataf 50 WP (atrazine) on medium to heavy textured soils and 500 g per acre in light soils in 200 litres of water or spray 250 g per acre Atrataf 50 WP (atrazine) as 20 cm wide band over the crop rows upto 10 days after sowing followed by hoeing/ interculture at 15 to 30 days after sowing. This herbicide is effective on broadleaf weeds particularly *itsit* and grasses.

Earthing up: The ridge-sown crop should be earthed up after the application of the second dose of fertilizer at knee height stage.

Irrigation: Uniformly spread 30 quintals per acre of paddy straw mulch at sowing for saving of precious irrigation water. Depending upon rains, apply first irrgation at 25-30 days after sowing. The subsequent irrigations should be applied at 2 weeks interval upto10th April and thereafter at one week interval upto maturity. Take special care to apply irrigation to evade high temperature stress during grain filling period.

Surface Drip Irrigation and Fertigation: Application of fertilizers with irrigation water is known as fertigation. Fertigation saves 20% of fertilizers. For using this system broad beds are prepared at 1.20 m apart from centre to centre of furrow. These beds are 80 cm wide on the top and the furrows between the two beds are 40 cm wide. The beds are covered with U.V stabilized plastic film (Black) of 25 micron thickness (23 grams per m^2). Two rows are planted at a spacing of 60 cm keeping plant to plant distance of 20 cm by dibbling. One lateral pipe is used to irrigate two rows of maize. The drippers are spaced 30 cm apart and are operated at a discharge of 2.2 litres per hour as per following table:

Month	Timing of irrigation (Minutes)*
February	22
March	64
April	120
May	130

* If discharge rate is different, time of irrigation may be adjusted proportionally by the formula:

Adjusted time (min) = (2.2 × Time of irrigation (min)*) ÷ Discharge of dripper (litre/hour)

For the medium fertility soils application of 80 kg of urea, 32 kg of mono ammonium phosphate (MAP) and 16 kg of muriate of potash (white) per acre is reccomended. Start fertigation 12 days after sowing of maize and apply 25% of the fertilizers in four equal splits during first month on weekly basis. Rest of the fertilizer should be applied in equal splits on weekly basis upto first week of May.

For sub-surface drip irrigation in spring maize, see chapter on 'Multiple Cropping' under *Kharif* maize-peas-spring maize cropping system.

Harvesting and Threshing: 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'.

Maize Drying: A portable maize dryer 3 ton capacity has been developed as per international norms and recommended to dry maize grains from a moisture level 25 to 15% in 8-10 hours. This cross-flow dryer has three pass, indirect type diesel fired heating system. A control panel to regulate and display the temperature of heated air, exit air and speed of air blower with variable frequency drive is provided for better operation. The dryer can maintain air temperature 60-75°C with the grain temperature of 45°C for seed and 60°C for commercial purpose. The dryer is capable of drying maize grain @ 1.0 – 1.5 % per hour consuming about 4 liters/hr of diesel initially for 1 hr. A provision of heat recovery from flue gases ensures higher fuel efficiency with reduced diesel consumption to about 2 litres/hr later on. The dryer can be operated both with tractor PTO or electricity. One each of skilled and unskilled labor is required to operate this dryer.

Seed Production of Hybrids: The seed of hybrids should be produced during *kharif* season only.

Plant Protection Measures

(a) Insect Pests

1. **Maize shoot fly**: Maize shoot fly is the most serious insect pest of spring maize. It attacks very young (3-7 days old) seedlings, producing deformed, twisted and dead hearted plants. For its control, prefer seed treatment with Gaucho. If seed treatment is not done, then apply 5 kg Furadan 3 G (carbofuran) per acre in the furrows at the time of sowing.
2. **Jassid, thrips, pyrilla, grey weevil and leaf-feeding insects**: These pests sometimes attack spring maize crop during March to May. Due to attack of sucking pests leaves turns pale.
3. **Armyworm and silk cutter**: 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. Silk cutter larvae feed on silks and later on may damage the few grains in the developing cob. The low incidence of this insect is noticed on timely sown spring maize crop. If attack occurs, collect and destroy the larvae.
4. **Fall armyworm** (*Spodoptera frugiperda*): The young larvae feed by scrapping the leaf surface making papery windows. The bigger larvae feed voraciously on the central whorl leaves causing round to oblong holes and produce a large amount of faecal matter. The larva can be identified by predominant white-coloured inverted Y-shaped mark on the head and presence of four spots arranged in square pattern at the tail end.

Adopt the following control measures:

- Sow the crop at recommended time only.
- Avoid staggered sowing of maize in adjacent fields to minimize spread of this pest.
- Spray the crop with Coragen 18.5 SC (chlorantraniliprole*) @ 0.4 mL/ litre or Delegate 11.7 SC (spinetoram*) @ 0.5 mL/ litre or Missile 5 SG (emamectin benzoate) @ 0.4g/ litre using 120 litres of water per acre, for crop up to 20 days old. Thereafter, the amount of water used per acre needs to be increased up to 200 litres with corresponding increase in dosage of above insecticides. For effective control, direct the nozzle towards the whorl.
- If the infestation is in patches or the crop is more than 40 days old and spraying is difficult, apply soil-insecticide/biopesticide mixture (about half gram) in the whorls of the infested plants to manage fall armyworm. To prepare soil–insecticide mixture, add 5 mL of Coragen 18.5 SC (chlorantraniliprole*) or Delegate 11.7 SC (spinetoram*) or 5 g of Missile 5 SG (emamectin benzoate) or 25 g of Delfin WG (*Bacillus thuringiensis* subsp. *kurstaki**) or 25 mL of Dipel 8 L(*Bacillus thuringiensis* subsp. *kurstaki**) in 10 mL of water and mix well in one kg of soil.
- **Precaution**: Use gloves for preparation and application of the mixture.

(b) Diseases

1. **Seed rot and seedling blight** (*Fusarium, Penicillium, Aspergillus* spp.): Poor germination, unthrifty seedlings and seedling mortality are the symptoms. Use disease free seed.
2. **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. Dry conditions at tasseling stage favour disease development. Water stress at the time of flowering favours the disease. Grow recommended varieties.

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

(c) Birds/Rodents

See Chapter - Management of Rodents and Birds.

MINOR MILLETS

Minor (or small) millets are a group of small-seeded cereal crops that are well suited to marginal growing conditions, require fewer inputs and are recognized for their high nutritional value, making them important for sustainable agriculture. The prominent small millets include finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*), proso millet (*Panicum miliaceum*), barnyard millet (*Echinochloa crusgalli*), kodo millet (*Paspalum scrobiculatum*) and little millet (*Panicum sumatrense*).

Climatic and Soil Requirements: Minor millets requires hot climate and can be grown successfully on well-drained sandy loam to loam soils. Avoid waterlogged and salt affected fields, as they cannot tolerate water logging.

PROSO MILLET

Proso millet (*cheena* in Punjabi) is a summer season crop being introduced for cultivation in Punjab. It is a short-duration and low water requiring crop. It possesses good nutritional quality, being high in protein, dietary fibre, minerals and antioxidants.

Improved Varieties

Punjab Cheena 1 (2024): It is a short statured (85 cm) and short duration (66 days) variety, yielding on an average of 3.2 quintal grains per acre. Seeds are shiny, light brown in color and possess good quantities of protein (12.28 mg/100 g), resistant starch (20.91 g/100 g), Calcium (40.95 mg/100 g) and Iron (4.02 mg/100 g) content. It has low predicted glycemic index (54.39), low glycemic load (32.51) and its value added products have very good organoleptic acceptability score.

Agronomic Practices

Land Preparation: Prepare the land after a pre-sowing irrigation (*rauni*) to ensure optimum soil moisture (*wattar*). Carry out 2-3 ploughings followed by planking to obtain a fine tilth.

Time of Sowing: Best sowing time for attaining higher grain yields is between 10 March to 30 March under Punjab conditions. Delayed sowing beyond March significantly reduces grain yield.

Seed Rate and Method of Sowing: Use 3.0 to 4.0 kg seed per acre. Sow the crop by *kera* or *pora* method at a row-to-row spacing of 22.5 cm and depth of 2-3 cm.

Fertilizer Application: Apply 24 kg nitrogen (52 kg urea) per acre in two equal splits, with half as a basal dose before sowing and the remaining half at 20 days after sowing or after first irrigation.

Weed Control: Inter-row cultivation with a wheel hoe can be practiced to manage weeds and improve soil aeration.

Irrigation: Proso millet is a drought-tolerant crop but yields better if irrigated timely. Irrigate the crop depending on prevailing weather conditions.

Harvesting: The crop should be harvested when the grains become hard and plants turn yellowish. Harvesting can be done by using sickles and the harvested crop should be stacked for 7-10 days before threshing. Threshing can be done manually.

FOXTAIL MILLET

Foxtail millet (*Kangni* in Punjabi) is also a short-duration summer season crop being recommended for cultivation in Punjab. It requires less water and possesses good nutritional quality.

Improved Varieties

Punjab Kangni 1 (2025): It is a short duration variety that matures in 76 days. It attains an average height of 100.5 cm and its average grain yield is 5.1 quintals per

acre. The grains have good nutritional properties in terms of protein (13.59 mg/l00 g), resistant starch (24.39 g/100 g), Calcium (54.85 mg/100 g) and Iron (4.53 mg/100 g) content. It also has low predicted glycaemic index (52.57) and low glycaemic load (31.68) and its value added products have very good organoleptic acceptability score.

Agronomic Practices

Land Preparation: Prepare the land after a pre-sowing irrigation (*rauni*) to ensure optimum soil moisture (*wattar*). Carry out 2-3 ploughings followed by planking to obtain a fine tilth.

Time of Sowing: Sow the crop from 25 March to 20 April for obtaining the higher grain yields under Punjab conditions. Delayed sowing beyond April significantly reduces grain yield.

Seed Rate and Method of Sowing: Use 4.0 to 5.0 kg seed per acre. Sow the crop by *kera* or *pora* method at a row-to-row spacing of 30.0 cm and depth of 2-3 cm.

Weed Control: Inter-row cultivation with a wheel hoe can be practiced to manage weeds and improve soil aeration.

Irrigation: Foxtail millet requires 5-6 irrigations for ensuring better yields. The first and second irrigation should be applied at 15 days interval after sowing and thereafter the crop requires 3 more irrigations at 10 days interval. Irrigations should be applied according to the prevailing weather conditions.

Harvesting: The crop should be harvested once the grains become hard and the plants turn yellowish. Harvesting can be done by using sickles and the harvested crop should be stacked for 7-10 days before threshing. Threshing can be done manually.

2. PULSE CROPS

GRAM

Gram is an important *rabi* pulse crop of Punjab. In 2023-24, it was grown on 1.4 thousand hectares with production of 2.2 thousand tonnes. The average yield was 15.61 quintals per hectare (6.32 quintals per 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.

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

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

Improved Varieties

Desi gram (Irrigated)

PBG 10 (2023): The plants are tall with semi-erect growth habit. It has bold seeds with brownish colour and 100-seed weight is 25.9 g. This variety is moderately resistant to Ascochyta Blight and Botrytis grey mould. It matures in about 153 days. Its average yield is 8.6 quintals per acre.

PBG 8 (2020): The plants are tall with semi-erect growth habit. It has medium bold seeds with brownish colour and 100-seed weight is 16.5 g. This variety is moderately resistant to Botrytis grey mould. It matures in about 158 days. Its average yield is 8.4 quintals per acre.

PBG 7 (2014): The plants are tall, semi-erect. It has medium bold seeds with brownish colour and 100-seed weight of 16 g. This variety is moderately resistant to Ascochyta blight (*Chaanani*) and fairly resistant to wilt and dry root rot. It matures in about 159 days. Its average yield is 8 quintals per acre.

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 (*Chaanani*) 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.

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 Ascochyta blight. Its average yield is 7.8 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 seeds weight). The seeds are creamy white in appearance with good culinary properties. Its average yield is 7.3 quintals per acre.

Varieties Recommended for Various Areas/Conditions

Varieties	Areas/Conditions for which recommended
PBG 10, PBG 7	Irrigated conditions throughout Punjab state.
PBG 5	Irrigated conditions in humid areas comprising the districts of Gurdaspur, Hoshiarpur, Ropar, Shaheed Bhagat Singh Nagar, Tarn Taran and Amritsar.
PBG 8, GPF 2 and L 552	Irrigated conditions in the entire state except humid areas.
PDG 4	Rainfed conditions in the entire state except humid areas.

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. It also helps the plants to develop deep roots.

Time of Sowing: The optimum sowing time for *desi* gram under rainfed conditions is from 10 October to 25 October. Under irrigated conditions both *desi* and *kabuli* gram should be sown from 25 October to 10 November. The early-sown crop suffers from wilt owing to high temperature at that time. It also attains 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.

- **PBG 10 is moderately resistant to Ascochyta Blight and Botrytis grey mould.**
- **PBG 8 is moderately resistant to Botrytis grey mould and PBG 7 to Ascochyta blight (*Chanani*).**
- **Follow raised bed sowing after rice, particularly on heavy soil.**
- **Inoculate the seed with recommended biofertilizer before sowing.**
- **For obtaining higher yield, spray 2% urea at 90 and 110 days of sowing.**
- **Sow the crop during October 25 to November 10 and follow crop rotation with cereals to prevent stem rot/ foot rot/ other soil borne diseases.**

Seed Rate: The optimum seed rate is 30 kg per acre for variety PBG 10, 24 kg per acre for PBG 5 and 15-18 kg per acre for other varieties of *desi* gram. For *kabuli* gram use 37 kg seed per acre. Seed rate of *desi* gram should be increased to 27 kg per acre for all varieties except PBG 10 and PBG 5 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 Inoculation: Moisten the seed recommended for one acre with minimum amount of water. Mix thoroughly one packet each of *Mesorhizobium* (LGR-33) and Rhizobacterium (RB-1) biofertilizers with it and dry the inoculated seed in shade. Sow the seed within one hour after inoculation. These bio-fertilizers are available with the Punjab Agricultural University, Ludhiana Seed Shop at Gate No. 1 and *Krishi Vigyan Kendra*/Farm Advisory Service Centres in different districts.

Method of Sowing: 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. Conventional seed-cum-fertilizer drill with broader flutes can be used for sowing gram (see Appendix III).

For reducing the incidence of gram caterpillar (*Helicoverpa armigera*), sow two rows of linseed (30 cm apart) as intercrop after every 20 rows of gram.

Raised Bed Sowing: Sowing of gram on medium to heavy textured soils particularly after rice should be done on beds spaced 67.5 cm apart (37.5 cm bed top and 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 sowing of gram. Raised bed sowing saves the crop from adverse effect of irrigation on heavy textured soils.

Fertilizer Application

Recommended areas/situation	Nutrients* (kg/acre)		Fertilizers (kg/acre)		Time and method of application
	N	P_2O_5	Urea	Single super-phosphate	
***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).

For obtaining higher yield, in addition to the recommended dose of fertilizers, spray 2% urea (3 kg in 150 litres of water per acre) at 90 and 110 days of sowing.

Enriching zinc content in gram grain: The zinc content in grain (for nutritional quality improvement) can be increased by tank mix foliar spray of 0.5% zinc sulphate heptahydrate (21% Zn) (750 g per acre) + 2% urea (3 kg per acre) using 150 litres of water at 90 and 110 days of sowing. This spray results in higher yield also.

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.

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.

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 generally be 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.

2. Gram caterpillar (*Helicoverpa armigera*): The larvae damage the gram crop by feeding on leaves, flower buds, flower pods and grains in the pods.

Bio-intensive IPM (BIPM) module for the management of gram caterpillar:

- Grow PAU recommended tolerant varieties of chickpea.
- Sow two rows of linseed (30 cm apart) as intercrop after every 20 rows of gram.
- Install Pheromone traps @ 2 traps per acre for monitoring the moth activity.
- Spray of homemade neem extract @ 1750 mL/acre in 80-100 litres of water at flowering stage.
- Spray the crop with following biopesticides at ETL level of 16 or more larvae, observed from a minimum of 10 randomly selected spots (100 plants) on per meter row length basis.

  800 g *Bacillus thuringiensis* var. *kurstaki** 0.5 WP (DOR Bt-1) or 200 mL Helicop 2% AS (HaNPV)* in 80-100 litres of water per acre and repeat after 10 days, if necessary

i. Cultural Control: Sow two rows of linseed (30 cm apart) as intercrop after every 20 rows of gram for reducing the incidence of gram caterpillar.

ii. Chemical Control: Monitor the gram crop at pod initiation stage to record larval population of gram caterpillar on per meter row length basis. Record the observations by gently shaking the plants from a minimum of 10 randomly selected spots per acre. If a total of 16 or more larvae are observed from 10 spots (100 plants), spray 800 g *Bacillus thuringiensis* var. *kurstaki**

- **To manage gram caterpillar, adopt the Bio-intensive IPM (BIPM) module.**
- **Observe a waiting period of 3 days after spray of Coragen 18.5 SC before consuming leaves and green grains.**

0.5 WP (DOR Bt-1) or 200 mL Helicop 2% AS (HaNPV)* or 50 mL Coragen 18.5 SC (chlorantraniliprole*) or 80 g Proclaim 5 SG (emamectin benzoate) or 160 mL Rimon (novaluron*) in 80-100 litres of water per acre and repeat after two weeks, if necessary. **Prefer to use biopesticides as first spray for younger larvae** and repeat the spray after a week if necessary.

Precaution: Before consuming leaves and green grains, ensure a waiting period of 3 days after the spray of Coragen 18.5 SC (chlorantraniliprole*).

3. Stored Grain Insect Pests: (See Appendix V)

(b) Diseases

1. Ascochyta blight/*Chanani* (*Ascochyta rabiei*): Dark-brown spots studded with black dot-like bodies are produced on the stem, branches, leaflets and pods. The lesions are elongated on stems, branches and twigs whereas; lesions are round to oval on pods and leaves. Black dot-like bodies concentrically arranged in the spots is the main symptom of disease. Shoot terminals are more liable to attack. Even the seeds in the pods are infected. In the event of excessive rains, whole crop may be blighted and killed rapidly. A temperature of 20°C, relative humidity above 85% and cloudy weather with intermittent rains is highly conducive for development of disease. Grow comparatively resistant varieties PBG 10, PBG 7 and PBG 5. After harvest, the diseased plants should not be allowed to stand in the field and should be destroyed. 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 high humid conditions, white mycelial strands and 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. The most suitable weather conditions for development of disease are temperature around 25°C, high relative humidity and rain during flowering. To manage this disease, sow disease free seed and grow variety PBG 10 and PBG 8. Destroy infected plant debris after harvest.

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 later become straw coloured. The most characteristic symptom of this disease is vascular dis-colouration of roots which is dark brown to black. Sometimes, only one sided branches are affected resulting in partial wilting. The soil temperature of 24-27°C favours disease development. Grow fairly wilt tolerant *desi* varieties PBG 10, PBG 8, PBG 7, GPF 2, PDG 4, PBG 5 and *kabuli* variety L 552. Conserve soil moisture in rainfed areas. Plough the field with a furrow-turning plough to eradicate weeds and promote water infilteration. Early sowing of the crop should be avoided.

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 embedded with black sclerotia. The whitish, fluffy fungal growth can also be seen on the debris at soil surface. The disease is predominant in cool and moist conditions. The seed should be free from sclerotia.

Sow the gram crop from 25 October to 10 November 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 occupied an area of 0.4 thousand hectares with production of 0.2 thousand tonnes during the year 2023-24. The average yield was 4.78 quintals per hectare (1.93 quintals per acre).

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

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

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

Improved Varieties

LL 1373 (2020): Its plants are short, erect with profuse branching and bear more number of pods. It has light green leaves, pink flowers, non-pigmented light green pods and rudimentary tendrils. It matures in 140 days and it is resistant to rust. Its seeds are bold and 100-seed weight is 3.5 g. It has good culinary properties. Its average yield is 5.1 quintals per acre.

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 and is fairly resistant to rust. 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.

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.

Seed Rate: The optimum seed rate is 18 kg per acre for LL 1373 and 12-15 kg per acre for LL 931.

- **LL 1373 is resistant to rust.**
- **Sow crop in second fortnight of October in sub-montane areas and from end of October to first week of November in other areas.**
- **The optimum seed rate is 18 kg per acre for LL 1373 and 12-15 kg per acre for LL 931.**
- **Inoculate the seed with recommended biofertilizer before sowing.**

Seed Inoculation: Moisten the seed recommended for one acre with minimum amount of water. Mix thoroughly one packet each of *Rhizobium* (LLR-12) and Rhizobacterium (RB-2) with it. Allow it to dry in shade. Sow the seed within one hour after inoculation. Application of consortium culture enhances the grain yield. *Rhizobium* and Rhizobacterium can be applied simultaneously with fungicide. These bio-fertilizers are available with the Punjab Agricultural University, Ludhiana Seed Shop at Gate No. 1 and *Krishi Vigyan Kendra*/Farm Advisory Service Centres in different districts.

Method of Sowing: The crop should be sown in rows 22.5 cm apart by seed cum fertilizer drill or *pora* method. Under late-sown conditions, the row-spacing should be reduced to 20 cm. 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.

Raised Bed Sowing: Lentil can be successfully grown on raised beds. Sowing of lentil on medium to heavy textured soils should be done on beds spaced 67.5 cm apart (37.5 cm bed top and 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 bed sown lentil. Raised bed sowing saves the crop from adverse effect of irrigation/heavy rainfall on heavy textured soils.

Fertilizer Application: Inoculate the seed with *Rhizobium* and apply 5 kg N (11 kg of urea) per acre and drill 8 kg P_2O_5 (50 kg superphosphate) per acre. Apply 16 kg P_2O_5 (100 kg superphosphate) per acre when seeds are not inoculated. Apply both the fertilizers at the time of sowing.

Weed Control: One or two weedings preferably with improved wheel hand hoe 30 and 60 days after sowing are enough.

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 conditions.

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.

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 arranged 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. The cool and humid conditions favour disease development and spread. Use disease free

seed. Destroy the diseased plant debris after harvest to reduce the inoculum of the fungus.

2. Rust (*Uromyces viciae 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. Cloudy weather with intermittent rains and temperature around 20-22°C favours the disease development. Use clean seed free from diseased plant debris. Grow resistant variety LL 1373.

FIELD PEA

Field pea can successfully be grown in the Punjab state.

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: Maize-Field pea, Maize/Rice/Fodder/other *Kharif* crop-Field pea-Summer *Moong*/Summer *Mash*/Summer Fodders, Summer Vegetables/Sugarcane/Cotton-Field pea.

Improved Varieties

IPFD 12-2 (2023): It is a medium duration variety. It matures in about 124 days. It has long pods with medium size grains. The weight of 100 grains is 15.6g. It is very attractive tendril type variety with plant height of 80 cm. It has very good nutritional and cooking quality. Its grains contain 24.5 per cent protein. It gives an average grain yield of 6.8 quintals per acre.

Agronomic Practices

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

Seed Rate: Use 20-25 kg seed per acre.

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: The crop should be sown in rows at a row spacing of 30 cm by pora or kera or by using seed-cum fertilizer drill.

Seed Inoculation: The inoculation of field pea seed with *Rhizobium* culture ensures proper nodulation and increases grain yield. Moisten the seed recommended for one acre with minimum amount of water. Mix throughly one packet of *Rhizobium* culture with it and let it dry in shade. Sow the seed immediately. The *Rhizobium* culture can be obtained from Department of Microbiology, Punjab Agricultural University.

Fertilizer Application: Apply 12 kg nitrogen (26 kg Urea) and 16 kg P_2O_5 (100 kg single 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.

Irrigation: The crop should be sown after pre-sowing irrigation (*rauni*). 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 sub-montane areas.

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

Plant Protection

(a) Insect Pests

1. **Pea stem fly**: 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**: It causes severe damage to the young crop by sucking cell sap.
3. **Pea leaf miner**: The larvae feed by making tunnels in the leaves and cause serious damage during December-March. Affected leaves develop white zig-zag galleries.
4. **Pea aphid**: It sucks cell sap resulting in yellowing and drying of leaves.
5. **Pod borers**: The larvae damage the crop by feeding on flowers and pods.
6. **Stored Grain Insect Pests:** (See Appendix V)

(b) Diseases

1. **Powdery mildew**: White floury patches, covering large areas appear on stems, branches, leaves and pods.
2. **Wilt**: Rotting of roots and yellowing of the lower most leaves is followed by wilting. Avoid sowing earlier than the recommended date in badly infested areas.
3. **Rust**: Yellowish, reddish-brown spherical raised pustules appear on leaves, stems, branches and pods from December onwards. 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. 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 for raising this crop.

Rotations: Sugarcane/Potato/Cotton/Raya-Summer *Moong*, Summer *Moong*-Maize/Rice-*Raya*/Wheat, Summer *Moong*-Maize-Potato, Summer *Moong*-Rice-Potato, Summer *Moong-Kharif Moong-Raya*/Wheat, Summer *Moong*-Rice/Maize-*Gobhi Sarson,* Summer *Moong*-Soybean-Peas, Fodder-Wheat, Summer *moong*-DSR/DSBR-Wheat.

Improved Varieties

SML 1827 (2019): It has erect plant type with medium stature. It bears pods in clusters and has synchronous maturity (about 62 days). Each pod contains about 10 seeds. It is resistant to yellow mosaic disease. Grains are shining green and medium sized with good culinary properties. Its average yield is 5.0 quintals per acre.

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

SML 668 (2002): It has erect plant type with short stature. It bears pods in clusters and possesses early and synchronous maturity (about 60 days). Pods are long with thick coat and each pod contains 10-11 seeds. Grains are bold with good cooking quality. Its average yield is 4.5 quintals per 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 PAU Happy Seeder/Smart Seeder/Super seeder in the presence of wheat straw under optimum moisture. Under dry condition, it can be directly sown with Happy seeder/Smart seeder followed by immediate irrigation.

Seed Rate: Use 15 kg seed for SML 668 and 12 kg seed per acre for other varieties.

Seed Inoculation: Inoculate the seed with single packet of consortium biofertilizer (*Rhizobium* sp. LSMR-1 and Rhizobacterium RB-3) at the time of sowing. Moisten the seed using one packet per acre with about 300 mL of water. Mix the seed thoroughly with culture and let it dry in the shade. Sow the seed within one hour of

- **Use 15 kg seed for SML 668 and 12 kg seed per acre for other varieties.**
- **Sow the crop from 20 March to 10 April.**
- **Inoculate the seed with recommended consortium biofertilizer before sowing.**
- **In the presence of wheat straw, sow the crop using PAU happy seeder.**
- **Prefer sowing summer *moong* on raised beds in case of medium to heavy textured soils.**
- **Fertilizer is not needed in summer *moong* sown after potato.**
- **For synchronus maturity, stop last irrigation at about 55 days after sowing.**

application of biofertilizer. Inoculation of seed with consortium biofertilizer enhances grain yield. This bio-fertilizer is available with the Punjab Agricultural University Seed Shop, Gate No. 1 Ludhiana and *Krishi Vigyan Kendra*/Farm Advisory Service Centres in different districts.

Time and Method of Sowing: Sow the crop from 20 March to 10 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 17.5 to 22.5 cm apart. The seed should be placed 4 to 6 cm deep with seed drill/*kera*/*pora*/zero-till drill/happy seeder.

Raised Bed Sowing: 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.

Fertilizer Application: Drill 5 kg of N (11 kg urea) along with 16 kg P_2O_5 (100 kg of single superphosphate) per acre at the time of sowing to summer *moong* to be sown after wheat.

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

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. Alternatively, spray 300 mL per acre imazethapyr 10 SL at 20-25 days of sowing for controlling grassy, broadleaf weeds and sedges. Dissolve the recommended quantity of herbicide in 150 litres of water per acre and spray uniformly.

Irrigation: Apply 3 to 5 irrigations to the crop depending upon the weather conditions and water holding capacity of the soil. Apply first irrigation 25 days after sowing. The last irrigation should be stopped about 55 days after sowing for obtaining high yields and synchronous maturity. For sub surface drip irrigation in summer moong, see chapter on Multiple Cropping.

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.

Plant-Protection Measures

(a) Insect Pests

1. Thrips: Summer *moong* crop is severely attacked by the thrips which is very small, dark brown insect, found in flowers and cause flower-drop, deformation of pods, deterioration of grain quality and ultimately high reduction in yield. Sometimes, there may be complete failure of the crop. For its management, install blue sticky traps @ 30 per acre at flower initiation stage to manage the pest. Replace the traps after 10 days, if necessary or spray the crop at flower initiation stage using homemade neem extract @ 1750 mL per acre using 80-100 litres of water per acre with manually operated knapsack sprayer.

To prepare neem extract, boil 5.0 kg mixture of neem leaves and fruits in 10 litres of water for 30 minutes. Then, filter this material through muslin cloth and use the filterate for spraying at the recommended dose.

2. Pod borer (*Helicoverpa armigera*): 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.

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

- **Cultural Control:** Ensure timely sowing of the crop. 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.

(b) Diseases

1. Yellow mosaic disease: 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. Incidence of this disease is very less in timely sown crop. The disease can be controlled by the following measures:

- Rogue out the affected plants early in the season.
- To manage this disease, grow yellow mosaic virus tolerant varieties SML 1827, Mash 1137 and Mash 1008.

2. 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 shred easily. Pycnidia can be seen on the affected portion.

3. Rhizoctonia blight: It is caused by *Rhizoctonia solani*. It starts from leaf laminae or petioles or the young branches. Eventually, the top of plants become blighted and patches of such plants are 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

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 1137 (2019): This variety is recommended for sub-montaneous zone of Punjab state. It has erect and compact plant type with short stature (30 cm). It matures in about 74 days. Pod bearing is profuse and each pod contains 6-7 seeds. It is resistant to yellow mosaic disease. Average grain yield is about 4.5 quintals per acre. Grains are medium bold, blackish in colour and possess good culinary properties.

- **Sow *mash* from 15 March to first week of April.**
- **Use 20 kg seed per acre.**
- **Inoculate the seed with recommended *Rhizobium* before sowing.**

Mash 1008 (2004): It has erect and compact 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 4.2 quintals per acre. Grains are medium bold, blackish in colour, contain about 24 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.

Seed Inoculation: Inoculate the seed with the recommended *Rhizobium* culture (LUR 6) before sowing. Wet the seed recommended for one acre with minimum amount of water. Mix thoroughly one packet of *Rhizobium* culture with seed on a clean pucca floor and let it dry in shade. Sow the seed immediately. Inoculation of seed with *Rhizobium* biofertilizer enhances grain yield. The biofertilizer is available with the Punjab Agricultural University Seed Shop at Gate No. 1 Ludhiana and *Krishi Vigyan Kendra*/Farm Advisory Service Centre in different districts.

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*.

Fertilizer Application: Drill 5 kg N (11 kg of urea) along with 10 kg of P_2O_5 (60 kg of single superphosphate) per acre at sowing.

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. Alternatively, spray 300 mL per acre imazethapyr 10 SL at 15-20 days after sowing for controlling grassy, broadleaf weeds and sedges. Dissolve the recommended quantity of herbicide in 150 litres of water per acre and spray uniformly.

Irrigation: The crop requires 3 to 4 irrigations. The last irrigation should be applied at about 60 days after sowing for obtaining high yields and synchronous maturity.

Harvesting: The crop should be harvested when 80% pods mature. The crop should not be uprooted.

Plant Protection Measures: See under summer *moong*.

3. OILSEED CROPS

RAPESEED AND MUSTARD

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 43.1 thousand hectares with a production of 69.4 thousand tonnes during 2023-24 in the State. The average yield was 16.11 quintals per hectare (6.52 quintals 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 to high rainfall areas.

Soil Type: The rapeseed and mustard grow best on well-drained, light-to-medium textured soils. *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

Toria: Summer *Moong*-*Toria*-Wheat; *kharif* Fodder-*Toria*-Wheat; *kharif* Fodder-*Toria*-Sunflower/Potato (spring); *kharif* Fodder-*Toria*-Sugarcane-Sugarcane ratoon; Rice/Maize-*Toria*-Sunflower.

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

Gobhi Sarson: Rice/Maize-*Gobhi sarson*-summer *Moong*; *kharif* Fodder/Groundnut-*Toria*+*Gobhi sarson*-summer *Moong*; Cotton-*Gobhi sarson* (transplanted).

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

Improved Varieties/ Hybrids

Canola is an internationally accepted nomenclature for Brassica varieties or hybrids having less than 2% erucic acid in the oil and less than 30 micro moles glucosinolates per gram defatted meal. Such varieties/hybrids are also known as double low ('00'). Oil rich in erucic acid is not desirable for edible purposes as it causes thickening of arteries and leads to heart problems. Similarly, the defatted meal of non canola varieties when used as animal feed reduces appetite, reproductivity and affects thyroid activity leading to thyroid associated health problems. Elimination of long chain erucic acid from the oil of canola varieties is accompanied by increase in the proportion of desirable MUFA (oleic acid) from 18-20% to about 60-67%. The oil from canola varieties is healthy oil for human consumption. The defatted meal from such varieties is specially suited as animal feed. Among different varieties/hybrids of rapeseed-mustard recommended by the PAU, RLC 3 variety of raya, RCH 1 hybrid of *raya*, GSC 6 and GSC 7 varieties of *gobhi sarson* and PGSH 1707 hybrid of *gobhi sarson* are of canola type.

Toria

TL 17 (2011): This variety is suitable for multiple cropping systems due to its early maturity. It matures in 90 days. It has profuse branching and siliqua bearing capacity. Its average yield is 5.2 quintals per acre. Its seeds contain 42.0 per cent oil.

TL 15 (1978): This variety takes about 88 days to mature. Because of its early maturity, it fits well in multiple cropping systems. It yields 4.5 quintals per acre. Its oil content is 41.0 per cent.

Raya

PHR 127 (2024): It is a medium-tall hybrid with profuse branching and high siliquae bearing. It is recommended for general cultivation in Punjab under timely sown and irrigated conditions. Its average seed yield is 9.5 quintals per acre, with 39.3 per cent oil content. It matures in 140 days.

RCH 1 (2019): It is the first canola quality ('00') hybrid of raya in the country. It is recommended for general cultivation in south-western region (Bathinda, Faridkot, Ferozepur, Muktsar and Mansa) of Punjab under timely sown irrigated conditions. This hybrid is tall with perfuse siliquae bearing. Its average seed yield is 9.2 quintals per acre with 39.4 per cent oil content. It matures in 152 days.

PHR 126 (2019): It is medium tall hybrid with perfuse branching and siliquae bearing. It is recommended for general cultivation in south-western region (Bathinda, Faridkot, Ferozepur, Muktsar and Mansa) of Punjab under timely sown irrigated conditions. Its average seed yield is 9.1 quintals per acre with 40.2 per cent oil content. It matures in 145 days.

Giriraj (2017): This variety is recommended for general cultivation in the state under timely sown irrigated conditions. This is a bold seeded variety and has tolerance to terminal heat stress. It is moderately resistant to white rust. Its average yield is 7.7 quintals per acre and it matures in 144 days. It contains 40.3 per cent oil.

RLC 3 (2015): This is the first canola quality ('00') variety of raya in the country. It is a yellow seeded, medium tall variety which is recommended for general cultivation in the state under timely sown irrigated conditions. It is resistant to white rust. Its average seed yield is 7.3 quintals per acre with 41.5 per cent oil content. It matures in 145 days.

PBR 357 (2014): This variety is recommended for general cultivation in the state under timely sown irrigated conditions. It is a medium tall variety with more number of branches per plant. It is bold seeded variety, moderately tolerant to Alternaria blight and white rust diseases. Its average yield is 8.5 quintals per acre. It contains 39.0 per cent oil content. It matures in 145 days.

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

PBR 91 (1994): This variety is recommended for cultivation in south-western region (Bathinda, Faridkot, Ferozepur, Muktsar and Mansa) of Punjab under timely sown irrigated conditions. This variety has 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.

Its average yield is 8.1 quintals per acre. It matures in 145 days.

Gobhi Sarson

PGSH 2155 (2024): It is a canola quality ('00') *Gobhi sarson* hybrid. It is recommended for general cultivation in Punjab under timely sown irrigated conditions. It is free from white rust. It is a tall hybrid with profuse branching and siliquae bearing. Its average seed yield is 9.7 quintals per acre with 41.2 per cent oil content. It matures in 156 days.

PGSH 1707 (2020): It is the canola quality ('00') hybrid of *gobhi sarson*. It is recommended for general cultivation in Punjab under timely sown irrigated conditions. It is resistant to white rust. This hybrid is tall with profuse siliquae bearing. Its average seed yield is 8.8 quintals per acre with 41.0 per cent oil content. It matures in 162 days.

GSC 7 (2014): This canola quality ('00') variety is recommended for general cultivation in the state under timely sown irrigated conditions. It is a medium tall variety which is free from white rust and is tolerant to Alternaria blight. It has lusterous brownish-black seeds. Its average yield is 8.9 quintals per acre with 40.5 per cent oil content. It matures in 154 days.

- **Canola varieties contain less than 2% erucic acid in oil and less than 30 micro moles glucosinolates per gram in defatted meal.**
- **High erucic acid in oil increases the risk of heart diseases in humans. Similarly high glucosinolates in defatted meal reduces appetite, reproductivity and affects thyroid activity in animals.**
- ***Gobhi sarson* varieties GSC 6, GSC 7, hybrid PGSH 1707 and raya variety RLC 3, hybrid RCH 1 are canola type.**
- **Sow the crop at recommended time as late sown crop is more attacked by insect-pests and diseases.**
- **Adopt transplanting of *gobhi sarson* and African *sarson* instead of direct sowing under late conditions.**
- **African *sarson* variety PC 6 is a determinate type variety which can be harvested by combine.**

GSC 6 (2007): This canola quality ('00') variety is recommended for cultivation in the state for timely sowing under irrigated conditions. It has lustrous bold seeds. Its average yield is 6.1 quintals per acre with oil content of 39.1 per cent. It matures in 145 days.

African *sarson*

PC 6 (2016): This variety is the world's first determinate oilseed Brassica variety. It is recommended for general cultivation in the state under timely sown irrigated conditions. This medium tall variety is resistant to seed shattering and is suitable for combine harvesting. It is free from white rust and has better tolerance to Alternaria blight and mustard aphid. Its average yield is 7.7 quintals per acre with 40.1 per cent oil. It matures in 157 days.

Taramira

TMLC 2 (1990): This variety is recommended for cultivation in Bathinda, Sangrur, Ferozepur and Kandi areas of Hoshiarpur, Gurdaspur, Rupnagar and Shaheed Bhagat Singh Nagar districts. It has longer main shoot length, more number of siliquae on main shoot and more number of seeds per siliqua. It gives an average seed yield of 2.9 quintals per 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, two to four ploughings are required. Planking is done after every ploughing. In rainfed areas, one or two ploughings each followed by planking are sufficient. *Toria* in particular requires a fairly moist seedbed for good germination, but too moist seedbed impairs its germination.

Zero Tillage Sowing: Rapeseed and mustard crops can also be successfully cultivated without preparatory tillage with zero till drill after the rice harvesting. This reduces cost of cultivation and helps in timely sowing of crop after *basmati* and cotton.

Time of Sowing: The optimum time of sowing for rapeseed and mustard is given below:

Crop	Sowing time
Toria	Whole September
Gobhi Sarson	10-30 October
Raya and *African sarson*	Mid October to Mid November
Gobhi Sarson and African *Sarson* by transplanting	November to Mid December
Taramira	Whole October

* 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.

Seed Inoculation: Moisten the recommended quantity of seed for one acre of any rapeseed mustard crop using minimum amount (50-100 mL) of water and apply 250 g *Pseudomonas putida* MLE8 biofertilizer on pucca floor/polyethylene sheet. Dry the inoculated seed in shade and sow as early as possible. Seed inoculation with this biofertilizer increases seed and oil yield. This bio-fertilizer is available in Punjab Agricultural University, Ludhiana Seed Shop at Gate No. 1 and *Krishi Vigyan Kendra*/ Farm Advisory Service Centres in different districts.

Seed Rate and Method of Sowing: When sown as sole crop, 1.5 kg seed per acre is sufficient for rapeseed-mustard. In case the soil moisture is inadequate, the seed should be mixed with moist soil and kept overnight before sowing. Seed mixed with soil increases the bulk and thus ensures uniform distribution in the field. The depth of sowing should be 4-5 cm.

Toria, raya, African *sarson* and *taramira* are sown in 30 cm and *gobhi sarson* in 45 cm apart rows. For sowing of canola *gobhi sarson* GSC 6 during November, reduce row to row spacing to 30 cm.

These crops are sown with a drill or a *pora* attached to a plough. Manually operated single-row oilseed drill can be used for sowing 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 per acre can be achieved. This seed drill can be conveniently used for sowing of rapeseed-mustard crops in sugarcane. **Tractor drawn dual seed drill** for rapeseed-mustard and wheat can be used for sowing of different varieties of *toria*, *raya, gobhi sarson,* African *sarson*

and wheat in the well prepared field as per recommended seed rate. 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. Roller with smaller flutes is used for sowing rapeseed-mustard and wide flutes roller are used for sowing of wheat. The operational speed of tractor drawn dual seed drill should be 3-4 km per hour.

Thinning is done three weeks after sowing to maintain plant to plant distance as per requirement depending on the crop. Plant to plant distance of 10 to 15 cm should be maintained in case of *toria, raya* and African *sarson,* 10 cm in case of gobhi sarson and 15 cm for *taramira*.

***Gobhi Sarson* + Oats fodder intercropping:** For getting higher productivity and monetary returns as compared to sole crop of *gobhi sarson,* intercrop two rows of oats as fodder crop in *gobhi sarson* sown at 60 cm row spacing by keeping plant to plant spacing at 7.5 cm. For this purpose, use recommended quantity of seed of *gobhi sarson* and 16 kg seed of oats per acre. Apply 22 kg urea and 33 kg single super phosphate per acre in addition to the recommended dose of fertilizers for sole *gobhi sarson* crop. Harvest the first cut of oats as fodder at 50-55 days after sowing and take the second cut 30 days after the first cut.

Transplanting of *Gobhi Sarson* and African *Sarson:* A successful crop of *gobhi sarson* or 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.

- **Nursery Raising:** Sowing of nursery should be undertaken about 30 days for canola *gobhi sarson* and African *sarson* ahead of the transplanting period. About eight marlas (200 sq. metre) of nursery is sufficient for transplanting in 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 super phosphate with last ploughing and level it. Broadcast uniformly 400 g seed of *gobhi sarson* or 600 g seed of African *sarson* 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.
- **Method of transplanting:** After applying pre-sowing irrigation, prepare the field well. Draw furrows 45 cm apart for *gobhi sarson* and 30 cm apart for African *sarson*. 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 per acre (130 kg urea) to *gobhi sarson*.

Crops	Nutrients (kg/acre)			Fertilizers (kg/acre)		
	N	P_2O_5	K_2O	Urea	Superphos-phate	Muriate of Potash
Irrigated Conditions						
Toria	25	8	-	55	50	-
Raya, Gobhi sarson and African *sarson* (direct seeded as well as transplanted)	40	12	#	90	75	#
Rainfed Conditions						
Raya	15	8	-	33	50	-
Taramira	12	-	-	26	-	-

Apply 6 kg K_2O (10 kg muriate of potash) per acre to *raya, gobhi sarson* and African *sarson* in potassium deficient soils only.

- If nitrogen is to be applied in the form of urea, it should be applied just before pre-sowing irrigation (*rauni*).
- Prefer phosphorus from single superphosphate as it contains sulphur along with phosphorus If this fertilizer is not available, apply @ 80 kg gypsum or 13 kg bentonite-S per acre at sowing particularly in sulphur-deficient soils along with 26 kg DAP and 35 kg urea per acre to supply phosphorus and nitrogen to these soils.
- In *toria,* drill the fertilizers (both N and P_2O_5) just before sowing under irrigated conditions.
- In *raya, gobhi sarson* and African *sarson,* drill 1/2 N and full phosphorus and potassium before sowing/transplanting and the remaining 1/2 N with first irrigation. Under rainfed conditions, drill the fertilizers before sowing to *raya* and *taramira*.
- In soils testing low in zinc, apply 10 kg zinc sulphate heptahydrate (21%) per acre to *raya, gobhi sarson* and African *sarson*.

Weed Control: One hoeing to *toria* three weeks after sowing and one or two hoeings preferably with improved wheel hand hoe to *raya, gobhi sarson,* African *sarson* and *taramira* are adequate. First hoeing should be done 3-4 weeks after sowing and second, if required 3 weeks after first hoeing. Alternatively, apply 350 mL per acre pendimethalin 38.7 CS in conventional sown *toria*, *raya*, *gobhi sarson* and African *sarson* within two days of sowing using 200 litres of water.

- **Prefer super phosphate as it contains sulphur along with phosphorous.**
- **Intercrop *gobhi sarson* with oats fodder for higher returns.**
- **Avoid water stress at flowering initiation, pod formation and seed filling stages of the crop.**

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

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 fertilizers.

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

In *gobhi sarson*, second irrigation to timely sown crop 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 may lead to lodging.

Drip Irrigation and Fertigation: *Raya* and *gobhi sarson* should be drip irrigated at 7 days interval with one lateral placed between two rows of the crop. If laterals are placed 60 cm apart with dripper spacing of 30 cm and water discharge of 2.2 litre per hour, *raya* and *gobhi sarson* should be drip irrigated as per following schedule:

Month	**Time of irrigation (Minutes)***	
	Raya	*Gobhi Sarson*
November	60	70
December	55	60
January	40	50
February	45	50
March	-	60

The time of irrigation for drippers of different discharge may be adjusted proportionally by the formula:

Adjusted time (min) = (2.2 × Time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

Fertigation should be started at 15 days after sowing and all fertilizers should be applied in 10 equal splits at 7 days interval. Fertigate with 32 kg nitrogen, 10 kg phosphorus and 8 kg sulphur per acre through 70 kg urea, 16 kg mono-ammonium phosphate and 9 kg elemental sulphur, respectively.

For sub-surface drip irrigation in transplanted *gobhi sarson*, see chapter on Multiple Cropping under Cotton-*Gobhi sarson* (transplanted) cropping system

Harvesting and Threshing: Harvest the crop when siliquae turn yellow. *Raya* and *taramira* mature in March and *gobhi sarson* and African *sarson* in first fortnight of April. Owing to grain shattering in *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. Spike tooth type thresher recommended for wheat can also be used for threshing of rapeseed-mustard after proper modifications (see Appendix III). For combine harvesting of African *sarson* variety PC 6, harvest the crop at full maturity. Maintain cylinder speed of 800 rpm.

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 siliquae which subsequenty dry up. Application of first irrigation 3-4 weeks after sowing reduces the painted bug population significantly.

- **Start monitoring the fields for aphid incidence from first week of January.**
- **Spray in the afternoon when pollinators are less active.**

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 managed by spraying 250 mL Ekalux 25 EC (quinalphos) in 60-80 litres of water per acre.

3. Mustard aphid (*Lipaphis erysimi*): Cold and cloudy weather is very favourable for the development of mustard aphid. The green plant lice become innumerable, covering the inflorescence and siliquae (See Plate No. 4, Page No. 178). They suck the plant sap in huge quantities and as a result, the plants remain stunted, siliquae shrivel up and seeds do not develop. The following integrated pest management programme is recommended for its effective and economic control:

i. Sow the crop at recommended time preferably upto 3rd week of October.

ii. Apply recommended dose of fertilizers.

iii. Apply insecticides on the basis of need by following any of the economic threshold levels 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 per 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 infestation by aphids reach 40-50% (observe 100 plants per acre).

Spray any of the following insecticides using 80-125 litres of water per acre depending upon the stage of the crop, and repeat application whenever the above mentioned economic threshold values are noticed:

Actara 25 WG (thiamethoxam)	40 g
Metasystox 25 EC (oxydemeton methyl)	400 mL
Rogor 30 EC (dimethoate)	400 mL
Dursban/Coroban 20 EC (chlorpyriphos)	600 mL

4. 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 siliqua formation and shrivelling of grains.

For its control, sow the crop in second 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 third week of February when this aphid starts congregating on top flower buds.

5. Leaf miner (*Chromatomyia horticola*): Larvae feed by making mines into the leaves and cause heavy damage.

Systemic insecticide Rogor 30 EC (dimethoate) recommended for control of mustard aphid should be used for controlling the leaf-miner or apply 13 kg Furadan 3 G (carbofuran) per acre followed by light irrigation.

6. Hairy caterpillar (*Spilosoma obliqua*) **and cabbage caterpillar** (*Pieris brassicae*): The caterpillars feed on leaves, young shoots and green siliquae. When young, they feed gregariously but the grown-up caterpillars migrate from one field to the other (See Plate No. 5, Page No. 178). When in the gregarious stage, they can be easily controlled by picking and destroying the infested leaves.

Note

- 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.
- Spray in the afternoon when the pollinators are less active.
- Assure a waiting period of 7 days for thiamethoxam 25 WG, 20 days for chlorpyriphos 20 EC and dimethoate 30 EC and 30 days for quinalphos 25 EC after spray on *Saag* crop.

(b) Diseases

1. Alternaria blight (*Alternaria brassicae*): Brown to blackish spots with concentric rings appear on leaves, siliquae and stems (See Plate No. 6, Page No. 178). In case of severe attack, the upper parts of the stem and siliquae wither and contain shrivelled seeds. Temperature in the range of 15-25°C and relative humidity of more than 75% favour the disease development. To avoid incidence of this disease, destroy diseased debris from the previous crop.

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. Relative humidity of more than 90% with temperature in the range of 10-20°C are conducive for disease development and spread. To avoid incidence of this disease, destroy diseased debris from the previous 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, become sterile and club shaped (See Plate No. 7, Page No. 178). All parts are attacked, except roots. Weather conditions of 13-25°C temperature and more than 75% relative humidity favour the disease development. To avoid incidence of this disease, destroy diseased debris from the previous crop. To manage white rust, spray 250 g of Ridomil Gold (metalaxyl 4%+ mancozeb 64%) by disolving in 100 litres of water per acre at 60 and 80 days after sowing. If needed, repeat the spray after 20 days interval.

4. Sclerotinia Stem rot (*Sclerotinia sclerotiorum*)**:** This soil borne disease appears as water soaked lesions on the stem which later on are covered with white cottony growth of mycelium. Black coloured sclerotia develop on these lesions as well as in the pith of the stem. Upon harvesting, these sclerotia are mixed in soil where they can survive for longer period. It appears generally in the month of January when the temperature is quite low and soil has abundance of moisture. The sclerotia lying under the soil germinate and the mycelium enter the plants. The affected plants look wilted, then dry up and stand erect with whitish appearance. If plant canopy is heavy then there is breaking of stem also. To manage this disease, avoid irrigation to the rapeseed-mustard crop during 25th December to 15th January.

5. Phyllody (*Mycoplasma* Like Organisms): 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 to minimise further spread of this disease.

Production of Pure Seed

For seed multiplication, rapeseed-mustard crops must be sown at safe isolation distance. Minimum isolation distance required is 300 m for canola varieties, *raya*, *gobhi sarson* and African *sarson*. In case of self-sterile crops such as *toria* and *taramira*, take seed from randomly selected, healthy and pyramidal plants which are profusely branching near the base. For maintaining the purity of largely self-fertile crops such as *raya*, *gobhi sarson* and *African sarson*, pull out the off-type plants atleast once before flowering and again just before harvesting.

Seed production of Hybrids: The Punjab Agricultural University has recommended three hybrids of rapeseed-mustard for cultivation viz; RCH 1 of canola quality *raya,* PHR 126 of *raya* and PGSH 1707 of canola quality *gobhi sarson* for cultivation in the state. Farmers are required to use fresh hybrid seed (also known as F1 seed) every year. The farmer saved seed of previous crop harvest can not be used to raise a new crop of these hybrids. The hybrid seed production involves crossing between cytoplasmic male sterile (CMS) line or female line (also known as A line) and male or pollinator line (also known as R line) in the isolated seed production plots. Female (A) and Pollinator (R) lines of the hybrids developed by the PAU can be purchased from the PAU. Seed production should be carried out only by trained seed producers under the guidance of PAU. Parents of the three recommended hybrids are listed below:

Crop / Hybrid	Female Line (A)	Pollinator Line (R)
Raya		
PHR 127	CMS-DTM 218	FR-401
RCH 1	CMS-ZM 20	OCRE-4NR
PHR 126	CMS-M 29	FR-AJR 102B
Gobhi sarson		
PGSH 2155	CMS-LG 5	FR-ZY 005-2
PGSH 1707	CMS-AG 24	FR-ZY 005

Hybrid seed production involves following steps:

A. Raising of seed production plots

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

ii) The quantity of seed required for sowing one acre of seed plot is about 500 g of female (A) line and 300 g of pollinator (R) line.

iii) Select an isolated field which is at least 1500 meters away from other *raya/gobhi sarson* fields. It must be ensured that no crop of *raya* or *gobhi sarson* was sown in the selected field for at least three previous years.

iv) Following ratio of female (A) and pollinator (R) lines in the hybrid seed production of *raya* and *gobhi sarson* should be followed:

Raya : 6 rows of female (A) line: 2 rows of pollinator (R) line

Gobhi sarson : 4 rows of female (A) line: 2 rows of pollinator (R) line

This means that two rows of the pollinator (R) line are planted after six rows of the female (A) line for production of hybrid seeds in *raya*. Recommended row to row spacing for *raya* is 30 cm. For *gobhi sarson* hybrid, two rows of pollinator (R) line should be sown after four rows of female (A) line at row to row spacing 45 cm. Plant to plant spacing of 10-12 cm should be maintained by thinning at about two weeks after sowing in both *raya* and *gobhi sarson.*

Sowing of pollinator (R) line should be carried out first in the entire seed production plot and thereafter sowing of female (A) line should be carried out. It is also advisable to leave one row vacant on both sides of all the row pairs of pollinator (R) line to avoid accidental spillover of pollinator seeds to the female (A) line. It is also recommended to sow a strip of pollinator (R) line on all sides of seed production block to augment the pollen supplies.

v) Cultural practices recommended for cultivation of respective crops may be followed for hybrid seed production.

B. Maximizing pollination on female (A) line through effective synchronization of flowering

i) The pollinator (R) line FR-ZY 005 of PGSH 1707 (canola *gobhi sarson* hybrid) and FR-AJR 102B of PHR 126 (*raya*) are about 4-7 days late to flower as compared to their respective female (A) line. It may be desirable to achieve complete synchronization between the pollinator (R) line and female (A) line by de-topping the main shoots of plants in the female (A) line in timely sown (second fortnight of October) crop. De-topping is to be carried out just after the initiation of the main flowering shoot. De-topping of main shoot of female (A) line of canola *raya* hybrid and for late (after 10th November) sown crop (all hybrids) is generally not required.

ii) Additional dose of urea @ 7.5 kg per acre (over and above the normal recommended dose) may be applied between the pollinator (R) line after first irrigation to improve vigour and height of pollinator plants.

C. Rogueing

The off-type plants, if any, in female (A) line and pollinator (R) line should be

removed before flowering. Rogueing of male contaminants (caused by accidental seed spill over from pollinator (R) line during sowing from female (A) line is strongly recommended. Rogueing may be carried during early hours of the day. It should be continued till all plants in the female (A) line have flowered.

D. Harvesting and packing

i) The pollinator (R) line should be harvested immediately after flowering is complete in both female (A) line and pollinator (R) line to avoid mechanical contamination of hybrid seed due to shattering in male line.

ii) The seed set on female (A) line is the hybrid seed and it should be harvested, threshed and graded separately. We recommend an additional round of rougeing of off-type plants before harvesting the female (A) line.

iii) Pack the seeds in dry bags and store them in moisture free store.

iv) Hybrid seed of about 3.0-3.5 quintals per acre is expected under timely sown conditions.

LINSEED

Linseed cultivation is mainly confined to Gurdaspur, Hoshiarpur and Rupnagar districts adjoining the main linseed growing area of Himachal Pradesh. The low yield can be stepped up by adopting the recommended package of practices.

Climatic Requirements: It does well in high rainfall areas.

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

Rotation: Rice-Linseed.

Improved Variety

LC 2063 (2007): It is a tall variety with profuse branching and blue flowers. It is tolerant to wilt, rust, *Alternaria blight* and moderately resistant to powdery mildew. It has lustrous brown, bold seeds with 38.4 per cent oil content. Its average yield is 4.9 quintal per acre. It matures in about 158 days.

LC 2023 (1998): It is recommended for both rainfed and irrigated conditions. It is a tall variety having blue flowers and profuse capsule bearing. It has brown medium sized seeds. 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 quintal per acre. It matures in 158 and 163 days under rainfed and irrigated conditions, respectively.

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. Linseed can also be raised without any tillage operation with zero till drill after rice.

Seed Rate: Use 15 kg seed per acre.

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

Weed Control: Two hoeings preferably with improved wheel hand hoe should be done at three and six weeks after sowing.

Irrigation: Depending upon the rains during the crop season, linseed requires 3-4 irrigations. Irrigation at flowering initiation is essential.

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 Pest

1. Lucerne caterpillar: This insect may cause damage by feeding on the leaves.

(b) Diseases

1. Rust (*Melampsora lini*): Pink fungal sori appear on the surface of leaves, stems and pods. Grow resistant varieties like LC 2023 and LC 2063.

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.

SUNFLOWER

The spring season is the most suited for assured crop and high yields of sunflower. Availability of honey bees during this season in abundance, also helps in good seed setting. Sunflower oil is very well suited for the manufacture of edible refined oil and *vanaspati*. Its oil can also be used for making soap and a number of allied products. During 2023-24, sunflower was grown on 0.9 thousand hectares with a production of 1.8 thousand tonnes and average yield of 20.22 quintals per hectare (8.18 quintal per acre).

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

Rotations: Rice/Maize-Potato-Sunflower; Rice-*Toria*-Sunflower; Cotton-Sunflower; Sugarcane-Sugarcane ratoon-Sunflower and *kharif* Fodder-*Toria*-Sunflower.

Basmati-Sunflower is more productive and remunerative as compared to prevalent *Basmati*-Wheat crop sequence.

Hybrids

PSH 2080 (2019): It is a short duration medium tall hybrid with average plant height of 151 cm. The average seed yield of this hybrid is 9.8 quintals per acre. The seeds of this hybrid are black and elongated with 100 seed weight of 5.8 g. The oil content of this hybrid is 43.7 per cent. It matures in 97 days.

PSH 1962 (2015): It is a short duration, medium tall hybrid with average plant height of 165 cm. The average seed yield of this hybrid is 8.2 quintals per acre. The seeds of this hybrid are black and bold with 100 seed weight of 6.4 g. The oil content of this hybrid is 41.9 per cent. It matures in 99 days.

DK 3849 (2013): It is a tall hybrid with an average plant height of 172 cm. The average seed yield of this hybrid is 8.4 quintals per acre and 100 seed weight is 4.5 g. The seeds of this hybrid contain about 34.5 per cent oil. It matures in 102 days.

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

- **Hybrids PSH 2080 and PSH 1962 have high oil content, shorter duration and medium-tall stature.**
- **For higher yield and water saving, sowing should be completed by end of January.**
- **Treat the seeds before sowing with recommended fungicide.**
- **In fields infested with cutworm (particularly after potato), crop should be sown on ridges.**
- **Avoid water stress at flowering and dough stages.**

Other hybrids in cultivation:

Pioneer 64 A 57: Not tested by the Punjab Agricultural University.

Champ: Not tested by the Punjab Agricultural University.

Armony Gold: Not tested by the Punjab Agricultural University.

NSFH-1001: It is tall, medium duration hybrid having high oil content. However, its 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.

Seed Rate: Use 2 kg seed per acre.

Seed Treatment: Treat the seeds before sowing with Tagron 35 WS (metalaxyl) @ 6 g per kg seed.

Seed Inoculation: Moisten the recommended quantity of seed for one acre of sunflower crop using 50 mL water and apply 250 g biofertilizer (*Bacillus aerius* SLE1 and *Pseudomonas putida* SRB1) on pucca floor/polyethylene sheet. Dry the inoculated seed in shade and sow as early as possible. Seed inoculation with this biofertilizer increases seed and oil yield. This bio-fertilizer is available in Punjab Agricultural University, Ludhiana Seed Shop at Gate No. 1 and Krishi Vigyan Kendra/ Farm Advisory Service Centres in different districts.

Time of Sowing: To realize high seed yield and to save irrigation water, the sowing of sunflower should be done in January. However, if the planting is delayed till first week of February, shorter duration hybrids (PSH 2080, PSH 1962, PSH 569 and PSH 996) 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.

Method of Sowing: 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 Appendix III). 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 direct seeded crop. About 30 sq.m. of nursery area is sufficient to raise seedlings for transplanting in 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 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 60 cm apart rows and irrigate the field.

Intercropping: Mentha can be successfully intercropped with sunflower. Sow two rows of mentha in end January between two rows 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 single super phosphate) per acre. Full phosphorus and half nitrogen be applied at planting and remaining half nitrogen at 40 days after planting.

Fertilizer Application: Sunflower following *toria* should be applied with 10 tonnes of farmyard manure (FYM) per acre along with the recommended fertilizers. However, sunflower grown after potato receiving 20 tonnes FYM per acre requires 12 kg N (25 kg urea).

In general, use 24 kg N (50 kg urea) per acre along with 12 kg P_2O_5 (75 kg single superphosphate) at sowing. In coarse textured soils, apply 24 kg N (50 kg urea) per acre to sunflower in two equal 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, Shaheed Bhagat Singh Nagar and Rupnagar districts apply 24 kg K_2O (40 kg muriate

of potash) per acre. Prefer superphosphate for phosphorus application as it also contains sulphur.

Irrigation: Sunflower generally requires 6-9 irrigations depending upon the soil type, rain and weather prevalent. Apply 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 and irrigation missed at these stages reduces seed yield by 21-25 %. Avoid moisture stress to the crop at these critical stages.

Drip Irrigation and Fertigation: This method is very useful for getting higher yield and saving of water and fertilizer. For this purpose, sow the crop on ridges spaced 60 cm apart with plant to plant distance of 30 cm. After sowing, lay down one lateral pipe having drippers at 30 cm spacing on each ridge. Apply irrigation at three days interval starting from one month of sowing. The month wise irrigation time for dripper discharge of 2.2 litre per hour is as under:

Month	Time of irrigation (Minutes)*
March	35
April	75
May	86

If discharge rate is different than 2.2 litre per hour, then time of irrigation must be revised by the formula:

Adjusted time (minutes) = (2.2 × Time of irrigation (minutes)*) ÷ Discharge of dripper (litre/hour)

Apply 8 kg urea and 12 kg superphosphate per acre at sowing. Also apply 20 kg muriate of potash per acre on soils testing low in K. In Hoshiarpur, Rupnagar and Shaheed Bhagat Singh Nagar districts apply 40 kg muriate of potash per acre. Starting from one month after sowing, apply 32 kg urea and 12 litres of orthophosphoric acid (88%) in 5 equal installments with drip irrigation system within next 45 days.

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.

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 seeds give 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.

Plant Protection

(a) Insect Pests

1. Cutworms (*Agrotis* spp.): This insect may be serious during March-April in fields where sunflower follows potato. Caterpillars cut the seedlings at the ground level. Sow the crop on ridges to avoid cutworm damage in the germinating seedlings.

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 infested leaves and destroyed. Grown up larvae of hairy caterpillar can also be managed by spray of 300 mL Superkiller 10 EC (cypermethrin) per acre in 100 litres of water.

Caution: Spray should be done in the evening when the non-target organisms including honeybees and predatory arthropods are less active.

3. 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.

(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. Warm (12-20°C) and moist weather conditions favour the disease development. Use disease free 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.

4. Downy mildew *(Plasmopara halstedii)*: Plants remain severely stunted, leaves become thick with green and yellow patches visible from upper side. White cottony shining downy growth of fungus appears on lower surface of the leaves. Leaves become necrotic and plants develop small and empty heads. Treat sunflower seeds with Tagron 35 WS (metalaxyl) @ 6 g per kg seed. Fungicide should be applied by making slurry in water and seeds should be dried before sowing.

(c) Birds

See Chapter - “Management of Rodents and Birds”.

Seed production of Hybrids

Fresh seed of hybrids have to be used every year. The hybrid seed production involves crossing of male or pollinator parent with cytoplasmic male sterile (CMS) line or female line in the isolated seed production plot. The female line and the pollinator line of any hybrid are commonly termed as 'A' line and 'R' line, respectively. Male and female parents of the hybrids developed by the PAU can be purchased from the PAU. Seed production should be carried out only by the trained seed producers under the guidance of PAU. The parents of different sunflower hybrids are as under :

Hybrid	Female Line (A)	Pollinator Line (R)
PSH 2080	CMS 67A	P160R
PSH 1962	CMS 67A	P 93R
PSH 996	CMS 11A	P 93R

Following steps are involved in the production of hybrid seed:

- Obtain fresh seed of female (A) and pollinator (R) parent from the Punjab Agricultural University every 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.
- Select an isolated field which is located at least 400 meters away from another sunflower field. It must be ensured that no crop of sunflower had been sown in the selected field in the previous year.
- 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. Distance between lines should be 60 cm. However, the first two border rows on either side should be sown with R line for adequate supply of pollens.
- To enhance seed production of PSH 1962, its pollinator (R) line, P 93 R should be sown 4-5 days earlier than the female (A) line, CMS 67 A. Similarly for enhanced seed production of PSH 2080, its pollinator (R) line, P 160 R should be sown 5-6 days earlier than the female (A) line, CMS 67 A.
- Cultural practices recommended for cultivation of crop should be followed for seed production.
- 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 have 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 :

    - Collect the pollen from the pollinator (R) plants in a dry plastic or metallic container by shaking the heads.
    - 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 moisture content of less than 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, 2.5 quintal hybrid seed per acre is obtained.

4. SUGAR CROPS

SUGARCANE

Sugarcane occupied 90.2 thousand hectares in Punjab during 2023-24. The average cane yield was 832.5 quintals per hectare (337 quintals per acre). The average sugar recovery was 9.38 per cent.

Important Hints

Plant crop

- Do not plant the crop in a field where the preceding crop was infected with red rot or wilt.
- Use seed cane from a healthy and completely disease free seed crop.
- Use recommended seed rate to ensure good stand of the crop.
- Avoid late planting. It reduces tillering and the crop is more prone to attack by insect pests, especially shoot borer.
- Keep the crop free from weeds using cultural control measures and recommended chemicals.
- Do not apply excessive dose of nitrogen than recommended. Over dose will cause lodging of the crop, resulting in poor cane yield and quality.
- Do not allow the crop to suffer from water stress especially during hot months.
- To prevent lodging, earth up the crop in May-June and prop up the crop during August-September.

Ratoon crop

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

Hints for obtaining high sugar recovery

- Do not plant whole area under a single variety. Plant recommended early and mid-late maturing varieties in the ratio of 3:2 on area basis.
- Save the crop from lodging by timely earthing up and propping.
- Save the crop from diseases and insect pests through recommended control measures.

- Protect the crop from frost by giving light irrigations.
- Avoid excessive irrigation and late application of nitrogen near crop maturity.
- Harvest the crop at proper maturity. Ratoon crop should be harvested first.
- Ensure removal of roots, mud, trash and immature tops (spindles) at the time of harvest.
- Supply cane to sugar mills without excessive binding material, immediately after harvesting as staling reduces sugar recovery.

Climatic Requirements

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

Soil Type

Sugarcane can be successfully grown on all types of soils ranging from sandy loam to clay loam. However, it thrives best on well-drained loamy soils. Sugarcane is semi-tolerant to sodicity and salinity. Sustainable sugarcane yields with assured levels of sugar recovery can be successfully obtained in sodic and saline-sodic soil/irrigation water conditions by adopting the following practices:

- If the soil/irrigation water is sodic, apply gypsum @ 50% of gypsum requirement on cumulative basis after the harvest of the previous crop or well decomposed farm yard manure @ 8 tonnes per acre before sowing. Higher and complimentary benefits can be obtained if both gypsum and FYM are used simultaneously.
- Do not apply gypsum if the soil/irrigation water is saline or saline-sodic. Apply only FYM.
- Under saline water conditions in south-western districts of Punjab, CoJ 88 should be planted.

Spring Sugarcane

Rotations

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

Improved Varieties

1. Early-Maturing Varieties

CoPb 95 (2021): The canes of this variety are tall, thick* with zigzag internode alignment and purplish green in colour with broader leaf canopy. Its' juice contains 17% sucrose in the month of December. It has field resistance to the prevalent pathotypes of red rot disease, moderately resistant to smut and also less susceptible

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

to top borer. It is a good ratooner, non-lodging and frost tolerant. The average cane yield is about 425 quintals per acre.

CoPb 96 (2021): The canes of this variety are medium thick, cylindrical and yellowish green in colour. Its' juice contains 16-17% and 18% sucrose in the months of November and December, respectively. It is a good ratooner. It is tolerant to the prevalent pathotypes of red rot disease. Quality of *gur* is very good. The average cane yield is about 382 quintals per acre.

Co 15023 (2021): The canes of this variety are medium thick, cylindrical and yellowish green in colour. Its' juice contains 16-17 and 18% sucrose in the month of November and December, respectively. It is tolerant to the prevalent pathotypes of red rot disease. The average cane yield is about 310 quintals per acre.

- **CoPb 95, CoPb 96, Co 15023, CoPb 98, CoPb 92, Co 118, CoJ 85, CoPb 93 and CoPb 94, CoPb 91, Co 238 and CoJ 88 are tolerant to most of the prevalent pathotypes of red rot disease.**
- **Gur (jaggery) from CoPb 96, CoPb 92, Co 118, CoJ 64 and CoJ 88 is of excellent quality.**
- **Seed rate of Co 118 and CoJ 85 should be kept 10% higher on weight basis.**

CoPb 92 (2017): The canes of this variety are tall, medium thick and purple green in colour. Its juice contains 16-17% sucrose in the month of November and 18% in December. It is a good ratooner. It is tolerant to most of the prevalent pathotypes of red rot disease and frost. Quality of *gur* is also good. The average cane yield is about 335 quintals per acre.

Co 118 (2015): It has thick, purple green coloured canes. Its juice contains 16% sucrose in the month of November and 17% in December. It has field resistance to the prevalent pathotypes of red rot disease. It is a shy tillering variety and an average ratooner. Its *gur* quality is excellent. The average cane yield is about 320 quintals per acre.

CoJ 85 (2000): It is a shy tillering variety with thick* green coloured canes. Its juice contains 16-17% sucrose in the month of November and 18-18.5% in December. It is tolerant to most of the prevalent pathotypes of red rot disease and is tolerant to frost. It is an average ratooner and susceptible to red stripe disease. Due to its heavy canes it is prone to lodging, hence requires proper earthing up. The average cane yield of plant crop is about 305 quintals per acre.

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

2. Mid-Late Maturing Varieties

CoPb 98 (2021): The canes of this variety are tall, thick, cylindrical and yellowish green in colour. Its' juice contains 17% and 19% sucrose in the months of January and March, respectively. It is a good ratooner. It is tolerant to the prevalent pathotypes of red rot disease. The average cane yield is about 400 quintals per acre.

CoPb 93 (2017): The canes of this variety are tall, thick and yellowish white in colour. Its juice contains 17% sucrose in the month of January and 19% in March. It is a good ratooner. It is tolerant to the prevalent pathotypes of red rot disease. Quality of *gur* is also good. The average cane yield is about 390 quintals per acre.

CoPb 94 (2017): The canes of this variety are tall, thick, cylindrical and yellowish green in colour. Its juice contains 16% and 19% sucrose in the months of January and March, respectively. It is a good ratooner. It is tolerant to the prevalent pathotypes of red rot and smut diseases. The average cane yield is about 400 quintals per acre.

Co 238 (2015): The canes of this variety are tall, medium thick and yellow green in colour. Its juice contains 17% sucrose in the month of January. It is susceptible to top borer and tolerant to the prevalent pathotypes of red rot disease. It is a good ratooner. Quality of *gur* is also good. The average cane yield is about 365 quintals per acre. The crushing of this variety by sugarmills can be done along with early maturing varieties.

CoPb 91 (2014): The canes of this variety are tall, thick and yellowish green in colour. Its juice contains 17% sucrose in the month of January. It is tolerant to the prevalent pathotypes of red rot disease. It is a good ratooner. Its average cane yield is about 410 quintals per acre.

CoJ 88 (2002): The canes of this variety are tall, medium thick and greyish green in colour. Its juice contains 17-18% sucrose in the month of December. It tends to behave as early-mid in maturity and is also suitable for saline water conditions. It is tolerant to the prevalent pathotypes of red rot disease. It is an excellent ratooner. It is good for co-generation. Quality of *gur* is excellent. The average cane yield of the plant crop is about 335 quintals per acre.

Unrecommended variety:

Co 89003: This is an early maturing variety. It is highly susceptible to wilt disease and root borer which reduce its sugar recovery.

Agronomic Practices

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

Land Preparation: Give three to four ploughings, each followed by planking. Use a furrow turning plough for the first ploughing. If the crop is to be sown after harvesting of senji (fodder), 3 to 4 ploughing are enough for seed bed preparation.

Time of Planting: Mid-February to the end of March is the optimum time for planting sugarcane in the Punjab. Do not plant early maturing varieties after March. Avoid late planting. If late planting has to be done, adopt the following practices:

- In case of late planting, any mid late maturing variety should be preferred.
- Use higher seed-rate, viz. 30 thousand three-budded sets per acre.
- Control the early shoot-borer effectively as it is particularly serious in the late-planted crop.

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

Seed Rate: Use 20 thousand three-budded setts or 15 thousand four-budded sets or 12 thousand five-budded setts per acre. Longer setts are particularly good for rain-fed conditions. In other words, 30-35 quintal of seed, depending upon the variety, is required for sowing one acre. Due to thick canes, seed rate of Co 118 and CoJ 85 should be kept about 10% higher (on weight basis).

Seed Treatment: To improve the germination, soak the setts in ethrel solution overnight. To prepare the solution, dissolve 25 mL of Ethrel 39 SL in 100 liters of water. Alternatively, soak the setts in water for 24 hours before planting.

Spacing and Planting Techniques

1. Trench Planting: Plant crop in rows 75 cm apart and 20-25 cm deep trenches. After placing the setts in trenches, cover the setts with 5 cm soil. Apply irrigation immediately after planting, if the planting is not done under proper moisture (*watter)* conditions. Repeat the irrigation at 4-5 days interval.

2. Paired Row Trench Planting: Adopt paired row trench planting for saving irrigation water. Plant two rows of sugarcane 30 cm apart in 20-25 cm deep trenches. Place the cane setts at the bottom of the trenches and cover with the soil left in between two rows. Distance between two trenches should be 90 cm. Trenches can be drawn using tractor operated PAU designed trencher. In addition to water saving, this method gives comparatively higher cane yield, easy propping up operation and reduces lodging.

Use **tractor operated paired row trench planter** to sow paired rows of sugarcane in trenches. The complete sugarcane, is fed by two labourers sitting on the machine, is cut automatically into pieces before dropping in the furrows, fertilizer is applied simultaneously. Length of setts varies from 36 to 38 cm. The speed of operation is 2-3 km/h. Capacity of machine varies from 2-3 acres per day.

For ease of mechanical harvesting with sugarcane harvester, the crop should be planted at either 120 cm row spacing or by 120:30 cm paired row trench method.

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

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

Intercropping: Intercrop one row of the recommended varieties of summer moong or summer *mash* in between two rows of sugarcane to get an additional grain yield of 1.5 to 2 quintals per acre of summer *moong*/summer *mash*. This does not affect the cane yield and improves the soil fertility. The details are as under:

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

Mentha can also be grown as an intercrop. Plant one row of mentha between two rows of sugarcane. Mentha and sugarcane can be planted simultaneously in the first fortnight of February. Use one quintal of mentha suckers per acre. In addition to fertilizers recommended for 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.

Okra can also be grown as an intercrop. Intercrop two rows of okra 45 cm apart in between the two rows of sugarcane planted either at 90:30 or 120:30 cm paired row planting systems in the second fortnight of February month. Use 11 kg seed of okra per acre for 90:30 cm planting system and 9 kg for 120:30 cm. Fertilizers to the intercrop should be applied as recommended for sole crop of okra. Terminate the okra crop in the second fortnight of June to avoid the intercrop competition.

One row of **cucumber** can be sown within the two rows of sugarcane as intercrop in paired row trench planted sugarcane either at 90:30 cm or 120:30 cm. The cucumber seeds should be sown by keeping plant to plant distance of 45 cm by using 1 kg seed per acre in the second fortnight of February. Use 40 kg nitrogen (90 kg urea), 20 kg phosphorus (125 kg superphosphate) and 20 kg potash (35 kg murate of potash) to cucumber crop in addition to fertilization to sugarcane crop.

Fertilizer Application

Organic and Bio-fertilizers: Apply 8 tonnes of FYM/press-mud per acre 15 days before planting and mix into the soil with a plough or tiller. In case of trench planting, apply press-mud at the base of the trench and mix it into soil with a *kasola*. In case FYM/ press-mud is applied, use 40 (90 kg urea) kg N per acre. However, on coarse textured soils if FYM is applied along with recommended dose of nitrogen, approximately 10% higher yields can be obtained. On sandy soils, nitrogenous fertilizer may be applied after irrigation in moist soil and the number of splits may be increased. Application of Azotobacter/Consortium bio-fertilizer @ 4 kg per acre in the furrows at the time of planting would be helpful in increasing the cane yield. If FYM is in limited quantity, apply 4 kg consortium bio-fertilizer with 4 tonnes FYM per acre to plant as well as ratoon sugarcane crop. This bio-fertilizer is available at the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Chemical Fertilizers: Apply fertilizers on soil test basis (See Chapter on 'Soil Testing'). In the absence of a soil test, apply the following quantity of fertilizers on medium fertility soils:

Crop	Nutrients (kg per acre)		Fertilizers (kg per acre)	
	N	P_2O_5	Urea	Single Superphosphate
Plant crop	60	#	130	#
Ratoon crop	90		195	

If the soil is low in available phosphorus, apply 12 kg P_2O_5 (75 kg single super phosphate) per acre at sowing.

- In soils testing low in available potassium, application of 50 kg per acre murate of potash to planted sugarcane in furrows at the time of planting and with first hoeing/ earthing in ratoon crop improves yield and quality.
- Apply only 100 kg urea per acre if, sugarcane is grown after potato crop.

Method of Fertilizer Application

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

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

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

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

Weed Control

Cultural Control: Two or three hoeings can be done with a *triphali* or tractor mounted tiller or tractor operated rotary weeder.The spreading of trash-blanket between the cane rows after the emergence of the shoots helps to suppress weeds. This practice has the added advantage of conserving soil moisture, particularly in rainfed areas.

Chemical Control: Pre-emergence application of 800 g per acre Atrataf/Solaro/ Masstaf/Markazine 50 WP (atrazine) or Sencor 70 WP (metribuzin) or Karmex/Klass 80 WP (diuron) or 1000 g per acre Authority NXT 58 WP (sulfentrazone+clomazone) in 200 litres of water within 2-3 days of planting effectively controls the broadleaf weeds and annual grasses. For control of hardy weed like *Bans Patta*, use only Sencor 70 WP or Karmex/Klass 80 WP.

Alternatively, post-emergence application of 1200 g per acre Triskele/Trishuk (2,4-D sodium salt 44% + metribuzin 35% + pyrazosulfuron ethyl 1.0%) WDG or 1000 g per acre Sindica (2,4- D sodium salt 48% + metribuzin 32% + chlorimuron ethyl 0.8%) WDG in 200 litres of water at 3-5 leaf stage of weeds provides effective control of seasonal grass, sedge and broad leaf weeds. For fields infested with *dila*, post-emergence application of 800 g per acre 2, 4-D sodium salt 80 WP in 200 litres of water is recommended. In fields infested with *Ipomoea* spp. (*Iapeta vel*) and other broadleaf weeds, apply 800 g of 2,4-D sodium salt 80 WP or 400 mL per acre 2,4-D amine salt 58 SL by dissolving in 200 litres of water when these weeds are at 3 to 5 leaf stage.

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

Irrigation and Drainage: Hot and dry period during April to June is the most critical period for the growth of sugarcane. During this period, irrigate the crop at 7 to 12 days interval. During the rainy-season, adjust the frequency of irrigation according to rainfall. Drain away excess water from the sugarcane fields, if these get flooded during the rainy season. During winters (November to January), irrigate the crop at monthly intervals. To save the crop from frost, apply one irrigation around mid-December and another in the first week of January.

Sub Surface Drip Fertigation: Paired row (30:120 cm) planted sugarcane should be drip irrigated every third day with a lateral pipe placed 20 cm deep and 150 cm apart having dripper spacing 30 cm. Drip irrigation with dripper discharge of 2.2 litre per hour should be given as per the following schedule:

Month	Time of irrigation (Minutes)*
April-June	120
July-Aug	100
Sept-Oct	80
Nov-Dec	60

If discharge rate is different, then time of irrigation may be adjusted proportionally by the formula:-

Adjusted time (min) = (2.2 × Time of irrigation (min)*) ÷ Discharge of dripper (Litre/hour)

Start fertigation of 104 kg urea per acre for plant crop and 156 kg urea per acre for ratoon crop in the month of April and complete in 90-100 days in 10 equal splits.

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

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

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

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

- Grow frost-resistant varieties viz. CoPb 95, CoPb 96, CoPb 98, CoPb 92, Co 118, CoJ 85, CoJ 64, CoPb 93, CoPb 94, CoPb 91, Co 238 and CoJ 88.
- Raise a bumper crop with adequate fertilization, irrigation and plant protection measures, because a poor and stunted crop suffers more from frost.
- Prevent lodging. A lodged crop is more damaged by frost.
- Irrigate the crop, as adequate soil-moisture during the frosty period keeps the soil comparatively warm and saves it from frost. Irrigate the harvested fields if meant to be ratooned. Plough the patch of land between the cane rows.
- In frosty areas, plant setts only from the top portion of the cane, as these buds are less damaged by frost. The top portion can be buried in the soil during the frosty spell and taken out in the spring for planting.

Autumn Sugarcane

Sugarcane can also be grown successfully as an autumn crop with various intercrops. Growing intercrops in autumn cane will enhance the total productivity/net profit per unit area per unit time. Recommendations concerning intercrops are given in Table 1.

Rotations

Kharif fodder/Green manure/Maize/Rice (short duration)/*Moong*-Sugarcane with intercrop (as in Table) ratoon I-ratoon II-Wheat.

Improved Varieties: Plant CoPb 95, CoPb 96, Co 15023, CoPb 92, Co118, CoJ 85 and CoJ 64

Agronomic Practices

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

Seed Rate: Plant 20 thousand of three budded or 15 thousand of four budded or 12 thousand of five budded setts per acre. The seed for autumn planting should be obtained from a well grown spring or autumn crop.

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

Intercropping: For higher returns per unit area, adopt intercropping in autumn sugarcane as given in Table 1.

Fertilizer Application: Apply fertilizers on soil test basis (See Chapter on 'Soil Testing'). In the absence of a soil test, apply the following quantity of fertilizers on medium fertility soils:

Table 1: Intercrops in autumn sugarcane

Name of of Intercrop	Variety	Sowing/ planting time	Seed rate (kg per acre)	No. of intercrop rows	Spacing between the rows of intercrop	Fertilizers recommended per acre	Harvest-ing time	Remarks
1	2	3	4	5	6	7	8	9
Wheat	Recommend-ed varieties	Last week of Oct. to 15th Nov.	16	2	20 cm	25 kg N (54 kg urea) 12 kg P_2O_5 (75 kg single superphosphate, SSP) 12 kg K_2O (20 kg muriate of Potash, MOP)	Mid-April	---
Raya (Brassica juncea)	Recommend-ed varieties	Whole Oct.	0.40	1 (in paired row trenches at 90:30 or 120 :30cm)	-	For sugarcane planted at 90:30 cm 20 kg N (44 kg urea) 8 kg P_2O_5 (50 kg SSP) For sugarcane planted at 120:30cm 16 kg N (36 kg urea) 4.8 kg P_2O_5 (30 kg SSP)	April	Preferably, intercrop should be sown after first irrigation to sugarcane.
Gobhi Sar-son (B. napus)	Recommend-ed varieties, including Canola	October 10 to 31						
African Sarson (B tournefortii)	PC 6	Mid Oct. to mid Nov.						
Toria (B campestris) var. Toria	Recommend-ed varieties	20-30 Sept.	1	2	30 cm	15 kg N (33 kg urea) 5 kg P_2O_5 (32 kg single super phosphate)	End Dec.	Wheat can also be sown after harvesting toria.
Gram	Recommend-ed varieties for different zones	25th Oct. to 10th Nov.	12	2	30 cm	6 kg N (13 kg urea) + 8 kg P_2O_5 (50 kg SSP)	April	---

1	2	3	4	5	6	7	8	9
Potato	Chandermukhi or any other short duration variety	20 Sept. to 15th Oct.	800	1	-	36 kg N (78 kg urea) 16 kg P_2O_5 (100 kg SSP) 35 kg K_2O (60 kg MOP)	End of Dec.	Wheat can also be taken after harvesting potato crop in end-December.
Cabbage	Recommended varieties	Last week of Oct. to Nov.	--	1	--	25 kg N (54 kg urea) 12.5 kg P_2O_5 (78 kg SSP) 12.5 kg K_2O (20 kg MOP)	Jan & Feb	Transplant 4 to 5 weeks, old seedling from end of October to November
Radish	Recommended varieties	October	4-5	2	30cm	25 kg N (54 kg urea) 12 Kg P_2O_5 (75 kg SSP)	Jan-uary	---
Peas	Recommended Varieties	October	22	2	30 cm	14 kg N (31 kg urea) 16 kg P_2O_5 (100 kg SSP)	---	---
Tomato	Recommended Varieties	Nursery: Oct -Nov Transplant-ing: Nov-Dec	0.05 (nurs-ery)	1 (in paired row trenches at 120:30cm)	At centre between two cane rows	12.5 kg N (28 kg urea) 12.5 kg P_2O_5 (78 kg SSP), 12.5 kg K_2O (21 Kg MOP)	End Mar to mid May	Protect intercrop from low temperature injury from end Dec-end Feb
Garlic	PG-17 PG-18	4th week of Sept. to first week of Oct.	112 to 125 kg	3	15cm	10 ton FYM, 25 kg N (54 kg urea), 12 kg P_2O_5 (75 kg SSP)	April	In paired row trench planted sugarcane, use 85 to 95 kg garlic seed

1	2	3	4	5	6	7	8	9
Onion	Recommended Varieties	Nursery: Mid Oct- mid Nov Transplant-ing: Jan.	2.0 to 2.5 (nurs-ery)	5 (in paired row trenches at 120:30cm)	15 cm	21 kg N (45 kg urea) 10 kg P_2O_5 (62.5 kg SSP), 10 kg K_2O (17 Kg MOP)	Mid May	Number of intercrops rows can be adjusted with sugarcane row spacing
Capsicum	Recommended varieties	Nursery: Mid Oct.	0.08	1 (in paired row trenches at 120:30cm)	-	28 kg N (62 kg urea) 11.2 kg P_2O_5 (70 kg SSP; 4.8 kg K_2O (8 kg MOP)	Mid Mar. to end May	Capsicum crop should be protected from low temperature injury from end December to end February
Broccoli/ Cauliflower	Recommended varieties	Nursery: Mid September Transplant-ing: Mid October to first week of November	0.150 (for nurs-ery)	2 (Sug-arcane planted in paired row trenches either at 90:30 cm or 120:30cm)	45 cm	For 90:30 cm system: apply 37.5 kg N (82 kg urea), 18.75 kg P2O5 (116 kg SSP), 18.75 kg K2O (30 Kg MOP) For 120:30 system: apply 30 kg N (65 kg urea), 15 kg P2O5 (94 kg SSP), 15 kg K2O (25 Kg MOP)	Mid De-cem-ber	

Nutrients (kg/acre)		Fertilizers (kg/acre)	
N	P_2O_5	Urea	Single Superphosphate
90	#	195	#

If the soil test is low in phosphorus, apply 12 kg P_2O_5 (75 kg single super phosphate) per acre at sowing.

- In soils testing low in available potassium, application of 50 kg per acre murate of potash to planted sugarcane in furrows at the time of planting and with first hoeing/ earthing in ratoon crop improves yield and quality.

Apply urea in three equal doses, 1/3 dose of N should be applied at planting, 1/3 at the end of March and the remaining 1/3 by the end of April. The fertilizer recommendations for intercrops are given in Table 1.

Weed Control: For control of *gulli danda* in wheat intercropped in autumn sugarcane, spray 400 mL Axial 5 EC (pinoxaden*) or 13 g per acre Leader/SF-10/ Safal/ Marksulfo 75 WG (sulfosulfuron*) using 150 litres of water at 30–35 days after sowing of wheat. A post- emergence application of 500 g per acre Isoproturon 75 WP at 30–40 days after sowing of wheat is recommended for controlling weeds in fields where *gulli danda* has not developed any resistance.

For controlling broadleaf weeds, use 10 g per acre Algrip/ Algrip Royal/Markgrip/ Makoto 20 WP (metsulfuron*) in 150 litres of water at 30-35 days after sowing. If there is infestation of *button booti*, spray 20 g per acre Aim/ Affinity 40 DF (carfentrazone ethyl*) in 200 litres of water at 25-30 days after sowing.

For control of mixed infestation of grass (*gulli danda* and wild oats) and broadleaf weeds, spray 16 g Total/Markpower 75 WG (sulfosulfuron + metsulfuron*) or 160 g per acre Atlantis 3.6 WDG (mesosulfuron + iodosulfuron) using 150 litres of water per acre at 30–35 days after sowing wheat.

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

Other recommendations are the same as for the spring crop.

- **Harvest the crop during last week of January to obtain good ratoon crop.**
- **During 1st week of March fill the gap of ratoon crop with planting of 3 budded setts.**

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

- Do not harvest the crop to be ratooned before the end of January. If the crop is harvested earlier, there will be poor sprouting of the stubbles due to low temperature during December and January.
- Soon after the harvesting of early varieties in November or December, remove the trash and irrigate the field. When the soil attains the optimum moisture conditions, loosen it by hoeing, ploughing or interculture. Do not cover the stubble with cane trash.
- Harvest the canes as close to the ground as possible to promote better sprouting. If still some big stubbles are left, shave or lop them off close to the ground. Also

remove late tillers or water-shoots, as they inhibit full sprouting of the stubbles.

- Plough the harvested field twice with a tractor-drawn tiller to check weeds or adopt chemical weed-control measures.
- The stand of the ratoon crop can be improved by planting the gaps with three budded setts in the beginning of March.
- Nitrogen requirement of the ratoon crop is one and a half-times than that of the plant crop. Apply 90 kg N (195 kg urea) per acre to the ratoon crop in three split doses one-third in February-March, one-third in April and the remaining one-third in the beginning of June. Drill phosphorus along the cane rows in March on the basis of a soil test.
- Shoot-borer, top-borer and black bug appear in the ratoon crop. Control them as soon as noticed.

Gur (Jaggery) Making

Gur is a natural sweetener rich in minerals like calcium, iron, phosphorus etc. The best quality *gur* and *shakkar* (powdered jaggery) are obtained from CoPb 92, Co 118, CoJ 64 and CoJ 88. Making of *gur* and *shakkar* from sugarcane involves juice extraction, clarification, boiling and concentration, cooling and moulding. Use an efficient cane-crusher for extracting juice.

For clarifying the juice, add *Sukhlai* emulsion. *Sukhlai* is a shrub which grows in the Shivalik Hills and is available at Hoshiarpur. For preparing emulsion, soak the dry bark of *Sukhlai* in a bucket of water for 24 hours. Then rub the bark to obtain a thick mucilaginous fluid. Add about one litre of this fluid to 100 litres of cane juice, when the scum begins to rise in the pan. Towards the end of boiling process, heating is regulated to avoid charring. The concentrated juice is transferred to the cooling pan when its temperature reaches the striking point (114-116°C) for *gur* making and (120-122ºC) for *shakkar* making. *Gur* is then moulded into desired shapes and sizes using moulding frames designed by Department of Food Science and Technology, PAU Ludhiana. For *shakkar*, at the time of solidification the material is made into powder manually using wooden scrappers. Powder is dried to 10.5-11.5 % moisture content, sieved and packed in polythene bags.

Crushing schedule of sugarcane varieties for sugar mills of Punjab (Developed in consultation with Sugarfed, Punjab)

Varieties*	Crop	Months
CoPb 92, CoPb 96, Co 15023, Co 238, Co 118, CoPb 95, CoJ 85 and CoJ 64	Ratoon (A &S)	November and December
CoPb 93, CoPb 98, Co 238, CoPb 91, CoJ 88 and CoPb 94	Ratoon (S)	December and January
CoPb 92, CoPb 96, Co 15023, Co 238, Co 118, CoPb 95, CoJ 85 and CoJ 64	Plant (A)	December and January
CoPb 92, CoPb 96, Co 15023, Co 238, Co 118, CoPb 95, CoJ 85 and CoJ 64	Plant (S)	January and February
CoPb 98, CoPb 93, CoPb 91, CoPb 94 and CoJ 88	Plant (S)	February, March and April

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

Note: The above crushing schedule would give sugar recovery of 10.5 percent if varietal ratio is as given below:

- The area under early and mid-late varieties should be in ration of 3:2, respectively.
- Under early varieties Spring: Autumn should be planted in the ratio of 2:1, respectively.
- Proportion of Ratoon crop: Plant crop be maintained as 1:1, respectively.

- **Do early sowing to reduce damage by early shoot borer.**
- **Use Tricho-cards for the control of borers.**
- **Do not plant sugarcane for one year and three years for control of red rot and wilt, respectively in diseased fields.**

Plant-Protection

A. Insect-Pests

Termite: The termite appears during April to June and again in October. It destroys the germinating buds and causes the drying up of shoots after germination. To avoid its attack, apply only well-rotten farmyard manure and remove the stubbles and debris of previous crop from the field. For the control of termites, apply 200 mL Coragen 18.5 SC (chlorantraniliprole*) using 400 litres of water over seed setts in furrows before covering them with soil or spray 45 mL Imidagold 17.8 SL (imidacloprid) in 400 litres of water with sprinkler along the rows at post germination stage (about 45 days after planting).

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

- Plant the crop early, i.e. before the middle of March.
- Apply 10 kg granules of Regent/Mortel/Rippen 0.3 G (fipronil) before the setts are covered with soil by planking. or
- Apply 10 kg Regent/ Mortel/Rippen 0.3 G (fipronil) mixed in 20 kg moist sand/ soil or 150 g Takumi 20 WG (flubendiamide) or 150 mL Coragen/Citigen 18.5 SC (chlorantraniliprole*) or 2 litres of Durmet/Classic/Dursban/Markpyriphos 20 EC (chlorpyriphos) in 400 litres of water per acre along the rows at post-germination stage (about 45 days after planting). Earth up slightly followed by light irrigation.

OR

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

Use of 10 pheromone traps per acre from April to June along with Tricho-card application. Change the pheromone lure at one month interval.

Black bug: This pest is active during April to June. The attacked crop looks pale. The black adults and pink young nymphs suck the sap from the leaf-sheaths. Spray

the crop with 350 mL of Dursban/Lethal/Massban/Goldban 20 EC (chlorpyriphos) in 400 litres of water per acre with manually operated sprayer. Direct the spray into the leaf-whorl.

Pyrilla: Pyrilla reduces cane yield and sugar recovery heavily. This pest appears in April-May and again in August-September. The leaves of the damaged crop turn yellow. Later due to the development of a fungus, the crop turns black and the tops become unfit for feeding to cattle. The incidence of this pest is particularly high in a luxuriant crop and in the interior of field. When the attack is severe it becomes difficult to make *gur*. Spray the crop with 600 mL Dursban 20 EC (chlorpyriphos) in 400 litres of water per acre with manually operated sprayer.

Top-borer: This pest appears from March to October and causes severe damage during July-August. The typical symptoms are the shot-holes in the leaf, white or red streaks on the upper side of the leaf midrib and bunchy tops from July onwards. The central leaf of the cane top dries up and turns dark. To control it:

- Collect and destroy the moths and egg-clusters.
- Cut the attacked shoots at the ground level from April to June.
- Use Tricho-cards having 20,000 eggs of *Corcyra cephalonica* parasitized (seven days old) by *Tricogramma japonicum* per acre at 10 days old interval from mid-April to end-June. The method to use these cards is given under early shoot borer.
- Use of 10 pheromone traps per acre from May to August along with recommended Tricho-card application. Change the pheromone lure at one month interval.
- Apply 10 kg granules of Ferterra 0.4 GR or 12 kg Furadan/Diafuran/Furacarb/Carbocil/Fury encapsulated 3G (carbofuran) at the base of the shoots or spray 150 mL Coragen 18.5 SC (chlorantraniliprole) in 400 liters of water per acre, in the last week of June or in the first week of July only if the top borer damage exceeds 5% level. Earth up slightly to prevent the granules from flowing with the irrigation water and irrigate the crop immediately. This operation will control the third brood of the top-borer which does the maximum damage. Take the following precautions in using carbofuran:
- Use rubber gloves while applying carbofuran granules. Never handle these granules with bare hands. A mask should be used to cover the face.
- Mix it with the moist soil to reduce the chances of its falling into the eyes of the person applying it.
- The person applying these granules should not eat or drink anything without washing his hands thoroughly with soap.
- **Carbofuran treated sugarcane leaves and weeds should not be fed to cattle for about one month after the treatment.**

Stalk borer or Tarai borer: This pest is active throughout the year. The larvae overwinter in the stubble and water-shoots. The attack remains low during April-June and increases in July. Its incidence is highest during October-November. There are no outward symptoms of the attack of this pest. Entrance or exit holes on the attacked canes can be seen only after stripping. A larva sometimes damages upto 3 nodes and

the cane may be attacked at several places. The cane yield and sugar recovery are adversely affected in the case of serious attack. The control measures against the pest are as under:

- Do not use the cane-seed from the infested field.
- Use tricho-cards having 20,000 eggs of *Corcyra cephalonica* parasitized by *Trichogramma chilonis*, 10-12 times at 10 days interval from July to October. Cut one tricho-card of size 10 x 15 cm into 40 small strips (5 x 0.75 cm), each having approximately 500 parasitized eggs. Staple these strips on the underside of leaves uniformly at 40 spots per acre during evening hours. These tricho-cards are available at the Biocontrol Labs, Department of Entomology, PAU Ludhiana and Regional Station, Gurdaspur.
- Use of 10 pheromone traps per acre from July to October along with recommended Tricho-card application. Change the pheromone lure at one month interval.
- At harvest, do not leave the water-shoots in the field.
- Do not ratoon a heavily infested crop. Plough the affected fields, collect and destroy the stumps.

Whitefly: The damaged crop looks pale during August-October. The underside of the leaves is full of nymphs and pupae which suck the sap from the leaves. The leaves turn black due to the development of a fungus.

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

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

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

B. Diseases

Red rot: Red rot is caused by the fungus *Colletotrichum falcatum.* The disease appears from July till the crop is harvested. The third or fourth leaf of cane from top shows yellowing at first, while rest of the leaves also loose colour afterwards and dry up. Later, the whole clump dries up. On splitting open the cane, the tissue is found to be reddened but the discoloration is not uniform and is interspersed with white patches

running across the width of the split cane. The pith of affected cane emits alcoholic smell. The control measures against this disease are as under:

- Use seed from absolutely disease free seed plot.
- Do not plant sugarcane in the disease affected fields for one year.
- Grow varieties fairly resistant to red rot.
- Crush the affected crop early and plough up the fields soon after harvesting the crop. Collect and burn the stubbles.
- Rogue out and bury the diseased canes. Uproot the entire clumps and not merely the affected stalks.
- Do not ratoon the diseased crop.

Wilt: This disease is caused by *Cephalosporium sacchari* or *Fusarium moniliforme*. It appears from July till the crop is harvested. The leaves of the affected cane at first turn yellow and finally the top dries up. On splitting open a diseased cane, the pith shows a dirty red discoloration near the nodes. The discoloration is invariably darker than that in the remaining portion of the internodes. The affected stalks become light and hollow. The control measures against this disease are the same as those for red rot. As the causal fungus persists in the soil over long period, the affected field should not be cultivated with sugarcane for 3 years.

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

- Use only smut free canes for seed. Reject even the healthy looking canes in the diseased stools or those growing in the vicinity of the smut infected clumps.
- Remove the smut whips gently (without shaking) after putting them inside a closely woven drill bag. Then uproot the entire diseased clumps and bury them deep. Immerse the bag used for collecting the smut whips in boiling water for 5 minutes after every roguing of the crop.
- Do not ratoon the smut infected crop.

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

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

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

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

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

C. Rodents

Being a long duration crop, sugarcane provides shelter to rodents and suffers heavy damage. The rat, *Bendicota bengalensis*, which digs extensive burrows with characteristic soil heaps, is often abundant in sugarcane. A lodged crop gets highly damaged. For effective rodent control in sugarcane, see Chapter ‘Management of Rodents and Birds’.

Management of Seed Crop

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

- Plant the crop in the last week of March.

- Obtain the seed stalks propagated from moist hot-air-treated seed. The treated seed is planted at the Research Stations and is further propagated at the sugar factory farms and the farms of selected cane growers. This seed is supplied to the growers to raise the seed-crop.
- Give a fertilizer dose of 90 kg of N (195 kg urea) per acre. Apply nitrogen in 3 equal doses i.e. at planting, in May and in mid-July. High dose of nitrogen will result in good quality of immature seed cane.
- Follow plant protection schedule strictly, to keep the crop free from insect pests and diseases.
- Frost injury results in low germination of sugarcane. Therefore, protect the seed crop against frost by irrigating it frequently during December and January.

SUGARBEET

Sugarbeet is the second largest sugar crop in the world, after sugarcane. It is a short duration (6-7 months) sugar crop. ***Before cultivation of sugarbeet, the farmers should ensure marketing of the produce by contacting sugarmill or other stake holders, before hand***.

Soil Type: Sugarbeet can be grown successfully on well-drained soils, loamy sand to clay loam,saline and alkali soils, though it prefers sandy loam soils.

Crop rotations: Rice/Basmati-sugarbeet; *Kharif* fodder- sugar beet

Varieties: The tropical sugarbeet hybrids have the potential to give average root yield of 240-320 q per acre with 13-15% sucrose under Punjab conditions.

Land Preparation: The field can be prepared by 2-3 ploughings followed by planking.

Time of Sowing: Whole of October to mid-November is optimum time of sowing.

Seed Rate and Method of Sowing: The crop can be sown on flat beds or on ridges spaced at 50 cm and plant to plant spacing of 20cm. The optimum plant population is 40,000 plants per acre. The seed is sown by dibbling at 2.5 cm soil depth. Maintain only one plant per hill.

Fertilizer Application: Apply 8 t per acre well rotten FYM and mix it well before sowing. In the absence of FYM, apply 60 kg N (135 kg urea) ad 12 kg P_2O_5 (75 kg SSP) per acre. Apply 45 kg urea and full phosphorous at the time of sowing and remaining urea in two splits of 45 kg each at 30 and 60 days after sowing. If FYM has been used reduce the nitrogen dose to 48 kg (105 kg urea) per acre. In potassium deficient soils, apply 12 kg K_2O (20 kg muriate of potash) per acre at sowing. In boron deficient (below 0.5 kg B per acre) soils, apply 400 g B (4 kg borax) per acre at sowing.

Weed Control: The crop requires 2 to 3 hand weedings at monthly interval.

Irrigation: Sugarbeet is very sensitive to water stagnation at all stages of growth. Apply first irrigation immediately after sowing and subsequent irrigation about two weeks after sowing. The crop needs irrigation at 3 to 4 weeks up to February-end, and at intervals of 10 to 15 days during March-April. Stop irrigation 2 weeks before harvesting.

Harvesting: The crop can be harvested from mid-April to May-end. The harvesting can be done with sugarbeet harvestor/potato digger/cultivator/by manual digging. The beet roots must be processed within 48 hrs after harvesting. The beet leaves should be allowed to remain in the field to serve as green manure or alternately, the leaves can be fed to cattle as forage.

Plant Protection Measures

Sclerotiania root rot, *Cercospora* leaf spot and Heart rot are important diseases of sugar beet. Army worm, Tobacco caterpillar and Cut worm are troublesome insect pests. Sugar beet must be grown in the same field only once in three years to prevent pests and diseases.

5. MEDICINAL, SPICE AND AROMATIC CROPS

MENTHA

There are four species; *Mentha arvensis, Mentha piperita, Mentha spicata* and *Mentha citrata,* which can be grown commercially in the Punjab State. In 2023-24, area under this crop in the state was 13,652 hectares. 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, wherever assured irrigation is available. It needs a well distributed rainfall of 200-250 mm 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-Potato, Mentha–*Toria*, Mentha–Oats (fodder), Mentha-Basmati, Mentha–Wheat–Maize–Potato, Mentha-Maize-Potato, Mentha-DSR-Potato, Mentha-DSBR-Potato

Improved Varieties

CIM Unnati (2025): It is high yielding variety of menthol mint (*Mentha arvensis* L.) with high oil content (0.81-0.83 %) in herb and suitable for planting from end of January to mid of February. Its average herb yield is 113 quintals per acre. It produces the highest herb and oil yield when harvested 145 day after planting.

CIM Kranti (2020): It is high yielding variety of menthol mint (*Mentha arvensis* L.) and suitable for planting from end of January to mid of February. Its oil content in herb is 0.6-0.7% and on an average produces 110 quintals per acre herb yield. It gets ready for harvesting 140-150 days after planting.

Kosi (2014): It is a high yielding variety of menthol mint (*Mentha arvensis* L.). On an average it gives 100-125 quintals per acre herb yield with oil content of 0.6 - 0.7%. It gives the highest herb and oil yield when harvested at 150 days after planting.

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 height of about 55 cm at flowering. Its fresh herb contains 0.57% oil with distinct woody flavour for which it is highly demanded by flavour industry.

Agronomic Practices

Land Preparation: Two or three ploughings followed by planking are necessary to get a fine seedbed. The field should be free from stubbles and weeds.

Bio-fertilizers : Apply consortium bio-fertilizer @ 4 kg per acre as soil application before planting along with recommended fertilizer.

Seed Rate: Mentha is propagated through suckers. About 2 quintals of freshly dug 5-8 cm long suckers are enough for one acre. This quantity can be had from half kanal (10 marla) of mentha.

Method of Planting: The suckers are laid end to end, 4-5 cm deep in furrows, 45 cm apart and are then covered with soil by planking lightly. For higher biomass production and water saving, planting should be done on 67.5 cm wide beds (two rows) or ridges should be made at 60 cm spacing after broadcasting the suckers. Apply 24 quintal of paddy straw mulch per acre and apply a light irrigation after planting. Do not plant sprouted suckers, as most of such suckers die.

- **Use two quintals of disease free sucker for planting an acre.**
- **Sow the crop during mid January to end January, however Kosi, CIM Kranti and CIM Unnati variety can be sown upto mid February.**
- **For water saving and higher yield, sow the crop on beds/ ridges and apply paddy straw mulch @ 24 quintals per acre.**
- **Grow mentha as an intercrop in sunflower/sugarcane or onion as an intercrop in mentha for higher returns.**

Time of Planting: The best planting time is the mid-January to the end of January, however, Kosi, CIM Kranti and CIM Unnati should be planted from end of January to mid of February. The crop can also be raised by transplanting in April.

Intercropping: 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 single superphosphate) per 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 January. Plant one row of onion in between the two rows of mentha planted at 45 cm, keeping plant to plant spacing of onion at 7.5 cm. Apply 13 kg N (29 kg urea), 7 kg P_2O_5 (44 kg SSP) and 7 kg K_2O (12 kg MOP) per acre in addition to recommended fertilizer of mentha. Full phosphorus

and potash and half nitrogen be applied at planting and the remaining half nitrogen about 40 days after planting.

Fertilizer Application: Mentha responds favourably to organic manuring. Apply 10-15 tonnes of well-rotten farmyard manure per acre before planting. The following quantities of inorganic fertilizers are recommended:

Nutrients (kg/acre)		Fertilizers (kg/acre)		
N	P_2O_5	Urea	DAP*	or Single Super phosphate
60	16	130	35	100

* When 35 kg DAP is used, apply 115 kg urea per acre.

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.

Drip Irrigation and Fertigation: Menthol mint should be drip irrigated at 3 days interval with a lateral pipe having dripper discharge of 2.2 litre per hour and dripper placed at 30 cm apart as per following schedule:

Month	Time of irrigation (Minutes)*
March	40
April	65
May	70
June	75

*If discharge rate is different, then time of irrigation may be adjusted proportionately by the formula:-

Adjusted time (min) = (2.2 × Time of irrigation (min)*) ÷ Discharge of dripper (litre/hour)

For first cut, apply 24 kg N and 12.8 kg P_2O_5 per acre in 10 equal splits with drip irrigation. Fertigate with first 1/10th of N and P_2O_5 with first irrigation just after planting and thereafter, remaining 9 doses of N and P_2O_5 should be fertigated in 9 equal splits at 9 days interval starting one month after planting. This will result in about 25 per cent higher oil yield along with saving of 36 per cent irrigation water and 20 per cent nutrients over check basin. Use urea (46 %) and mono ammonium phosphate (12-61-0 grade) for supplying N and P_2O_5 respectively.

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. Alternatively, pre-emergence application of 350 mL per acre Goal 23.5 EC (oxyfluorfen) using 200 litres of water can effectively control the weeds.

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.

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. **The farmers are advised to plant mentha only in that area where the distillation units are available.**

Plant Protection

A. Insect Pests

1. Termite *(Odentoterms obseus):* Termites attack the underground parts of the plants and damage the roots and the stems of mentha.

2. Cutworm *(Agrotis spp.)***:** Cutworms cut the young plants at the ground-level. They remain hidden near the base of the plants during day-time.

3. Jassid and Whitefly: The attack of these sucking pests adversely affects the plant growth and oil content.

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

- Use light-traps for the destruction of moths.
- Young larvae are gregarious. They can be destroyed by plucking the infested leaves or by pulling out the infested plants and burying them underground.

  The grown up caterpillars can be destroyed by crushing them under feet.

B. Diseases

1. 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.

CELERY

Celery, commonly known as *Karnauli*, is grown mostly in districts of Amritsar, Gurdaspur and Tarntaran. 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.

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.

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

Punjab Celery 1 (2016): It is a high yielding variety of celery. It produced an average seed yield of 4.5 quintal per acre. Its seeds contain 1.9 per cent essential oil with total oil content of 20.1 per cent. The seeds are brown in colour with characteristic odour and pungent taste. Punjab Celery 1 starts bearing flowers in March and matures in 140-150 days after transplanting.

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 seed per acre.

Time of Nursery Sowing: September 15 to October 15.

Nursery Raising: Mix 8-10 tonnes of well-rotten farmyard manure or compost per acre into the soil and give 4 or 5 ploughings to obtain fine tilth. Prepare seedbeds measuring 8m x 1.25 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 irrigation. To each bed apply 150 g mixture of calcium ammonium nitrate and single superphosphate in equal proportions. Sow 50 g 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.

For early and higher germination, apply 4-6 kg paddy straw mulch on each bed of 10 m^2. The seed germinates after 12-15 days. The mulch should be removed 5 to 10 days after the initiation of germination. About a fortnight after the germination of seed, apply 100 g calcium ammonium nitrate to each bed. If seedling size is not normal, apply another dose of 100 g 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.

- **Sow the nursery between 15 September and 15 October.**
- **Transplant 60-70 days old seedlings of same size during mid November to end December.**
- **To avoid shattering losses, harvest the crop when seeds in most of the umbels turn light brown.**

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. Apply light irrigation to the seedbeds a day before uprooting the seedlings.

Relay Cropping of Celery in Pea: Adopt relay cropping of celery in short duration varieties of pea for higher returns. For this purpose, sow 2 rows of pea on 60 cm ridges. Broadcast 4 kg seed of celery per acre immediately after first irrigation to pea or sow 2 rows of pea on 60 cm ridges in the fields where celery was grown during previous year and retain naturally germinated celery from the shattered seed of previous year crop. Uproot pea after taking 1-2 pickings and give hoeing to celery. Maintain proper plant population by thinning and/or gap filling wherever needed. Apply irrigation after gap filling. In relay cropping of pea and celery, adopt recommended practices for pea and after uprooting of pea, follow the practices recommended for celery.

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

Nutrients (kg/acre)		Fertilizers (kg/acre)		
N	**P_2O_5**	**Urea**	**DAP* or**	**Superphosphate**
40	16	90	35	100

* When 35 kg DAP is used, apply 75 urea per acre.

Apply 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.

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.

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.

Insect Pests: Aphids sometimes appear as pest. They suck cell-sap from the leaves and thus, adversely affect the crop growth.

Hints to minimize shattering losses

1. Use seedlings of the same age and size.
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

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

Sow 8-10 kg healthy and disease free capsules (seeds) per acre. Rub the capsules gently to break them into 2 to 4 parts to get uniform and good germination. Sow the

crop during last week of October to first week of November. The sowing should be done in rows 30 cm apart using pora method. Apply 30 kg N (65 kg urea) per acre in 2 splits, half at sowing and the remaining half at flower initiation. Two weedings should be done, first about 4 weeks after sowing and the second 5-6 weeks thereafter. The first irrigation may be given about 3 weeks after sowing. Subsequent irrigations (3-4) may be given when required taking care that there should not be moisture stress at flowering and seed development stages.

Harvest when the capsules are mature but green as green coloured capsules fetches a premium price over the brown coloured over-ripe capsules. Its average yield is 2.5 to 3 quintals of seed per acre.

FENNEL

Fennel is commonly known as *saunf*. Well drained sandy loam to loamy soil is best for its cultivation.

Ajmer Fennel 2 (2023): It produced an average seed yield of 5.0 quintals per acre which was 17.1 % higher than Local variety. Its seeds contain 1.6 to 1.8 % of essential oil. It takes 170-175 days for maturity.

The time of sowing is last week of October to first week of November.

Sow the seed 3-4 cm deep by kera method in rows 45 cm apart using 4 kg seed per acre. Apply 20 kg nitrogen (45 kg urea) in 2-3 splits depending upon the texture of the soil. Apply the first irrigation 10-15 days after sowing to ensure proper seedling-emergence and subsequent irrigation when needed. One or two weedings are required depending upon the intensity of the weeds.

Harvest when the umbel changes its colour from green to light yellow. For getting quality seeds for table purpose, harvest the crop at dough stage in early April.

DILL SEED

Dill seed is commonly known as *soe.* Well drained sandy loam to loamy soil is best for its cultivation.

Sow 2 kg seed per acre in 45 cm apart rows with a depth of 3-4 cm during second fortnight of October. Apply 35 kg nitrogen (75 kg Urea) in 2 or 3 splits depending upon the texture of the soil. Apply first irrigation 10-15 days after sowing to ensure proper seedling emergence. Subsequent irrigations should be given to ensure proper moisture throughout the growth period. In March and April, apply light irrigations on calm days to avoid lodging. Give 1-2 hoeings depending upon the intensity of weeds. The first hoeing may be done 30-40 days after sowing and overcrowded seedlings may be thinned at this stage.

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. The average yield is 3-4 quintals of seed per acre.

HONEY PLANT

Honey plant is an important medicinal crop grown for seeds. It performs best in well drained sandy loam to loamy soils. The time of nursery sowing is whole of September. Use 400 g seed for one acre crop.

Mix 8-10 tonnes well-rotten farmyard manure per acre into the soil. Prepare beds measuring 8 m x 1.25 m with a shallow channel around the beds to facilitate drainage and irrigation. Eight such beds will provide seedlings for transplanting in an acre. Sow 50 g clean seed on each bed after mixing of 80 g urea and 150 g single superphosphate in surface soil. Cover the seed with a mixture of farmyard manure and soil. Apply water with a sprinkler immediately after sowing. Apply 50 g urea to each bed about a fortnight after the emergence of seedlings. If seedling growth is not normal, apply another dose of 50 g urea per bed after about a month. Irrigate the nursery regularly and keep it free from weeds. Apply light irrigation to the seedbeds a day before uprooting the seedling.

Transplant 60 to 70 days old seedlings during November at a row spacing of 60 cm and plant-to-plant distance of 30 cm. Apply 25 kg nitrogen (55 kg urea) in 2-3 splits depending upon the texture of soil. Two or three hoeing are enough to keep the crop free from weeds. 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.

The crop is ready for harvest by the first week of May. Harvest when the umbels change colour from green to light yellow as delay in harvesting causes shattering of seeds. The crop should be harvested in the morning hours and transported to the threshing floor immediately to prevent seed shedding. It yields about 4-5 quintals seeds per acre.

FENUGREEK

Fenugreek commonly known as *metha* can be grown on all types of soils except water logged, alkaline and saline ones. However, it thrives best on well drained loamy soils.

ML-150 (1995) is an improved variety, moderately resistant to powdery mildew and stem rot diseases. Its plants are erect with dark green leaves. It has bright, yellow and bold seeds. Its average grain yield is 6.0 quintal per acre. It can also be grown for fodder purpose.

To get fine seedbed, 2-3 ploughings followed by planking are required. Sowing should be done in last week of October to first week of November at proper soil moisture conditions. Sow 12 kg seed per acre 3-4 cm deep in lines 22.5 cm apart. Apply 5 kg nitrogen (11 kg urea) and 8 kg P_2O_5 (50 kg single superphosphate) per acre at the time of sowing.

Three or four irrigations are enough to raise the crop. One or two hoeings may be given for effective weed control. Harvest the crop when colour of the pods changes from green to light yellow. Delay in harvesting results in shattering of seeds. It yields 6 quintals of seed per acre.

6. FODDER CROPS

The area under fodder crops in the state remains around 9.0 lakh hectares (about 3.5 lakh hectares in *rabi*) and the annual production of green fodder is about 716 lakh tonnes. As per 20th Livestock Census-2019, the total livestock population in Punjab is 70.5 lakh, out of which 65.5 lakh are bovines which are to be provided sufficient fodder of good quality. Each bovine gets green fodder supply of about 30 kg per day, but actually 40 kg green fodder per animal is required. Therefore, the present availability of green fodder is inadequate. On the basis of requirement per animal per day, approximately 956 lakh tonnes of green fodder is required annually. Therefore, fodder production in the state has to be substantially increased. With the increase of cross bred animals which need more fodder, its deficiency will be further aggravated unless efforts are made to increase the production of fodder. Therefore, fodder production in the state needs to be substantially increased.

Important Hints

- The supply of protein to animals from legumes is cheaper than from concentrates. The non-legume forages are rich in energy. It is, therefore, essential that fodders should be grown as mixtures, in which legumes, such as *berseem, shaftal, senji* and non-legumes, such as oats, ryegrass are grown together.
- Follow recommended time of sowing and seed rate and treat the seed before sowing.
- Use fertilizers in balanced amount.
- To get better quality of fodder, cut the fodder crop at proper stage.
- Irrigate the fodder crop one week before cutting to minimize anti-quality factors.
- Use specific herbicide as per recommendation in case of mixture of forage crops grown. Avoid use of unrecommended agro-chemicals on fodder crops as this may be harmful to dairy animals.
- Plants attacked by any insect-pest or disease-affected plants should be uprooted and destroyed.
- Do not grow fodder crops on soils high in selenium.
- An adequate supply of quality fodders during the lean periods of November-December and May-June can be ensured by preserving the green fodder as silage and hay.

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

BERSEEM

Berseem gives a highly nutritious and palatable fodder in repeated cuttings from November to mid-June. It is cultivated on about 2.25 lakh hectares.

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

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

Improved Varieties

BL 44 (2021): It is a quick growing variety with more number of tillers. It is moderately resistant to stem rot disease. It has superior nutritional quality especially for in-vitro dry matter digestibility. It supplies green fodder up to first week of June and yields about 395 quintals per acre of green fodder.

BL 43 (2017): It is a quick growing, tall variety with more number of tillers. It supplies about 390 quintals green fodder per acre up to first week of June and gives good seed yield.

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 quintals per 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.

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 2-3 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.

Seed Inoculation: The inoculation of berseem with the specific *Rhizobium* culture will increase the forage yield. Moist 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/terpal and dry it in shade. Then broadcast the inoculated seed in standing water on the same day, preferably in the evening because the direct sun light kills the bacteria. This bio-fertilizer is available with the Punjab Agricultural University, Ludhiana Seed Shop at Gate No. 1 and *Krishi Vigyan Kendra*/Farm Advisory Service Centres in different districts.

Seed Rate and Method of Sowing: When the weather is calm, broadcast 8 kg seed in standing water. In case of high winds, the seed should be broadcast evenly in dry field 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 seeds 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 12 kg seed of oats. In this case, oat 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 good 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 1 kg 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.

- **To check reddening of leaves**
  - **Do not grow berseem where tubewell water is not fit for irrigation.**
  - **Treat berseem seed with Rhizobium culture before sowing.**
  - **Use well rotten farm yard manure.**
- **To manage manganese deficiency, spray the crop with 0.5% manganese sulphate solution as per recommendations.**
- **For the control of stem rot disease don't sow the crop in badly infested fields for 3-4 years.**
- **For higher seed yield spray the seed crop with potassium nitrate or salicylic acid as per recommendations.**

Fertilizer Application: Apply 6 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 1/3rd 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: 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.

In sandy loam soil, irrigate the crop with good quality water at sowing and later irrigations with alternate use of saline tubewell water with canal water can be given.

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, thus giving 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 42, BL 43 and BL 44 varieties whereas it is second fortnight of April for BL-10 variety. *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.

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.

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.

To get higher seed yield, give two sprays of 2% Potassium nitrate (13:0:45) (2 kg potassium nitrate in 100 litres of water per acre) at weekly interval, starting from flower initiation. Alternatively, give two sprays of 7.5 g of Salicylic acid using 100 litres of water per acre. Salicyclic acid must be dissolved in 225 mL of ethyl alcohol before making the final volume in 100 litres.

Plant Protection

(a) Insect Pests

1. Black ants: Ants takes away the germinating seed in to their nest. 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 in 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 plant foliage 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.

4. Gram caterpillar: (*Helicoverpa armigera*) The attacks of this pest is serious on **seed crop**. Avoid raising of berseem seed crop adjoining to tomato, gram, late sown wheat, *sathi moong, sathi 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. 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 disease symptoms are visible during January and February when temperature is low. The fungus which is present as sclerotia 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 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. Do not sow berseem in badly infested fields for 3-4 years.

OATS

It comes second after berseem from nutritional point. It is grown on about 1.04 lakh hectares.

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 soils.

Improved Varieties

OL 17 (2024): It is a single cut variety for irrigated areas of Punjab. Its plants are tall, having long and broad leaves with more leafiness and tillering ability. Its fodder and silage quality parameters viz; *In vitro* dry matter digestibility and crude protein are at par to OL 15 and OL 13. On an average, it yields about 315 quintals of green fodder per acre. Its average seed yield is 9.6 quintals per acre.

OL 16 (2022): It is a dual type variety for irrigated areas of Punjab. Its plants are medium tall having broad leaves and more leafiness with profuse tillering. It has good fodder, grain and flour quality as well. Its first cut for fodder can be taken at 65-70 days after sowing and yields on an average about 90.0 quintals of green fodder per acre. Its regenerated crop, upon maturity gives on an average of 7.6 quintals per acre of grain yield.

OL 15 (2021): It is a single cut variety for irrigated areas of Punjab. Its plants are tall, having long and broad leaves with more leafiness and tillering ability. Its fodder quality is better than OL 12, OL 11, Kent and at par with OL 13. On an average, it yields about 319 quintals of green fodder per acre. Its seed yield is about 9.8 quintals per acre.

OL 14 (2020): It is a multicut variety for irrigated areas of Punjab. Its plants are tall with profuse tillering and leafy growth. The leaves are longer and broader. Its fodder quality is superior in terms of total digestible nutrients (TDN) and digestible crude protein (DCP) than OL 10. On an average, it yields about 307 quintals of green fodder per acre. Its seed yield is 10.9 quintal per acre.

OL 13 (2020): It is a single cut variety for irrigated areas of Punjab. Its plants are tall with profuse tillering and leafy growth. The leaves are longer and broader. Its fodder quality is superior in terms of DCP than OL 12 and Kent. On an average, it yields about 305 quintals of green fodder per acre. Its seed yield is 9.7 quintal per acre.

OL 12 (2018): It is a single cut variety for irrigated areas of Punjab. Its plants are tall, having long and broad leaves with more leafiness and tillering ability. Its fodder quality is better than OL 11, OL 9 and Kent. On an average, it yields about 258 quintals of green fodder per acre. Its seed yield is about 8.6 quintals per acre.

OL 11 (2017): It is a single cut variety with tall plants, leafy and profused tillering ability. Its fodder quality is superior to OL 9 and Kent. On an average, it yields about 245 quintals of green fodder and 8.5 quintals of seed per acre.

OL 10 (2014): It is a multicut variety. Its plants are tall with profused tillering and leafy growth. The leaves are longer and broader. Its fodder quality is superior in terms of TDN and DCP than OL-9 and Kent. On an average, it yields about 275 quintals of green fodder per acre.

Kent (1986): 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 Method of Sowing: Drill 25 kg seed per acre 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. Oats can also be sown without seed bed preparation with zero till drill after the harvesting of rice. This also helps in timely sowing of crop after basmati. “PAU Happy Seeder” can be used for sowing and simultaneous inter-row paddy straw mulch application without straw removal/burning after stubble shaving in combine harvested paddy fields.

In oats + *raya* mixture, sow oats as given above and broadcast 1.0 kg *raya* per 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.

Fertilizer Application: In single cut oats, apply 15 kg 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. In two cut variety, apply fertilizer to first cut as recommended for single cut oats and apply 20 kg N (44 kg urea) per acre to second cut after sprouting.

Weed Control: Interculture is generally not necessary, but the growth of weeds must be checked in the early stages of the crop by weeding, if necessary.

Irrigation: Three to four irrigations including the pre-sowing irrigation are sufficient.

Harvesting: The harvesting of single cut oats should be done from boot to milk stage. In multicut oats take first cut at 65-70 days after sowing and second cut at 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. Use 15 kg seed per acre in rows 30 cm apart. Apply 10 kg N (22 kg urea) and 8 kg P_2O_5 (50 kg superphosphate) per acre at sowing and 10 kg N (22 kg urea) 30-40 days after sowing.

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

(a) 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 natural check on its multiplication. Do not spray any insecticide on fodder crop as it is hazardous to animals and also kills the predators of the aphid.

(b) Diseases

1. Loose smut (*Ustilago avenae*): The individual flowers of the oats panicle are replaced by spore masses. Use disease free 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. Use disease free 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. It is grown approximately on an area of 11 thousand hectares.

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 2 (2020): It is a multi cut, fast growing, late flowering variety. Its leaves are long and broad. It has better fodder nutritional quality especially *in vitro* dry matter digestibility than Punjab Ryegrass 1 variety. It gives six cuttings from November to May with a green fodder yield of 327 quintals per acre.

Punjab Ryegrass 1 (1991): It is quick growing variety with 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.

Seed Rate and Method of Sowing: Sow 3 kg 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 per 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.

In sandy loam soil, irrigate the crop with good quality water at sowing and later irrigations with rotation of two irrigations with saline water followed by one irrigation of canal water can be given.

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. Apply 15 Kg N per acre (33 kg urea) for higher seed yield. 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 upto November at the seed rate of 2-3 kg per 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 herbicides. Therefore, no herbicide should be sprayed.

SHAFTAL

Shaftal commonly known as *Chhattala* or *Bhukal* is a highly nutritious legume fodder.

Shaftal 69 is an improved variety having long stalks leafy plants and light pink flowers. It is highly resistant to stem rot disease and suitable for disease infested fields. Shaftal supplies on an average 390 quintals of green fodder per acre up to mid may.

The optimum sowing time is last week of September to first week of October. Sow 4-5 kg seed per acre by same method as given in berseem. Shaftal can be sown in mixture with mustard (750 g), oats (12 kg) and ryegrass (2-3 kg) per acre.

Apply 5 kg nitrogen (11 kg urea), 20 kg phosphorus (125 kg single super phosphorus) per acre at sowing. When ryegrass has been mixed with shaftal, apply 5 kg nitrogen (11 kg urea) per acre after each cutting.

Apply first irrigation within 3-5 days after sowing, then irrigate at 8-10 days interval in summer and 10-15 days during winter depending upon the weather.

The first cutting is ready in about 55 days after sowing and subsequent cuttings can be taken at an interval of 30 days. The plant protection measures of shaftal are same as that of berseem.

LUCERNE

Lucerne is a leguminous crop which is grown on about 1.5 thousand hectares.

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

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

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 and is highly resistant to downy mildew. It gives eight cuttings upto first week of July and yields 280 quintals green fodder per acre.

Agronomic Practices

Preparatory Tillage: Plough the field once with a disc harrow and 2-3 times with a cultivator, followed by planking each time for securing a fine seedbed.

Seed Rate and Method of Sowing: Mid-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 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 along with the full seed rate of lucerne.

Seed Inoculation: The inoculation of lucerne with the specific Rhizobium culture will increase the forage yield as well as improve the fodder quality. *Rhizobium meliloti* culture is available at PAU Seed Shop, Gate No. 1, Ludhiana and *Krishi Vigyan Kendra*/ Farm Advisory Service Centres in different districts. 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.

Weed Control: To the planted crop, give the first hoeing about one month after sowing and the second after the rainy season.

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: 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: 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. 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 sometimes serious in this crop.

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

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.

Senji safed 76 (white flowered) and **YSL 106** (yellow flowered) are recommended varieties, which yield about 128 quintals of green fodder per acre.

YSL 106 is sown from end of September to end of October, while Senji safed 76 can be sown during second fortnight of November.

Broadcast 15 kg husked seed per acre, mix it in the soil and irrigate there after. In all two or three irrigations are enough.

Apply 25 kg Phosphorus (155 Kg Single superphosphate) per acre at sowing.

Harvest the crop, when it is full blossom.

SILAGE MAKING

Oat crop can be preserved as silage. It is essential that in making silage, the material is thoroughly chopped to a preferable length i.e. between 5 to 8 cm. Important points for preparing a high quality silage are given below:

1. Prepare silo trench of 10 m x 3 m x 1.5 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 6-7 cows or buffaloes for 4 months at 40 kg per head per day.
2. Oat crop should be harvested at their optimum stage of digestibility i.e. at milk stage.
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 *turi*. 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.
8. A well preserved material has pH of 4.5 and is low in losses of nitrogen. A good quality silage almost retains the nutritional value of original crop and has a high lactic acid and a low butyric acid content.

HAY MAKING

The aim of hay-making is to reduce the moisture content of green fodder to below 15 per cent so that little or no change in nutritive value occurs during storage. The fodder crops having soft stems are suitable for hay-making. In legumes such as berseem and lucerne, care should be taken to avoid shattering of leaves during drying. Non-legumes such as maize, *jowar, bajra* are more suitable for silage making than for hay making. Harvest the fodder crops at pre-flowering stage. Chop the fodder to a length of 5 to 8 cm and spread it in a 10-15 cm thick layer on a hard-surface to dry it in the sun. The usual threshing floor can also be used for this purpose.

To speed up the drying process, stir the fodder with a rake after every 2 to 3 hours during the day. When thoroughly dried (usually 2-3 days depending on the frequency of stirring), collect the dried material for storage. A practical method of determining the safe limit of moisture content for storage of dried material is to twist some of the stems. If the stem breaks easily, the hay is fit for storage. It can be stored in a room normally used for storing wheat *bhusa*.

A kilogram of dried hay containing 90 per cent dry matter is equivalent to about 6 kilograms of green fodder containing 15 per cent dry matter.

7. SOIL TEST BASED FERTILIZER APPLICATION

Soil testing is a best tool to ensure optimum and balanced use of fertilizers. Improper use of fertilizers leads not only to imbalanced nutrition but also deterioration of the environment. Soil testing comprises determination of organic carbon content and the amount of available nutrients besides, the basic characteristics such as soil reaction (pH) and soil salinity (electrical conductivity). Based on the soil test values, the soils are categorized as low, medium and high with respect to the status of available nutrients as under:

Nitrogen: Organic carbon (OC) content of soil is taken as an index of nitrogen (N) availability and thus it is used to make nitrogen fertilizer recommendations. 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) in available nitrogen. Soils low in organic carbon are poor in supplying nitrogen, therefore, apply 25 % higher dose of fertilizer over the dose recommended for soils which are medium in organic carbon content. On the other hand, in high organic carbon soils apply 25 % less fertilizer as compared to medium soils. Amount of urea required for major *rabi* crops in low, medium and high nitrogen soils is given in Table 1.

Phosphorus: Based on available phosphorus (P) content, soils are rated as low (less than 5 kg P per acre), medium (5-9 kg P per acre), high (9-20 kg P per acre) and very high (more than 20 kg P per acre). For soils testing low in phosphorus, need to apply 25 per cent more fertilizer over the recommended dose, whereas in high P soils reduce it by the same amount (Table 1). In soils testing very high in available phosphorus, omit phosphorus fertilizer application for 2-3 years and then again get the soil tested. However, in maize-wheat cropping system, when soil test phosphorus level is more than 16 kg per acre, there is no need to add any phosphorus fertilizer to both the crops.

In addition to soil phosphorus status, organic carbon content also influences the amount of fertilizer phosphorus required. 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 between 0.4 to 0.6 per cent, reduce the phosphatic fertilizer dose by one fourth in medium P soils, by one 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 per acre, apply half the recommended dose of phosphatic fertilizer. However, if the soil phosphorus status is more than 9 kg per acre, omit the application of phosphatic fertilizers. In all other categories of soil viz. soil with less than 5 kg P per 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.

Table 1. Fertilizer recommendations (kg/acre) for crops grown on different fertility category soils

Nutrient	Nitrogen			Phosphorus							
Soil test category	Low	Medium	High	Low		Medium		High		Very high	
Fertilizer	Urea			SSP or	DAP*	SSP or	DAP *	SSP or	DAP*	SSP or	DAP*
Wheat	130	110	90	190	65	155	55	125	45	-	-
Barley	65	55	40	100	35	75	25	55	20	-	-
Spring Maize	**(i) Varieties:** P 1844, PMH 10, DKC 9108 , PMH 8 and PMH 1										
	130	110	90	190	65	155	55	125	45	-	-
	(ii) Varieties: PMH 7										
	95	75	55	95	35	75	27	55	20	-	-
Toria	65	55	40	65	25	50	20	35	15	-	-
Raya and *Gobhi Sarson*	110	90	70	100	35	75	25	60	20	-	-
Sugarcane (Plant Crop)	165	130	100	75	25	-	-	-	-	-	-
Sugarcane (ratoon crop)	250	195	150	75	25	-	-	-	-	-	-
Sugarcane (Autumn)	250	195	150	75	25	-	-	-	-	-	-

* For each kg of DAP applied, reduce the amount of urea by 0.4 kg.

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

Soil organic carbon (%)	Soil category for phosphorus			
	Low (below 5 kg/acre)	Medium (5-9 kg/acre)	High (9-20 kg/acre)	Very high (above 20 kg/ acre)
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 fertility soils as given in Table 1

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, Shaheed Bhagat Singh Nagar, Jalandhar and Ropar districts generally show K deficiency.

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, Ludhiana 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 (21%) 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 from 2 weeks after 1st cutting.

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

For proper reclamation of the alkali (sodic) soils (pH more than 9.3), gypsum application must be accompanied with other management practices. In these soils, it is recommended to apply 25 per cent higher fertilizer nitrogen over that for the normal soils. Crops grown on alkali soils generally show zinc deficiency and require application of zinc sulphate at rates higher than those recommended for normal soils.

Saline soils (electrical conductivity more than 0.8 millimhos/cm) require 25 per cent extra fertilizer nitrogen. In these soils, addition of organic manures/green manures/ crop residues is beneficial. Farmers are advised not to apply gypsum to saline soils.

Collection of soil sample

For making fertilizer recommendations in field crops: Scrap away surface litter and make a V-shaped cut with a spade or a *khurpa* to a depth of 6 inches. Remove about 1” thick uniform slice of soil from one side of the cut. Similarly, collect samples from 7 to 8 places in the field of uniform texture and uniform fertility. Put the samples in a clean bucket, tray or cloth and mix it thoroughly. Take approximately half kg of 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.

Soil Testing Laboratories

Soil and water samples are tested by the following laboratories in Punjab:

1. Soil Testing Laboratory, Deptt. of Soil Science, Punjab Agricultural University, Ludhiana.
2. Soil Testing Laboratory, Regional Station (Punjab Agricultural University), Gurdaspur and Bathinda.
3. Soil Testing Laboratory, KVK's, Amritsar, Bathinda, Faridkot, Ferozepur, Gurdaspur, Bahowal (Hoshiarpur), Langroya (Shaheed Bhagat Singh Nagar), Patiala, Ropar, Kheri (Sangrur), Noormahal (Jalandhar), Samrala (Ludhiana), Kapurthala, Goneana (Sri Muktsar Sahib), Budhsinghwala (Moga) and Fatehgarh Sahib.
4. MARKFED and the Department of Agriculture and Farmer Welfare, Punjab have also established Soil-Testing Laboratories in the state.

8. ORGANIC FARMING

Organic farming prohibits the use of synthetic agro-chemicals and relies on crop rotations, crop residues, animal manures, composts, legumes, green manures and on-farm wastes to maintain the soil productivity and to supply plant nutrients to the crops. Disease and insect-pest management is done by using biopesticides.

Basic organic standards

- Conversion from chemical to organic farming requires a three year conversion period during which all the practices should be organic.
- A buffer zone must be created around the organic field to avoid any contamination or run off from the adjoining chemical fields.
- Seed should be from the organic produce and should not be treated with any chemical. Genetically modified (GM) crops are not allowed. The cultural practices of organic crops like seed rate, sowing time and spacing may be same as that of conventional crops, if otherwise not mentioned.
- Herbicides should not be used for weed control and weeds should be managed by cultural practices/methods and need based weedings.
- Chemical fertilizers, pesticides and growth regulators are prohibited.

Organic crop production

The best fields should be preferred for organic farming. The yields of organic crops are less than the inorganically grown crops during initial 3-4 years but later on they may become equal. Organic farming can be practiced in the following cropping systems:

1. Rice/Basmati Rice-Wheat

Rice/Basmati Rice

Biofertilizers: Make a solution of one packet of *Azospirillum* biofertilizer in requisite amount of water so as to dip the root of nursery seedlings for one acre in this solution for 45 minutes and transplant immediately.

Nutrition: The nutritional requirement of crop can be met by green manuring. Grow cowpea or sunnhemp or dhaincha 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 also be sown with no-till drill after harvesting wheat.

Weed Control: The water should be ponded for first 20-25 days. One manual weeding can be done as per need.

Insect-Pest Control

Stem borers: The larvae of these insects bore into the stem and cause damage from July-October. The infected young plants show dead-hearts whereas the old one produce empty earheads which turn white and stand erect. Use two tricho-cards each of *Trichogramma japonicum* and *T. chilonis* per acre, each card having 20,000 parasitized eggs of *Corcyra cephalonica*, 5-6 times at weekly interval, starting from 30 days after transplanting. Cut each tricho-card into 20 strips, each having approximately 1000 parasitized eggs. Staple these strips on the underside of leaves uniformly at 40

spots per acre during evening hours. These tricho-cards are available at the Biocontrol Labs, Department of Entomology, PAU Ludhiana and Regional Station, Gurdaspur.

Spray the crop with 80 mL neem based bio-pesticide, Ecotin (azadirachtin 5%) or 1000 mL or Neem Kavach/Achook (azadirachtin 0.15 %) in 100 litres of water per acre at pest initiation stage.

Leaf folder: The Larvae fold the leaves, eat out the green tissue and produce whitestreaks. The mechanical control of leaf folder can be done only before flowering by passing the 20-30 m long coir/jute rope, forwards and then backwards, both ways while touching the crop canopy. While passing the rope, ensure that water must be standing in the crop.

Biological control with neem and tricho-cards is same as mentioned for stemborers.

Planthoppers: These hoppers include whitebacked planthopper and brown planthopper. Both nymphs and adults of these pests suck the cell sap particularly from the leaf-sheath from July to October. The crop dries up in patches. As the plants dry up, the hoppers migrate to the adjoining plants and kill them. In a few days, the area of the dry patches enlarges. About one month after transplanting, a few plants in the field should be slightly tilted and tapped 2 or 3 times at the base at weekly interval. When planthoppers are noticed floating in the water, spray 80 mL Ecotin (azadirachtin 5%) or 4 litres PAU Homemade Neem Extract* in 100 litres of water per acre. Prefer Ecotin or PAU Homemade Neem Extract at pest initiation stage. Repeat the spray if necessary. For better effectiveness, use knapsack sprayer while directing its spray towards the base of the plants. If the damage is noticed at hopper burn stage, treat the affected spots along with their 3-4 metre periphery immediately as these spots harbor high population of the insect.

*Method of preparation is same as given under Wheat chapter at page no. 18.

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

Wheat

Method of Sowing: Wheat may be sown with any one of the conventional methods as given in wheat chapter. Prefer raised bed sowing with bed planter (2 rows on 37.5 cm wide bed with 30 cm furrow between two beds) for better weed control.

Seed Inoculation: Inoculate recommended quantity of seed for one acre with 500 g consortium or 250 g each of *Azotobacter* and *Streptomyces* (Azo-S) biofertilizer and one litre of water on pucca floor. Let it dry in shade and sow immediately.

Organic Manures: The organic sources like FYM and compost can be used. The quantity of the organic sources depends on the nitrogen content of the source and the organic matter content of the soil. These organic sources can be applied at the rate of 80, 120 and 160 kg N per acre in soils having high, medium and low organic matter content, respectively. The above amount of nitrogen can be obtained from the 8, 12 and 16 tonnes of FYM. To desi varieties of wheat apply half the doses of organic sources in respective soils. The nutritional requirement of 50 kg nitrogen per acre

to wheat can also be supplied through FYM, vermicompost and castor cake, each supplying 1/3 of the total nitrogen requirement. Apply 1.7 tonnes per acre FYM (1% N), 1.1 tonnes per acre vermicompost (1.5% N) and 0.7 tonnes per acre castor cake (2.5% N). The quantity of FYM may be increased or decreased depending upon its N content.

Weed Control: Cultural methods recommended for conventional crop can be used to control the weeds. The practices like dry soil surface mulch, stale seed bed, manual weeding before first irrigation and uprooting the weeds before they produce seeds can be followed to control the weeds. Give hand weedings as per the need.

Insect-Pest Control: There is no serious problem of insect-pests. The natural predators (*Coccinella septumpunctata*) become active on the appearance of the aphid. In case aphid infestation exceeds economic threshold level of 5 aphids per earheads (recorded from 10 randomly selected ear heads in each of the 4 quarters of one acre field), spray 2 litre per acre PAU homemade neem extract* at weekly interval in 80-100 litres of water per acre using knap sack sprayer.

*Method of preparation is same as given on page no. 18 under Wheat chapter

For the management of yellow rust of wheat in organic farming spray 20% fermented buttermilk (For one acre, dissolve 40 litres of fermented buttermilk in 200 litres of water) after one month of wheat sowing followed by three more spray after the appearance of yellow rust at an interval of ten days on moderately resistant varieties.

2. Maize/Soybean-Wheat

Maize

Seed Inoculation: Mix half kg packet of recommended consortium biofertilizer with one litre of water and then thoroughly mix it with maize seed on clean pucca floor. Let it dry in shade and sow the seed immediately.

Organic Manures: Incorporate the residues of previous wheat crop in the field. Apply well rotten farm yard manure on dry weight basis @ 8 tonnes per acre during the first five years and later on reduce it by 50 per cent. The green manure crop like sunnhemp/dhaincha should be sown @ 20 kg seed per acre in the third week of April or immediatly after harvesting wheat. Incorporate 40 to 45 days old green manure crop at 5 to 7 days before sowing the maize.

Weed Control: Give two hoeings about 15 to 30 days after sowing with *khurpa/ kasaula/*wheel-hoe/*triphali/*tractor-drawn cultivator or grow one or two rows of fodder cowpea in between maize rows and harvest it at 35 to 45 days after sowing, thereafter no weed control operation is required. For inter-cropping of cowpea, use 16 kg per acre for variety cowpea 88 and 8 kg per acre for variety CL 367. Sow maize and cowpea simultaneously.

Insect-Pest Control: To control maize borer and other insects, apply bio-insecticides like 120 mL per acre Neemazal (1%). The maize borer can also be managed by using tricho-cards twice having 40,000 eggs of *Corcyra* parasitized by *Trichogramma chilonis*. Make first release on 10 days old crop and second one week after first release. Cut tricho-cards into 40 equal strips and staple them uniformly on the underside of the central whorl leaves in evening hours. The tricho-cards should not be applied on rainy days.

Soybean

Seed Inoculation: Moisten the seed recommended for one acre with minimum amount of water and mix throughly one packet of *Bradyrhizobium* sp. (LSBR 3) with it and let it dry in shade. Sow the seed immediately.

Organic Manures: Incorporate the residues of previous wheat crop in the field. Apply well rotten farm yard manure on dry weight basis @ 4 tonnes per acre during the first five years of the start of organic farming and later on reduce it by 50 per cent. The green manure crop like sunnhemp/dhaincha should be sown @ 20 kg seed per acre in the third week of April or immediately after harvesting wheat. Incorporate 40-45 days old green manure crop at 5 to 7 days before sowing the soybean.

Weed Control: Apply 24 quintals per acre rice straw mulch at the time of sowing and if needed, give one hand weeding to remove the emerged weeds. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Appendix III). If paddy straw mulch has not been applied then give need based 2-3 weedings.

Insect-Pest Control: For controlling white fly and other insects, apply bio-insecticides like 120 mL per acre Neemazal (1%).

Wheat

Method of Sowing: Wheat may be sown with any one of the conventional methods as given in wheat chapter. Prefer raised bed sowing with bed planter (2 rows on 37.5 cm wide bed with 30 cm furrow between two beds) for better weed control.

Seed Inoculation: Inoculate recommended quantity of seed for one acre with 500 g consortium or 250 g each of *Azotobacter* and *Streptomyces* (Azo-S) biofertilizer and one litre of water on pucca floor. Let it dry in shade and sow immediately.

Organic Manures: Incorporate the residues of previous maize or soybean crop in the field. Apply well rotten farm yard manure on dry weight basis @ 8 tonnes per acre during the first five years of the start of organic farming and later on reduce it by 25 per cent.

Weed Control: Give need based 2-3 weedings.

Insect-Pest Control: There is no serious problem of insect-pests. The natural predators (*Coccinella septempunctata*) become active on the appearance of the aphid. In case aphid infestation exceeds economic threshold level of 5 aphids per earheads (recorded from 10 randomly selected ear heads in each of the 4 quarters of one acre field), spray 2 litre per acre PAU homemade neem extract* at weekly interval in 80-100 litres of water per acre using knap sack sprayer.

*Method of preparation is same as given under wheat chapter

For the management of yellow rust of wheat in organic farming spray 20% fermented buttermilk (For one acre, dissolve 40 litres of fermented buttermilk in 200 litres of water) after one month of wheat sowing followed by three more spray after the appearance of yellow rust at an interval of ten days on moderately resistant varieties.

3. Maize-Potato-Onion

This cropping system enables to harvest the comparable yield with the chemical

farming in the very first year if potato is intercropped with radish and onion with coriander. Sow maize in 1st fortnight of June, potato in the 1st fortnight of October and transplant onion in the 1st fortnight of January.

Maize

Seed Inoculation: Inoculate the seed as given under maize/soybean-wheat system in this chapter.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre to maize can be supplied through 1.7 tonnes FYM (1% N) + 1.1 tonnes vermicompost (1.5% N) + 0.7 tonnes castor cake (2.5% N).

Weeds and Insect-Pest Control: Control pests as given under maize/soybean-wheat system in this chapter.

Potato

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at planting.

Organic Manures: The nutritional requirement of 75 kg nitrogen per acre to potato can be supplied through 2.5 tonnes FYM (1% N) + 1.7 tonnes vermicompost (1.5% N) + 1.0 tonnes castor cake (2.5% N).

Weed Control: Give need based mechanical or manual weedings.

Intercropping: Radish can be intercropped in potato in the first fortnight of October on the southern side of each potato ridge and can be dugout in December after 50-70 days after sowing.

Onion

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of transplanting or mix two packets (0.5 kg each) of biofertilizer (*Azotobacter* sp. + *Sphingobacterium* sp. + *Burkholderia* sp.) in 80-100 litres of water. Dip the roots of rabi onion seedlings for one acre in this mixture for 30 minutes and transplant immediately.

Organic Manures: The nutritional requirement of 40 kg nitrogen per acre to onion can be supplied through 1.3 tonnes FYM (1% N) + 0.9 tonnes vermicompost (1.5% N) + 0.5 tonnes castor cake (2.5% N).

Intercropping: Coriander can be intercropped in transplanted onion by sowing one row of coriander after every five rows of onion in the first fortnight of January and can be harvested as green coriander 40 days after sowing and as seed crop in the second week of May.

4. Maize-Potato-Summer *Moong*

Maize

Seed Inoculation: Inoculate the seed as given under maize/soybean-wheat system in this chapter.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre of maize can be met through 5.0 tonnes dry FYM (1% N) or 3.3 tonnes dry FYM and 1.1 tonnes vermicompost (1.5% N).

Weeds and Insect-Pest Control: Control pests as given under maize/soybean-wheat system in this chapter.

Potato

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of planting.

Organic Manures: The nutritional requirement of 75 kg nitrogen per acre of potato can be met through 7.5 tonnes dry FYM (1% N) or 5.0 tonnes dry FYM and 1.7 tonnes vermicompost (1.5% N).

Weed Control: Give need based mechanical or manual weedings.

Summer *moong*

Seed Inoculation: Inoculate the seed with single packet of consortium biofertilizer (*Rhizobium* sp. LSMR-1 and Rhizobacterium RB-3) at the time of sowing. Moisten the seed using one packet per acre with about 300 mL of water. Mix the seed thoroughly with culture and let it dry in the shade. Sow the seed within one hour of application of biofertilizer.

Organic Manures: The nutritional requirement of 5 kg nitrogen per acre of summer moong can be met through 0.5 tonnes dry FYM (1% N) or 0.3 tonnes dry FYM and 0.1 tonnes vermicompost (1.5% N).

Weed Control: Give need based manual weedings.

5. Maize-*Durum* Wheat-Cowpea (fodder)

Maize

Seed Inoculation: Inoculate the seed as given under maize/soybean-wheat system in this chapter.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre to maize can be supplied through FYM, vermicompost and castor cake each supplying 1/3 of the total nitrogen requirement. Apply 1.7 tonnes per acre FYM (1% N) + 1.1 tonnes per acre vermicompost (1.5% N) + 0.7 tonnes per acre castor cake (2.5% N).

Weeds and Insect-pest Control: Control pests as given under maize/soybean-wheat system in this chapter.

Durum wheat

Seed Inoculation: Inoculate recommended quantity of seed for one acre with 500 g consortium or 250 g each of Azotobacter and Streptomyces (Azo-S) biofertilizer and one litre of water on pucca floor. Let it dry in shade and sow immediately.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre to durum wheat can be supplied through FYM, vermicompost and castor cake each supplying 1/3 of the total nitrogen requirement. Apply 1.7 tonnes per acre FYM (1% N) + 1.1 tonnes per acre vermicompost (1.5% N) + 0.7 tonnes per acre castor cake (2.5% N).

Weed Control: Integrated cultural practices should be adopted to reduce the incidence of weeds and the emerged weeds should be removed manually or mechanically twice or thrice depending upon the weed intensity.

Cowpea Fodder

Organic Manures: 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.

6. Turmeric-Onion

Turmeric

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of planting.

Organic Manures: The nutrition requirement of turmeric can be met by applying 6 trolleys of farmyard manure (6 tonnes of fully dried farmyard manure having 1% N) per acre. 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 Control: Apply 40 quintals per acre paddy straw mulch at the time of planting and if needed, give one hand weeding at 3 months after planting. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Appendix III). If straw mulch is not applied then give three hand weedings at 1, 2 and 3 months after planting the crop.

Onion

Biofertilizers: Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of transplanting or mix two packets (0.5 kg each) of biofertilizer (*Azotobacter* sp. + *Sphingobacterium* sp. + *Burkholderia* sp.) in 80-100 litres of water. Dip the roots of *rabi* onion seedlings for one acre in this mixture for 30 minutes and transplant immediately.

Organic Manures: The nutritional requirement of onion can be met by applying 4 trolleys of farmyard manure (4 tonnes of fully dried farmyard manure having 1% N). In case of non availability of required farmyard manure, apply 3 trolleys of farmyard manure (2.7 tonnes of fully dried farmyard) supplemented with 0.9 tonnes vermicompost (1.5% N). Apply consortium biofertilizer @ 4 kg per acre as soil application at the time of transplanting.

Weed Control: Weeds should be controlled by manual hoeing.

7. *Gobhi Sarson*

Sowing Method: Use 1.5 kg seed per acre. Sow the crop in rows 67.5 cm apart with plant to plant spacing of 10 cm.

Organic Manures: Farm yard manure @ 6 t/acre should be applied on loamy sand soil when crop is sown under organic farming practices. The quantity of FYM may be increased or decreased depending upon its N content.

Biofertilizer application: Moisten the recommended quantity of *gobhi sarson* seeds for one acre using minimum amount (50-100 ml) of water and apply 250 g of biofertilizer (*Bacillus* sp.) on pucca floor/polyethylene sheet. Dry the treated seeds in shade and sow immediately. Seed inoculation with this biofertilizer increases seed and oil yield. This bio-fertilizer is available in the Punjab Agricultural University,

Ludhiana Seed Shop at Gate No. 1 and Krishi Vigyan Kendra/Farm Advisory Service Centres in different districts.

Weed Control: Weeds can be managed by mechanical weeding with tractor or power weeder at 25 and 45 days after sowing. The escaped weeds, if any, can be removed by hand weeding.

Mustard aphid (*Lipaphis erysimi*)**:** Cold and cloudy weather is very favourable for the development of mustard aphid. The green plant lice become innumerable, covering the inflorescence and siliquae. They suck the plant sap in huge quantities and as a result, the plants remain stunted, siliquae shrivel up and seeds do not develop. The following integrated pest management programme is recommended for its effective control under organic farming conditions:

i. Sow the crop at recommended time preferably up to 3rd week of October
ii. Apply recommended dose of organic manures
iii. Spray any of the following biopesticides using 80-125 litres of water per acre at initiation of aphid attack, and repeat application at weekly interval, if required

Homemade neem extract - 4 litres
Modified *Brahmastra* - 4 litres

Preparation:

a) Homemade neem extract: Boil 4.0 kg terminal parts of the shoots of neem trees including leaves, green branches and fruits in 10 litres of water for 30 minutes. Then, filter this material through muslin cloth and use the filtrate for spraying at the recommended dose.

b) Modified *Brahmastra*: Put 2 kg leaves of guava, papaya, karanj and castor each, and 5 kg leaves of neem after grinding (paste form with little bit water) into 10 litres of dairy cattle urine. Boil the extract for 30 mintues and keep under shade for 48 hours followed by filtration. Use the filtrate as per recommended dose. This extract can be stored up to 5 months.

8. *Kharif moong*-Wheat-Summer *moong*

Kharif moong

Seed Inoculation: Moisten the seed recommended for one acre with minimum amount of water and mix it thoroughly with one packet of recommended Rhizobium culture and let it dry in shade. Sow the seed immediately.

Organic Manures: Apply 1.1 tonnes per acre farmyard manure (1.0% N) on dry weight basis at the time of sowing.

Weed Control: Give need based hand weedings.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests.

Wheat

Method of Sowing: Wheat may be sown with any one of the conventional methods as given in wheat chapter of *Rabi* package, 2024-25. Prefer raised bed sowing with bed planter (2 rows on 37.5 cm wide bed with 30 cm furrow between two beds) for better weed control.

Seed Inoculation: Inoculate recommended seed for one acre with 500 g consortium or 250 g each of Azotobacter and Streptomyces (Azo-S) biofertilizer and one litre of water on pucca floor. Let it dry in shade and sow immediately.

Organic Manures: Apply 5 tonnes per acre well decomposed farmyard manure on dry weight basis at the time of sowing.

Weed Control: Give need based 2-3 weedings.

Insect-Pest Control: The natural predators (*Coccinella septempunctata*) become active on appearance of the aphids. In case of aphid infestation, spray 2 litre per acre PAU homemade neem extract* at weekly interval in 80-100 litres of water using knap sack sprayer.

*Method of preparation is same as given under wheat chapter.

For the management of yellow rust of wheat in organic farming spray 20% fermented buttermilk (For one acre, dissolve 40 litres of fermented buttermilk in 200 litres of water) after one month of wheat sowing followed by three more spray after the appearance of yellow rust at an interval of ten days on moderately resistant varieties.

Summer *Moong*

Seed Inoculation: Inoculate the recommended seed for one acre with single packet of consortium biofertilizer (*Rhizobium* sp. LSMR-1 and *Rhizobacterium* RB-3) at the time of sowing. Moisten the seed with about 300 mL of water and mix thoroughly with culture and let it dry in the shade. Sow the seed within one hour of application of biofertilizer.

Organic Manures: Apply 0.5 tonnes per acre farmyard manure (1.0% N) on dry weight basis at the time of sowing.

Weed Control: Give need based hand weedings.

9. Okra-Radish-Pea

Okra

Organic Manures: Apply 3.6 tonnes farm yard manure per acre (1.0 % N) on dry weight basis at the time of sowing.

Mulching: Immediately after sowing, apply 3.6 tonnes per acre paddy straw mulch.

Weed Control: Use of mulch effectively manages weeds. Escaped weeds, if any, can be removed by hand weeding.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests. For the management of jassid and whitefly, spray 80 mL Ecotin 5% (neem-based insecticide) or 2.0 litre PAU Homemade Neem Extract*. Method of preparation of neem extract is same as given earlier.

Radish

Organic Manures: Apply 2.5 tonnes farm yard manure per acre (1.0% N) on dry weight basis at the time of sowing.

Mulching: Apply 3.2 tonnes per acre paddy straw mulch immediately after sowing.

Weed Control: Use of mulch effectively manages weeds. Escaped weeds, if any, can be removed by hand weeding.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests.

Pea

Seed Inoculation: Treat the seed with bacterial culture (*Rhizobium leguminosarum*). One acre culture packet should be mixed with half litre of water. Rub the mixture thoroughly on seed to give a fine covering of the culture to every seed. Thereafter, spread the seed in shade for drying and sow it immediately afterwards.

Seed Treatment: Treat the seed with 15 g Talc based formulation of *Pseudomonas fluorescens* per kg seed before sowing to control wilt, root rot and collar rot (*Fusarium oxysporum* and *Rhizoctonia solani*) diseases.

Organic Manures: Apply 2.0 tonnes farm yard manure per acre (1.0% N) on dry weight basis at the time of sowing.

Mulching: Immediately after sowing, apply 4.0 tonnes per acre of paddy straw mulch. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Appendix III).

Weed Control: Use of mulch effectively manages weeds. Escaped weeds, if any, can be removed by hand weeding.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests.

10. Brinjal-Pea

Brinjal

Organic manures: Apply 5 tonnes farmyard manure per acre (1.0% N on dry weight basis) at the time of seed bed preparation. The quantity of FYM may be increased or decreased depending upon its N content.

Weed management: Apply 4.8 tonnes per acre paddy straw mulch immediately after transplanting. Use of mulch effectively manages weeds. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (see Appendix III). The escaped weeds, if any, can be removed by hand weeding.

Insect-pest management: For management of whitefly, spray 1200 mL PAU Neem Extract* or 1500 mL maize/sorghum/bajra juice per acre.

***Method of preparation:** Boil 4.0 kg terminal parts of the shoots of neem trees including leaves, green branches and fruits in 10 liters of water for 30 minutes. Then filter this material through muslin cloth and use the filtrate for spraying at the recommended dose.

Pea

Seed treatment: Treat the seed with 15 g Talc based formulation of *Pseudomonas fluorescens* per kg seed before sowing to control wilt, root rot and collar rot **(***Fusarium oxysporum* and *Rhizoctonia solani***)** diseases.

Seed inoculation: Treat the seed with bacterial culture (*Rhizobium leguminosarum*) to ensure nodule formation and quick growth. One acre culture packet should be mixed with half litre of water. Rub the mixture thoroughly on seed to give a fine covering of

the culture to every seed. Thereafter, spread the seed in shade for drying and sow it immediately afterwards.

Organic manures: Apply 2 tonnes farmyard manure per acre (1.0% N on dry weight basis) at the time of seed bed preparation. The quantity of FYM may be increased or decreased depending upon its N content.

Weed management: Apply 4 tonnes per acre paddy straw mulch immediately after sowing. Use of mulch effectively manages weeds. The escaped weeds, if any, can be removed by hand weeding.

Insect-pest management: If needed, neem based biopesticides may be used to control insect-pests.

11. Maize-Pea-Summer *moong*

Maize

Seed Inoculation: Mix half kg packet of recommended consortium bio-fertilizer with one litre of water and then thoroughly mix it with maize seed on clean pucca floor. Let it dry in shade and sow the seed immediately.

Organic Manures: The nutritional requirement of 50 kg nitrogen per acre to maize can be supplied through 1.7 tonnes FYM (1% N) + 1.1 tonnes vermicompost (1.5% N) + 0.7 tonnes castor cake (2.5% N).

Weeds and Insect-Pest Control: Control pests as given under maize/soybean-wheat system in this chapter.

Pea

Seed inoculation: Treat the seed of one acre with half kg packet having consortium of three bacterial cultures (*Rhizobium leguminosarum* + PSB+ PGPR) to ensure nodule formation and quick growth. Rub the mixture thoroughly on seed to give a fine covering of the culture to every seed. Thereafter, spread the seed in shade for drying and sow it immediately afterwards.

Seed Treatment: Treat the seed with 15 g Talc based formulation of *Pseudomonas fluorescens* per kg seed before sowing to control wilt, root rot and collar rot (*Fusarium oxysporum* and *Rhizoctonia solani*) diseases.

Organic Manures: Apply 2.0 tonnes farm yard manure per acre (1.0% N) on dry weight basis at the time of sowing. The nutritional requirement of 20 kg nitrogen per acre to pea can also be met through 0.7 tonnes FYM (1% N), 0.44 tonnes vermicompost (1.5% N) and 0.28 tonnes castor cake (2.5% N) each supplying 1/3 of the total nitrogen requirement.

Mulching: Immediately after sowing, apply 4.0 tonnes per acre of paddy straw mulch. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Appendix III).

Weed Control: Use of mulch effectively manages weeds. Escaped weeds, if any, can be removed by hand weeding.

Insect-Pest Control: If needed, neem based biopesticides may be used to control insect-pests.

Summer *Moong*

Seed Inoculation: Inoculate the seed with single packet of consortium biofertilizer (*Rhizobium* sp. LSMR-1 and *Rhizobacterium* RB-3) at the time of sowing. Moisten the seed using one packet per acre with about 300 mL of water. Mix the seed thoroughly with culture and let it dry in the shade. Sow the seed within one hour of application of biofertilizer.

Organic Manures: The nutritional requirement of 5 kg nitrogen per acre of summer moong can be met through 0.5 tonnes dry FYM (1% N) or 0.3 tonnes dry FYM and 0.1 tonnes vermicompost (1.5% N). The nutritional requirement of 5 kg nitrogen per acre of summer moong can also be met through through 0.17 tonnes FYM (1% N), 0.11 tonnes vermicompost (1.5% N) and 0.07 tonnes castor cake (2.5% N) each supplying 1/3 of the total nitrogen requirement.

Weed Control: Give need based manual weedings.

12. Mentha (*Pudina*)

Seed Rate: About 2 quintals of freshly dug 5-8 cm long suckers are enough for one acre. This quantity can be had from half *kanal* (10 *marla)* of mentha.

Bio-fertilizers: Apply consortium bio-fertilizer @ 4 kg per acre as soil application before planting along with recommended fertilizer.

Organic Manures: Mentha responds favourably to organic manuring. Apply 6 tonnes FYM per acre (1.0 % N) on dry weight basis before planting. The quantity of FYM can be increased or decreased depending upon its N content.

Weed Control: To obtain good yield and high-quality oil, the crop should be kept free from weeds at all the stages of growth. For higher yield, apply paddy straw mulch @ 24 quintals per acre. Paddy straw bale shredder cum mulcher can be used for mulching of paddy straw (See Appendix III).

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.

13. Organic Fodder Production

The production technology for organic fodders is similar to that of conventional fodder crops except that chemical fertilizers, herbicides, insecticides and fungicides are not to be used on organic crops. The quantity of farmyard manure may be adjusted as per the nitrogen content of the farmyard manure.

Maize-Berseem-*Bajra*: Apply 3.5 tonnes of dry farmyard manure (1% N) per acre and sow maize in 2nd week of August. Harvest it after 50-60 days after sowing between milk ripe and dough stage of grain development. Then apply 1.0 tonnes of dry farmyard manure and sow berseem in the 2nd week of October which gives 4-5 cuttings. After berseem harvesting, apply 2.0 tonnes of dry farmyard manure and sow bajra in the 2nd week of June. Harvest it after 45-55 days after sowing at the ear initiation stage.

Maize-Berseem-Maize+Cowpea: Apply 3.5 tonne of dry farmyard manure (1%N) per acre and sow maize in 2nd week of August. Harvest it after 50-60 days after sowing

between milk ripe and dough stage of grain development. Then apply 1.0 tonne of dry farmyard manure and sow berseem in the 2nd week of October which gives 4-5 cuttings. After berseem harvesting, apply 3.5 tonnes of dry farmyard manure and sow maize+cowpea mixture in 2nd week of June by using 15 kg seed of maize and 15 kg of Cowpea 88 variety or 6 kg of CL 367. Harvest the mixture after 50-60 days after sowing at milk ripe to dough stage of grain development in maize.

Management of Maize Borer: The maize borer can be controlled by using tricho-cards twice having 50,000 eggs of *Corcyra cephalonica* per acre parasitized by *Trichogramma chilonis*; first release on 10 days old crop and second one week after first release. Cut tricho-cards into 50 strips, each having approximately 1000 parasitized eggs. Place these strips in the central whorl uniformly at 50 spots per acre during evening hours. These tricho-cards are available at the Biocontrol Labs, Department of Entomology, PAU Ludhiana and Regional Station, Gurdaspur.

Note: The bio-fertilizer cultures are available with the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

Certification of Organic Produce

The Government of India has formulated organic standards for certified organic production and accredited 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

Method of Preparing Phospho-compost

Collect rice-straw from fields and bring it to the composting site near the tubewell on the farm to have easy water availability. It can be made into bundles of convenient size (about 10-15 kilograms). Prepare large quantity of a “soaking solution” by thoroughly mixing one kg cow dung for every 1000 litre of water in a big tank. (The volume of the tank can be calculated by measuring Length x Breadth x Height of the tank in metres. One cubic metre is equal to 1000 Litres of water). Dip the bundles one by one into the “soaking solution” for 2-3 minutes.

Drain the excess solution by placing 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 composted in multiple heaps of 500 kg at one time leaving a passage of 1.0 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 penetrates the heap by using a lance with a sharp point to pierce the heap of rice-straw. Pierce the lance deepest possible with an aim to water uniformly). Composting can be terminated after 80-90 days by which time it is ready for processing or for field application. By this time its carbon and nitrogen ratio changes to 15:1. At this stage, strands of the rice straw are weak and twisting can readily break a hand-full of it.

Method for preparation of Vermicompost from paddy straw/ waste maize silage

1. For making vermicompost, cemented beds of dimensions 6' (length)×3' (breadth)×2' (height) should be constructed on leveled ground. The length of the bed may vary depending upon the space and resources.
2. The floor of the bed must be pucca floor to avoid seepage of vermin wash, faeces and urine of earthworms.
3. Firstly, lay the beds with one feet layer of paddy straw (chopped/unchopped)/waste maize silage. Paddy straw/waste maize silage is well moistened by sprinkling water to maintain moisture up to 60-70%.
4. Then second layer of 4-5 days old animal dung is applied up to 2 feet depth.
5. Introduce one kg earthworms of species (*Eisenia foetida*) per 6 feet length. The quantity of worms may vary if the bed size varied from standard dimensions.
6. Two inch layer of soaked paddy straw is applied on the beds to avoid water loss through evaporation.
7. Turning after every week is required to maintain aeration for earthworms and decomposition of paddy straw.
8. Water spray is applied two times a day in summer and 2-3 days interval in winter.
9. Vermicompost will be ready after 60-70 days and 45 days of composting of paddy straw and waste maize silage, respectively.

Precautions:

1. Fresh animal dung should be avoided as it has high temperature and high amount of gases which can be harmful to the earthworms.
2. The bed must be kept under the shed to protect the earthworms from direct sunlight, heat, cold and heavy rains.
3. The moisture in the beds must be 60-70%.

NATURAL FARMING

Natural farming is a chemical-free, agro-ecological farming system that integrates crops, trees and livestock to optimize biodiversity and promote ecological processes. It emphasizes using on-farm resources, indigenous practices and local knowledge to minimize external inputs and enhance soil health and fertility. It is largely based on on-farm biomass recycling with major stress on biomass mulching, use of on-farm cow dung-urine formulations; maintaining soil aeration and exclusion of all synthetic chemical inputs.

Key Principles of Natural Farming

1. Avoids use of chemical fertilizers, herbicides, or pesticides.
2. Uses natural formulations like *beejamrit, ghanjeevamrit* and *jeevamrit* from cow dung, cow urine, jaggery and pulse flour.
3. **Mulching:** Covers soil with crop residues, dried leaves, or green biomass to retain moisture, regulate temperature and improve fertility.
4. **Crop Diversity and Rotation:** Encourages intercropping, crop rotation and mixed cropping to maintain soil health and pest control.
5. **Promoting Soil Biology:** focuses on feeding the soil microflora instead of feeding the plant directly.
6. **Self-reliance and Low Input Cost:** Prepare all required inputs on the farm itself, significantly reducing cultivation costs.

Crop production under Natural Farming Practices

Natural Farming is best initiated on fertile and well-manured fields to ensure successful establishment. In the initial 4-5 years, crop yields under Natural Farming may be lower compared to those from conventional inorganic farming. However, with sustained practices, yields often stabilize and can eventually match those of conventional systems.

1. Maize-Potato-Summer *Moong*

In this cropping system, *kharif* maize and potato are cultivated using recommended organic practices, while summer *moong* is grown under Natural Farming practices.

Summer *Moong*

For seed treatment, soak the quantity of seed required for one acre in *beejamrit* for 30 minutes, then dry it in the shade before sowing. For nutrition, incorporate 4 quintals of *ghanjeevamrit* per acre into the soil two days prior to sowing. Additionally, apply *jeevamrit* at 200 litres per acre along with each irrigation. To manage weeds and conserve soil moisture, apply paddy straw mulch at 15-20 quintals per acre immediately after sowing.

Method of preparation of NF concoctions

i. ***Beejamrit*:** To prepare *beejamrit*, 5 kg of fresh dung from an indigenous cow is tied in a cloth and hung in a drum containing 20 litres of water for 12 hours. Afterward, the dung is squeezed into the water three times to extract the material. A handful of soil from under the tree/undisturbed/unused/forest land is added to the extract and mixed thoroughly. Then, 50 g of lime solution (prepared by dissolving 50 g of

lime in one litre of water) and 5 litres of cow urine are added to the drum and stirred well. *Beejamrit* is now ready for seed treatment and is used @ 20 litres per 100 kg seed.

ii. ***Jeevamrit*:** To prepare *jeevamrit*, 10 kg of fresh dung from an indigenous cow, 10 litres of cow urine, 2 kg of jaggery, 2 kg of gram flour and a handful of virgin soil are mixed in a 250-litre plastic drum. Then, 200 litres of water is added to the mixture and stirred well using a wooden stick. The drum is kept under shade and covered with a gunny bag. In summer, the mixture is allowed to ferment for 3 days and in winter, for 7-8 days. It is stirred twice (morning & evening) daily in a clockwise direction. Use *jeevamrit* within two days of its preparation.

iii. ***Ghanjeevamrit*:** To prepare *ghanjeevamrit,* 100 kg of indigenous cow dung is air-dried for 4-5 days. The dried dung is then mixed with 1 kg of jaggery, 1 kg of pulse flour, 3 litres of cow urine and 250 grams of virgin soil. The mixture is blended thoroughly and stored in a shaded area for 10 days. After the fermentation period, *ghanjeevamrit* is ready for field application.

9. MULTIPLE CROPPING

Multiple cropping is a system in which more than two crops are grown one after the other on the same piece of land in quick succession during a year. The success of this system depends upon the selection of suitable crops/varieties, availability of labour, farm machinery, irrigation, fertilizers, pesticides, finance, etc. in addition to the required technical know-how. Timely cultural operations, alertness and managerial capability of the farmer are highly critical factors in the success of multiple cropping. The objective is to grow one or two additional crops in between the main season crops. This can be made possible through selection of short duration high yielding varieties, older nursery seedlings under delayed rice transplanting, adoption of minimum tillage and inter-relay cropping and harvesting of wheat and maize by about 5-7 days earlier than the dead ripe stage.

Some of the important high intensity rotations for multiple cropping systems are:

1. Green manuring (*Dhaincha*/Cowpea/Sunnhemp)-Rice-Wheat: After harvesting wheat apply *rauni* and sow 20 kg seed per acre of *dhaincha* (pre-soaked in water for about 8 hours) or sunnhemp or 12 kg seed per acre of cowpea upto the end of April. Bury 6-7 weeks old *dhaincha*/sunhemp/cowpea, 1-2 days before transplanting of paddy. This will help in saving of about 25 kg N per acre for rice besides maintaining the soil health. However, for getting higher productivity of rice, practise green manuring and apply recommended dose of nitrogen (50 kg N per acre) in sandy to sandy loam soil. Likewise sowing of summer moong immediately after the harvesting of wheat in April end, after picking of pods, burying of its stover a day before transplanting of rice also helps to increase the paddy yield and in reducing the nitrogen dose of rice by one-third.

2. Cowpea/Bajra/Maize (fodder) - Maize/Rice-Wheat: Grow summer fodder crop (Cowpea/Bajra/Maize) with recommended seed rate and other practices, immediately after the harvest of wheat in the last week of April. These fodder crops will vacate field for timely sowing of the succeeding maize/rice crop. These fodder crops provide green fodder during the lean period in summer in the months of June. A fodder crop of 45-55 days old generally provides 80-100 quintals per acre of green fodder.

3. Green manuring-Maize-Wheat: Sow a green manure crop of *dhaincha*/ sunhemp/cowpea with recommended practices in the last week of April and burry it after 6-8 weeks stage. Allow it to decompose for about 10-12 days before sowing maize in the end of June. This practice will help in maintaining the soil fertility. In green manured field maize crop does not require any more application of organic manure (FYM etc.)

4. Maize/Rice-Potato-Wheat: Grow a short duration variety of maize/rice in mid of June. The short duration crop varieties shall vacate the field in the mid of September for timely sowing of succeeding crop of potato. Sow early maturing varieties of potato like Kufri Chandermukhi with recommended practices in the end of September. Harvest

12 weeks old crop of potato and later on sow late sown wheat variety (PBW 752) with 50% recommended N per acre without P and K application.

5. Maize/Rice-Potato-Summer *Moong*: Summer moong sown after wheat is liable to caught up in early monsoon rains. For getting successful crop of summer moong, it should preferably be sown after seed crop of potato in the second or third week of March. In these cropping sequences maize/rice could be planted in mid June to vacate the field for timely sowing of potato crop in the second fortnight of September. Further, the summer mung after potato do not require any fertilizer application if the preceding potato crop received recommended dose of NPK and FYM.

6. Rice-Potato/*Toria*-Sunflower: Transplant short duration variety of rice (PR 126) in mid June. This will vacate the field in mid-September. Potato (Kufri Chandermukhi) can be sown in the 3rd week of September and harvested in end of December. Alternatively, *toria* (TL-15) can also be grown after rice. Thereafter sow short duration variety of sunflower in the early January on southern slope of East-Westerly drawn ridges. Apply 12 kg N per acre to sunflower 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 cropping system, maize could be sown in early June to vacate the field for timely sowing of potato crop in second fortnight of September. Potato can be harvested after twelve weeks in end December. Alternatively short duration variety of *toria* (TL-15) can be grown after maize. Thereafter sunflower (short duration variety) can be grown successfully in early January southern slope of East-Westerly drawn ridges. Apply 12 kg N per acre after potato, if potato crop received recommended level of NPK alongwith 20 tonnes of FYM per acre. The sunflower crop will vacate the field in mid May for timely sowing of maize.

8. Groundnut-Potato/*Toria*/Pea/late *Kharif* fodder-Wheat: In groundnut-wheat cropping system, a crop of potato/*toria*/pea/late *kharif* maize fodder could be raised successfully. For this sow groundnut (variety SG 99 and M-522) during end of April and first week of May after the harvest of wheat. Further, as groundnut, crop vacates the field in early September, an additional crop of potato or early Pea (Ageta-6 or Arkel) or *Toria* (TL 15) or late sown maize fodder could be taken during the second fortnight of September. *Toria*/Pea/late sown fodder and potato vacate the field during December then the late sown wheat could be sown. Such a groudnut based cropping system has been found remunerative.

9. Maize-Potato-Onion: This cropping 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 in mid-June, potato (Kufri Chandermukhi) in first week of October and onion (Punjab Naroya) from 10-15 January for high yield realization. The soil fertility in relation to OC, available N, P and K also improve over time.

10. Groundnut-Potato-*Bajra* (fodder): This cropping system gives better productivity levels than rice-wheat system with sizeable saving of water and also ensures improvement in soil fertility. For this system sow groundnut (SG-99, M-522) in

first week of May, potato in first week of October and bajra fodder in the first fortnight of March.

11. Basmati Rice-Celery-*Bajra* (fodder): This cropping system is more remunerative and productive than the existing basmati rice-wheat system. Transplant basmati rice in mid July which will vacate the field in mid November. Then grow celery in December which vacates the field in first fortnight of May and after this grow *bajra* crop for fodder.

12. Basmati Rice-Berseem (fodder and seed): This cropping system provides substaintial net returns than the existing basmati rice-wheat system. Transplant basmati rice in mid July which will vacate the field in mid November. A successful crop of berseem for seed production can be grown in end November after the harvest of basmati rice. It provides three cuttings of green fodder before leaving the crop for seed production.

13. Maize-Potato-Mentha: This cropping system is doubly profitable than rice-wheat system and provides considerable saving of irrigation water. In this system sow maize in mid June which will vacate the field in second fortnight of September. Then grow potato (Kufri Chandramukhi) in the first week of October which will vacate the field in mid January and after this grow mentha crop in the second fortnight of January. The soil fertility in relation to OC, available P & K also improves over time.

14. Maize/Rice-*Gobhi sarson*-Summer *Moong*: These cropping systems produce more yield and economic returns than the maize-wheat and rice-wheat systems. Therefore, maize should be sown in the first fortnight of June, rice in second fortnight of June, *gobhi sarson* from 10-30 October and summer moongbean in the first fortnight of April. The summer moongbean can be sown without tillage after applying pre-sowing irrigation.

15. Rice-Gram-Summer *Moong*: This cropping 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.

16. Maize/Summer groundnut-Green Onion-Onion: These cropping systems produce higher yield and economic returns than the rice-wheat system. The groundnut should be sown in the second fortnight of May and maize in the first fortnight of June. The bulbs of onion sown in March should be uprooted in the month of June and stored in an airy place. These onion bulbs should be sown in the field after uprooting/ harvesting of summer groundnut/maize in second fortnight of September. The green onions are uprooted in the second fortnight of December. For *rabi* onions, nursery should be transplanted in the first fortnight of January. These onions are ready for harvesting in mid May.

17. Maize-Vegetable pea/Potato-Spring maize: These cropping systems produce more yield and economic returns than the rice-wheat system. The maize should be sown in the first fort night of June. The vegetable pea/potato can be sown in

the second fortnight of September and spring maize during first fortnight of February. Preferably grow spring maize under drip irrigation system.

Apply 2.5 tonnes per acre of crop residue mulch to each crop grown under surface and sub surface drip irrigation in *kharif* maize-potato-spring maize cropping system for water saving and higher productivity.

18. DSR-Potato-Mentha/Onion: These cropping systems produce more yield and economic returns than the rice-wheat system. Direct seeded rice should be sown in the first fortnight of June, potato can be sown in the second fortnight of October, mentha in second fortnight of January or onion can be transplanted in second fortnight of January.

19. DSBR-Potato-Mentha: This cropping system produce more yield and economic returns than the rice-wheat system. Direct seeded basmati rice should be sown in the second fortnight of June, potato can be sown in the first fortnight of November and mentha in first fortnight of February.

20. Soybean-Peas-Summer *moong*: This pulse based cropping system gives higher productivity and profitability as compared to rice-wheat system along with the improvement in the soil health. Soybean should be sown during first fortnight of June; Peas can be sown in the first fortnight of November and summer moong during second fortnight of March.

21. Groundnut-Peas-Sunflower: This cropping system gives higher productivity and profitability as compared to rice-wheat cropping system along with the improvement in the soil health. Groundnut should be sown during second fortnight of May, peas can be sown in the second fortnight of October and sunflower during first fortnight of February.

22. Spring Groundnut-Maize-Potato/Peas: These systems give higher productivity and economic returns than the rice-wheat cropping system along with improvement in soil fertility and soil microbial diversity. Spring Groundnut can be sown up to first fortnight of March, maize during first fortnight of July and sow potato and peas during mid of October.

23. Spring Groundnut-*Moong*-Potato/Peas: These systems give higher productivity and economic returns than the rice-wheat cropping system along with improvement in soil fertility and soil microbial diversity. Spring Groundnut can be sown up to first fortnight of March, moong during first fortnight of July and sow potato and peas during mid of October.

24. Summer *moong*-DSR-Wheat cropping system: This cropping system gives higher productivity and economic returns than DSR-wheat system. Summer *moong* can be sown in second week of April followed by DSR in the first fortnight of June. Incorporation of summer moong residue after picking of pods helps to increase the rice yield and also saves nitrogen. This system also improves soil fertility and soil micro flora and fauna over DSR-wheat.

25. Maize (Green cobs/fodder) Potato-Onion cropping system: This cropping system gives highest net returns with substantial saving of water and higher rice equivalent yield than rice-wheat system. For this system sow maize in the last week

of May to end of June and pick green cobs after 55 days of sowing for table purpose and green fodder can be used for milch animals, potato (Kufri Pukhraj) in first week of October and onion (Punjab Naroya) from 10-15 January for high yield realization. The soil fertility in relation to OC, available N, P and K also improve over time.

26. Summer *moong*-DSBR-Wheat cropping system: This system gives more yield and economic returns than the DSBR-wheat cropping system. Summer *moong* can be sown upto 20th April, followed by DSBR in the second fortnight of June and wheat in second fortnight of November. Incorporation of summer *moong* residue after picking of pods helps to increase the basmati yield and also saves nitrogen. This system also improves soil fertility and soil micro flora and fauna over DSBR-wheat.

Fodder cropping system

27. Maize-Berseem-*Bajra*: In this cropping system, 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 first or second week of October and take 4-5 cuttings. Then sow bajra in second week of June and harvest it after 45 to 55 days after sowing at the start of ear initiation stage.

28. Maize-Berseem-Maize+Cowpea: In this cropping system, sow maize in second 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 first or second week of October and take 4-5 cuttings. Then sow maize+cowpea mixture in second week of June and harvest it after 50 to 60 days after sowing when the maize crop is between milkripe and dough stage of grain development.

29. Sorghum multicut-Berseem cropping system: In this cropping system, sow multicut forage sorghum hybrid (Punjab Sudax Chari 4) in first week of May in rows 30 cm apart. The first cutting is ready in 55-65 days after sowing. Subsequently, cuttings can be taken after an interval of about 35-40 days. Sow berseem in the first or second week of October and take 4-5 cuttings.

SUB SURFACE DRIP IRRIGATION AND FERTIGATION

30. Maize-Wheat-Summer *moong*: Place drip inline having dripper having 20 cm spacing at 20 cm depth with lateral to lateral spacing of 67.5 cm spacing for sub surface drip fertigation in maize-wheat-summer moong cropping system. Sow one row of maize, two rows of wheat and two rows of summer moong on each drip inline during respective season.

Apply sub surface drip irrigation at 3 days interval for maize and summer moong with fertigation of 80 % recommended dose of NPK. In maize, apply 1/5 dose of NPK at sowing and fertigate remaining P and K in 5 splits and N in 7 splits at 9 days interval starting from 15 DAS. Apply sub surface drip irrigation at 7 days interval up to mid February and thereafter at 5 days interval to wheat with fertigation of 80 % recommended dose of NPK.

In wheat, apply 1/5th dose of NPK at sowing and fertigated the remaining NPK in 8 splits at seven days interval starting from crown root initiation. In summer moong fertigated NPK dose in 5 equal splits at 6 days interval starting from 10 DAS. Use urea, mono ammonium phosphate and muraite of potash as source of N, P and K,

respectively. If dripper discharge is 2.2 litre per hour, the following schedule should be adopted for sub surface drip irrigation in maize-wheat-summer *moong* cropping system:

Crop	Month	Time of irrigation (Minutes)*
Maize	July	35
	Aug	35
	Sept	50
	Oct	30
Wheat	Dec	30
	Jan	65
	Feb	70
	March	50
Summer Moong	May	60
	June	45

If discharge rate is different then time of irrigation may be adjusted proportionally by the formula

= (2.2 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

In field experiments, sub surface drip irrigation and fertigation resulted in 18.4% higher system productivity with saving of 28.5 % applied irrigation water and 20% nutrients than control.

31. Zero till direct seeded rice-Wheat: Place drip line having inline emitter with discharge rate of 2 litre per hour having 30 cm spacing at 15 cm depth with lateral to lateral spacing of 67.5 cm. Sow rice in dry soil without rauni but just after sowing apply irrigation on alternate days up to 21 days for proper establishment of the crop. Fertigate with 80 % recommended dose of nitrogen in five equal splits starting from 15 days of sowing at 12 days interval.

Sow the wheat crop without pre sowing irrigation. Fertigate with 80 % recommended dose of nitrogen in five equal splits starting from 21 days of sowing at 10 days interval. The following schedule should be adopted for rice and wheat crops:

Crop	Month	Time of irrigation (Minutes)*	Interval (days)
Rice	June	65	2
	July	65	2
	August	65	2
	September	65	2
	October	65	2

Wheat	November	45	21
	December	45	10
	January	45	10
	February	45	7
	March	45	5
	April	45	5

If the discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (2.0 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

This system improves the system productivity about 2.3 % with saving of 47% applied irrigation water and 20% nitrogen over conventional rice-wheat system.

32. Maize-Wheat raised on permanent beds: Place drip line having inline emitter with discharge rate of 1.6 litre per hour having 30 cm spacing in the center of permanent beds of 37.5 cm bed top with 30 cm wide furrow at 20 cm depth. Apply pre-sowing irrigation and sow one row of maize on the centre of the bed with double disc planter for better crop emergence.

For wheat, apply pre-sowing irrigation for 40 minutes about one week prior to sowing and sow two rows of wheat on the bed. Fertigate with 80 % recommended dose of nitrogen in five equal splits starting from 21 days of sowing at 10 days interval in both crops. The following schedule should be adopted for maize and wheat crops:

Crop	**Month**	**Time of irrigation (Minutes)***	**Interval (days)**
Maize	June	45	20
	July	45	10
	August	45	10
	September	45	7
Wheat	November	40	21
	December	40	10
	January	40	10
	February	40	10
	March	40	7
	April	40	5

If the discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (1.6 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

This system improves system productivity about 9% with saving of 53% applied irrigation water and 20% nitrogen over conventional maize-wheat system.

33. Cotton-Wheat: Place drip inline having emitter spacing of 20 cm at 20 cm depth keeping lateral to lateral spacing of 67.5 cm. Sow one row of cotton at 67.5 cm spacing and three rows of wheat at 22.5 cm spacing on each drip inline during respective season. In cotton, apply irrigation at 5 days interval starting from 30-35 days after sowing (DAS). Fertigate100 kg urea (45 kg N) per acre in 10 equal splits at 10 days interval starting from 30-35 DAS.

In wheat, apply irrigation at 7 days interval up to mid-February and thereafter at 5 days interval with fertigation of 80% recommended dose of NPK. Apply 1/5 dose of NPK at sowing and fertigate the remaining NPK in eight equal splits at 7 days interval starting from crown root initiation stage. If emitter discharge is 2.2 litre per hour, the following schedule should be adopted:

Crop	Month	Time of irrigation (Minutes)*
Cotton	May	40
	June	40
	July	35
	August	30
	September	25
Wheat	December	30
	January	65
	February	70
	March	50
	April	50

If the discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (2.2 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

34. *Kharif* maize-Peas-Spring maize: Install drip inlines having emitter spacing of 30 cm at 20 cm depth keeping lateral to lateral spacing of 60 cm. One drip lateral will serve one row of *kharif* maize, two rows of peas and one row of spring maize during respective seasons. Use 80% of the recommended dose of nutrients in all the crops. Irrigate the *kharif* maize at 3 days interval. Apply 1/5 dose of NPK at sowing and fertigate the remaining P and K in 5 splits, and N in 7 splits at 9 days interval starting from 15 DAS.

For peas, apply irrigation at 3 days interval. Apply 1/5 dose of N and P at sowing as basal and fertigate the remaining N and P in 9 splits at 6 days interval starting from 25 DAS. Use SSP fertilizer for basal application of P.

Irrigate the spring maize at 3 days interval starting from 12 DAS. Apply 1/5th dose of N and P at sowing and fertigate the remaining amount in 10 equal splits at 6 days interval starting from 30 DAS. Use urea, MAP and MOP as a source of N, P_2O_5 and K_2O, respectively for fertigation. If emitter discharge is 2.2 litre per hour, the following schedule should be adopted:

Crop	Month	Time of irrigation (Minutes)*
Kharif Maize	June	40
	July	35
	August	35
	September	50
Peas	October	20
	November	25
	December	25
	January	30
Spring Maize	February	25
	March	35
	April	65
	May	65

If discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (2.2 × time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

35. Cotton-*Gobhi sarson* (transplanted) cropping system: Place drip inline having emitter spacing of 20 cm at 20 cm depth keeping lateral to lateral spacing of 67.5 cm and sow one row of cotton at 67.5 cm spacing. Apply irrigation at 5 days interval starting from 30-35 days after sowing (DAS). Fertigate 85 kg urea and 20 kg mono-ammonium phosphate (12-61-0) per acre in 10 equal splits at 10 days interval starting from 30-35 DAS.

Transplant the succeeding *gobhi sarson* as per the recommended technology and apply irrigation immediately. Initiate drip irrigation at 15 days after transplanting at 7 days interval as per the given schedule. Fertigation should be started at 15 days after transplanting and all fertilizers should be applied in 10 equal splits at 7 days interval.

Fertigate 70 kg urea, 16 kg mono-ammonium phosphate and 9 kg elemental sulphur, respectively. If emitter discharge is 2.2 litre per hour, the following schedule should be adopted:

Crop	Month	Time of irrigation (Minutes)*
Cotton	May	40
	June	40
	July	35
	August	30
	September	25
Gobhi sarson (transplanted)	December	60
	January	50
	February	50
	March	60

If discharge rate is different, then time of irrigation may be adjusted proportionally by the formula

= (2.2 x time of irrigation (min)*) ÷ Discharge of dripper (litre per hour)

CONSERVATION AGRICULTURE

36. Rice-Wheat: Retention or incorporation of both paddy and wheat residue for 12 year continuously in rice-wheat cropping system gives more wheat yield (22.68 q per acre) and rice-wheat system productivity (50.88 q per acre) over only paddy straw incorporation or retention. Retention or incorporation of both paddy and wheat residues also improved soil health which is desirable for sustainable rice-wheat production.

10. INTEGRATED FARMING SYSTEM

'Integrated Farming System' is an economically viable option to enhance the farm productivity, reduce the environmental degradation, nutritional security and upliftment of resource poor farmers. Integrated farming system is the favourable and adequate combination of crops, livestock, aquaculture, agro-forestry, agri-horticulture so as to ensure sustainability, profitability, balanced food availability and employment generation. In addition, integrated farming system is the resource management strategy for sustained production and to meet diverse requirements of farm households to make the agriculture cost-effective, remunerative and above all to ensure livelihood security of the farming community.

The Punjab Agricultural University, Ludhiana based on long-term research, has come out with 2.5 acre model of integrated farming system for small farmers with the following components:

Component	**Area (*kanal*)**
Field crops	7.0
Fodder	4.0
Oilseeds/pulses	1.0
Fruit trees with intercropping of seasonal vegetables	4.0
Agro-forestry	1.0
Dairy(2 cows/buffaloes) shed with composting/vermicomposting unit	0.5
Goat Farming (9 does+1 buck)	-
Fishery (with high density boundary planting of fruit trees and Napier *bajra*)	2.0
Kitchen gardening	0.5
Planting of turmeric on bunds around field crops	-
Boundary plantation of *karonda* and *galgal* (optional)	-

The integrated farming system involving crop + dairy + kitchen gardening and other secondary components alongwith location. Specific agri-based enterprises can be included after acquiring proper training. The integrated farming system is highly remunerative as compared to conventional rice-wheat cropping system.

11. SPRAY TECHNOLOGY

The success of insect-pests, diseases and weed control depends upon use of proper spraying technology. Adopt following recommendations for efficient and effective management of weeds, insect-pests and diseases:

Selection of pesticide: Correct identification of insect-pest, disease and weed is very essential for proper selection of pesticides. Always use the recommended brand of herbicide, pesticide and fungicide.

Selection of spray pump and nozzle: Spraying of pesticides can be done with knapsack sprayer (manually or battery operated) or tractor operated sprayer (See Appendix V). For spray of pre-emergence herbicides at the time of sowing, use flat fan or flood jet nozzles. Always use flat fan nozzles for spraying post emergence herbicides. Use cone type nozzle for the control of insect-pests and diseases.

Quantity of water: Always use 200 litres of water for pre-emergence herbicides at the time of sowing and 150 litres of water per acre for post emergence application. Use 200 litres of water for control of diseases and 100-150 litres of water per acre for control of insect pests. To estimate the water required for spraying, fill the spray pump with measured quantity of water and spray in the field. After spraying, measure the area sprayed and calculates the required quantity of water per acre by the following formula:

$$\text{Quantity of water (l/acre)} = \frac{\text{Volume of water consumed (litre)} \times 4000}{\text{Sprayed Area } (m^2)}$$

Preparation of spray fluid: According to the quantity of water needed for an acre as calculated above, calculate the number of spray pumps required for spraying one acre. For example, if water required for spraying in one acre is 150 litres and capacity of spray pump is 15 litre. It means 10 pumps are required for spraying one acre area. In this case dissolve the quantity of pesticide required for one acre in less quantity of water and make the volume to 10 litre. Now, pour one litre of this pesticide solution in one spray pump. For tractor operated sprayer, prepare the pesticides solution as per the capacity of spray tank.

Method of spray: Nozzle height at the time of spraying is very important. Maintain nozzle height around 1.5 feet from the crop canopy during spraying of herbicides, insecticides and fungicides on the crop. Similarly in case of pre-emergence herbicides, maintain the nozzle height at 1.5 feet from ground surface. Always spray in strips by keeping the spray lance straight. Do not move the spray lance to and fro. Use multiboom nozzles for uniform spray. In case of backpack type electrostatic sprayer, electrostatic nozzle should not be lifted above the shoulder height. Maintain the distance of the electrostatic nozzle tip about 1 to 1.5 feet above the crop canopy. Only 15 litres of water per acre is required for spraying with electrostatic sprayer.

Precautions during spraying

- Always purchase recommended brands of pesticides and obtain bill from the shopkeeper.
- Read carefully instructions given on pesticide label and follow the same.
- Clean the spray pump with washing soda/surf solution before and after spray. If possible, keep separate pumps for spraying herbicide and other pesticides.
- Do not tear open the pesticide packet but use scissor or knife for this purpose.
- Use recommended dose of pesticides and apply at appropriate time.
- 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.
- Always use clean water for spraying to avoid clogging in the nozzles.
- Wear hand gloves for preparation of spray fluid, and gas mask, full sleeve shirt and trousers during spraying.
- Only healthy person without any wound on body should be engaged for spraying.
- Do not spray on an empty stomach.
- Never spray accross the direction of the wind flow. Spray should be done on calm days.
- Do not blow the clogged nozzle. If nozzle clogs, remove and disassemble the nozzle assembly. Clean the openings/filter and nozzle tips of any obstructions and reassemble.
- If the discharge rate of the nozzle exceeds by 10-15% than the initial discharge rate, the nozzle is considered as worn out. Replace the worn out nozzle.
- Do not touch the nozzle tip while operating the backpack type air-assisted electrostatic sprayer.
- Operator should not work for more than 8 hours a day. Those engaged in handling pesticides should be checked by a physician regularly.
- The worker should not smoke, chew, eat or drink while spraying and must wash hands and feet thoroughly with soap and water after handling or use of pesticide.
- Keep pesticides in labelled containers only.
- Store pesticides in a safe and locked place, out of the reach of children, irresponsible persons and pets.
- Never store pesticides near foodstuffs or medicines.
- Do not use the empty containers of pesticides for any purpose. Destroy them by making holes.

12. 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 behaviour and tremendous potential to multiply, they maintain their large populations which cause extensive damage in crop fields and other premises. They cause more damage at seedling and ripening stages of the crops. 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.

Methods of Control:

i. Mechanical Control

- **Killing:** During irrigation of vacant harvested fields, rats coming out of flooded burrows may be killed with sticks.
- **Trapping:** 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. 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. Do not place the traps at the same place again and again.

ii. Cultural Control

Weeds, grasses and bushes should be removed from the fields as these provide shelter and food to rats and mice. Highly infested bunds, water channels and field pavements should be periodically rebuilt to destroy permanent rat burrows. Keep the height and width of bunds to minimum and avoid crop lodging.

iii. Biological Control

Owls, kites, hawks, falcons, eagles, snakes, monitor lizards, cats, mongoose etc. are the natural predators of rats and mice. These should be protected.

iv. Chemical Control

Poison Bait Preparation

The acceptance of poison baits by rats and mice depends upon the quality, texture, taste and odour of the baiting materials, therefore, bait should be prepared as under:

- **Zinc phosphide bait (2%):** Take 1 kg of bajra or sorghum or cracked wheat or their mixture and mix it thoroughly with 20 g of edible vegetable oil, 20 g of powdered sugar and 25 g of 80% zinc phosphide powder.

Caution: Never allow water to mix in zinc phosphide bait and always use freshly prepared bait. Minimum interval between two baitings of zinc phosphide must be 2 months. To increase the acceptance and efficacy of zinc phosphide bait, do pre-baiting. For this place bajra or sorghum or cracked wheat or their mixture smeared with oil and powdered sugar @ 400g/acre at 40 bait points on pieces of paper for 2-3 days.

- **Bromadiolone bait** (**0.005%**)**:** Take 1 kg of bajra or sorghum or cracked wheat or their mixture or flour and mix it thoroughly with 20 g of edible vegetable oil, 20 g of powdered sugar and 20 g of 0.25% bromadiolone powder.

Poison Bait Placement and Timings

a. Wheat Crop

- In fields sown under **conventional tillage**, period of mid February to early March (before milky grain stage) is critical for the control of rats and mice as acceptance of bait is poor after this period due to abundant food available to them in the form of ripening crops. During this period place zinc phosphide or bromadiolone bait @ 400g/acre throughout the field on pieces of paper.
- Rat infestation and damage is more in fields sown under **zero tillage**. In such fields do first poison baiting with zinc phosphide in burrows before sowing (late October and early November) of wheat. Do second poison baiting with zinc phosphide or bromadiolone @ 400 g/acre on pieces of paper in mid February to early March.
- Rat infestation and damage is still higher in fields sown with **Happy Seeder**. In such fields do first poison baiting with zinc phosphide in burrows twice at an interval of 10-15 days after sowing of crop in the months of November-December. Do second poison baiting with zinc phosphide or bromadiolone @ 400 g/acre on pieces of paper in mid February to early March.

b. Sugarcane Crop

Since sugarcane crop harbours high rodent population, poison baiting should be done first in July (after paddy transplantation) and second in October-November (after paddy harvest). At each of these two timings do baiting with zinc phosphide or bromadiolone followed by another baiting after 15 days with bromadiolone @400 g per acre each. If the crop is to be harvested after January-February, third baiting should be done with bromadiolone @800 g per acre on 40 bait papers in January.

For burrow baiting, close all the burrows in the evening and in the reopened burrows on the next day insert a paper boat containing about 10 g of poison bait 6 inches deep in each burrow. In case of covered burrows, gently remove the soil from the burrow opening to locate the tunnel and then put the poison bait deep inside it.

For paper baiting, place 10 g of zinc phosphide or bromadiolone bait on pieces of paper at 40 bait points per acre on dry sites throughout the field covering runways and activity sites of rats.

Note: In crop fields, the rodenticide baiting should be done when the number of live rodent burrows is more than 10/acre.

Safety Measures:

- Keep the rodenticides and poison baits away from reach of children, domestic animals, pets and birds.

- Mixing of rodenticides in the baiting material should be done with a stick, spade or by wearing gloves. Avoid inhaling of poison through mouth and nose.
- Household utensils should never be used for preparation of the poison bait.
- Collect and burry the left over poison bait and dead rats.
- 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.

v. Integrated Approach

No single method is 100% effective in controlling rats and mice. Left over population reproduces reaching the original size in a short time. Therefore, adopt an integrated approach by using different methods at different stages of the crop.

Village Level Campaign

Control of rats and mice in smaller areas usually becomes 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.

Rodent Proof Storage Structure

For rodent proofing of cover and plinth storage structure made under outdoor bulk grain storage conditions, built plinth at a height of 2.5 feet from ground level and extend platform by one foot from all the four sides of the plinth.

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 harmful to sunflower. House crows damage sprouting maize, sunflower and maturing maize. Doves and pigeons damage pulses. Sparrow and weaver birds damage stored grains at shellers and godowns. These birds also damage rice nurseries and maturing bajra and sorghum.

Management Techniques for Harmful Birds

i. Mechanical Control:

- Use crackers to scare the birds at different intervals.
- 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 at least at 10 days interval. The height of the scare crow should be 1 meter above from the crop height.

- Use automatic bird scarers by shifting their position periodically and supplementing their noise with other simple method like 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 the 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.

ii. Cultural Practices

- The traditional practices of planting 2-3 border rows of less costly crops like millet, maize and dhaincha equally preferred by birds will reduce the bird pressure to the inside sown cash crops particularly sunflower and maize etc. Moreover, planting of these crops also act as physical barriers/ wind breakers and help in preventing lodging of crops during stormy/rainy days.
- 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.
- To prevent parakeet damage in sunflower and maize crops sowing should be discouraged in small block areas, at least 2-3 acre block area is more suitable, for lessening bird damage pressure because parakeet avoid feeding /venturing in the core of the field.

iii. Alarming Calls

Playing of CD (available with Centre of Communication and International Linkages, PAU, Ludhiana) of distress or flock calls of parakeets and crows respectively at peak volume for ½ 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 hour, 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 integrated pest management. For covering larger area use of amplifier and additional speakers as per requirement can be done.

Conservation of useful Birds

Predatory birds like owls, falcons, hawks, eagles, kites etc. eat large number of rats and mice. A single owl normally eats 4-5 rats a day. Insect eating birds like drongos, babblers, shrikes, lapwings, mynas and many other small birds eat away numerous insect pests. Even grainivorous birds like sparrows and weaver birds feed a large number of insects to their young ones. A single pair of house sparrow feed insects to their young about 250 times a day. Therefore, the useful birds should not be killed. Rather they can be attracted to crop fields in several different ways.

APPENDIX- I(A)

MINIMUM SUPPORT PRICE OF DIFFERENT CROPS

(₹ per quintal)

Crop	Crop year				
	2020-21	2021-22	2022-23	2023-24	2024-25
Paddy (Common)	1868	1940	2040	2183	2300
Paddy (Grade 'A')	1888	1960	2060	2203	2320
Jowar (Hybrid)	2620	2738	2970	3180	3371
Bajra	2150	2250	2350	2500	2625
Maize	1850	1870	1962	2090	2225
Arhar (*Tur*)	6000	6300	6600	7000	7550
Moong	7196	7275	7755	8558	8682
Mash (*Urad*)	6000	6300	6600	6950	7400
Groundnut	5275	5550	5850	6377	6783
Sunflower Seed	5885	6015	6400	6760	7280
Soybean	3880	3950	4300	4600	4892
Sesamum	6855	7307	7830	8635	9267
Cotton (Medium staple)	5515	5726	6080	6620	7121
Cotton (Long staple)	5825	6025	6380	7020	7521
Wheat	1975	2015	2125	2275	2425
Barley	1600	1635	1735	1850	1980
Gram	5100	5230	5335	5440	5650
Lentil (Massar)	5100	5500	6000	6425	6700
Rapeseed/ Mustard	4650	5050	5450	5650	5950
Sugarcane#	310/300/295	360/350/345	380/370/365	391/381/381	401/391/391

State Advisory Price for early/mid/late sugarcane varieties

APPENDIX- I(B)

DISTRICT-WISE AREA, PRODUCTION AND YIELD OF VARIOUS *RABI* CROPS, 2023-24

District	Wheat			Barley			Total *Rabi* Cereals	
	A	P	Y	A	P	Y	A	P
Amritsar	188.6	956.4	5071	-	-	-	188.6	956.4
Barnala	113.2	643.1	5681	0.3	1.3	4209	113.5	644.4
Bathinda	254.4	1299.7	5109	0.6	2.3	3684	255	1302
Faridkot	114.9	619.1	5388	0.1	0.5	4598	115	619.6
Fatehgarh Sahib	84.5	427.6	5060	0.2	0.7	3642	84.7	428.3
Fazilka	198	1022.9	5166	0.8	3.1	3857	198.8	1026
Ferozepur	188.5	989.1	5247	-	-	-	188.5	989.1
Gurdaspur	185	900.6	4868	-	-	-	185	900.6
Hoshiarpur	144	611.7	4248	-	-	-	144	611.7
Jalandhar	173.5	840.6	4845	-	-	-	173.5	840.6
Kapurthala	106.2	535.8	5045	-	-	-	106.2	535.8
Ludhiana	243.6	1247.7	5122	1	3.5	3455	244.6	1251.2
Malerkotla	52	292.3	5621	0.4	1.6	4014	52.4	293.9
Mansa	172.8	980.5	5674	0.3	0.9	2877	173.1	981.4
Moga	177.6	977.3	5503	0.2	0.7	3651	177.8	978
Pathankot	40.5	165.7	4092	-	-	-	40.5	165.7
Patiala	232.8	1182.4	5079	0.2	0.7	3499	233	1183.1
Rupnagar	67.2	327.7	4877	0.1	0.4	3588	67.3	328.1
S.A.S. Nagar	52.2	226.9	4347	0.1	0.3	2725	52.3	227.2
S.B.S. Nagar	77.8	379.2	4874	-	-	-	77.8	379.2
Sangrur	239.2	1355.3	5666	0.6	2.6	4279	239.8	1357.9
Sri Muktsar Sahib	216.7	1208.8	5578	0.2	0.8	3804	216.9	1209.6
Tarn Taran	192.6	985.1	5115	-	-	-	192.6	985.1
State	**3515.8**	**18176**	**5170**	**5.1**	**19.1**	**3737**	**3520.9**	**18195.2**

A: Area in 000 hectares, P: Production in 000 metric tonnes, Y: Average yield in kg/ha

Source: Department of Agriculture & Farmers' Welfare, Punjab

District-wise Area, Production and Yield of Various *Rabi* Crops, 2023-24

District	Rapeseed & Mustard			Gram			Lentil (*Massar*)		
	A	P	Y	A	P	Y	A	P	Y
Amritsar	2.5	4.5	1799	-	-	-	-	-	-
Barnala	0.8	1.5	1841	0.1	0.18	1799	-	-	-
Bathinda	3	5	1681	0.1	0.1	960	-	-	-
Faridkot	0.7	1.3	1836	0.13	0.05	1495	-	-	-
Fatehgarh Sahib	0.9	1.7	1925	-	-	-	-	-	-
Fazilka	7.9	13.1	1655	0.9	1.51	1679	-	-	-
Ferozepur	0.7	1.4	1965	-	-	-	-	-	-
Gurdaspur	3	4.2	1413	-	-	-	0.1	0.05	471
Hoshiarpur	4	4.7	1186	0.03	0.03	888	0.1	0.05	462
Jalandhar	0.8	1.2	1489	-	-	-	-	-	-
Kapurthala	0.7	1.2	1755	-	-	-	-	-	-
Ludhiana	2.1	4.2	2007	-	-	-	-	-	-
Malerkotla	0.4	0.6	1585	-	-	-	-	-	-
Mansa	2.8	4.9	1744	0.1	0.13	1323	-	-	-
Moga	0.9	1.6	1731	-	-	-	-	-	-
Pathankot	1	1.4	1396	0.02	-	96	-	-	-
Patiala	1.1	1.8	1650	-	-	-	-	-	-
Rupnagar	3.2	4.7	1463	0.1	0.16	1576	-	-	-
S.A.S. Nagar	1.2	1.6	1374	-	-	-	0.2	0.1	491
S.B.S. Nagar	1.4	2.2	1552	-	-	-	-	-	-
Sangrur	1.6	2.9	1798	0.02	0.05	1804	-	-	-
Sri Muktsar Sahib	1.3	1.9	1485	-	-	-	-	-	-
Tarn Taran	1.1	1.7	1578	-	-	-	-	-	-
State	**43.1**	**69.4**	**1611**	**1.4**	**2.2**	**1561**	**0.4**	**0.2**	**478**

A: Area in 000 hectares, P: Production in 000 metric tonnes, Y: Average yield in kg/ha

Source: Department of Agriculture & Farmers' Welfare, Punjab

District-wise Area, Production and Yield of Various *Rabi* Crops, 2023-24

District	Sugarcane (cane)			Sunflower		
	A	P	Y	A	P	Y
Amritsar	6.6	551	83430	-	-	-
Barnala	0.2	18	88080	-	-	-
Bathinda	0.1	8	83254	-	-	-
Faridkot	-	-	-	-	-	-
Fatehgarh Sahib	2.3	182	78994	0.1	0.2	1988
Fazilka	1	43	42673	-	-	-
Ferozepur	0.1	6	63940	-	-	-
Gurdaspur	22	1996	90724	-	-	-
Hoshiarpur	25.1	1989	79246	-	-	-
Jalandhar	9.6	796	82931	-	-	-
Kapurthala	3.7	318	86000	-	-	-
Ludhiana	2.4	214	89035	-	-	-
Malerkotla	0.6	54	90175	-	-	-
Mansa	-	-	-	-	-	-
Moga	0.1	8	83254	-	-	-
Pathankot	3.7	271	73345	-	-	-
Patiala	1.5	141	93931	0.2	0.4	2087
Rupnagar	2.6	189	72517	-	-	-
S.A.S. Nagar	1.6	122	76451	0.6	1.2	2006
S.B.S. Nagar	5.3	452	85196	-	-	-
Sangrur	1	99	99261	-	-	-
Sri Muktsar Sahib	0.2	17	83254	-	-	-
Tarn Taran	0.5	36	72260	-	-	-
State	**90.2**	**7510**	**83254**	**0.9**	**1.8**	**2022**

A: Area in 000 hectares, P: Production in 000 metric tonnes, Y: Average yield in kg/ha

Source: Department of Agriculture & Farmers' Welfare, Punjab

APPENDIX- II(A)

FIELD STANDARDS FOR FOUNDATION AND CERTIFIED SEEDS

Crop	Isolation distance (metre)		% Pollen shedders (maximum)		% Off type plants (maximum)		% Inseparable other crop plants/ earheads (maximum)		% Objectionable weeds (maximum)		% Plants/earheads affected by seed born disease (maximum)		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	-	-	-	-	-	-	
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	-	-	-	-	-	-	
Berseem	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

F: Foundation C: Certified

* Barley, Oats, Gram & Triticale ** Oats, Wheat, Gram & Triticale # Mexican prickly poppy (*Satyanasi*)

Chicory (*Kasni*) ## # Wild Helianthus spp. (Wild Sunflower)

APPENDIX- II(B)

SEED CERTIFICATION STANDARDS FOR FOUNDATION AND CERTIFIED SEEDS

Crop	% Pure Seed (Minimum)	% Inert matter (Maximum)	No. of Seeds per Kg (Maximum)						Diseased seeds (%)		Germination % (Minimum)	Moisture % (Maximum)
			Other crop seeds		Weed seeds		Objectionable weed seeds					
	F & C	F & C	F	C	F	C	F	C	F	C	F & C	F & C
Wheat	98	2	10	20	10	20	2#	5#	None* 0.05**	None* 0.25**	85	12
Barley	98	2	10	20	10	20	-	-	-	-	85	12
Gram	98	2	-	-	-	-	-	-	-	-	85	9
Lentil	98	2	5	10	10	20	-	-	-	-	75	9
Pea	98	2	None	5	None	None	-	-	-	-	75	9
Rape-seed and Mustard	97	3	10	20	10	20	5##	10##	-	-	85	8
Linseed	98	2	10	20	5	10	-	-	-	-	80	9
Berseem	98	2	10	20	10	20	5###	10###	-	-	80	10
Sun-flower Hybrids	98	2	None	None	5	10	None	None	None^	None^	70	9

F: Foundation C: Certified # Wild morning glory (*Hiran Khuri*) and *Gulli Danda* ## *Satyanashi*

Chicory *(kasni)* * 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

I) Recommendations for Implements/Machines

General recommendations in respect of implements and machines used in agriculture are given below:

- The selection of the implements or machinery should be made on the basis of size and draft requirements which should match with the power available on the farm.
- Design, field capacity, materials, availability of spare parts and cost of operation per hour or per acre are important criteria to be considered in order to arrive at the decision to own a machine or any implement.
- Implements and machines including tractor involve a lot of investment. Periodic maintenance before and after the use of machinery is therefore, very necessary. In most cases, owner's manuals will provides safe guidelines. On following these guidelines, machinery is expected to give un-interrupted service throughout its life.
- The seed-cum-fertilizer drill and the tractor mounted sprayer should be calibrated before they are used.
- Safety rules must be followed and adhered to strictly while operating tractors and high-speed agricultural machinery to avoid the loss of life and property.

Seed-cum-Fertilizer Drill

In selecting a seed-cum-fertilizer drill, the following points should be considered:

- It must have provision for varying line-to-line distance.
- The machine must have provision to control the depth of seed placement.
- The metering system of the drill should not damage the seeds which pass through the system.
- All furrow openers must deliver the same quantity of seed and fertilizer.
- A good agitator in the fertilizer box is desirable to avoid bridging.
- 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.

Calibration of Drill

Calibration means such a setting of the metering mechanism that ensures the dropping of the right quantity of seed and fertilizer in the field. The drills are already calibrated by the manufacturers, but the calibration may become defective during transportation. Further, the same calibration may not be found appropriate for all varieties of seed. The method of calibration is given below:

- Jack-up the seed-cum-fertilizer drill and check the free rotation of the driving wheel and the grain and fertilizer feed-shafts.

- Place the container or bag under each seed tube.
- Measure the circumference of the wheel. The circumference gives the distance covered in one revolution of the wheel.
- Find out the size of the drill by multiplying the number of furrow-openers by the distance between the furrow openers.
- Find out the number of revolutions required to sow one acre area as follows:

$$\text{Number of revolutions} = \frac{\text{Area of an acre (4000 sq. m.)}}{\text{Size of drill (m) X Circumference of wheel (m)}}$$

- Multiply this figure by 9/10 to take care of the wheel-slippage in the field.
- Mark a point on the rim of the wheel. Rotate the wheel by 1/10th of the number of revolutions required to sow one acre as above. Collect the seed quantity from each container separately and weigh.
- For getting seed rate per acre, multiply by 10.
- If the quantity collected from each container is not uniform, then check for a defect in the seed-dropping mechanism.
- Adjust the shift-lever on the feed box for grain rate accordingly, i.e. if the seed rate seems to be less than the actual quantity required per acre and then move the indicator a little to the higher side and vice-versa.
- Repeat this process twice to get the correct setting of the seed rate.
- Calibrate in the same manner for fertilizer rate.

Weight of Seeds Dropped in Five Revolutions of ground wheel

(For each seed tube of seed-cum-fertilizer drill)

Distance between rows	Size of Wheel			
	45 cm/18”	**60 cm/24”**	**75 cm/30”**	**90 cm/36”**
20 cm/8”	15-18 grams	20-22 grams	25-28 grams	32-34 grams
22 cm/9”	18-20 grams	24-26 grams	30-33 grams	37-39 grams

Combine Harvester

Some farmers own combines while some other get this facility on custom hire basis from the other agencies. There have been reports that in several instances the combine did a poor job, resulting in considerable loss of grain. The loss of grains as loose grains or ear heads can occur at the following points in a combine:

(i) At the cutter bar: These losses can be seen on the ground if all the discharge from behind the machine is collected in a bag and then the machine performance is observed for some distance. These can be avoided or reduced by setting the proper height of cutter-bar-reel and forward speed.

(ii) Behind the Machine: These losses will be either in the form of unthreshed heads or loose grains. Too many unthreshed heads mean that the cylinder-speed and the cylinder-concave clearance are not properly adjusted. Too many loose grains may be due to many chocked sieves or excessive air blasts or both. Proper machine adjustment including running at speed according to the plant density can reduce such losses.

(iii) Grain Delivery: Unclean grain or broken grain or both will result from excessive cylinder speed or improper sieve-chaffer setting or improper forward speed.

Combine is very sensitive to adjustments which are required to be made at turning or according to the varying plant density, crop conditions (lodged etc.) and ground level (bunds) etc.

To get a rough estimate of losses, measure one metre square area and collect the grain and loose material fallen on it behind a combine. Separate the grains and weigh in grams. Multiply this by 10 to get the loss in kilograms per hectare. Alternatively, estimate the loss by counting the number of grains collected from one square metre area. One hundred grains per sq. metre mean about 40 kg per hectare for wheat.

Tips to Save Diesel

- Badly maintained tractor wastes upto 25 per cent of the diesel used.
- Prevent leakage of diesel as it is a direct wastage.
- Wrong gear selection can increase fuel consumption upto 30 per cent and reduce output upto 50 per cent.
- A smoky tractor wastes diesel upto 20 per cent.
- 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.
- 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.
- Relug worn out tyres.
- Operate the tractor at the correct throttle setting to give the recommended PTO speed for operating pumping set or thresher.
- Keep the correct inflation pressure in tyres.

Guidelines for proper maintenance of farm machinery

- 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.
- 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.
- 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.

- 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.
- Check the oil level of the gear box and top up if necessary.
- If machine has belt-drive, one must check the belt tension and tight the belt if necessary.
- Clean the chains thoroughly; wash them with oil and coat the links with grease or use engine oil to prevent them from rusting.
- In the off-season, keep your machine under covered shed to protect against sun, rain and dust, otherwise its life will be shortened. Paint your equipment if it has come off.
- For all equipment with tyres, place logs or bricks under the axle or frame to remove the load from the tyres.

Farm Equipment/Implements Recommended for Various Operations for *Rabi* Crops

Operation	Implement	Source of Power	Capacity/ output	Remarks/Comments
Tractor	Machines for tillage and sowing operation	Tractor (any hp)	As per tractor-machine capacity	An auto-steering system can be installed on tractors for various field operations to enhance operational efficiency and reduce operator discomfort.
Lawn grass cutter and collecter	Tractor Operated Turf Manager for cutting and collecting grass	Tractor (50 hp or above)	5.0 acres/day, Fuel consumption 5-8 l/acre and Capacity 300-700 kg/hr	It can cut and collect grass simultaneously. It helps saving labour and time for collection of grass after cutting.
Paddy Straw Management				
	Combine harvester with PAU Super SMS attachment	Self-propelled (80-120 hp)	13-16 acre/day	Super straw management system (SMS) attached at rear of combine harvester for chopping and even distribution of loose straw.
	Happy seeder	Tractor (45 hp or above)	5.0-6.25 acre/day	Wheat can be directly drilled into combine harvested paddy field without any burning or removal. The loose straw should be uniformLy spread in the field before sowing either manually or harvest paddy with combine harvested fitted with PAU Super SMS.
	PAU straw cutter cum spreader	Tractor (35 hp or above)	9-10 acre/day	It improves the efficiency (20%) of PAU Happy Seeder by chopping and spreading of straw after combine harvesting of paddy.

	PAU Happy seeder	Tractor (45 hp or above)	6.0-7.0 acre/day	Wheat can be directly drilled into combine harvested paddy field without any burning or removal. The loose straw and standing stubbles should be cut and spread by stubble shaver/cutter.
	Paddy straw chopper cum spreader	Tractor (40 hp or above)	6-7 acre/day	The paddy straw chopper cum spreader chop the straw into small pieces and spread it on the surface.
	Stubble Shaver	Tractor (35 hp or above)	12-14 acre/day	For cutting standing stubbles
	Mould-board plough	Tractor (35 hp or above)	5.4-6.75 acre/day	Used to open up unploughed land. Field capacity will depend upon size of implement and soil conditions.
	Reversible Mould-board plough	Tractor (45 hp or above)	5.8-7.25 acre/day	
	Biomass Incorporator (Modified Mould Board Plough with Clod Crusher)	Tractor (50 hp or above)	5.0-5.6 acre/day	Used to simultaneously perform the function of mould board plough along with breaking big soil clods. This will reduce the number of secondary tillage machinery operations needed for seedbed preparation. It can also be used to incorporate chopped green manure/biomass into the soil.
	Straw Baler	Tractor (50 hp or above)	8.0 acre/day	It collects the straw and compress in the form of bales.
	Zero-till-Drill	Tractor (35 hp or above)	7-10 acre/day	Wheat can be sown in unprepared field after harvest
	Strip-till-Drill	Tractor (35 hp or above)	6.25-8.75 acre/ day	Wheat can be sown in unprepared field after harvest
	Super Seeder	Tractor (55 hp or above)	4.5-5.5 acre/day	Wheat seeds can be directly drilled into combine harvested paddy fields without any straw burning or removal and also in cotton stalks. Harvest paddy with combine harvester fitted with Super SMS before sowing of wheat. Wheat straw can be incorporated into soil with this machine also.
	PAU Smart Seeder	Tractor (45 hp or above)	7-8 acre/day	

	Combine with SMS attachment	Tractor mounted combine (50-60 hp) Self-propelled combine 80-120 hp	1.0-1.25 acre/h 2.0-2.50 acre/h	SMS attached at rear of combine below the straw walkers and behind the chaffer sieves for uniform distributions of loose straw. SMS is operated with- • V-belts and pulley arrangement used for power transmission should be appropriately covered against paddy residues. • Counter rotating discs should remain in motion during harvesting operation in the field for uniform spreading of residues.
	PAU Surface Seeder	Tractor (40 hp or above)	15 acre/day	For uniform broadcasting of seed and fertilizer along with cutting and spreading of whole straw in a combine harvested (fitted with Super SMS) field.
Harrowing				
	Sub-soiler	Tractor (45 hp or above)	6-8 acre/day	Used to open up unploughed land. Field capacity will depend upon size of implement and soil conditions.
	Disc-Harrow (Spike Tooth)	Tractor (35 hp or above)	6.25-8.75 acre/ day	Used to break clods, chop weeds and pulverising soil
	Bar-harrow (Spike Tooth)	Tractor (35 hp or above)	7.5-8.75 acre/day	Breakes soil crust and uproots early weeds
	Cultivator	Tractor (35 hp or above)	6.25-12.5 acre/ day	Loosen the soil for better aeration and pulverisation
	Cultivator with pulverising roller	Tractor (35 hp or above)	6.25-12.5 acre/ day	For better pulverisation and fuel saving
Seeding and Fertilizer application				
	Seed-cum-Fertilizer Drill	Tractor (35 hp or above)	9.0-11.0 acre/day	For uniform seed and fertilizer distributions in rows
	Dual seed drill		6.25-8.75 acre/ day	Single machine can sow oil seed (small seeds) and wheat.
	Lucky-seed-drill	Tractor (35 hp or above)	6.0-8.0 acre/day	This machine has automatic spraying attachment which is used for sowing and simulaneous spray of pre-emergence herbicides.
	Row crop planter (Inclined plate)	Tractor (35 hp or above)	7.5-10.0 acre/day	Sunflower and maize seed can be planted on ridges or flat field using ridger/flat type planters.

	Manual oilseed drill	Two persons	1.25-2.0 acre/day	For sowing of gobhi sarson and raya and for intercropping in wheat
	PAU manually operated seeder	Manual	0.15-0.28 acres/hr	For direct sowing of crops like peas, radish, turnip, spinach, gram, fenugreek, okra, mustard, millets etc. and suitable for small farmers.
	Ridger planter	Tractor 35 hp	7.50 -10.0 acre/ day	Maize seed can be planted on ridges
	Tractor operated Sugarcane planter	Tractor 35 hp or above	4.0 acre/day	Use setts of 20" length
	Tractor operated Sugarcane cutter planter	Tractor 40 hp or above	2.5-30 acre/day	This machine cuts sugarcane setts, applies fungicide, insecticides automatically. Row spacing 60-90 cm adjustable.
	Tractor operated Sugarcane trench digger	Tractor 35 hp or above	6-8 acre/day	This machine makes trenches for paired row sugarcane planting and a bed for intercropping. The paired two row spacing 30 cm.
	Tractor operated Sugarcane trench planter	Tractor 45 hp or above	2-3 acre/day	This machine makes trench and cut sugarcane setts, apply fertilizer and plant two rows of sugarcane.
Sprayers				
	Knapsack sprayer	Manual	1.5-1.75 acre/day	--
	Power operated Boom Sprayer	Engine/ Tractor	6.25-30.0 acre/ day	Depending upon the power source and number of nozzles.
	Boom Type Sprayer attachment	Four wheel drive self propelled paddy vehicle	2.0-3.45 acre/ hour	For spraying in row crops such as paddy, wheat etc.
	Drone/ Unmanned Aerial Vehicle (UAV) fitted with spraying system	Battery (Lithium Polymer)	2.5 acre /hour	A hexacopter drone fitted with a flat fan nozzle or anti-drift/air induction nozzles to be operated (by certified pilot) at a pressure of 1.38 kg cm-2 along with a forward speed of drone 2.0-3.0 m/s and at height of 2.0-3.0 m above the crop.
Mulching for weed control and moisture conservation				
	Paddy straw bale shredder cum mulcher	Tractor (35 hp or above)	6.0-7.0 acre/day	It reduces straw size and spreads it uniformly in the field to act as a mulch.

Interculture				
	Kasola-hoe	Manual	0.38-0.50 acre/ day	--
	V-Blade hoe	-do-	-do-	--
	Wheel hand hoe	-do-	0.75-1.25 acre/ day	--
	Rotary weeder	Tractor 35 hp or above	0.75-1.0 acre/h	For weeding in wide row crops especially sugarcane.
Harvesting				
a) Wheat stacking	Vertical Conveyor Reaper	Tractor (35 hp or above)	7.5-10 acre/day	Eight persons are required for crop collection
b) Berseem	Scythe	Manual	0.38-0.50 acre/ day	Saves 60% labour in comparison to sickle
Threshing				
a) Wheat	Spike Tooth Thresher	5-20 hp motor/ Tractor	0.8-7.5 q/h	--
	Syndicator/ Toka Thresher	-do-	1.5-12.0 q/h	Can handle wet crop also.
	Harambha Thresher	15-20 hp motor/ Tractor	10-15 q/h	-- do --
b) Sunflower	Sunflower Thresher	7.5-15 hp motor or Tractor	4-10 q/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/ tractor	5-10 q/h	
	Maize dehusker cum thresher	5-20 hp motor/ tractor	15-20 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.

e) Moong Thresher	Spike tooth thresher	7.5 hp electric motor/ equivalent diesel engine/ Tractor	2.5 q/h	Spike tooth thresher for wheat can be used with following modifications: i) Retain only one spike in each row in a spiral manner. ii) Increase concave clearance to 25 mm. iv) Operate the thresher at peripheral speed of 19-21. This can be achieved by increasing the existing pulley size on thresher by factor of 1.1 to 1.2.
Combine				
	Tractor mounted combine	Tractor (50-60 hp)	1.0-1.25 acre/h	--
	Self-propelled combine	80-120 HP	2.0-2.50 acre/h	--
	Self- Propelled combine (with Maize header)	-do-	5- 8 acre/day	1. Adjustment needed 2. Six persons are required for machine operation
	Wheat straw combine	Tractor (50 hp or above)	6.25-7.0 acre/day	Stubbles can be bruised as wheat straw (TURI)

II) Selection, Installation and Operation of Farm Pumps

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:

- Source of water supply (open well, tubewell, canal etc.)
- Water table depth in the area.
- Crops to be sown.
- Total area under crops.
- Discharge required.
- Type of Prime-mover (engine or motor). In case of electric motor, the hours of electric supply.
- Location of tubewell in the farm.
- Type of drive (Belt drive, direct coupled, monoblock).
- Water conveyance system (lined or unlined or underground pipeline).
- Ground water quality in the area.

(b) Instructions for Efficient Use of Pumps

- The centrifungal pump should be installed at 1 to 2 m above the water level.
- Select a proper pump by consulting the different performance tables or charts from the dealer.
- Use large radius bends.
- Keep the height of delivery pipe at the minimum possible height above the ground level.
  (a) Use proper material of joint dori.
  (b) Fix joint dori in such a way that it leaks about 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.
- Servicing and annual overhauling of the pump set should be done as per manufacturer's instructions.
- To avoid leakage in joints, tighten the joints properly using good quality gaskets.
- The pump must be run at the recommended revolutions.
- Use proper quality of driving belts, in case of belt driven pumps.
- Use proper size of suction and delivery pipes according to discharge.
- Use good quality reflax valve whose flap should open fully.
- Foundation should be pucca, levelled and with bolts embedded in it.
- 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:

- 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.
- One can use an empty juite bag or bucket or umbrella and move it up and down in the pit to remove the gas.
- 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.

APPENDIX- IV

FERTILIZER SOURCES FOR THE SUPPLY OF PLANT NUTRIENTS

(A) Nutrient Content (%) in Different Fertilizers

Fertilizers	N	P_2O_5	K_2O	Others
Ammonium Sulphate	20.5	—	—	—
Ammonium Chloride	25	—	—	—
Urea	46	—	—	—
Superphosphate	—	16	—	12(S)
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

GRAIN STORAGE AND MANAGEMENT OF STORED GRAIN INSECTS

1. Storage of Wheat

(a) Home consumption: Improved storage structures of various capacities are now available. For indoor use, PAU metal bins of 1.6, 3.5, 7.5, 10 and 15 quintal capacity are available. The air-tight bin is so constructed that it does not allow entry of any outside insects and rodents and the insects present in the grain do not get favourable atmosphere to develop. It is also economical, portable and simple to fabricate.

For filling and using the PAU metal bin, the following storage practices are recommended:

(i) Clean the bin thoroughly and do not allow the left-overs of the previously-stored grains to remain in the bin. Inspect the covers to ensure that the gaskets are intact.

(ii) Clean and sort the grains of all impurities. Broken kernels and other impurities lead to insect attraction and, hence, should be separated.

(iii) Do not mix the new grains with old stock as the latter may be infested with insects.

(iv) Never store infested grains, or grains with high moisture content. Dry the grains out in the sun, cool it and fill in the bin later in the evening. The moisture content of the grains should not be higher than 9 per cent.

(v) Fill-in the bin to full capacity and tight the lid properly.

(vi) Do not open the bin for the first 30 days and thereafter open it fortnightly. The cover should be replaced immediately after use.

(vii) Inspect the grains frequently.

(b) Commercial Purposes: For storing wheat for commercial purposes, the farmers should make use of the facilities provided by the following agencies.

(i) State Warehousing Corporation in the State and its regional offices.

(ii) Central Warehousing Corporation and its regional offices.

2. Management of Stored Grain Insects

Pests and Symptoms of attack: Twenty species of insects infest grains in the Punjab. Khapra beetle (*Trogoderma granarium*), lesser grain-borer (*Rhizopertha dominica*) rice weevil (Sitophilus oryzae) and flour beetles (*Tribolium* spp.) are serious pests of wheat jowar, rice barley and maize. Mung dhora (*Callosobruchus analis*), gram dhora (*C. chinensis*) and cowpea dhora (*C. maculatus*) attack different pulses. Grain moth (*Sitotroga cerealella*) attacks wheat, maize, jowar, oats, barley grains which lose nutritive value and germinating capacity, besides loss in weight.

Recommendations

Preventive measures

1. Dry the grains properly before storage.
2. Plug all cracks, crevices and holes in the godowns thoroughly.
3. Store new grains in the clean godowns or receptacles.
4. Use new gunny bags.
5. Disinfect empty godowns or receptacles by spraying 0.05% malathion emulsion (100 mL Malathion 50 EC in 10 litres of water) on the floor, walls and ceiling or fumigate the godowns using 25 tablets of aluminium phosphide per 100 cum of empty space before storing the grains. Exposure 7 days.
6. Against dhora, cover the pulses stored in bulk with 7 cm layer of sand or sawdust or dung ash.

Curative measures

1. Phostoxin or Delicia or Celphos (aluminium phosphide) one tablet of 3 g per tonne or 25 tablets per 100 cum space. Exposure 7 days.

Caution/limitation

- Before storing, the metal bins should be cleaned and placed in the sun for 2-3 days.
- Grains stored in metal bin also get infested if not treated with any insecticide. Control this infestation by giving fumigation.
- Where there is infestation of Khapra, use double the dose of aluminium phosphide.
- The fumigant should be only used in air-tight stores or under tarpaulins in the open by specially trained persons because these fumigants are deadly poisonous.

APPENDIX- VI

AGRICULTURAL ACCIDENTS - PREVENTIVE AND CURATIVE MEASURES

1. First-aid precautions during spraying accidents

In case of pesticide poisoning, call a physician immediately. Awaiting the physician's arrival apply the FIRST-AID.

a. Swallowed Poisons

- 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.
- If the patient is already vomitting, do not give common salt.
- Do not induce vomitting if the patient is in a coma.

b. Inhaled poisons

- Carry the patient (do not let him walk) to fresh air immediately.
- Open all doors and windows.
- Loosen all tight clothing.
- Apply artificial respiration if breathing has stopped or is irregular. Avoid vigorous application of pressure to the chest.
- Cover the patient with a blanket.
- Keep the patient as quiet as possible.
- If the patient is convulsing, keep him in bed in some dark room.
- Avoid any jarring noise.
- Do not give alcohol in any form.

c. Skin Contamination

- Drench the skin with water (giving shower with a hose or pump).
- Apply a stream of water to the skin while removing the clothing.
- Cleanse the skin thoroughly with soap and water.
- Rapid washing is most important for reducing the extent of injury.

d. Prevention of Collapse

- Cover the patient with a light blanket.

- Raise the feet of the patient on the bed.
- Apply elastic bands to arms and legs.
- Give strong tea or coffee.
- Give fluid administration of normal saline intravenously.
- Give blood or plasma transfusion.

e. Eye Contamination

- Hold eyelids open.
- Wash the eyes gently with stream of running water immediately.A delay of even a few seconds greatly increases the extent of injury.
- Continue washing until the physician arrives.
- Do not use chemicals. They may increase the extent of the injury.

2. 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.

3. Honey Bee and Wasp Bites

- Cooling of the part with ice pads.
- Removal of stings.
- Cleaning with soap and water.
- Local and systemic anti allergics to be given.
- Perfumes and bright colours attract these insects and should be avoided.
- Sensitive person can have severe anaphyllatic shock with even a single bite.
- Every such patient must get the medical aid from a doctor.

4. 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.

5. Safety Precautions During Threshing

- Don't wear loose clothes, wrist watch etc. while working on a thresher.
- Never operate thresher under the influence of intoxicants like opium, liquor, etc.
- 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.
- A person is advised not to work on a thresher for more than 10 hours a day.
- Do not indulge in talking or any other distraction while working on the thresher.
- 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.
- The exhaust pipe of the tractor should be fixed vertically upward and not under the tractor.
- 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.
- Do not cross over the belt or move near it.
- Keep a fire control equipment and first aid box for use in the event of need.

6. Safely Precautions During Tractor-Trolley use

- Purchase tractor with driver's safety structure to make operator safe during roll back of tractor.
- Use Triangular Reflector (Slow Moving Vehicle Emblem) on tractors, trolleys, carts etc.
- 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.
- Tractor used for trailer should also be weight blasted at the front axle to make it stable to check rearward rolling.
- When tractor-trailer moving up the slope, do not disengage the gear otherwise trailer may pull back tractor during gear change.
- Be careful while crossing un-manned railway crossing.

7. Safety Precautions During Chaff Cutting

- Purchase chaff-cutter with safety features like flywheel lock and cover on blade, fly wheel, gearbox, shafts, pulleys and belts etc.
- Feeding chute of chaff cutter should be 90 cm long and 45 cm cover on top with a warning roller in it.
- A reversal gear mechanism should be provided and located near the worker to stop or reverse the speed in emergency.
- The chaff cutter should be installed with firm foundation, in shade with sufficient space and lighting arrangement.

8. Safety Precautions to Avoid Fire Accidents

- To avoid fire accident the silencer of tractor or engine should be up in vertical direction.
- 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.
- The arrangement of water (tubewell or canal) or heap of sand should be available near the site to control fire.
- 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

- Working on agricultural implements in the field.
- Digging of well or electrocution while operating tubewell on the farm.
- Using pesticides or due to snake bite in the field.
- Use of implements in the notified market committees in Punjab.

Mandi Board Rates of Monetary aid to Accident Victims:

Type of injury	Rate of monetary aid (Rs.)
Loss of life	2,00,000/-
Loss of two limbs i.e. hands, arms, legs, feet etc.	60,000/-
Loss of one limb i.e. hand, arm, leg, foot etc.	40,000/-
Loss of four fingers i.e. equivalent to amputation of one body part.	40,000/-
Loss of finger/finger parts equivalent to amputation of complete finger	10,000/-
Physical disability (more than 25%)	50,000/- to 1,00,000/-

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.

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. **Phenobarbitone** 100-300 mg in drip.
Organophosphates (monocrotophos, chlorpyriphos, methyl parathion acephate,triazophos malathion, quinlphos, dimethoate etc)	**Atropine:** 2-4 mg intravenous as a first dose. If no effect double dose may be given every 10 minutes till atropinization. Maintain upto 24-48 hours. **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 till 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. + Glycopyrolate 7.5 mg in 200 mL saline in case of respiratory inf.
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. Avoid 2 PAM. **Warning : Do not use oxime or morphine.**
Pyrethroids (cyper-methrin, fenvalerate, deltamethrin etc).	Only symptomatic treatment, antihistamine are of value, if large amounts are ingested to cause nervous infestation, pentabarbitone (0.7g/day)/diazepam 5-10 mg for convulsions 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. 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). 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. + Dopamine - 4.6 micrograms/ kg/min i/v to treat Hypotension. **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
Neonicotinoids (thiamethoxam etc.)	No specific antidote. Treat symptomatically
II Fungicides	

Carbendazim (Bavistin, Agrozim, Parazim, Derosal etc.)	**Atropine:** 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours.
Streptocycline	Injection of adrenalin, antihistamine and cartisone in case of acute anaphylactic shock, high or low blood pressure, profuse respiration and urticaria.
Copper oxychloride Copper sulphate (Blitox etc.)	**Dimercaprol (BAL)** 3-4 mg/kg body weight. Comes as 3 mL, given deep intramuscular every 4 hours for 2 days and then twice for another 10 days. + Sod. Bicarbonate 44-88 meq/lit. + D-penicillamine - 0.5 g 6 hrly before meals for 5 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 bicarbonate 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. BAL - i/m Inj 2.5-3 mg/kg every 4 hours for 2 days then BD for 7-10 days.
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 mancozeb) metalaxyl+64% may be recommended as this combination contains 64% mancozeb.
Triadimifon (beylton), **Dinocap** (karathane)	No specific antidote, gastric lavage with 5% sodium (Bayleton) bicarbonate. No specific antidote. Gastric lavage with Karathane) 5% sodium bicarbonate and medicinal charcoal suspension. Then give 15-30 g sodium sulphate in half litre of water.
Carboxin (Vitavax)	Treat symptomatically
Captan (Captaf)	If ingested, induce vomiting by administering a spoon-ful of salt in hot water.
Chlorothalonil (Kavach)	Treat symptomatically
Propiconazole (Tilt)	Treat symptomatically
Wettable sulphur (Sultaf)	If chemical has gotten into the victim's eyes, flush eyes with plenty of water for atleast 5 minutes
III. Herbicides	
Anilophos (Arozin, Libra, Anilguard)	Atropine: 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours. 2-PAM: 1-2 g intravenous as 5% solution in dextrose to be given in 5-7 minutes or 150 mL of Anilfos Padigard etc.) saline drip every 30 minutes. If required it may be repeated every hour if the muscle weakness and fasiculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2g/hr. 2-PAMCL: dose same as above. Gastric lavage with 5% sodium bicarbonate.
2,4-D	**Ingestion:** Gastric lavage with activated charcoal slurry. For muscle and cardiac irritability give Lidocaine 50-100 mg intravenous, followed by 1-4 mg/minas needed. Alkalize urine by sodium bicarbonate 10-15 g daily intravenously.
Glyphosate	**Ingestion:** immediately dilute by swallowing milk (Roundup) or water.

Isoproturon (Arelon, Delron Milron etc.)	Flush eyes with soap. Wash skin with soap and water.
Paraquat (Grammoxone)	Induce vomiting unless unconscious. Give gastric lavage with one litre of 30% aqueous suspension with Fuller's earth together with magnesium 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.

The Punjab Agricultural University, Ludhiana accepts no legal responsibility.

APPENDIX- VIII

ADDITIONAL GUIDELINES FOR WHEAT CULTIVATION IN PADDY STRAW MANAGED FIELDS

General

- The operator of different machines for straw management (like Super SMS, Happy Seeder, Smart Seeder, Super Seeder, Chopper/Mulcher, Mould-board Plough, etc.) should be fully trained. The training can be taken from Punjab Agricultural University or *Krishi Vigyan Kendras*.
- All techniques to manage paddy straw in field can be used in medium and heavy textured soils but in light textured soils, prefer straw incorporation.
- Grow recommended short to medium duration rice varieties, which provide more time for straw management, facilitate sowing and minimise pink stem borer infestation in succeeding wheat crop due to less straw load.

Guidelines for paddy cultivation preceding wheat crop

- Make at least 2 plots of an acre before transplanting of paddy as it is difficult to make plots in Happy Seeder and Smart Seeder sown wheat.
- Regular monitoring of paddy crop should be done in the months of September-October. If the attack of rice ear cutting caterpillar (armyworm of wheat) or pink stem borer is observed, adopt recommended practices for their management to check their carry-over to wheat.
- Use of Mulcher before Smart Seeder/Super Seeder is not necessary.
- In fields with heavy soil having high straw load, avoid use of Mulcher before Happy Seeder.

Wheat sowing using Happy Seeder, Smart Seeder and Super Seeder

- The last irrigation to paddy crop should be planned in such a way that proper moisture remains in soil at the time of sowing of wheat with Happy Seeder/Smart Seeder/Super Seeder.
- Depth of sowing in case of Happy Seeder/Super Seeder should be between 1.5 to 2.0 inches.
- In case of sowing with Happy Seeder, use 5 kg more seed per acre of wheat than recommended for conventional sowing except for PBW 869.
- Drill 55 kg DAP per acre at sowing of wheat. Apply 45 kg urea per acre before first and second irrigation. It is cautioned that in heavy textured soils to avoid delay in urea application due to delay in second irrigation, give two foliar sprays of 10% urea solution (20 kg urea in 200 litre water per acre) at 42 and 54 days after sowing.

- Care should be taken that there is no clogging of seed and fertilizer tubes of Happy Seeder/Smart Seeder/Super Seeder. Tap the tubes with a stick to remove clogging, if required.
- If pink stem borer/rice ear cutting caterpillar damage is observed in previous paddy crop, avoid sowing wheat in the month of October.
- In light textured soils, where wheat is sown with Happy Seeder/ Smart Seeder first irrigation should be light and applied at 25-30 days after sowing and in medium to heavy textured soils apply irrigation at 30-35 days after sowing. In case of wheat sown with Super Seeder, apply irrigation as recommended for wheat cultivated with conventional methods. Apply irrigation after taking into account rainfall forecast.
- Prefer to irrigate the fields during day time to maximize predation of insects by birds.
- Regularly monitor wheat crop sown in straw managed fields in the month of November- December to identify the problems related to insect pests, diseases or rodents and use recommended practices for their management.
- Use recommended pre and post-emergence herbicides for control of weeds in case of crop sown with Happy Seeder/Super Seeder. Use Post emergence herbicide only in case of crop sown with Smart Seeder.

Wheat sowing after straw incorporation with other machines

- Incorporation can be done by different methods depending upon the availability of machinery and irrigation water available with the farmer.
- Chopper/Mulcher is used to chop straw into pieces and spread it in the field uniformly. The chopped straw can be mixed/incorporated in the soil as follows:

i) After paddy harvesting, if sufficient moisture is available at the time of sowing of wheat then mix the chopped paddy straw into the soil with the help of Mouldboard Plough. Thereafter, prepare the field using rotavator.

ii) If sufficient period of 2-3 weeks is available between harvesting of paddy and sowing of wheat give shallow irrigation and mix the chopped straw with the use of Disc harrow or Rotavator.

Note: All other recommendations for straw managed wheat crop are same as in Package of practices for crop of Punjab for wheat cultivation.

APPENDIX - IX
IMPORTANT TELEPHONE NUMBERS OF PUNJAB AGRICULTURAL UNIVERSITY, LUDHIANA (DIAL EXCHANGE 0161-2401960 TO 2401979 FOR EXTENSION NO.)

Name/Designation	Telephone Number	
	Office	Mobile
Dr. Makhan Singh Bhullar Director Extension Education	0161-2401644	98728-11350
Dr. G P S Sodhi Additional Director Extension Education	0161-2400429 418 (Ext. No.)	94176-26843
Dr. Tarsem Singh Dhillon Additional Director Extension Education	0161-2401070 214 (Ext. No.)	94640-37325
Dr. T S Riar Additional Director Communication	0161-2405731 373 (Ext. No.)	98142-10269
Dr. Rupinder Kaur Associate Director (Skill Development)	---	97797-00905

Help Line Numbers for the Farmers

Kisan Call Centre	**1800-180-1551 (Toll Free)**	
Dr. Gurpreet Singh Makkar, Plant Clinic	417	81464-00248
Dr. B S Gill, Plant Breeding & Genetics	435	98721-63567
Dr. Amarjit Singh, Plant Pathology	505	94637-47280
Dr. R S Chandi, Entomology	504	81460-39400
Dr. Amit Kaul, Agronomy	401	81464-00233
Dr. Gobinder Singh, Soil Science	506	95011-92500
Dr. Ruma Devi, Vegetable Science	452	98783-99555
Dr. Jaswinder Singh Brar, Fruit Science	303	99158-33793
Dr. Mahesh Narang,Farm Machinery & Power Engineering	446	94173-83464
Dr. Arashdeep Singh, Food Science and Technology	305	98762-35555
Dr. Jugraj Singh, Soil & Water Engineering	284	98155-47607
Dr. Raj Kumar, Economics & Sociology	461	81460-96600
Dr. Tarsem Chand, Processing & Food Engineering	384	97790-00640

Dr. Simrat Singh, Landscaping & Floriculture	440	98157-93196
Dr. Dharminder Singh, Extension Education	321	98726-12124
Dr. Neena Singla, Rodent Management	382	93573-25446
Dr. Tejdeep Kaur Kler, Bird Management	382	99559-65904
Seed Shop	419	---

Phone Number of Heads of Various Departments

Plant Breeding & Genetics	224
Wheat Section	250
Cotton Section	334
Maize Section	437
Oilseed Section	433
Pulses Section	413
Fodder Section	443
Entomology	320
Plant Pathology	319
Agronomy	308
Soil Science	317
Vegetable Science	370
Fruit Science	303
Landscaping & Floriculture	440
Extension Education	321
Farm Machinery & Power Engineering	257
Economics & Sociology	301/461
Microbiology	330
Rats & Birds Control	429

Associate/Deputy Directors of *Krishi Vigyan Kendras*

Dr. Bikramjit Singh (Incharge), Amritsar	0183-2505672	98723-54170
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Dr. Hardeep Singh (Additional Charge), Fatehgarh Sahib	01763-221217	81468-60099
Dr. Gurmail Singh, Ferozepur	01632-279517	81462-60400
Dr. Sarbjit Singh Aulakh, Gurdaspur	01874-220743	94640-70131
Dr. Maninder Singh Bons (Incharge), Hoshiarpur	---	98157-51900
Dr. Sanjeev Kataria, Jalandhar	01826-292053	99889-01590
Dr. Vipan Kumar Rampal (Additional Charge), Ludhiana	01628-261597	81465-70699
Dr. Harinder Singh (Incharge), Kapurthala	01822-233056	97800-90300
Dr. Gurdeep Singh (Additional Charge), Mansa	01652-280843	88722-00121
Dr. Kamaldeep Singh, Moga	---	98882-05158
Dr. Karamjit Sharma, Sri Muktsar Sahib	---	98722-17368
Dr. Bikramjit Singh (Additional Charge), Pathankot	0186-2920895	98733-54170
Dr. Hardeep Singh, Patiala	0175-2225473	81688-60099
Dr. Satbir Singh, Ropar	01881-220460	99882-27872
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Dr. Mandeep Singh (Incharge), Sangrur	01672-245320	70097-84182

Senior Most Extension Scientists of Farm Advisory Service Centre

Dr. Jagdish Arora, Abohar	01634-225326	81959-50560
Dr. Narinderpal Singh, Amritsar	0183-2501989	84270-07023
Dr. Amandeep Kaur, Barnala	---	94646-59995
Dr. Amarjit Singh Sandhu, Bathinda	0164-2212684	94633-71120
Dr. Manveen Kaur, Chandigarh/Mohali	0172-2775348	81460-88233
Dr. Fatehjeet Singh Sekhon, Faridkot	01639-250143	82848-00299
Dr. Jagjot Singh Gill, Ferozepur	01632-242136	82839-32427
Dr. Narinderdeep Singh, Gurdaspur	01874-220828	92762-95717

Dr. Charanjeet Kaur, Hoshiarpur	01882-222392	94172-87920
Dr. Maninder Singh, Jalandhar	---	81460-88488
Dr. Harinder Singh (Additional Charge), Kapurthala	01822-232543	97800-90300
Dr. Gurpreet Kaur, Patiala	0175-2200646	94633-69063
Dr. Raminder Singh Ghuman, Ropar	01881-222257	98885-21200
Dr. Ashok Kumar, Sangrur	01672-293098	95018-55223
Dr. Parvinder Singh, Tarntaran	---	81463-22553

Directorate Research

Dr. Ajmer Singh Dhatt Director Research	0161-2401221 216 (Ext. No.)	99151-35797
Dr. G. S. Mangat Addl. Director Research (Agriculture)	0161-2407309 341 (Ext. No.)	98145-16464
Dr. Mahesh Kumar, Addl. Director Research (Agricultural Engineering)	---	94786-40539
Dr. Amandeep Singh Associate Director (Seed)	438 (Ext. No.)	81465-70699
Dr. Balkaran Singh Gill Deputy Director (Farm)	253 (Ext. No.)	81469-00244

Regional Research Station/Seed Farm

Abohar	01634-225326
Bathinda	0164-212159; 97800-24223
Bahadurgarh (Patiala)	0175-2381473
Faridkot	01639-251244
Gurdaspur	01874-220825; 88720-03010
Gangian (Hoshiarpur)	01883-85075; 98772-52692
Ladhowal (Ludhiana)	0161-2801566; 81463-00510
Kheri (Sangrur)	01673-285020; 70097-84182
Kapurthala	98722-04523
Amloh (Naraingarh)	94649-92257
Ballowal Saunkhri (SBS Nagar)	98880-14851
Jallowal (Lesriwal) Jalandhar	98141-37547
Usman (Tarntaran)	81463-22553
Dyal Bharang (Amritsar)	98723-54170