



## A REVIEW

# Escalation efficiency in millets agrarian with bio-fortified hybrids

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## INTRODUCTION

Millet is a collective term referring to a number of small-seeded annual grasses that are cultivated as grain crops, primarily on marginal lands in dry areas in temperate, subtropical and tropical regions. The most important species are pearl millet, finger millet, proso millet and foxtail millet. Pearl millet accounts for almost half of global millet production. It is the most important species of millet both in terms of cropped area and contributions to food security in regions of Africa and Asia that can produce little else. Finger millet is widely produced in the cooler, higher-altitude regions of Africa and Asia both as a food crop and as a preferred input for traditional beer. Proso millet is important for bird seed in the developed countries and for food in parts of Asia. Foxtail millet is important in parts of Asia (mainly China) and Europe. The other species (barnyard, kodo and little millets, the fonios and teff) are locally important food grains restricted to smaller regions or individual countries. The various species differ in their physical characteristics, quality attributes, soil and climatic requirements and

growth duration.

Millet is better adapted to dry, infertile soils than most other crops, and are therefore often cultivated under extremely harsh conditions-for example, high temperatures, low and erratic precipitation, short growing seasons and acidic and infertile soils with poor water-holding capacity. Most millet have strong, deep rooting systems and short life cycles, and can grow rapidly when moisture is available. As a result, they can survive and reliably produce small quantities of grain in areas where mean annual precipitation is as low as 300 mm. This compares with a minimum water requirement of 400 mm for sorghum and 500-600 mm for maize. Some species (pearl and proso millets) also appear to tolerate higher temperatures than sorghum and maize, although they do not tolerate long drought periods as well as sorghum.

In Asia, millet is restricted almost exclusively to two countries, India and China, although Myanmar, Nepal and Pakistan also produce small quantities. India is the world's largest producer, harvesting nearly 40 per cent of the world's output. Pearl millet, which accounts for

about two-thirds of India's millet production, is grown in the drier areas of the country, mainly in the states of Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana. Finger millet is produced mainly in the state of Karnataka, but also in Orissa, Uttar Pradesh and Tamil Nadu. It is also the most important millet in Nepal and Bhutan. China produces millet (mainly foxtail), largely in the provinces of Hebei, Shanxi and Shandong.

Millet production in Africa is distributed among a much larger number of countries, notably Nigeria (over 40 percent of the regional output), Niger, Burkina Faso, Mali, Senegal and Sudan. Pearl millet is grown along the southern peripheries of the Sahara (*i.e.*, the Sahelian countries and the northern parts of the coastal countries in Western Africa) and in the drier areas of Eastern and Southern Africa. Finger millet production is concentrated in Eastern and Southern Africa, where the leading producers are Uganda and Tanzania. As a grain crop, Tef is largely confined to Ethiopia. Small quantities of white fonio are grown throughout sub-Saharan Western Africa, most importantly in Mali. Black fonio is grown in isolated pockets in Nigeria, Togo and Benin. Guinea millet

is cultivated only on the Fouta-Djallon plateau of northwestern Guinea and adjacent Sierra Leone. Foxtail and proso millets are very minor crops in Africa, but are cultivated to a limited extent in Kenya and other upland areas in Eastern Africa. Kodo millet is commonly harvested from wild forms in Western Africa, but cultivated forms of this "ditch millet" are only found in Asia. In Latin America, millet production is confined to a small area in Argentina. Therefore, its production and productivity can be enhanced by using scientific management practices.

#### Selection of soil :

Millets can be grown in different soils but sandy loam and light or loam soils with proper drainage are considered as best. The field should be ploughed once or twice followed by harrowing to create fine tilth. Prepare the field by doing 1st ploughing with mould-bold plough followed by 2-3 ploughing with cultivator to pulverize the soil. Where as It does not grow well in soils prone to waterlogged conditions.

The latest list of hybrids and varieties of pearl millet is given below			
Region/ State	Season	Recommended hybrid	Recommended variety
Rajasthan	<i>Kharif</i>	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	
	<i>Kharif</i> – arid parts	HHB 234, Bio 70, HHB-226, RHB-177	CZP 9802
Gujarat	<i>Kharif</i>	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	
	<i>Kharif</i> – arid parts	HHB 234, Bio 70, HHB-226, RHB-177	CZP 9802
Haryana	<i>Kharif</i>	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
	<i>Kharif</i> – arid parts	HHB 234, Bio 70, HHB-226, RHB-177	CZP 9802
Punjab	<i>Kharif</i>	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	<i>Kharif</i>	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	<i>Kharif</i>	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	<i>Kharif</i>	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	<i>Kharif</i>	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

**Important 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. Two types of varieties remain available for sowing of bajra commonly referred as Composite and hybrid varieties. The important composite varieties suitable for growing areas varieties are: as ICMB-155, WCC-75, ICTP-8203, Raj-171, CZP 9802, ICMV 221, ICMV 155, Parbhani Sampada, Samrudhi, PC 612, NDFB-3, and Dhanshakti etc. Among hybrids as following RHB 234, RHB 233, Pusa-322, Pusa-23, RHB-173, HHB 67, HHB-226, GHB 905, MPMH 17, HHB 234, HHB-226 and RHB-177, etc.

**Seed rate :**

For arid-western plain of Rajasthan, Haryana and Kutch of Gujarat, 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, 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 5 kg/ha for obtaining required plant stand.

**Plant population :**

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

**Sowing time and method:**

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. For grain bajra should be sown from July to mid-August and for fodder purpose it can be sown from last week of June to first week of July'. First fortnight of October is appropriate time for rabi season in coastal areas of India. bajra should be sown at the depth of 4 cm in lines (max.) with a spacing of 45cm. Gap filling should be done by transplanting seedlings after 2-3 weeks of sowing is recommended in dry sowing prior to first monsoon rains if scanty population exists. Summer pearl millet should be sown from 4<sup>th</sup> to 5<sup>th</sup> Standard Meteorological Week (SMW) *i.e.* last week

of January to 1<sup>st</sup> week of February to obtain higher production of summer pearl millet in summer growing areas of millet in India. 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.

**Seed treatment:**

Seed treatment with biopesticides (*Trichoderma harzianum* @ 4g kg<sup>-1</sup>) or thiram 75% dust @ 3 g kg<sup>-1</sup> seed will help against soilborne diseases. Seed treatment with 300-mesh sulfur powder @ 4 g kg<sup>-1</sup> seeds controls the smut disease. Seed treatment with metalaxyl (Apron 35 SD) @ 6 g kg<sup>-1</sup> seed controls downy mildew. Seeds are treated with Azospirillum (600g) and Phosphobacterium to enhance the availability of nitrogen and phosphorus. Treat the seed with thiram or cabendazim @2-2.5g per 1 kg of seed before sowing to avoid seed borne diseases. To manage Ergot treat the seed in 20% salt solution.

**Fertilizer management:**

Use balance fertilizers as per the soil test basis. Generally for hybrid varieties 80-100kg nitrogen, 40-50kg phosphorous and 40kg potash is recommended, while composite varieties needs 40-50kg nitrogen, 25kg phosphorous and 25kg potash per hectare. Application of 40 kg N + 20 kg P<sub>2</sub>O<sub>5</sub>/ha for arid regions and 60 kg N/ha + 30 kg P<sub>2</sub>O<sub>5</sub>/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 25-30 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 bio-fertilizer (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 ZnSO<sub>4</sub>/ha is recommended. To correct the zinc deficiency in standing crop, spray of 0.2% ZnSO<sub>4</sub> 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.

### Thinning and gap filling:

It is an important operation to be done after 10-15 days of sowing. Transplant the plant from high density area to poor germination area and fill the gap to maintain crop geometry and population.

### Inter-cultivation and weed management:

Two weeding, hoeing and earthing are done manually with khurpi after 15-20 and 30-35 days of sowing it helps in proper aeration and good establishment of crop. And with the herbicidal weed control through pre-emergent application of Atrazine @1.25kg per hectare in light to medium soils within 48 hours of sowing. For very hardy weeds add penda methylene 30EC @2.5 litres with atrazine to control weeds.

### Irrigation management :

bajra crop is highly susceptible to moisture especially at the times of flowering and grain formation, thus, if rain fails two irrigations on these stages must be provided. 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%.

### Plant protection :

(Major Diseases): 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 etc.

### Ergot:

It is a serious disease of bajra in which sclerotia are developed in the ears and black powder is formed in grains with the eruption of slesma (honey like sticking liquid) from the affected ears. To manage this disease treat the seed before sowing with chemicals or 20% salt solution. Use Zeerum 80% WP or Zeneb 75% WP 2kg or Mencozeb 75% WP @ 2kg per hectare.

### 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 is 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 assume 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.

### **Bajra 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. Black powder is formed in grains. 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.
- Pray with Captafol followed by Zineb on panicle at boot leaf stage which reduces infection.
- Remove smutted ears from the field. To manage this disease treat seed and use fungicides as recommended for ergot.

### **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.

### **Ear kokkle/green ear disease:**

In this disease the wholebajra ear converts into green leaf and de-shaped which finally looks like a broom. To control this disease use 2 sprays of carbendazium 50% WP or Thiophinate methyl 70% WP @ 2gm per litre of water at an interval of 10 days.

### **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.

### **Important insects and pests: Termites:**

Use chloropyriphos 20% EC @ 2.5 litre in standing crop with irrigation water.

### **Nematodes:**

Use 10kg forate 10G before one week of sowing in soil.

### **Stem borer:**

Use Cabofuron 3G or Forate 10G @ 20kg or spray Di methoate 30%EC 1 litre or Quiolphos 25%EC 1.50 litre per hectare.

### **Shoot borer:**

Use Cabofuron 3G or Forate 10G @ 20kg or spray Di methoate 30%EC 1 litre or Quiolphos 25%EC 1.50 litre per hectare.

### **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.

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