

# RICE

Rice crop occupied 31.45 lakh hectares in Punjab with total paddy production of 203.71 lakh tonnes (136.48 lakh tonnes of rice) during 2021-22. The average yield of paddy was 64.78 quintals per hectare (26.22 quintals per acre).

## Important Hints

- To save water and for ease in management of paddy straw, grow PAU recommended short duration varieties.
- Avoid cultivation of Pusa 44, *Peeli Pusa*, *Dogar Pusa* as these require 15-20 per cent more water and demand atleast two extra sprays of pesticides, thereby lowering the net profit.
- Restrict to timely sowing of nursery (20 May-20 June) and timely transplanting (20 June-10 July) schedule for better grain quality, water saving and low build-up of stem borers.
- For higher yield and better grain quality from PR 126, transplant 25-30 days old nursery.
- Adopt direct seeding of rice in *tar-wattar* field from 1 June onwards for higher savings in irrigation water.
- Apply fertilizers as per soil test. Omit phosphorus application in rice following wheat that received recommended dose of phosphatic fertilizer. Use nitrogen judiciously based on Leaf Colour Chart (LCC). Excessive use of nitrogen fertilizer encourages multiplication of insect pests and diseases.
- To control false smut disease, initiate the spray of recommended fungicides at boot stage of the crop.
- Plant hoppers feed at the base of rice plants and are often overlooked. Their damage is noticed only when the crop is hopper burnt. Hence, regular monitoring of the insect population is necessary.
- Use of synthetic pyrethroids leads to increase in the population of rice planthoppers. Hence, these insecticides should not be used for the control of rice insect-pests.
- Stop irrigation about a fortnight before maturity.
- Harvesting should be done at proper maturity and variety-wise. Avoid harvesting during night.

## Climatic Requirements

Rice is best suited to regions of high temperature, high humidity, prolonged sunshine and assured water-supply. In Punjab, high productivity of rice can be expected if the maximum temperature remains within 34-40, 33-35 and 32-35°C, minimum temperature within 23-28, 25-27 and 20-25°C and the bright sunshine ranges between 7-11, 6-10 and 7-10 hours/day during vegetative, flowering and grain development stages, respectively.

## **Soil Type**

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

## **Rotations**

Rice-Wheat / Berseem / Linseed / Gram / Barley, Rice-Wheat / Summer Moong/Green manuring, Rice-Celery, Rice-Potato/Peas-Celery, Rice-Potato-Potato/Summer Moong/Sunflower/Celery/Wheat/Cucurbits, Rice-Toria-Sunflower, Rice-Gram-Summer Moong, Rice-Gobhi Sarson-Summer Moong, DSR-Potato-Mentha/Onion.

## **Improved Varieties/Hybrids**

**PR 131 (Adhoc release, 2022):** It is a high yielding, medium maturing and lodging tolerant variety. Its average plant height is 111 cm and matures in about 110 days after transplanting. It possesses long slender translucent grains with high total and head rice recoveries. It is resistant to all the ten pathotypes of bacterial blight pathogen prevalent in the Punjab state. Its average yield is 31.0 quintals per acre.

**PR 130 (2022):** It is a high yielding, mid early and lodging tolerant variety. Its average plant height is 108 cm and it matures in about 105 days after transplanting. It possesses long slender translucent and lustrous grains with high total and head rice recoveries. It is resistant to all the ten pathotypes of bacterial blight pathogen prevalent in the Punjab state. Its average yield is 30.0 quintals per acre.

**PR 129 (2020):** It is an improved version of PAU 201. It possesses long slender clear translucent grains. Its' average plant height is 105 cm and matures in about 108 days after transplanting. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.0 quintals per acre.

**PR 128 (2020):** It is also an improved version of PAU 201. It possesses long slender clear translucent grains. Its' average plant height is 110 cm and matures in about 111 days after transplanting. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.5 quintals per acre.

**HKR 47 (2020):** It is a mid-early maturing variety. It takes about 104 days to mature after transplanting with an average plant height of 117 cm. It possesses long slender, clear translucent grains. It is susceptible to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state and is prone to lodging. Its' average paddy yield is 29.5 quintals per acre.

**PR 127 (2018):** It is a medium maturing rice variety with an average height of 104 cm. It matures in about 107 days after transplanting. It possesses long slender, clear translucent grains with high total and head rice recoveries. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.0 quintals per acre. Do not grow this variety in alkali soils and under brackish water.

**PR 126 (2017):** It is an early maturing rice variety. Its' average plant height is 102 cm and matures in about 93 days after transplanting. It possesses long slender, clear translucent grains. It is resistant to seven of the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.0 quintals per acre. Transplant 25-30 days old nursery.

**PR 122 (2013):** Its' average plant height is 108 cm and matures in 117 days after transplanting. It possesses long slender translucent grains. It is resistant to all the ten

presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 31.5 quintals per acre.

**PR 121 (2013):** It is a short statured, stiff strawed lodging tolerant variety with dark green and erect leaves. It attains height of about 98 cm and matures in 110 days after transplanting. Its' grains are long slender, translucent with good cooking quality. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state. Its' average paddy yield is 30.5 quintals per acre.

**PR 114 (1999):** It has narrow, dark green erect leaves. It attains an average height of about 102 cm and matures in about 115 days after transplanting. It possesses extra long, clear translucent grains. It is resistant to five of the ten pathotypes of bacterial blight pathogen presently prevalent in Punjab state. Its' average yield is 27.5 quintals of paddy per acre.

**PR 113 (1998):** Its' average plant height is about 105 cm. Its' grains are bold and heavy. It matures in about 112 days after transplanting. It is resistant to eight of the ten pathotypes of bacterial leaf blight pathogen presently prevalent in Punjab state. Its' average paddy yield is 28.0 quintals per acre.

### **Do not grow these varieties**

**Pusa 44/Peeli Pusa/Dogar Pusa:** These long duration varieties consume 15-20 per cent more water than PR varieties, have more straw load and are susceptible to all the prevalent pathotypes of bacterial blight in the State. Due to severe outbreak of insect-pest and diseases, these demand atleast two extra sprays of pesticides thereby lowering the net profit.

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

## **Agronomic Practices**

### **Transplanted Rice**

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

#### **I. For Conventional Transplanting**

**Time of Nursery Sowing:** 20 May- 20 June is the optimum time of sowing:

PR 121, PR 122, PR 128, PR 129, PR 131, PR 114, PR 113	May 20-25
PR 127, PR 130, HKR 47	May 25-31
PR 126	May 25-June 20

**Seed Rate and Seed Treatment:** Dip the seed in suitable lots in water contained in a tub/ bucket. Stir the seed and remove immature grains which float at the top. The heavy

- Sow nursery of various varieties as per recommended schedule.
- Transplant 25-30 days nursery of PR 126.
- Level the fields with laser land leveller before direct sowing or transplanting of rice.
- Keep water standing in paddy field only for 2 weeks and thereafter apply irrigation 2 days after the ponded water has infiltrated into soil.

seeds will settle down at the bottom. Eight kg of heavy seed is sufficient for transplanting an acre. Heavy seed ensures healthy, sturdy and uniform seedlings. Treat the seed with Sprint 75 WS (carbendazim + mancozeb) by making slurry of 3 g fungicide formulation in 10-12 ml water for one kg seed (24 g fungicide in 80-100 ml water for 8 kg seed) before sowing.

**Land Preparation, Fertilizers and Method of Sowing:** Mix 12 to 15 tonnes of well-rotten farmyard manure or compost per acre in the soil. Irrigate the field to permit the germination of weeds. Plough the field twice after about a week to kill germinated weeds.

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

Apply 26 kg urea, 60 kg single superphosphate and 40 kg zinc sulphate heptahydrate (21% Zn) or 25.5 kg zinc sulphate monohydrate (33% Zn) per acre at sowing. Sow 8 kg seed by broadcasting on an area of 160 square meter (6.5 marlas) to raise nursery for one acre. To check the damage from birds, broadcast a thin layer of well-decomposed farmyard manure immediately after broadcasting rice seed. Keep the soil moist by irrigating the field frequently. Apply another dose of 26 kg urea per acre about a fortnight after sowing so as to get the seedlings ready for transplanting in 25-30 days. However, under forced circumstances, if nursery of about 45 days or above is to be transplanted, apply another dose of 26 kg urea after 4 weeks of sowing. In case, any insect attack or disease appears in the nursery, adopt the recommended plant protection measures. Irrigate the nursery regularly. The seedlings are ready when they are 20-25 cm tall or with 6 to 7 leaves.

If the seedlings in the nursery show the yellowing of new leaves, spray them three times with 0.5-1% ferrous sulphate solution (0.5-1.0 kg ferrous sulphate dissolved in 100 litres of water per acre) at weekly intervals. If the leaves turn rusty brown after becoming yellow, give a spray of 0.5% zinc sulphate heptahydrate solution (500 g zinc sulphate heptahydrate dissolved in 100 litres of water) or 0.3% zinc sulphate monohydrate solution (300 g zinc sulphate monohydrate dissolved in 100 litres of water per acre).

**Weed Control:** Swank and some other annual grasses are the main problems in rice nursery. These weeds can be controlled by applying 1200 ml per acre Butachlor 50 EC mixed with 60 kg of sand after 7 days of broadcasting seed or 500 ml per acre of Sofit 37.5 EC (pretilachlor + safener readymix) as sand mix, 3 days after sowing or 100 ml per acre of Nominee Gold/Taarak/Wash out/Macho 10 SC (bispyribac) as spray in 150 litres of water at 15- 20 days after sowing.

## II. For Rice Transplanter - Mat-type nursery

Select a location having fertile soil, assured irrigation and minimum transportation distance of location to the field. There should be no stones or other hard material in the soil. The field should be preferably laser leveled and 20 metres away from tubewell and trees. Prepare the field at proper moisture. Spread polythene sheet 50-60 gauge, 90 cm wide having 1-2 mm dia perforations over it. Polythene sheets weighing 270 g spread to a length of about 15 meters (for about 150 mats) is sufficient for preparing seedlings for one acre.

Place one or more iron frames over the polythene sheet having compartments of size 45x21x2 cm for engine operated transplanter and 58x28x2 cm for self propelled transplanter. Number and size of compartments vary according to machine specifications. Fill the soil from both sides of the frames uniformly upto the top surface.

Spread 50-60 g of pre-germinated seed evenly in each compartment to achieve uniform density of 2 or 3 seeds/sq cm in the mat. For uniform seed distribution, use drum type nursery sowing seeder. The length of nursery sowing seeder is to be equal to width of frame and has openings of 1 cm diameter on full length of the roller. About 10-12 kg seed is sufficient to sow about 150 mats required for transplanting in one acre. Cover the seeds by a thin layer of soil and sprinkle water by hand sprayer for proper setting of the soil. Lift frames and put these at the next place and repeat the above procedure for sowing the required number of seedling mats. Two persons can sow seedlings for 3-4 acres in a day.

After sowing, irrigate the field on same day, but the flow of water for first 2-3 irrigations should be very mild and level should be uniform so that there is no damage to newly formed mats. Care must be taken that the seedling mats should be always wet. Spray the fertilizer after an interval of about 10 days with 200 g urea dissolve in 15 litre water to 150 mats. The seedling mats will be ready after 25-30 days of sowing. Drain water from the nursery field a few hours before uprooting of nursery. Give a cut with a sharp blade/knife along the nursery boundaries of the mat. The uprooted nursery mats are ready for transport to the field.

**Tractor operated seeder for mat type paddy nursery:** The tractor operated seeder for mat type paddy nursery can be used to lay a 1.0 m wide perforated polythene sheet (50-60 gauge) over 1.0 m wide soil bed with simultaneous uniform seed placement over the soil bed for raising Mat type nursery for mechanical paddy transplanters.

## Operations before Transplanting

**Organic Manures/*Prali Char*:** Apply 6 tonnes of farmyard manure or 6 tonnes of press mud or 2.5 tonnes of poultry manure or 2.4 tonnes of dried gobar gas plant slurry or 2.0 tonnes *prali char* (details of *prali char* are given under Management of Paddy Straw) per acre before preparatory tillage for transplanting of rice.

**Green manuring:** Since organic manures are not available in required quantities, green manuring with *dhaincha*/cowpea/sunnhemp is a very practicable alternative. After harvesting wheat or any other preceding crop, apply pre-sowing irrigation (*rauni*) and sow 20 kg per acre of *dhaincha* seed pre-soaked in water for 8 hours or 12 kg per acre of cowpea (20 kg if bold seed is used) or 20 kg per acre of sunnhemp up to the first week of May. Apply 75 kg superphosphate per acre to *dhaincha*/cowpea/sunnhemp in soils testing low in phosphorus and omit application of phosphorus to the succeeding rice crop. Bury 6 to 8 weeks old *dhaincha*/cowpea/sunnhemp one day before transplanting of paddy. *Dhaincha* should be preferred in *kollar* and recently reclaimed soils. This practice results in saving of 25 kg of N (55 kg urea) per acre. If the moong crop after picking of pods has been incorporated one day before transplanting then reduce fertilizer N dose by one-third. Green manuring with *dhaincha* also ameliorates iron deficiency in rice.

**Rice straw incorporation/retention:** Continuous incorporation/retention of rice straw improves soil health and rice yield. Whenever, the soil organic carbon content come under

high (as per soil test report) category or after 8 years, reduces urea by 20 kg per acre in rice.

**Land Preparation:** Use laser land leveler for precision land leveling before puddling to enhance the efficiency of water and other farm inputs. Repair all bunds. Obtain a fine well levelled puddled field to reduce water loss through percolation, to maintain good seedling vigour and to control weeds.

## Transplanting

**Dates of Transplanting:** Time of transplanting is a single factor which influences rice yield substantially. For getting maximum yield of rice and for the timely vacation of the field for sowing wheat and other crops, transplant rice seedlings from 20 June to 10 July. Under late sown conditions, prefer transplanting of PR 126.

**Age of Seedlings at Transplanting:** Use 30-35 days old seedlings for medium duration varieties. However, for short duration variety (PR 126), seedlings of 25-30 days should be used. Transplanting of aged seedlings results in reduction of yield and quality.

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

**Seedling Inoculation:** Mix half kg packet of *Azospirillum* biofertilizer with 100 litre of water. Dip the root of rice nursery seedlings for one acre in this solution for 45 minutes and transplant immediately. The bio-fertilizer culture is available with the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

## Method of Transplanting

**a. Flat puddled transplanting:** Transplant seedlings in lines at 20 x 15 cm (33 hills/sq m) for normal transplanting of all varieties and for late transplanting of PR126. Transplant seedlings in lines at 15 x 15 cm (44 hills/sq m) for the late transplanting of other varieties. Put 2 seedlings per hill. The seedlings should be transplanted upright and about 2-3 cm deep. This practice ensures good establishment of seedlings and early tillering, which are essential for good tiller development and synchronous flowering.

**b. Ridge or Bed transplanting without puddling:** In heavy textured soils, rice can be transplanted on ridges or beds to save irrigation water. After field preparation, apply basal dose of fertilizer and prepare ridges or beds with ridger or wheat bed planter. Irrigate the furrows and immediately transplant seedlings on the middle of the slopes (both sides) of 60 cm spaced ridges keeping plant to plant spacing of 10 cm or on 67.5 cm spaced beds keeping plant to plant spacing of 9 cm.

During the first 15 days after transplanting, apply irrigation on daily basis. Thereafter, apply irrigation in furrows only two days after the ponded water has infiltrated into the soil. Every care should be taken that field does not develop cracks in the furrows.

For controlling weeds, spray 120 ml per acre Nominee Gold/ Wash out/Taarak/Macho 10 SC (bisperibac) in 150 litres of water at 20-25 days of transplanting. Hand pulling of weeds can be done, if needed. Follow other cultural practices as recommended for flat puddled transplanted rice.

**c. Mechanical transplanting:** Mat type nursery should be transplanted with rice transplanter at spacing of 30x12 cm.

## Weed Control

**Interculture with a Paddy Weeder (V),** 15 days after transplanting and again after a fortnight. Where a paddy weeder cannot be run, hand weeding may be done.

**Chemical weed control:** The control of weeds with herbicides is both efficient and economical.

1. **Control of swank and other weeds:** Use of any of the following pre-emergence, early post-emergence and post-emergence herbicides provides effective control of *swank* and moderate control of other weeds.
- i. **Pre-emergence (within 2 to 3 days of transplanting):** Any of the herbicide listed in the table below may be applied by mixing with 60 kg of sand/acre in standing water within 2 to 3 days of transplanting.

Brands (Herbicide)	Dose per acre	Remarks
Machete/Delchlor/Rasayanchlor/Exachlor/Punch/Hiltachlor/ Thunder/Teer/Capchlor/Trapp/ Milchlor/Narmadachlor/Fychlor/Arochlor/Megachlor/Butachlor-Sunbeam /Markchlor/Paklor /Banweed/Butacid/Jaibutachlor 50 EC (butachlor)	1200 ml	These herbicides are highly effective against <i>swank</i> give moderate control of other weeds.
Fast-mix 50 EW (butachlor)	1200 ml	
Arozin 18 EC (anilofos)	850 ml	For control of <i>kanki</i> , Arozin/Aniloguard/Libra/ Control H-30/Jaifos/ Pestoanilofos/Markanil/ Haragro-anilofos/Padigard have an edge over other herbicides.
Stomp 30 EC (pendimethalin)	1000 to 1200 ml	In case of Stomp, use lower dose on light textured soils and higher dose on medium to heavy textured soils.
Rifit/Eraze/Markpretila/ Revenge/Mif Pretila/Sokusai 50 EC (pretilachlor*)	600 ml	
Rifit Plus 37 EW (pretilachlor*)	750 ml	
Sathi 10 WP (pyrazosulfuron ethyl)	60 g	
Topstar 80 WP (oxadiargyl*)	45 g	
<b>Use hand gloves while applying these herbicides.</b>		

- ii. **Early post-emergence (within 10-12 days of transplanting):** Early post-emergence spray of 40 ml per acre Granite 240 SC (penoxsulam\*) at 10-12 days of transplanting



in 150 litres of water, particularly in fields where continuous standing of water is a problem, provides effective control of grass weeds including *swank*, paddy *mothas* and broadleaf weeds in transplanted rice. Do not spray the herbicide in the standing water and irrigation may be applied one day after spray.

- iii. **Post-emergence (within 20-25 days of transplanting):** For the effective control of *swank* and paddy *mothas*, spray 100 ml per acre Nominee Gold/Wash out/Macho/ Taarak 10 SC (bispyribac) using 150 litres of water, at 20-25 days of transplanting. In crop infested with *Leptochloa (chini) gha* and *kanki*, apply 400 ml per acre Ricestar 6.7 EC (fenoxaprop) at 20-25 days of transplanting in 150 litres of water. Do not spray the herbicide in standing water and irrigation may be applied one day after spray.
- 2. **Control of sedges and broadleaf weeds:** For control of sedges (paddy *mothas* like *chhatri wala dila*) and broadleaf weeds including *ghrilla*, *sanni* etc, spray 30 g per acre Algrip 20 WG (metsulfuron\*) or 50 g Sunrice15 WG (ethoxysulfuron) or 40 g Londex 60 DF (bensulfuron methyl) or 16 g Segment 50 DF (azimsulfuron\*) or 8 g per acre Almix 20 WP (metsulfuron methyl +chlormuron ethyl) if the crop is infested with paddy *mothas* including *gandi wala motha* in 150 litres of water at 20 days of transplanting. Do not spray the herbicide in standing water and irrigation may be applied one day after spray. The spray should be done on a clear and calm day for getting good efficacy from herbicides.
- Use different group of recommended herbicides in rotation to avoid the problem of herbicide resistance in weeds.
- Delay in application of herbicides results in poor control of weeds.

### Fertilizer Application

Apply organic manures, bio-fertilizer along with chemical fertilizers for higher crop yield and maintenance of soil health.

a) **Organic manures/*Prali Char*:** As described earlier apply farmyard manure or pressmud or poultry manure or gobar gas plant slurry or *prali char* or incorporate green manure before transplanting of rice. Where organic manures are used, reduce the dose of urea as under:

Organic manure	Dose (t/acre)	Fertilizer saving
Farmyard manure	6	16 kg Nitrogen (35 kg urea)
Pressmud	6	25 kg Nitrogen (55 kg urea)
Poultry manure	2.5	25 kg Nitrogen (55 kg urea)
Gobar gas slurry	2.4	16 kg Nitrogen (35 kg urea)
<i>Prali Char</i>	2.0	16 kg Nitrogen (35 kg urea)##
Green manure	-	25 kg Nitrogen (55 kg urea)##
Summer moong crop residue incorporation	-	16 kg Nitrogen (35 kg urea)##

# In addition to saving of nitrogen, application of *prali char* @ 2.0 t/acre increase the crop yield by 10 %.

## In loamy sand to sandy loam soils incorporate green manure or summer moong residue and apply recommended dose of nitrogen (50 kg N/acre) to get higher yield.

**b) Bio-fertilizer:** Treat the nursery roots with one packet of recommended bio-fertilizer before transplanting.

**c) Chemical Fertilizers:** Apply fertilizer on soil test basis (See Chapter on 'Soil Testing'). However, in the absence of soil test, apply the fertilizers as under:

*Nutrients (kg per acre)			Fertilizers (kg per acre)			
N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Neem coated urea	DAP	or single superphosphate	Muriate of potash
42	12	12	90	27	75	20

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

To reduce sterility in paddy, apply foliar spray of 1.5% potassium nitrate (3 kg potassium nitrate in 200 litre of water per acre) at boot stage.

**Note:**

- Skip phosphorus application to rice if recommended dose of phosphorus had been applied to the preceding wheat crop.
- Apply phosphorus and potassium fertilizers only when the soil test shows deficiency of these nutrients (See Chapter on Soil Testing).
- Apply the whole of phosphorus and potassium as per soil test before the puddling. Phosphorus can be top dressed up to 21 days after transplanting.
- When 27 kg DAP is used in deficient soil, reduce the urea dose by 10 kg.
- Apply nitrogen fertilizer in 3 equal splits to all recommended varieties. The first split should be applied upto 7 days of transplanting and second split at 21 days of transplanting. The third split to short duration (PR 126) should be applied at 35 days of transplanting while for other varieties, it should be applied at 42 days of transplanting.
- Apply the second and the third split of nitrogen when water is not standing in the field. Irrigate on the third day of the application of fertilizer.

### PAU-Leaf Colour Chart (PAU-LCC) for need based Urea application

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

**Note:** Need based nitrogen management using LCC holds good for all the prevalent rice varieties grown in all type of soils. The use of LCC is highly beneficial for optimum fertilizer nitrogen use when fields are

- Prefer to use organic/green manures and reduce dose of chemical fertilizer accordingly.
- Skip phosphorus application if recommended dose of phosphorus had been applied to the preceding wheat crop.
- Use PAU-Leaf Colour Chart for need based nitrogen application.
- Excessive use of nitrogenous fertilizers particularly during flowering causes sterility and consequently heavy reduction in yield.
- To manage iron deficiency apply foliar sprays of 1% ferrous sulphate solution.

amended with organic manures. Always match colour of the leaf with LCC under shade of the body. The leaves selected for measuring leaf greenness should be free of insect-pest incidence. There should not be water stress to the crop and nutrients other than nitrogen should be supplied as per recommendations. The LCC can be purchased from PAU Seed Shop at Gate No. 1, Krishi Vigyan Kendras and Farm Advisory Service Centres in different districts.

**Zinc Deficiency:** The symptoms of zinc deficiency appear 2-3 weeks after transplanting (Plate No. 1, page 186). The lower leaves become rusty brown near the base and ultimately dry up. The seedlings with zinc deficiency remain stunted and tillerless. To control this malady, apply 25 kg of zinc sulphate heptahydrate (21%) or 16 kg zinc sulphate monohydrate (33%) per acre at puddling in case previous crop in this field had shown the symptoms of zinc deficiency. Where the deficiency is noticed in the growing crop, apply this quantity of zinc sulphate as soon as possible.

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

**Iron Deficiency:** Under scarcity of water, chlorosis among seedlings appears in the youngest leaf about three weeks after transplanting (Plate No. 2, page 186). Plants die and often the crop fails completely. Start giving copious irrigations as soon as chlorosis appears and give 2 or 3 sprays of one per cent ferrous sulphate solution at weekly intervals (1 kg of ferrous sulphate in 100 litres of water per acre).

**Irrigation and Drainage:** Keep the water standing continuously in the crop for two weeks only after transplanting so that the seedlings get properly established. Afterwards, apply irrigation two days after the ponded water has infiltrated into the soil. To save irrigation water, irrigate with tensiometer installed at 15-20 cm soil depth at soil matric tension of  $150\pm20$  cm or when water level in tensiometer enters yellow strip. Every care should be taken that field does not develop cracks. In this way, irrigation water can be saved without causing any reduction in yield. The depth of standing water should not exceed 10 cm. Drain away excess water before interculturing or weeding and irrigate the field after these operations. Stop irrigation about a fortnight before maturity to facilitate easy harvesting and the timely sowing of the succeeding *rabi* crop.

**Harvesting and Threshing:** Harvest the crop just when the ears are nearly ripened and straw has turned yellow. If harvesting is delayed till the crop is dead ripe, the shattering of grains occurs. The milling quality of the grains is also affected. Combines are successfully used for harvesting paddy. Operate the combine at proper speed. Prefer combines fitted with a PAU Super S.M.S. (Straw Management System) for chopping and even distribution of straw. After harvesting of paddy with such combines, wheat can directly be sown with the help of Happy Seeder without burning of paddy straw. Tractor-drawn vertical conveyor reaper windrower can also be used for harvesting paddy. Multi-crop threshers can also be used for threshing paddy (Appendix V).

**Production of Pure Seed:** Select a good plot of the standing crop and rogue it thoroughly so that it is made free from all admixtures and diseased plants. Harvest and

thresh this plot separately. Dry the produce well and store separately in disinfested bins.

## **Marketing and Storage**

Marketing of the farm produce is an important function as income of the farmer to some extent depends upon it. As per specified norms, the moisture content in paddy should not be more than 17 per cent at the time of its marketing. The farmer has to pay only **unloading and cleaning charges** of the produce. The farmers are advised to get '**J**' form from the commission agent. The produce kept for home use should be dried thoroughly in the sun for about a week and stored in bins or kept in a heap inside the room. The optimum moisture content for storage is 12 per cent.

## **Management of Paddy Straw**

In Punjab, about 220 lakh tonnes paddy straw is produced annually and a large portion of the straw is being burnt by the farmers. The straw contains a significant amount of essential plant nutrients. One tonne of paddy burning causes loss of 400 kg organic carbon, 5.5 kg of N, 2.3 kg of P, 25 kg of K and 1.2 kg of S. The burning of residue causes complete loss of nitrogen and sulphur. Due to burning of paddy straw poisonous gases like carbon dioxide, carbon monoxide, methane and nitric oxide are produced which are harmful for human and animal health. To avoid burning of straw, the following techniques are recommended:

### **1. In-situ management of paddy straw**

**a. Wheat sowing with Happy Seeder:** Happy Seeder is recommended to sow wheat in combine harvested paddy field without any straw burning. It is a PTO driven machine operated by 45 HP tractor and it covers about 0.75-0.80 acre per hour. The loose straw needs to be spread uniformly in the field for the proper working of Happy Seeder. It can be done manually or harvest the paddy by combine harvester fitted with PAU super straw management system (SMS). After the harvesting of paddy with combine fitted with Super SMS, wheat can be sown with Happy Seeder or Spatial Zero Till Drill, without straw burning. The paddy straw acts as mulch which adversely affects the weed population.

In case the paddy is harvested with a combine without SMS system, use PAU Straw Cutter cum Spreader for chopping and spreading of paddy straw. After chopping of straw, sow wheat with PAU Happy Seeder (fitted with press wheels).

**b. Wheat sowing with Super Seeder:** Harvest paddy with combine harvester fitted with the PAU Super SMS for sowing wheat with Super Seeder in combine harvested paddy field without any straw burning. It is a PTO driven machine operated by 55 HP or above tractor and it covers about 4.5-5.5 acre per day.

**c. Wheat sowing with PAU Smart Seeder:** Harvest paddy with combine harvester fitted with the PAU Super SMS for sowing wheat with PAU Smart Seeder in combine harvested paddy field without any straw burning. It is a PTO driven machine operated by 45 HP or above tractor and it covers about 7-8 acre per day.

**d. Incorporation:** Chop the straw and stubbles with Paddy Straw Chopper cum Spreader after combine harvesting of paddy. The chopped straw can be mixed in to the soil with rotary tillers after applying a light irrigation. The field comes in wattar condition in 2- 3 weeks depending on type of soil. Sow wheat seed with zero till drill or with conventional

drill. **Grow short duration rice varieties for increasing window period for straw management.**

## **2. Management after removal of paddy straw**

Use Straw baler for baling the paddy straw after combine harvesting. It collects the loose straw or complete straw after chopping the standing stubbles with stubble shaver. These bales can be used for different purposes as follows:

**a. Power generation:** Eleven biomass power plants have been established in Punjab for the generation of electricity from paddy straw bales. Heat produced by burning paddy straw is used to run steam turbine which further generates electricity.

**b. Paddy straw based bio-gas plant:** Paddy straw can be used in a specially designed biogas plant for bio gas production. This biogas plant is filled one time with 16 quintal chopped paddy straw along with 4-5 quintal cattle dung and it provides 3-4 m<sup>3</sup> biogas daily for 3 months.

**c. Paddy straw geyser:** A geyser has been developed by the University for heating water by using paddy straw bales. In this geyser about 100 litres of water can be heated to 45-50°C in 3-4 hours. The water once filled in the geyser remains hot for up to 24 hours or even more.

**d. Phospho-compost:** Phospho-compost can be prepared from the paddy straw. (see details in Organic Farming Chapter )

**e. Prali Char:** *Prali Char* is a carbon rich porous product obtained after the partial combustion of rice straw at low temperatures in the presence of little or no oxygen. It can be prepared in a pyramid or dome type kiln, made up of bricks and clay. To prepare 8 quintals of *Prali Char* from 12 quintals of rice straw, the height of this dome should be 14 ft with 10 ft diameter. Two windows each at the top and at the bottom of the kiln are provided for loading of paddy straw. Six vents of 2 inch diameter in the upper portion and eight vents are provided at three heights on the remaining portion of the structure. Fill the kiln with rice straw up to top. Seal the lower loading window and ignite the straw from the top loading window and immediately seal it with clay.

The partial combustion of rice straw will start from the top and proceeds towards the bottom. The emission of thin blue smoke from the vents indicates that the process of *Prali Char* formation is complete in this zone. To facilitate the combustion in the next zone, seal the vents located in the upper portion of the dome and likewise proceed to seal the vents of the middle and lower zone, respectively. The whole process usually takes about 10-12 hours. To seal the cracks developed during combustion and to cool the kiln, pour a diluted mixture of clay and water on the outer surface of the kiln. Normally it takes about two days to cool, however it can be cooled by sprinkling water for removing the *Prali Char* on the same day. On an average, it contains 30-36 % carbon, 0.5-0.6 % nitrogen, 0.16-0.22 % phosphorus and 1.6- 2.2 % potassium. Its' application to rice and wheat @ 2.0 t/acre saves 16 kg N (35 kg urea), increases crop productivity and improves soil health.

Besides, paddy straw can also be used as mulch material in different crops, mushroom cultivation and as animals bedding.

## **Plant Protection**

### **A. Insect Pests**

**Rice stem borers:** The larvae of these insects bore into the stem and cause damage from July to October. The affected young plants show dead-hearts (yellowing and drying of central shoot) whereas the old ones produce empty earheads which turn white and stand erect (Plate No. 3, page 186).

The fields showing more than **5% dead hearts (Economic Threshold Level, ETL)** should be sprayed with 60 ml Coragen 18.5 SC (chlorantraniliprole\*) or 20 ml Fame 480 SC (flubendiamide\* 39.35%) or 50 g Takumi 20 WG (flubendiamide\* 20%) or 170 g Mortar 75 SG (cartap hydrochloride) or 1 litre Coroban/Dursban/Lethal/Chlorguard/Durmet/Classic/Force 20 EC (chlorpyriphos) or 80 ml neem based bio-pesticide, Ecotin (azadirachtin 5%) in 100 litres of water per acre. Further application of any of these insecticides may be repeated as and when damage reaches economic threshold level. Prefer Ecotin at pest initiation stage.

**Leaf folder:** The larvae fold the leaves, eat out the green tissue and produce whitestreaks (Plate No. 4, page 186). The damage is highest during August-October. When the leaf damage reaches **10% (ETL)**, adopt the following control measures:

- **Mechanical Control:** 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**.
- **Chemical Control:** Spray the crop with 60 ml Coragen 18.5 SC (chlorantraniliprole\*) or 20 ml Fame 480 SC (flubendiamide\* 39.35%) or 50 g Takumi 20 WG (flubendiamide\* 20%) or 170 g Mortar 75 SG (cartap hydrochloride) or 1 litre Coroban/Durmet/Force 20 EC (chlorpyriphos) or 80 ml neem based bio-pesticide, Ecotin (azadirachtin 5%) in 100 litres of water per acre. Prefer Ecotin at pest initiation stage.

**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 enlarge.

About one month after transplanting, a few plants in the field should be slightly tilted and tapped 2 or 3 times at the base at weekly interval. When minimum **5 planthoppers per hill (ETL)** are seen floating in the water, spray 94 ml Pexalon 10 SC (triflumezopyrim) or 80 g Osheen/Token/ Dominant 20 SG (dinotefuran) or 120 g Chess 50 WG (pymetrozine) or 400 ml Orchestra 10 SC (benzpyrimoxan) or 300 ml Imagine 10 SC (flupyrimin) or 800 ml Ekalux/Quinguard/Quinalmass 25 EC (quinalphos) or 80 ml neem based bio-pesticide, 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

- **For need based insecticides application, spray the crop at Economic Threshold Level (ETL) of insect-pests as under:**
- **Stem borers:** 5% dead hearts
- **Leaf folder:** 10% leaf damage
- **Planthoppers:** Minimum 5 planthoppers per hill

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 alongwith their 3-4 metre periphery immediately as these spots harbour high population of the insect.

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

**Rice hispa:** Rice hispa is a serious pest in some areas of the Gurdaspur and Amritsar districts and is also found in the other rice growing areas of the State. The grubs of this pest tunnel into the leaves, whereas the adults are exposed feeders. The grubs cause damage by producing bold, white streaks on the leaves.

If the attack starts in nursery, clip-off and destroy the leaf tips of the affected seedlings before transplanting. On the transplanted crop, spray 800 ml Ekalux 25 EC (quinalphos) or 1.0 litre Dursban 20 EC (chlorpyriphos) in 100 litres of water per acre with a manually operated sprayer. Repeat the spraying if the attack persists.

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

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

## B. Diseases

**Sheath blight (*Rhizoctonia solani*):** Greyish green lesions with purple margin develop on the leaf-sheath above the water level. Later, the lesions enlarge and coalesce with other lesions (Plate No. 5, page 186). Its' severe attack results in the poor filling of the grains. Destroy the rice straw and stubbles after harvesting the affected crop. Avoid the excessive use of nitrogenous fertilizers. Keep the bunds clean by removing the grass.

At maximum tillering to boot stage of crop, as soon as the disease appears, spray 150 ml Iglare/Pulsor 24 SC (thifluzamide) or 26.8 g Epic 75 WG (hexaconazole) or 400 ml Galileo Way 18.76 SC (picoxystrobin + propiconazole) or 200 ml Amistar Top 325 SC or Tilt/Bumper/Pikapika 25 EC (propiconazole) or Folicur/Orius (tebuconazole) 25 EC or 80 g Nativo 75 WG (trifloxystrobin+tebuconazole) or 320 ml Lusture 37.5 SE (flusilazole + carbendazim) or 200 ml Monceren 250 SC (pencycuron) in 200 litres of water per acre. Give second spray 15 days thereafter.

**False smut (*Ustilaginoidea virens*):** It is a fungal disease in which the individual grains transform into large yellowish/greenish velvety spore-balls (Plate No. 6, page 186). High relative humidity, rainy and cloudy days during the flowering period increase the incidence of the disease. The application of organic manures and high dose of nitrogenous fertilizers also increases the intensity of attack.

To control this disease, give spray of 400 ml Galileo Way 18.76 SC (picoxystrobin + propiconazole) or 500 g Kocide 46 DF (copper hydroxide) in 200 litres of water per acre at boot stage of the crop in disease prone areas.

**Brown leaf spot (*Drechslera oryzae*):** It produces oval, eye-shaped spots with a conspicuous dark-brown dot in the centre and light brown margin. Spots are also produced on the grains. This disease occurs in poor soils, therefore, give adequate and balanced nutrition to the crop. To control the disease, give two sprays of 80 g Nativo 75 WG (trifloxystrobin + tebuconazole) in 200 litres of water/acre. Give first spray at boot stage of crop and second spray after 15 days.

- **To prevent rice diseases, avoid excessive use of nitrogen.**
- **Early transplanting, excessive ponding of water, continuous dizzling, 25-30°C temperature and high relative humidity are favourable for development of diseases.**
- **Monitor the crop for sheath blight appearance and apply recommended fungicides for its timely management.**
- **For the management of false smut, apply preventive application of recommended fungicide at boot stage.**

**Blast (*Pyricularia grisea*):** The fungus causes spindle shaped spots with greyish centre and brown margin on the leaves at maximum tillering. It also causes brown lesions on the neck of the panicle, showing neck rot symptoms and the panicles fall over. The disease is more severe on Basmati cultivars particularly in the submontaneous areas and under application of heavy nitrogenous fertilizers. Spray the affected crop with 200 ml Amistar Top 325 SC (azoxystrobin + difenoconazole) or 500 g Indofil Z-78, 75 WP (zineb\*) per acre in 200 litres of water, at the boot and ear-emergence stages.

**Bunt/Kernel Smut (*Neovossia horrida*):** Only a few grains in the panicle are infected. Frequently, only a part of the grain is replaced by a black powder. Sometimes, entire grain is also attacked and the black powder scatters on to other grains or leaves, and this is often the easiest way to detect the disease in the field. Also avoid heavy doses of nitrogenous fertilizers.

**Sheath rot (*Fusarium moniliforme*):** The rot occurs on the uppermost leaf-sheaths where oblong to irregular and grey-brown to light-brown lesions develop. The lesions often coalesce to cover the entire sheath. In severe cases, young panicles either do not emerge or emerge partially. A white-powdery growth of the fungus appears on the panicle inside the sheath. The glumes of infected florets are discoloured, dark-red or purple brown to black and often do not fill. The fungus over-winters in rice straw and grains. Destroy the rice straw after harvesting the infected crop. Use disease free seed for sowing.

Give two sprays of 26.8 g Epic 75 WG (hexaconazole) in 200 litres of water per acre. The first spray should be given at boot stage and second 15 days afterwards.

**Stem rot (*Sclerotium oryzae*):** The fungus affects the stem at earring and black lesions are produced on the sheath at water level. Later on, the stem gets infected and rots leading to withering and lodging of the plant. The incidence of this disease has declined on high yielding varieties due to improved cultural practices. Destroy the diseased debris of infected crop. Avoid excessive irrigation and use recommended dose of nitrogenous fertilizer.

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

- For the management of bacterial blight, grow rice varieties PR 131, PR 130, PR 129, PR 128, PR 127, PR 126, PR 122, PR 121 and PR 113 which are resistant to most of the pathotypes of bacterial blight pathogen.
- Use disease free seed.
- Do not grow nursery and crop under shade and near wheat straw stack (*Kup*)
- Do not apply excessive dose of nitrogen. Nitrogen should not be applied beyond six weeks after transplanting (except when LCC is used).
- Do not pond water in the field continuously.

**Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*):** Small translucent streaks appear in the interveinal areas of the leaf. The streaks gradually enlarge and turn reddish, when the plants near maturity. Use disease free seed.

**Root-knot Nematode (*Meloidogyne graminicola*):** The disease first appears in uneven yellow patches. The affected seedlings show poor and patchy growth with chlorotic symptoms and characteristic terminal hook or bead like galls on the roots.

For the management of root knot nematode, apply mustard cake @ 40 g per square metre (1.0 kg per marla) 10 days before sowing of nursery with last preparatory tillage operation after *rauni*. Also, practice puddling for nursery sowing.

**Caution:** Exercise waiting period of 10 days between application of Mustard cake and sowing of nursery.

### **C. Rodents**

Do rodent control before milky grain stage in August-September as per the method given in chapter 11 "Management of Rodents and Birds".

## Rice Cultivation in Alkali Soils

- **Addition of Gypsum:** If the pH of soil is more than 9.3 then apply gypsum on soil test basis and give one or two heavy irrigations.
- **Preparation of Seed bed:** Do not puddle, because water intake rate in these soils is very low. Irrigate the tilled field and give a light planking to pulverize the clods.
- **Transplanting:** Transplant seedlings a week earlier than the normal time of transplanting, because the initial growth of plants in alkali soils is slow. Plant three or four 40 days old seedlings per hill. More seedlings per hill are recommended because of higher mortality in these soils. **Do not grow PR 127 under alkali conditions.**
- **Fertilizer Application:** Apply 20-25 per cent more nitrogen than in normal soils. Alkali soils are low in organic carbon and the efficiency of nitrogen fertilizer in these soils is also low. Add 60 kg of nitrogen through 130 kg of urea per acre in three splits, 1/3 at transplanting, 1/3 three weeks after transplanting and the remaining 1/3 six weeks after transplanting. Apply the same amount of phosphorus as to the normal soils. In addition, apply 25 kg of zinc sulphate heptahydrate or 16 kg zinc sulphate monohydrate per acre during the preparatory tillage. Where *dhauncha* is grown for green manuring, add the quantity of  $P_2O_5$  recommended for rice to this legume and omit the application of phosphorus to the succeeding rice crop.

## BASMATI RICE

### Climatic Requirements

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

### Rotations

Basmati Rice-Wheat/Sunflower, Basmati Rice-Wheat-Summer Moong, Basmati Rice-Mentha, Basmati Rice-Berseem (Fodder & seed), Basmati Rice-Celery-Bajra (Fodder), DSBR-Potato-Mentha

### Improved Varieties

**Punjab Basmati 7 (2021):** It is a semi-dwarf Basmati variety which is about 111 cm tall. It possesses extra-long slender grains which are soft, non-sticky and almost double upon cooking. It is highly aromatic like traditional Basmati varieties. Its' average yield is 19.0 quintals per acre. It matures in about 101 days after transplanting. It is resistant to all the ten presently prevalent pathotypes of bacterial blight pathogen in the Punjab state.

**Pusa Basmati 1718 (2019):** It is a bacterial blight resistant version of Pusa Basmati 1121 which is resistant to all the ten pathotypes of bacterial blight presently prevalent in the Punjab state. Its' average plant height is 121 cm and it matures in 114 days after transplanting. It possesses extra long slender grains with good cooking quality. Its' average paddy yield is 17.0 quintals per acre.

**Pusa Basmati 1637 (2018):** It is a new version of Pusa Basmati 1 which is moderately tolerant to blast disease. Its' average plant height is 109 cm and matures in 108 days after transplanting. It possesses extra long slender grains. Its' average paddy yield is 17.5 quintals per acre.

**Punjab Basmati 5 (2017):** It is a semi-dwarf Basmati variety which is about 112 cm tall. It possesses extra-long slender grains with excellent cooking and eating quality characteristics. The grains almost double upon cooking, are non-sticky and highly aromatic. Its' aroma is even better than the existing traditional Basmati varieties. It is resistant to all the ten pathotypes of bacterial blight pathogen presently prevalent in the state. It matures in about 107 days after transplanting. Its' average paddy yield is 15.0 quintals per acre.

- **Pusa Basmati 1637** is moderately resistant to blast.
- **Punjab Basmati 7, 5 and Pusa Basmati 1718** are resistant to bacterial blight.
- **Do not apply nitrogenous fertilizer to Basmati sown after green manuring.**
- **For the control of Foot rot, treat the seed and seedlings as per recommendations.**

**CSR 30 (2017):** It is about 139 cm tall. It possesses extra-long slender grains with excellent cooking and eating quality characteristics. The grains are non-sticky, soft to eat and highly aromatic. It is susceptible to all the pathotypes of bacterial blight presently prevalent in the state. It matures in about 112 days after transplanting. Its' average paddy yield is 13.5 quintals per acre.

**Pusa Basmati 1509 (2013):** It is an early maturing variety which matures in about 95 days after transplanting. Its' average height is 92 cm. It possesses extra-long slender grains with excellent cooking and eating quality characteristics. Its' grains become almost double upon cooking and are scented. It is suitable for multiple cropping system. Transplant 25 days old seedlings for better tillering. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the state. Its' average paddy yield is 15.7 quintals per acre.

**Pusa Basmati 1121 (2008):** It is about 120 cm tall. It possesses extra long slender grains with good cooking quality. It has longest cooked rice length among all the aromatic rice varieties recommended for Punjab. It matures in about 107 days after transplanting. It is susceptible to all the pathotypes of bacterial blight pathogen prevalent in the state. It yields on an average 13.7 quintals of paddy per acre.

## Agronomic Practices

### Puddled Basmati

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

**Seed and Seedling Treatment:** Foot rot is a major disease of Basmati. To control this disease, seed and seedling treatment is mandatory. Smear the seeds with talc formulation of *Trichoderma harzianum* @ 15 g per kg of seed immediately before sowing and seedling root dip for 6 hrs with *T. harzianum* @ 15 g per litre of water before transplanting. Or treat the seed with Sprint 75 WS (carbendazim + mancozeb) by making slurry of 3 g fungicide formulation in 10 ml water for one kg seed before sowing.

**Nursery sowing and transplanting time:** The time of transplanting is a crucial factor in determining the yield and quality of Basmati.

Varieties	Time of Nursery Sowing	Time of Transplanting
Punjab Basmati 7 and 5, Pusa Basmati 1121, 1637 and 1718	First fortnight of June	First fortnight of July
CSR 30 and Pusa Basmati 1509	Second fortnight of June	Second fortnight of July

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

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

### Fertilizer Application

Use organic and chemical fertilizers as under:

a) **Organic Manures:** Practice green manure before basmati. Do not apply urea if the field has been green manured with 45-55 days old sunnhemp/dhaincha or summer moong straw has been incorporated after picking of pods.

b) **Chemical Fertilizers:** Apply fertilizers on soil test and crop rotation basis. Skip phosphorus application if the recommended dose of phosphorus has been applied to the preceeding wheat crop. However in phosphorus deficient soils, apply 75 kg of superphosphate per acre before last puddling. Recommended dose of urea for different varieties is as under:

- CSR 30 - 18 kg urea per acre
- Punjab Basmati 7 & 5 and Pusa Basmati 1121, 1637 & 1718 - 36 kg urea per acre
- Pusa Basmati 1509 - 54 kg urea per acre

High doses of nitrogen application to basmati causes excessive vegetative growth and plant height. This makes the crop more prone to lodging thus resulting into poor yield. Apply urea in two equal splits at 3 weeks and 6 weeks after transplanting. If possible, apply urea when water is not standing in the field. Irrigate on third day of the application of urea.

### PAU-Leaf Colour Chart (PAU-LCC) for need based Urea application

- No basal urea should be applied at the time of transplanting of basmati rice.
- Start matching colour of first fully exposed leaf from top of plant with the PAU-LCC at 7 days interval after 21 days of transplanting.
- Every time match colour of the ten intact leaves with LCC shade 3.5 (for CSR 30) and LCC shade 4 (for Punjab Basmati 7, 5 and Pusa Basmati 1121, 1509, 1637 and 1718).
- When ever the greenness of 6 or more out of 10 leaves is lighter than the specified LCC shades, apply 9 kg urea per acre.
- No urea should be applied if colour of 6 or more out of 10 leaves is equal to or darker than specified LCC shades.
- Use of LCC should be discontinued after initiation of flowering and no more urea should be applied.

#### Note:

- The LCC is highly beneficial for optimum fertilizer nitrogen applications in fields amended with

organic manures.

- The leaves selected for measuring leaf greenness should be free of insect-pest disease incidence.
- There should not be any water stress to the crop and the nutrients other than nitrogen should be supplied as per recommendations.

The leaf colour chart can be purchased from the PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

**Irrigation:** Keep the water ponded continuously for 2 weeks after transplanting. Afterwards apply irrigation two days after the ponded water has infiltrated into the soil. The crop should not suffer any water stress particularly during flowering. Stop irrigation about a fortnight before harvesting to facilitate easy harvesting and timely sowing of succeeding rabi crop.

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

## Plant Protection

### A. Insect Pests

**Stem borers:** Basmati rice varieties are highly susceptible to stem borers namely yellow stem borer, white stem borer and pink stem borer. The yellow and white stem borers are serious up to flowering stage. The pink stem borer generally appears late and is more serious at/after maximum tillering stage when its damage affects grain formation. It is, therefore, necessary to monitor the crop regularly for stem borer damage. As and when there are more than 2% dead hearts (ETL) in the field, adopt the following control measures:

Stem borers can be managed by spraying neem based biopesticide, 80 ml Ecotin (azadirachtin 5%) or 1000 ml Achook/Neem Kavach (azadirachtin 0.15%) or 20 ml Fame 480 SC (flubendiamide\* 39.35%) or 50 g Takumi 20 WG (flubendiamide\* 20%) or 60 ml Coragen 18.5 SC (chlorantraniliprole\*) or 170 g Mortar 75 SG (cartap hydrochloride) or 1.0 litre Coroban/Dursban/Lethal/Chlorguard/Durmet/Classic/Force 20 EC (chlorpyrifos) or 15 g Fipronil 80% WG (fipronil) in 100 litres of water per acre. Prefer Ecotin or Achook/Neem Kavach at pest initiation stage.

These insects can also be controlled by applying 4 kg Ferterra/ Marktera 0.4 GR (chlorantraniliprole\*) or 4 kg Vibrant 4 GR (thiocyclam hydrogen oxalate) or 10 kg Padan/ Caldan/Kritap/Sanvex/Nidan/Marktap/Miftap/ Faltap-G/ Katsu 4 G (cartap hydrochloride) or 6 kg Regent/Mortel/Mifpro-G/Mahaveer GR/Shinzen 0.3 G (fipronil) or 4 kg Dursban 10 G (chlorpyrifos) per acre in standing water. Use gloves while applying granular insecticides.

Fame 480 SC or Takumi 20 WG or Coragen 18.5 SC or Mortar 75 SG or chlorpyrifos 20 EC or Fipronil 80 WG or Ferterra/Marktera 0.4 GR or Vibrant 4 GR or Padan/ Kritap/Caldan/Sanvex/Nidan/Marktap/Miftap/Faltap-G/ Katsu 4G or Regent/Mortel/Mifpro-G/Mahaveer GR/ Shinzen 0.3 G or Dursban 10 G or Ecotin or Achook/Neem

- |  |
|--|
| <ul style="list-style-type: none"><li>• Monitor the insect-pests regularly and apply insecticides on the basis of Economic Threshold Level.</li><li>• For effective management of neck blast spray the fungicides at boot stage.</li></ul> |
|--|

Kavach also control leaf folder. Use above insecticides alternately.

**Planthoppers, Rice hispa and Leaf folder:** These pests also damage basmati rice in the State. For their control, follow recommendations as mentioned in rice for these pests.

## B. Diseases

**Foot rot (*Fusarium moniliforme*):** This disease is both seed and soil borne. The infected seedlings turn pale yellow and become elongated. Later on these seedlings start drying from bottom and usually die. The symptoms also appear after transplanting in the field and the infected plants become taller than the normal plants and are killed after a few days. Adventitious roots also appear on the lower nodes. Pinkish growth of the fungus appears on the lower sheaths. Adopt following integrated approaches to manage the disease:

- Use disease free seed
- Treat the seed and seedlings as per recommendations.
- Rogue out and destroy infected seedlings from nursery and field.

**Blast (*Pyricularia grisea*):** It is relatively more important in Basmati varieties. This fungus causes spindle shaped spots with greyish centre and brown margins on the leaves at maximum tillering stage. It also causes black lesions at the neck of panicle leading to its dropping. Grow Pusa Basmati 1637, which is moderately tolerant to blast. For control of this disease, spray per acre 200 ml Amistar Top 325 SC (azoxystrobin+difenoconazole) or 500 g Indofil Z-78 75 WP (zineb)\* in 200 litre of water at maximum tillering and ear emergence stages.

**Bacterial blight:** Punjab Basmati 7, 5 and Pusa Basmati 1718 are resistant to most of the pathotypes of bacterial blight pathogen. Other practices to control the disease are same as for rice.

**Note:** Manage the other diseases, insects and rodents as per rice.

## Unpuddled Direct Seeded Rice (DSR)

The declining water resources of the state demand the highest priority to development of water conservation technologies. Direct seeding of rice in unpuddled fields (DSR) is one such technology that has water saving potential. DSR provides several benefits such as 1) 10-20% saving in irrigation water, 2) 10-12% higher ground water recharge, 3) saves labor, 4) less prone to infestation of diseases (e.g. sheath blight, foot rot), 5) provides 100 kg/acre higher yield of succeeding wheat as compared to conventional practice of puddled transplanted rice.

DSR technology was recommended in 2010 in the state. The technology was further refined and in 2020, a novel DSR technique coined as 'tar-wattar DSR' was recommended. In tar-wattar DSR, a major departure from the earlier practice is delayed first irrigation which is applied at 21 days after sowing which has many added advantages like higher saving in irrigation water, better root development, lesser incidence of nutrient deficiency especially iron, lesser weeds and wider soil adaptability. Further, a new method of DSR 'Direct seeding on raised beds in tar-wattar fields', which offers higher saving in irrigation water as compared to earlier methods, has been recommended in 2022.

In 2020, DSR occupied 5.4 lakh ha (about one-fifth of total area under rice) in the state. In 2021, area under DSR increased further to 6.0 lakh ha.

The success of DSR lies in the adoption of improved production practices which are discussed below:

- **Suitable soils:** Sow DSR only in medium to heavy textured soils. Its' cultivation is not successful in light textured soils due to severe iron deficiency and lower crop yields.
- **Laser levelling:** Laser levelling improves irrigation water use efficiency and ensures better germination. Plough the field with disc harrow followed by cultivation with cultivator and planking, then level the field with laser leveller.
- **Suitable varieties:** Short and medium duration varieties
- **Sowing time:** 1-15 June
- **Seed rate and seed treatment:** Use 8-10 kg seed per acre. Imbibe rice seed by dipping in 2% potassium nitrate solution (prepare solution by dissolving 200 g KNO<sub>3</sub> in 10 litre water for 8 kg seed) for 12 hours. Dry the seed in shade and treat with 3 g Sprint 75 WS (mencozeb + carbendazim) per kg seed.
- **Method of sowing:** Rice can be direct seeded by three methods:
  1. **Direct seeding in tar-wattar fields:** Divide the field into *kiyaras* of desirable size after Laser Leveling and apply *rauni* irrigation. When the field comes to *tar-wattar* (sufficiently high but workable soil moisture) conditions, prepare field *kiyara*-wise with shallow cultivation followed by 2-3 plankings with load of 3 sandbags on planker and sow immediately. Seed should be placed at 3-4 cm depth in 20 cm spaced rows. Avoid field preparation and sowing during noon hours for better results.  
Preferably, use Lucky Seed Drill (which sow rice and spray pre-emergence herbicide simultaneously) for direct seeding. Alternatively, use conventional rice drill having inclined plate metering system and spray herbicide immediately. Direct seeding with Lucky Seed Drill (fitted with press wheels) help in tackling the problem of *krand* formation (which occur if there is rainfall after sowing), conserves soil profile moisture and improves the efficacy of pre-emergence herbicide.
  2. **Direct seeding on raised beds in tar-wattar fields:** This method saves higher irrigation water than other two methods.  
Laser level the field and make 67.5 cm wide shallow beds (bed with 37.5 cm flat top with adjacent 30 cm furrow), preferably by using same bed planter that will be used for final

• **Direct seeding of rice should not be done on light textured sandy soils.**

- **Tar-wattar DSR technique is suitable for direct seeding in medium and heavy textured soils (including sandy loam, loam, silt loam and clay loam) which accounts for around 87% area of the state.**
- **Sowing should be done in the first fortnight of June.**
- **For effective weed control, spray 1.0 litre Stomp/Bunker 30 EC per acre in moist soil immediately after sowing and thereafter use other herbicides as per recommendation.**

sowing. Then apply *rauni* (pre-sowing irrigation) in furrows only.

When field come to *tar-wattar* conditions (within 2-3 days depending on soil type), use bed planter (fitted with bed compacter) for reshaping beds and simultaneous sowing (2 rows/bed) of treated seed, and apply pre-emergence herbicide immediately. Avoid sowing during noon hours for better results.

**3. Direct seeding in dry fields:** Treated seed should be placed 2-3 cm deep in rows spaced at 20 cm in a dry field and irrigation is applied immediately after sowing.

- **Weed Control**

**Pre-emergence:** Spray 1.0 litre per acre Stomp/Bunker 30 EC (pendimethalin) in 200 litres of water for control of annual grass weeds and some broadleaf weeds. In case of *tar-wattar* DSR, if sown using Lucky Seed Drill, sowing and herbicide spray are done simultaneously and, if conventional rice drill is used, then spray immediately after sowing. In case of sowing in dry fields, irrigation is applied immediately after sowing and herbicide is sprayed when the field comes to wattar condition which in general is within 1 to 2 days of sowing.

**Post-emergence:** Depending on the weed flora present in the field, any of the herbicide listed in the table below may be applied at 15-25 days of sowing, by dissolving in 150 litres of water, when weed plants are at 1-4 leaf stages as given under each herbicide (see page 185).

Name of herbicide	Dose per acre	Target weed flora	Weed leaf stage at time of spray
Nominee Gold 10 SC (bispipyribac sodium)	100 ml	<i>Swank, swanki, paddy mothas</i>	2-4
Ricestar 6.7 EC (fenoxaprop-p-ethyl)	400 ml	<i>Madhana, chini gha, chiri gha, takri gha</i>	2-4
Almix 20 WP (chlorimuron ethyl 10% + metsulfuron methyl 10%)	8 g	Broadleaf weeds, paddy mothas, <i>gandi wala motha</i>	2-4
Vivaya 6 OD (penoxsulam 1.02% + cyhalofop 5.1%)	900 ml	<i>Swank, swanki, chini gha, broadleaf weeds, paddy mothas</i>	1-2
Council Activ 30 WG (triflafamone 20% + ethoxysulfuron 10%)	90 g	<i>Swank, swanki, chini gha, broadleaf weeds, paddy mothas, gandi wala motha</i>	1-2

- Always spray herbicide when weed plants are at the right leaf stage as mentioned against each herbicide.
- Always spray herbicide in moist field and maintain proper soil moisture (wattar) in the field for one week after spray.
- The leftover weeds may be uprooted before they produce seeds.
- **Fertilizers:** Apply 130 kg urea/acre in three equal splits at 4, 6 and 9 weeks of sowing. Apply phosphorus and potash on soil test basis. In case of zinc and iron deficiency,

follow the recommendations as given under puddled transplanted rice (Page 10).

#### **PAU-Leaf Colour Chart (PAU-LCC) for need based Urea application**

- No urea should be applied at the time of sowing.
- After four weeks of sowing, apply 25 kg urea per acre.
- After six weeks of sowing, start matching colour of the topmost fully exposed intact leaf of the randomly selected ten rice plants with PAU-LCC under shade of your body at 7 day interval.
- Whenever the greenness of 6 or more out of 10 leaves is lighter than the LCC shade 4, apply 30 kg urea per acre.
- No urea should be applied if colour of leaves is equal to or darker than the LCC shade 4.
- Use of LCC should be discontinued after initiation of flowering and no more urea should be applied.

**Note:** The leaves selected for measuring leaf greenness should be free from insect/disease incidence. There should not be water stress to the crop and nutrients other than nitrogen should be supplied as per recommendations. The PAU-LCC can be purchased from PAU Seed Shop at Gate No. 1, *Krishi Vigyan Kendras* and Farm Advisory Service Centres in different districts.

- **Irrigation**

**1. Direct seeding (flat/raised beds) in tar-wattar fields:** Apply first irrigation at around 21 days after sowing. After that, apply irrigations at 5-7 days interval depending on soil type.

**2. Direct seeding in dry fields:** Apply first irrigation immediately after sowing and second irrigation at 4-5 days after sowing. Subsequent irrigations should be applied at 5-7 days interval depending on soil type.

The irrigation interval may be adjusted according to rainfall. Stop irrigation 10 days before harvesting. In this way, DSR saves around 10 to 20% irrigation water as compared to puddled transplanted rice.

For sub-surface drip irrigation and fertigation in zero till DSR, see chapter on 'Multiple Cropping' under zero till direct seeded rice-wheat cropping system.

- **Rodent management:** Rodents cause damage to direct seeded rice crop at germination stage. Control weeds and rebuild bunds to destroy rat burrows and reduce their height and width. Do burrow baiting during lean period (May-June) as per the method given in chapter 11 "Management of Rodents and Birds".