

Recommended package of practices: Pearl millet

Preparation of land

Pearl millet can be grown in different soils. It does not grow well in soils prone to waterlogged conditions. The field should be ploughed once or twice followed by harrowing to create fine tilth

Selection of high yielding hybrids and varieties

Most of the pearl millet area is grown with hybrids while the varieties are preferred in drought prone ecologies. The latest list of hybrids and varieties of pearl millet is given below.

Region/ State		Recommended Hybrid	Recommended Variety
Rajasthan	Kharif	KBH 108, GHB 905, 86M89, MPMH 17, Kaveri Super Boss, Bio 448, MP 7872, MP 7792, 86M86, 86M66, RHB-173, HHB 67	MBC 2, PC 443, JBV 3, PC 383, ICMV 221, Raj 171
	Summer	Nandi 70, Nandi 72, 86M64	
	Kharif – arid parts	HHB 234, Bio 70, HHB-226, RHB-177	CZP 9802
Gujarat	Kharif	KBH 108, GHB 905, 86M89, MPMH 17, Kaveri Super Boss, Bio 448, MP 7872, MP 7792, 86M86, 86M66, RHB-173, HHB 67	MBC 2, PC 443, JBV 3, PC 383, ICMV 221, Raj 171
	Summer	Nandi 70, Nandi 72, 86M64	
	Kharif – arid parts	HHB 234, Bio 70, HHB-226, RHB-177	CZP 9802
Haryana	Kharif	KBH 108, GHB 905, 86M89, MPMH 17, Kaveri Super Boss, Bio 448, MP 7872, MP 7792, 86M86, 86M66, RHB-173, HHB 67	MBC 2, PC 443, HC 20, JBV 3, PC 383, HC 10, ICMV 221, Raj 171
	Kharif – arid parts	HHB 234, Bio 70, HHB-226, RHB-177	CZP 9802
Punjab	Kharif	KBH 108, GHB 905, 86M89, MPMH 17, Kaveri Super Boss, Bio 448, MP 7872, MP 7792, 86M86, 86M66, RHB-173	PCB 164, ICMV 221, Raj 171
Delhi	Kharif	KBH 108, GHB 905, 86M89, MPMH 17, Kaveri Super Boss, Bio 448, MP 7872, MP 7792, 86M86, 86M66, RHB-173	JBV 3, PC 383, ICMV 221, Raj 171
Uttar Pradesh	Kharif	KBH 108, GHB 905, 86M89, MPMH 17, Kaveri Super Boss, Bio 448, MP 7872, MP 7792, 86M86, 86M66, RHB-173	JBV 3, PC 383, ICMV 221, Raj 171
Madhya Pradesh	Kharif	KBH 108, GHB 905, 86M89, MPMH 17, Kaveri Super Boss, Bio 448, MP 7872, MP 7792, 86M86, 86M66, RHB-173	JBV 4, JBV 3, PC 383, ICMV 221, Raj 171
Maharashtra	Kharif	Kaveri Super Boss, Pratap, PKV Raj, Shine, MP 7792, 86M86, PAC 909, 86M64, 86M53	ABPC-4-3, PC 612, Parbhani Sampada, Samrudhi, ICMV 221, Raj 171, ICMV 155

	Summer	Nandi 70, Nandi 72, 86M64	
Tamilnadu	Kharif	Kaveri Super Boss, Pratap, Co 9, Shine, MP 7792, 86M86, PAC 909, 86M64, 86M53	PC 612, CoCu 9, Samrudhi, ICMV 221, Raj 171, ICMV 155
	Summer	Nandi 70, Nandi 72, 86M64	
Andhra Pradesh	Kharif	Kaveri Super Boss, Pratap, Shine, MP 7792, 86M86, PAC 909, 86M64, 86M53	PC 612, Samrudhi, ICMV 221, Raj 171, ICMV 155, Ananta
Karnataka	Kharif	Kaveri Super Boss, Pratap, Shine, MP 7792, 86M86, PAC 909, 86M64, 86M53	PC 612, Samrudhi, ICMV 221, Raj 171, ICMV 155

Method of sowing

Three systems of pearl millet sowing are followed: (1) on a flat surface, or (2) using ridge and furrow system, or (3) on a broad-bed and furrow system

The seed should be sown at 2.5 cm – 3 cm depth

Time of sowing

Sowing of *kharif* pearl millet should be done with the onset of monsoon i.e. first fortnight of July in north and central parts of the country. First fortnight of October is appropriate time for rabi season in Tamil Nadu. Gap filling should be done by transplanting seedlings after 2-3 weeks of sowing if scanty population exists. In Marathwada area of Maharashtra, dry sowing prior to first monsoon rains is recommended. Summer pearl millet should be sown from 4th to 5th Standard Meteorological Week (SMW) i.e. last week of January to 1st week of February to obtain higher production of summer pearl millet in zone B.

Seed treatment

Seed treatment with biopesticides (*Trichoderma harzianum* @ 4g kg⁻¹) or thiram 75% dust @ 3 g kg⁻¹ seed will help against soilborne diseases. Seed treatment with 300-mesh sulfur powder @ 4 g kg⁻¹ seeds controls the smut disease. For removing ergot affected seeds, they are soaked in 10% salt solution. Seed treatment with metalaxyl (Apron 35 SD) @ 6 g kg⁻¹ seed controls downy mildew. Seeds are treated with *Azospirillum* (600 g) and *Phosphobacterium* to enhance the availability of nitrogen and phosphorus.

Seed rate, Spacing and Plant population

Seed rate: 3 kg/ha

Spacing: For arid-western plain of Rajasthan, Haryana and Kutch of Gujarat (A1 zone), pearl millet should be planted in rows 60 cm apart, maintaining low plant population of 1.00 to 1.25 lac/ha. For the area receiving rainfall more than 450 mm (zone A & B), the crop should be

planted at the spacing of 45 x 10-15 cm keeping plant population of 1.75 to 2.0 lakhs/ha. Seed rate for the crop should be taken @ 3 to 4 kg/ha for obtaining required plant stand.

Plant population: The recommended plant stand for pearl millet under normal conditions is 180,000 plants ha⁻¹ or 72,000 plants acre⁻¹. Under irrigation or high levels of management on highly productive soils, a population of 225,000 plants ha⁻¹ (100,000 plants acre⁻¹) is recommended. On extremely sandy, droughty soils, a population of about 90,000 plants ha⁻¹ (40,000 plants acre⁻¹) is desirable.

Nutrient management

Application of 40 kg N + 20 kg P₂O₅/ha for arid regions and 60 kg N/ha + 30 kg P₂O₅/ha for semi-arid regions is recommended for sole pearl millet as well as intercropping system. In light soils (sandy loams) the applied nitrogen may be lost due to leaching with heavy rains. So, only about half of the recommended nitrogen dose should be applied at seedbed preparation. The remaining half of nitrogen dose is side-dressed when the crop is 25 days old. On soils which do not leach easily like black soils, all of the nitrogen may be applied during seedbed preparation. Pearl millet seeds are sensitive to fertilizer burn. Do not apply fertilizer in the furrow with the seed or very near the seed in the row after sowing. It should be applied as side dressing Use of biofertilizer (*Azospirillum* and PSB) can economize the N and P fertilizer application.

In zinc deficient soils of the pearl millet growing area of the country, application of 10 kg ZnSO₄/ha is recommended. To correct the zinc deficiency in standing crop, spray of 0.2% ZnSO₄ at tillering to pre-flowering stage is recommended. Under prolonged dry spell, skip top dressing of N and spray 2% urea. Under excessive rain situation during vegetative phase, additional dose of nitrogen @ 20 kg/ha should be given.

Intercultivation and weed control

Two hoeings and weedings at 15 and 30 DAS are sufficient for controlling weeds effectively which is comparable with the herbicidal weed control through pre-emergent application of atrazine @ 0.5 kg/ha superimposed with one hand weeding. Second weeding helps to conserve soil moisture.

Pearl millet-based cropping systems in kharif

Rotation of cultivars also should be adopted to avoid downy mildew disease problem. Pearl millet hybrids and open-pollinated varieties should be used in alternate years/seasons. It is advised not to grow the same hybrid or open pollinated variety continuously on the same piece of land.

Rajasthan	Pearl millet + cluster bean/ cowpea/ green gram/mothbean/ sesame
Haryana	Pearl millet + Green gram/ sesame / cluster bean/ cowpea
Gujarat	Pearl millet + Green gram/ sesame/cowpea
Uttar Pradesh	Pearl millet + Green gram/ sesame/cowpea

Madhya Pradesh	Pearl millet + Black gram/ soybean/ Pigeonpea/cowpea
Delhi	Pearl millet + Pigeonpea/ groundnut / castor
Punjab	Pearl millet + Chickpea/fodder sorghum/wheat
Maharashtra	Pearl millet + Moth bean / Pigeonpea/soybean/blackgram, greengram/cowpea/sunflower
Karnataka	Pearl millet + Pigeonpea greengram/sunflower/soybean
Tamil Nadu	Pearl millet + Pigeonpea greengram/sunflower/soybean/cowpea
Andhra Pradesh	Pearl millet + Pigeonpea/ greengram/sunflower/soybean/groundnut

Irrigation: Under prolonged dry spells, irrigation should be applied at critical stages of crop growth i.e. tillering, flowering and grain developmental stage, if water is available. In summer, pearl millet should be irrigated at regular intervals (0.75-1.0IW/CPE with 40 mm) as per need of the crop.

Harvesting: The best stage to harvest pearl millet is when the plants reach physiological maturity determined by the black spot at the bottom of the grain in the hilar region. When the crop matures, the leaves turn yellowish and present a nearly dried up appearance. The grains are hard and firm. The usual practice of harvesting pearl millet is cutting the earheads first and the stalks later. The stalks (straw) are cut after a week, allowed to dry and then stacked. Grain at or below 14% moisture is considered dry. For long-term storage (more than 6 months), grain moisture content should be less than 12%.

Major Insect Pests

Insect pests are considered to be relatively less important in most of the pearl millet growing areas in India. The most important insect pests of pearl millet are white grub, shoot fly and grey weevil.

White Grub: A common pest in Gujarat and Rajasthan States. The grubs attack the root of the growing seedlings and cause complete withering of the plants. Patchy gaps are formed due to death of plants which result in poor or uneven plant stand. Grubs cause maximum damage during July-August. The adults emerge from May to July with the pre- monsoon/monsoon showers and feed on pearl millet flower and grains in the milky stage. The extent of damage ranged from 5-25% in Rajasthan.

Control

- Inter-cropping with Sunflower and Pigeon pea reduces the incidence of white grub
- Collect and destroy the adult beetles immediately after first showers when they visit *Neem/ Acacia* trees mating
- Mixing of *Carbofuran 3 G* @ 12 Kg/ha with *Bajra* seed and application in seed furrows at the time of sowing is effective
- Spray host trees with *Carbaryl 0.2 %* or *Chlorpyrifos 0.2%* with onset of monsoon and the spraying within 2-3 days after receipt of first showers.

Shoot fly: A common pest of Gujarat and Tamilnadu State. Larvae cut the growing point causing “dead heart” during the seedling stage whereas in advance stage, they feed on ear heads and cut down panicles. Infestation is more on late sown crop.

Control

- The crop should be sown with the onset of the monsoon or latest within 10-15 days of first shower of monsoon;
- Staggered sowing to contain the buildup of shoot fly population
- Transplanting is suggested for late sown crop. In case direct seeding, a seed rate of 4 Kg per ha is recommended and the affected seedlings are thinned within 15 days after sowing
- In case of heavy incidence of shoot fly in endemic areas, spray the crop with 0.07 % *Endosulfan* at 10 and 20 days after germination.
- In places where water is a problem, 4 % dust of *Endosulfan* can be used.

Grass Hoppers : Eggs are laid in the soil 75-200 mm deep; hoppers and adults feed on foliage, at times causing severe defoliation of the crop; adults are short winged and can fly short distances only.

Control:

- weed free cultivation; deep summer ploughing after harvest of the crop to expose “egg pods” in soil
- scrapping of bunds and clean cultivation
- dust the crop with 4 % *Endosulfan* or *Fenvalerate* dust @25 Kg/ha or spray the crop with 0.07% of *Endosulfan*.

Termites: A social insect that live underground in colonies, attack young seedlings as well as grown up plants. Infested plants wither and ultimately die.

Control:

Deep ploughing after harvesting of the crop followed by collection of stubbles/plant refuge and burning thereof

- Use well decomposed FYM
- Irrigate the crop timely

Apply *Chloropyriphos* 20 EC @ 1.25 litre/*Endosulfan* 35 EC @ 2.5 litres along with irrigation water in standing crop as a last resort.

Grey Weevil: A polyphagous insect. Adult beetles feed on green leaves, cause serious damage when seedlings are infested.

Control: Dusting of *Quinalphos* 1.5% or *Methyl Parathion* 2% or *Malathion* 5% @ 25 Kg/ha on appearance of the pest.

Ear head bug: A common pest in Southern parts of the country. Nymphs and adult bugs suck the sap from tender grains at the milk stage, making them chaffy/shriveled.

Control: early planting reduces the infestation of the pest, application of Carbaryl 50 SP @ 3 Kg in 500 litre of water/ha or Endosulfan 4D @ 20 Kg/ha on panicles.

Stem borers: A nocturnal moth, dirty brownish in colour. Caterpillars feed on foliage and bore in to the stem causing “Dead heart”, also tunnel the stem and bore into ear heads.

Control: Release of *Trichogramma chilonis* @ 75, 000 per ha/week; and spray *Endosulfan* 35 EC @ 0.1%.

Hairy caterpillars: It attacks the crop sporadically. The larvae cause heavy defoliation of the plants. Pest is commonly found in Gujarat and Semi-arid region of Rajasthan.

Control: Release of *Trichogramma chilonis* @ 75, 000 perha/week; and spray *Endosulfan* 35 EC @ 0.1%.

Major Diseases

Although more than 50 diseases caused by different biotic factors have been reported in pearl millet in India but only few are important. These are downy mildew, smut, ergot, rust and blast. These diseases directly reduce grain yield by affecting grain formation. In addition ergot can also reduce grain quality. Use of resistant cultivars is the most cost-effective method of the control of pearl millet diseases.

Downy mildew: Downy mildew is widely distributed in all the pearl millet growing areas in the world. Systemic symptoms as chlorosis generally appear on the second leaf and all the subsequent leaves and panicles of infected plant show symptoms. Leaf symptoms begin as chlorosis at the base of the leaf lamina and successively higher leaves show a progression of greater leaf area coverage by the symptoms. Infected chlorotic area produce massive amount of asexual spores, generally on the lower surface giving the leave a ‘downy’ appearance. Systemically infected plants remain stunted either do not produce panicle or produce malformed panicles. In many affected plants ‘green ear’ symptoms appear on the panicles due to the transformation of floral parts into leafy structure that may be total or partial and such plants do not produce seed or produce very few seeds. The infected leaves produce sexual spores (oospores) in the necrotic leaf tissue late in the season. Currently in India about 50% of the 9 million ha under pearl millet cultivation is grown with more than 70 hybrids in which DM incidence has been highly variable, with some hybrids showing more than 90% incidence at farmer’s field. This disease can assuming alarming levels when a single genetically uniform

pearl millet cultivar is repeatedly and extensively grown in a region. Yield losses within the region can reach 30-40%.

Management: The diseases of pearl millet can be best controlled by integrating methods of chemical or biological control, and cultural practices.

- Use of resistant cultivars
- Rotate hybrids with variety alternately to keep soil inoculum under control.
- Seed treatment with Apron 35 SD @ 6g/kg seed
- Seed treatment with *Bacillus pumulis* (INR7)
- Seed treatment with Chitosan 10g/kg seed
- Foliar spray of Ridomil 25 WP (100 ppm) after 21 days of sowing if infection exceeds 2-5 %
- Rogue out infected plants and bury or burn
- Seed treatment with Ridomil MZ-72 @ 8g/kg seed and a foliar spray of Ridomil MZ-72 2g/l.

Rust: Rust symptoms first appear on lower leaves as typical pustules containing reddish brown powder (uredospores). Later, dark brown teliospores are produced. Symptoms can occur on both upper and lower surface of the leaves but mostly on upper surface and also on stem. Highly susceptible cultivars develop large pustules on leaf blades and sheaths.

Rust has generally been considered as a relatively less important disease in most of the pearl millet growing areas than downy mildew, ergot and smut because of its appearance, generally after the grain-filling stage, causing little or no loss in grain yield. Worldwide this disease is probably of greater importance of multicut forage hybrids where even low rust severities can result in substantial losses of digestible dry matter yield.

Management:

- Use of resistant hybrids/verieties.
- Sow the crop with the onset of monsoon.
- Destruction of collateral hosts like *Ischaemum pretosum* and *Panicum maximum* on the field bunds.
- Dusting of fine sulphur @ 17kg/ and two sprays of 0.2% Mancozeb at 15 days intervals

Smut: Smut disease is of greater importance in India especially with the adaptation of hybrids. The disease is more severe in CMS-based single-cross hybrids than in open-pollinated varieties. The infected florets produce sori that are larger than grains and appear as oval to conical, which are initially bright green but later turn brown to black. The estimated grain yield loss due to smut is 5-20%. The disease occurs during the month of September/ October. Early sown crop generally escapes from the smut infection.

Management

- Use of resistant cultivars.

- Spray with Captafol followed by Zineb on panicle at boot leaf stage which reduces infection.
- Remove smutted ears from the field.

Ergot: The disease is easily identified as a honeydew substance of creamy to light pinkish ooze out of the infected florets which contains numerous conidia. Within two weeks these droplets dry out as hard dark black structures larger than seeds, protruding out from the florets in place of grain, which are called sclerotia. Here the loss in grain yield is directly proportional to the percentage of infection as the infected seed is fully transformed into sclerotium. The disease occurrence and spread is highly influenced by weather conditions during the flowering time. It became more important due to cultivation of genetically uniform single-cross F1 hybrids based on cytoplasmic male-sterility system in India.

Management

- Mechanical removal of sclerotia from seed and washing of seed in 2% salt water.
- Adjust sowing dates so that ear emergence does not coincide with more rainy days.
- Plough the field soon after harvest so that ergot is buried deep.
- Three foliar application of Thiram 0.2% or Copper Oxochloride 0.25% or Ziram @ 0.2% starting from 50% flowering.

Blast: The disease is known as leaf spot of pearl millet caused by *Pyricularia grisea* (Cooke) Sacc [telemorph: *Magnaportha grisea* (Herbert) Barr.] has become a serious disease during the past few years. The disease affects both quality and production of forage and grain. The symptoms appear as distinct large, indefinite, water soaked, spindle shaped, grey centred and purple grey horizon with yellow margin, resulting in extensive chlorosis and premature drying of young leaves.

Contingency Planning

To conserve *in situ* rainwater, deep plough the field during summer on heavy soils of Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka and Eastern Rajasthan. A wider row spacing of 60 cm is advocated where rainfall is less than 400 mm. Adopt suitable intercropping system select early maturing hybrids/composite of pearl millet under late onset of monsoon. Keep the crop weed-free by timely weeding. If dry spell occurs immediately after sowing, replant pearl millet in between the existing row or relay cropping may be practiced including short duration oilseed/pulse crops. Under normal onset of monsoon and occurrence of prolonged dry spell during grand growth period of the crop, reduce plant population to the extent of 25 to 40%. Skip top dressing of nitrogen and spray 2% urea. If drought prevails for 2-3 week during pre-flowering to grain setting stage, one life saving irrigation may be given if water is available. Under excessive rains during vegetative phases, additional dose of 20 kg N/ha should be applied.

Sources:

1. AICRP on Pearl millet (<http://www.aicpmip.res.in> as on 25-02-2016)
2. Khairwal IS, Rai KN, Diwakar B, Sharma YK, Rajpurohit BS, Bindu Nirwan and Ranjana Bhattacharjee. 2007. Pearl millet: Crop management and seed production Manual. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 104 pp.
3. Contingency planning in crop plants (<http://www.crida.in>)