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IMPROVED PRACTICES FOR ENHANCING PRODUCTIVITY AND PROFITABILITY OF FODDER AND GRAIN TYPE PEARL MILLET UNDER SEMI-ARID CONDITIONS: A REVIEW

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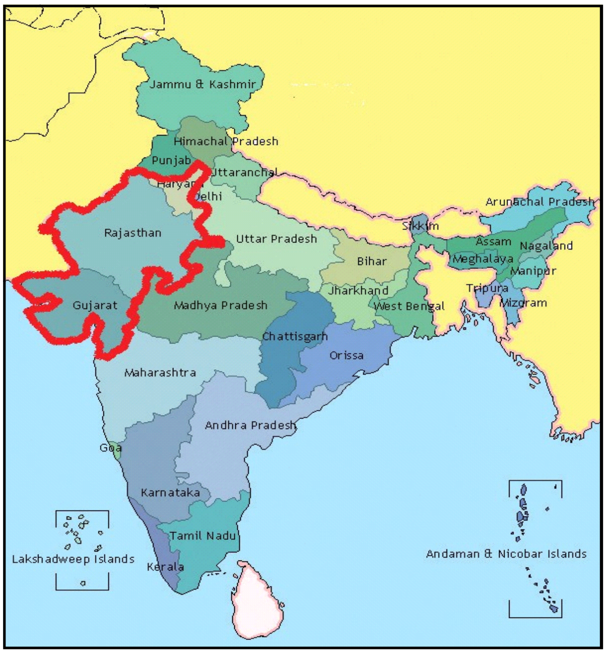
SUMMARY

Pearl millet is a major cereal crop in northwestern India. It is the most drought-tolerant cereal grown in the arid and semi-arid regions. Its grains are valued as human food while its fodder makes important livestock ration in crop–livestock farming system. The production potential of rainfed pearl millet is continued to be low as a result of frequent drought due to high variability in rainfall (amount and distribution) during the growing season, low soil fertility, low plant nutrient use, and poor socio-economic conditions of farmers, could not use high technology input. This review mainly highlighted various improved practices for increasing productivity and profitability of fodder and grain type pearl millet. It includes soil moisture conservation practices by practicing the improved planting methods, supplemental irrigation, use of improved varieties, and intercropping. Integrated use of fertilizer and use of low energy input for enhancing the crop productivity.

Key words : Moisture conservation, supplemental irrigation, intercropping, improved varieties, nutrients management, energy management and Pearl millet

Pearl millet (*Pennisetum glaucum* L.) is one of the important food as well as fodder crops of areas with low rainfall and shallow soils. Due to its short duration, it is the most drought-tolerant cereal grown in the arid and semi-arid regions of the world (Bhagavatula *et al.* 2013). It is the sixth most important cereal crop in the world after wheat, rice, maize, barley and sorghum (Singh *et al.,* 2003). Pearl millet grains are enriched with high protein content, amino acid, and high levels of iron, zinc and insoluble dietary fibre which is desirable for diabetic and heart patients as it is a major source of dietary carbohydrates in the human diet. Because of its nutrient qualities pearl millet is also an important component of livestock ration feed as fodder crop, as it provides lots of dry matter during the dry period of the year. (Dakheel *et al.,* 2009 and Islam *et al*., 2018). Pearl-millet fodder has less anti-quality factors like hydrocyanic acid (HCN) and oxalic acid, while enriched with protein, calcium, phosphorus and other minerals (Gupta, 1975; Arya *et al.,* 2009).Globally, India ranks first in pearl millet growing area (about 8.5 million ha), which is after rice and wheat among cereals. Several states of the country have share in growing of pearl millet crop but northwestern dry regions are the major pearl millet growing areas in India, which comprises parts of Gujarat, Rajasthan and Haryana (Map 1). A total production of 9.6% contributed by Haryana because of a high productivity of 1,908 kg/ha. Pearl millet is primarily a fodder crop in the western part of Rajasthan and Gujarat - especially during the summer when green fodder is scarce. In arid regions of India, pearl millet is a major source of food (Reddy *et al.* 2013).

The best optimum temperature for the germination of pearl millet seed is 23-32°C. The maximum temperature above 35°C inhits the normal growth of seedling (Arya *et al.,* 2014 and Yadav *et al.,* 2016). Most of pearl millet growing regions are characterized by less moisture availability or rainfed areas with an annual rainfall of 150–800 mm and less input intensive (Spencer *et al.,* 1987 and Reddy *et al.* 2013). Usually, pearl millets are cultivated on rainfed areas without or less application of fertilizers or other inputs. (Brar and Kumar, 2020). Due to frequent drought occurrence because of variability in rainfall both intensity as well as distribution during the growing season, low soil fertility, low plant nutrient use, and poor socio-economic conditions of farmers, and minimum use of technology input, the production potential of rainfed crop is continued to be low (Sharma *et al.,* 2009 and Sahrawat *et al.,* 2010). Rainfed pearl millet crop is rarely applied with fertilizer; however, it



Map 1. Map of India showing study area (Reddy *et al.* 2013).

responds well to their application. Application of fertilizers in rainfed condition does not provide nutrients only but also enhances water use efficiency, controls soil erosion by promoting rapid and heavier crop growth, checks run-off and increases water holding capacity of soil. However, increment in pearl millet productivity and profitability can be achieved under rainfed condition by adoption of improved agronomic practices. Soil moisture availability is the major limitations of rainfed agriculture, thus rainwater harvesting and soil moisture conservation practices like planting methods, mulching and organic manures seems to be beneficial to obtain the full potential of other applied inputs. Growing of improved varieties and legumes intercropping in pearl millet intensifies the productivity via efficient utilization of natural resources viz. solar radiation, soil moisture, space, nutrients, and other inputs applied. It helps in giving additional production and return per unit area and time. Integrated nutrient management, energy management by following tillage practices and intercultural operation helps in improving productivity and profitability of pearl millet.

Rainwater harvesting

An age-old practice of water storage in India is rainwater harvesting. Here, excess of rain water can be managed on farm (in-situ) or in water harvesting structure like pond through ex-situ techniques. It is a process of collecting runoff water from treated or untreated land surfaces or rooftops and storing it in an open farm pond or closed water tanks and dug out pond. The in-situ moisture conservation practices and recycling of harvested rainwater techniques were found to very effective for drought mitigation in pearlmillet crop (Jat *et al*., 2008). Rainwater that exceeds the infiltration and storage capacity of soil may be harvested nearby in the same field or at another convenient point in the watershed. Estimates reveal that areas receiving up to 1000 mm annual rainfall have a potential to add 6.3 million ha water equivalent through rainwater harvesting (Singh *et al.,* 2000). The harvested water can be utilized judiciously for life saving irrigations to crop during dry spells.

Soil moisture conservation practices

Crop grown in rainfed condition are prone to water stress, owing to rapid loss of soil water from profile resulting in low water availability for root growth. Moisture conservation practices maintains soil structure, controls the weeds and improves the water holding capacity of soil (Yadav *et al.* 2008). Use of organic manure as well as mid-season corrections through mulches, and planting methods are effective in conservation of soil moisture, improve soil fertility, and water use increase efficiency of pearl millet. Planting methods plays critical role in for the development of sustainable agriculture in dryland area (Govaerts *et al.,* 2006). It is an agronomic practice that sustains the availability of input resources. Several methods for enhancing rainwater utilization can support *in-situ* water conservation allowing higher amount of infiltration and water use by crops (Rockstrom *et al.* 2002). Significant higher plant height, dry weight accumulation, green fodder yield, and other growth parameters were observed where pearl millet was grown with ridge method compared to bed planting (Sharma *et al*., 2015 and Deshmukh *et al,* 2013). The ridge planting method stimulates higher crop growth due to better surrounding environment for crop growth and development. Consequently, the crop utilised water more efficiently and increase in photosynthetic potential also observed (Zhang *et al.,* 2007). The maximum yield (1.84 t/ha) and yield attributes (ear-head length, ear-head girth, test weight etc.) as well as more crop biomass of pearl millet was observed under the ridge planting compared with the bed planting system and broadcasting methods. The higher simulated grain and fodder yield under ridges compared with broadcast was due to more effective utilization of the conserved rainwater and improved penetration of sunlight that might have resulted in photosynthesis enhancement (Zhang *et al.,* 2007). The green leaf manure with maize residue mulch showed significantly increased grain yield (30.68%) and yield attributes *viz.*, plant height (15.3%), and a greater number of tillers (36.9%) as compared to control. Increased growth and yield character both in terms of grains as well as fodder of pearl millet in green leaf manure with maize residue mulch treatment might be attributed to improved moisture holding capacity of the soil besides reducing evaporation losses due to mulching (Rajput and Bhadouriya 2017). Similar results were also observed by (Mallareddy *et al.* 2015 and Yadav *et al.* 2015). (Rajashekarappa *et al*., 2014) also observed 15-54% improvement in maize yield with moisture conservation practices compared to control. (Khatiyar *et al*., 2017) also reported that the more yield attributes, fodder yield, and grain yield was recorded when pearl millet planted through ridge and furrow method because of more efficient moisture conservation in soil which increased regular availability of moisture throughout reproductive phase (Gargi and Gautam, 2003). Plant spacings also affects the green fodder yield of bajra. Velayudham *et al.,* (2011) observed that adoption of 60 cm × 50 cm spacing in Bajra Napier Hybrid recorded 271.30 tonne/ha green fodder yield which is 7.53% higher than the recommended spacing of 50 cm×50 cm. Application of moisture conservation practices through modification in surface configuration as ridge and furrow, plastic mulch and seed hardening with 0.02% KNO_3 significantly enhanced grain yield of pearl millet by 22.21, 48.82 and 10.50 per cent, respectively and gave net returns of INR 23985, 28189 and 22765/ha, with B: C ratio of 2.92, 3.29 and 2.86, respectively (Kanwar *et al*., 2015).

Ex-situ water harvesting and supplemental irrigation

Significance of supplemental irrigation lies in its capacity to bridge the gap of dry spells and thereby reduce the risks in rainfed agriculture. The crop yield in rainfed regions could be boosted by harvesting rainwater and using that as supplemental irrigation (Zhang *et al.,* 2014). The harvesting rainwater is collecting the excess rain water by various technologies like construction of mini or small dams and dug out ponds where large storage reservoirs are not feasible. On an average, 24 × 106 ha m out of 400 × 106 ha m of precipitation received annually in dry land areas of India, is estimated to be available as harvestable rainwater through on-farm facilities. Drylands receiving 500 to 1000 mm annual rainfall has an estimated harvestable rainwater potential of 5.54 × 106 ha m (Katyal, 1997). Better results, both in terms of fodder and grain yield of pearl millet can be achieved with proper scheduling of irrigation (Patel *et al*., 1994). Patel *et al.* (2010) recorded significantly higher values for growth, yield attributes, grain and fodder yield of pearl millet when irrigation scheduled at 1.1 IW: CPE ratio. Irrigation scheduled at 1.00 IW/CPE ratio produced maximum grain yield but the water use efficiency was found to be significant at 0.50 IW/ CPE ratio which was at par with irrigation given at critical growth stages. For obtaining the higher grain yield, fodder yield, and water use efficiency of summer pearl millet, the application of 40 mm depth of irrigation water at critical growth stages was best (Keshavarz *et al.* 2013). During *kharif* season, grain yield of pearl millet was significantly higher with supplemental irrigation (1766 kg/ha) than without supplemental irrigation (1431 kg/ha). (AICRPDA, APR 2020).

Intercropping

The basic concept of intercropping system involves growing of two or more crops with the assumption that two crops can exploit the environment better than one and ultimately produce higher crop yield since the component crops differ in resources use and when grown together, they complement each other and make overall better use of resources (Yadav *et al*., 2015). It is recommended in areas receiving annual rainfall 600 to 800 mm and having a 20 to 30 week of effective growing season. The ratios of rows of principal crop to component crop (row ratios) in intercropping systems were optimized to minimize competition and realizing optimum biological productivity (Singh and Subba Reddy, 1986). Further, to ensure higher production and returns from pearl millet in abnormal years, different crops are recommended for intercropping with pearl millet in various states in the country. Suitable pearl millet-based intercropping in northwestern India is pearl millet + cluster bean mothbean, sesamum in Rajasthan, pearl millet + green gram/ sesamum in Haryana, pearl millet + green gram/ sesamum in Gujarat. Usually, pearl millet is rotated with sesamum, guar, moong, moth and soybean in rainfed conditions. However, farmers widely practice pearl millet + guar as mixed crop and pearl millet + pigeonpea (2:1) as inter crop (Reddy *et al.* 2013). Intercropping also helps in improving the efficiencies of nutrients, moisture, light and better management of pest control, which ultimately leads to higher productivity (Baldev *et al.,* 2005). Singh *et al.* (1981) found that intercropping of green gram and cluster bean in between the rows of pearl millet had no adverse effect on its grain and fodder yield and gave additional grain yield of 100-163 and 564-895 kg/ha, respectively. Further, the leguminous crops increase content of nitrogen in soil and help in maintaining soil fertility (Gregorich *et al.,* 2001 and Gathumbi *et al.,* 2003). The intercropping of pearl millet triple rows 30 cm apart in an inter space of 90 cm between 2 rows of *Vigna radiata* increased the *Vigna radiata* yield by 13-16 per cent as compared with intercropping in paired rows 30 cm apart in interspaces of 70 cm and the total yield of all the intercropping systems was higher than the yield of pearl millet in pure stand (Anjeneyula *et al.* 1982). Pearlmillet with pigeonpea intercropping (8:2), the higher pearl millet equivalent yield (5324 kg/ha) was observed in green leaf manure with maize residue mulch compared to control. Higher pearlmillet equivalent yield might be due to availability of sufficient moisture and nutrients to the crop (Rajput and Bhadouriya 2017). The pearlmillet gave higher grain yield in intercropping system (26.67 and 26.98 q/ha) along with additional yield of cowpea intercrop (7.19 and 7.25 q/ha) against 24.85 and 25.49 q/ha grain yield of sole pearl millet. Intercropping system produced more pearl millet equivalent yield (PMEY) with more economical return and high B:C ratio. Higher number of tillers/plant in intercropping than sole pearl millet might be associated with symbiotic N fixation in cowpea roots and availability of more space for pearlmillet plants in paired row sowing (Khatiyar *et al.,* 2017). Islam *et al.* (2018) reported that both forage quality and quantity of forage millet mixed with cowpea can be obtained by growing two rows of millet with one row of cowpea (2M:1C).

Selection of improved varieties

The selections of improved varieties and high fodder yielding cultivars of pearl millet plays crucial role to bridge the gap in demand and supply of grain and fodder yield of pearl millet (Arya *et al.*, 2009a).Yield improvement of between 15 to 50% was recorded when traditional varieties were replaced by high yielding varieties (Rao, 2004). The difference in grain and fodder yield of early varieties is less than medium and late varieties, but they are more suitable for poor conditions (require less fertilizer dose NPK 40:20:0, while late varieties require 80:40:0) and escape terminal floods and hence give higher grain yield even during unusual years. In among various pearlmillet varieties (HHB 67-Improved, HHB 197, HHB 223, HHB 226 and HHB 234, HHB 272, HHB 299) the HHB 67(I) most accepted by farmer (AICRPDA, APR 2019). Yadav *et al.,* (2014) evaluate the performance of pearl millet genotypes (HHB 67 'Improved', HHB 197, HHB 223 and HHB 234) under different environment (rainfed and irrigated) and found that irrigated pearlmillet have higher yield and yield attributes rainfed condition. Root length was significantly higher under rainfed than irrigated condition. These genotype HHB 223 and HHB 234 perform good under both irrigated and rainfed condition respectively.

Sharma (2014) evaluated nine open pollinated varieties (OPVs), among these more grain yield per hectare was recorded for Raj-171 followed by JBV-2 and Pusa-266. However, higher fodder yield per hectare was observed for JBV-3 followed by JBV-2 and Pusa-266. In hybrids GHB-744, RHB-173, GHB-732 are high yielding hybrids in terms of grain yield per hectare. The higher fodder yield per hectare was exhibited by RHB-173 followed by GHB-744 and HHB-197. They also reported that under similar agronomic practices in the arid and hot climatic conditions OPVs out yielded hybrids by 93.38% for stover yield whereas, hybrids out yielded OPVs by 31.74% for seed yield. The hybrid HHB-67 improved was early and took 34 days for exhibiting 50% flowering and RHB-173 appears to be higher productive and appropriate hybrids for arid Rajasthan (Akmal *et al.* 2002 and Bidinger *et al.*2008). Kumar *et al.*, (2010) reported that the improved hybrid HHB-97 gave significantly higher yield over the local check, i.e. HHB-67 (Improved) under both irrigated and rainfed conditions. The yield advantage of HHB-197 over HHB-67 (Improved) was between 8.4 to 13.0% under rainfed condition. Whereas, Other improved hybrids, *i.e.* HHB-117, HHB-60, HHB-94 and HHB-67-2, performed significantly better over the local checks, *i.e.* HC-4, HC-20 and HHB-68. Damame *et al.,* (2013) conducted study for various varieties and he reported that the variety BAIF bajra produced significantly higher green forage yield of 477.82 q/ha which is at par with Giant bajra. Whereas, Gaint Bajra recorded the highest dry matter yield of 75.88 q/ha. Sheoran *et al.*, (2016) also reported that Giant Bajra performs significantly better than remaining genotypes (Raj Bajra Chari-2, AVKB-19, DFMH-30) in term of green fodder as well as dry matter yield. Genotype AVKB-19 recorded highest crude protein content (10.2%) followed by DFMH-30 (10.1%). He also reported that the statistically higher crude protein content of 9.33 per cent was recorded in variety Raj bajra chari-2 which was at par with BAIF bajra and PHB-2172. Shashikala *et al*., (2013) revealed that among nine genotypes studied, the variety ICMV 08111 (811q/ha) has recorded significantly high green fodder yield and it was on par with the genotypes ICMA 00999×ICMA 05444 (810 q/ha) followed by Rijko Bajra, ICMV 05777, ICMV 05555. It is also observed that, there is no much significant difference in the green fodder yield potential between hybrids and varieties.

Energy Managements

The crop yield and economics in the dryland land crops depend upon conserved moisture and cost of cultivation. Tillage has a marked influence on the conservation of soil and rainwater. Tillage makes the soil surface more permeable and thus, supports water intake. Deep tillage (25-30 cm) helps in soil pulverization, increased rainwater infiltration, and better root growth thereby increasing crop yield (Thyagaraj *et al.,* 1999; Vittal *et al.,* 1983; AICRPDA, 2000).In traditional tillage ploughing of field with cultivator for seedbed preparation results in loosening of the soil and forming clods, this may lead to more moisture loss through evaporation. This traditional practice is time consuming, costly and not effective to conserve soil moisture.

The minimum tillage and direct drilling systems were significant in energy saving, production cost and environmentally friendly by reducing the soil pollution as compared to conventional practices (Sharma *et al.,* 1995). Sharma *et al.* (2016b) also reported significant increase in seed yield with oil seed drill over the traditional farmers practice.

In dryland agriculture resource conservation plays an important role in minimizing the cost of cultivation as the yields are stagnating and the economic returns from agriculture are highly vulnerable in dryland area. The resources conservation practices in pearl millet was studied by (Sidhpuria *et al.,*2014) and found that conventional tillage and low tillage with two intercultural operations yielded at par proving that a preparatory tillage could be saved without compromising the yield. The highest energy output/ input ratio was observed for low tillage followed by two intercultural operations which was also accompanied by highest B: C values. The intercultural operation was carried by use of wheel hand hoe (WHH), firstly in removal of weeds and secondly, by slicing a thin layer of top soil which acted as soil mulch in moisture conservation. Estimation of net energy additions over "no tillage" treatment found that for every additional one unit energy input in low tillage plus two intercultural operations gave additionally highest output of 39.6 MJ. So, two intercultural operations seemed to be necessary for optimum harvests more crop yield through moisture conservation as well as proper weed management. Pameela and George (2013) recorded highest forage yield of pearl millet in herbicide based zero tillage followed by minimum tillage. The performance of maize and bajra were the best in herbicide based zero tillage as compared to minimum tillage.

Integrated Nutrient Management

In dryland agriculture, integrated nutrient management (INM) is the key to sustaining soil productivity. The nutrients requirement of pearl millet in dryland area could be met by integrated use of farmyard manure (FYM), vermicompost, composted organic wastes, and bio- fertilizers which helped in improving grain and fodder yield as well as maintaining soil fertility (Singh *et al*., 1999). FYM application along with fertilizers significantly increases the plant growth of pearl millet over FYM alone and fertilizers (control, 50% RDF). Combined application of fertilizer along with FYM proved better when compared with fertilizers alone. This might be due to the role of FYM in improving soil physio-chemical and biological properties and also has synergistic relationship with N and P (Parihar *et al.*2010 and Satyajeet and Nanwal 2007). Pearl millet crop respond favorably to application of N and P, however, the major part of N and P remains unutilized by first crop; its effect is invariably reflected in succeeding crop (Mahala *et al*., 2006). The continued and balanced supply of nutrients enhancing their availability and with their active involvement in shoot and root development exhibited better plant growth (Meena *et al.,*2001 and Meena and Gautam 2005). This might be owing to role of nitrogen in cytokinin synthesis, thereby higher number of effective tillers and better root growth coupled with higher photosynthetic area helped in better growth and development and ultimately higher grain and fodder yield of pearlmillet. Phosphorus also plays vital role in root development, energy transformation and metabolic processes of plant, which resulted in greater translocation of photosynthates towards the sink development (Satyajeet *et al.,* 2007). Kadam *et al*., (2019) found that, application of recommended dose of fertilizer *i. e.* 120 kg N + 45 kg P + 45 kg K per ha + 20 kg/ha $ZnSO_4$ recorded maximum grain yield and fodder yield of pearl millet.

The significant effect of vermicompost was observed on growth attributes, yield and yield attributes of pearl millet with application of vermicompost @ 10 tonnes/ha with 100 per cent RDF. Increase in these growth parameters has evidently resulted from favorable function on manure and the increased availability of nutrients to plant initially through inorganic fertilizers and then by organic manures. The basic fact is that vermicompost provides secondary elements like Ca, Mg, and S and fairly high amounts of micronutrients to the plants. It also increases CEC, water holding capacity and phosphate availability in the soil. Being a cereal crop, pearl millet required nutrients throughout the growing season. Thus balanced nutrition due to release of macro and micro nutrients due to application of vermicompost under favorable environment might have helped in higher uptake of nutrients. This accelerated the growth of new tissues and development of new shoots that have ultimately increased the plant height and dry mater accumulation (Khadadiya *et. al.*, 2019). The seed inoculation with Azotobacter*,* increases growth and yield in pearlmillet which might be due to the increased number of efficient and healthy strain of *Azotobacter* in the rhizosphere, which in turn resulted in better utilization of atmospheric nitrogen (Patel *et al.,* 2014 and Rinku *et al.,* 2014). Application of recommended dose of fertilizer (RDF) being at par with application of N equivalent through vermicompost recorded significantly higher grain and fodder yield (1211 kg/ha) of pearl millet compared to other treatments, with higher net returns, BC ratio and RWUE (AICRPDA, APR 2020). Bijarnia *et al*., (2020) founded that integrated nutrient management having combination of organic and inorganic sources of nutrients would be worthwhile to improve fodder yield and achieving greater economic returns in fodder pearl millet. Further, enhancement in green fodder productivity due to supplementation of nutrients through FYM and biofertilizer could be due to its beneficial role in improving soil physical, chemical and biological properties (Moharana *et al.,* 2012). Mehra *et al*., (2019) reported that application of Biomix bio-inoculants along with RDF (40 kg N+20 kg P2 O5 / ha) the grain and dry fodder yield of pearl millet were increased by 44.2% (33.40 q/ha) and 42.4% (81.50 q/ha) over the control.

Low-cost inputs improved practices for enhancing productivity of pearlmillet

The scope for increasing the adoption improved practices rate of low-cost inputs such as (i) application of 20 kg $ZnSO_4$/ha as basal, (ii) application of atrazine @ 1.0 kg *a.i.*/ha as pre-emergence spray followed by atleast one hand weeding for combating weeds and thereby increasing grain and fodder yield of pearl millet to increase profitability, (iii) dust mulching and spray of 0.1% thiouorea at tillering and flowering, which helped to mitigate drought stress, reduce loss of crop and increase stability in profitability in the *kharif* season, (iv) seed treatment with neem oil 5ml/kg seed + spray of 5% NSKE (neem seed kernel extract) at 50% flowering, which was found to be an

Significance of improved package of practices over conventional practice

S. No.	Farmers's practice	Improved practices	Percent Improvement in grain yield over FP	Source
1.	One hoeing at 30 DAS	Hand-weeding twice at 30 and 45 DAS or pendimethalin and oxadiazon each at 1.0 kg/ha supplemented with hand-weeding once at 45 DAS.	15-17%	Ram Baldev *et al.,* 2005
2.	One hoeing at 25-30 DAS	Oxyfluorfen + hand weeding at 20 DAS	24.96%	Deshveer and Deshveer, 2005
3.	Only urea/ SSP or both	10 kg Zn+ RDF every year or 2.5 kg Zn + 5 t FYM +RDF alternate year	10-12%	Chaube *et al.,* 2007
4.	Only urea/ SSP or both	100% RD+ Vermicompost + Biofertilizers or 75 % RD+ Vermicompost + Biofertilizers	10-12%	Satyajeet *et al.,* 2007
5.	Only urea/ SSP or both	Application of 60+40 kg/ha of N+P2O5 along with 10 t FYM/ha andbiofertilizers.	15%	Choudhary and Gautam, 2007
6.	Only urea/ SSP or both	Application of 5 t FYM + biofertilizers (Azospirilium+PSB @ 25 g/kg each) + 60:30:30 kg NPK/ha	12-15%	Girase *et al.,* 2010

effective treatment in controlling pest attack of pearl millet (All India Coordinated Pearl Millet Improvement Project: AICPMIP 2011).

CONCLUSION

Pearl millet is quick growing short duration cereal crop provides food grains and fodder for the animals inhabitants in arid and semi-arid regions. Its productivity and profitability can improve by adopting various practices which includes rain water harvesting through in-situ measure by planting crop in ridge and furrow method, mulching and the rainwater water collected in pond can be used for supplemental irrigation during dry spell. The uncertainty of rainfall in dryland area, cultivation of sole crop is risky and less profitable so, improved short duration varieties (HHB 67, HHB 223, HHB, 234 and HHB 197) and improved fodder pearl millets Giant bajra and BAIF bajra produced significantly higher green forage yield grain yield. Some varieties like Raj Bajra Chari-2 and PHB-2172 have higher crude protein. The intercropping of pearl millet as main crop with various other short duration crops like cowpea, pigeonpea, moong and guar is the only alternative to compensate this total loss due to crop failure and also to get an additional yield benefit in normal crop season. The nutrients requirement of crop in dryland area is met by integrated use of farmyard manure (FYM), composted organic wastes, and bio- fertilizers along with use of chemical fertilizers which helps in improving yield and maintaining soil fertility. Use of low cost energy input has a marked influence on the conservation of soil and rainwater. The optimum ploughing with high energy out/input ratio along timely intercultural operation make the soil surface more permeable and thus, supports water helps in conserving more water in soil profile. The performance of bajra was the best in herbicide based zero tillage as compared to minimum tillage.

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