BIOFERTILIZERS SUPPLEMENT TO CHEMICAL FERTILIZERS IN PEARLMILLET—A REVIEW

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SUMMARY

Biofertilizers are microbial preparations, which help in augmenting crop production by enriching the soil fertility, soil enzymes and soil microbial population. The biofertilizers may play important role in minimizing our dependence on inorganic fertilizers. The occurrence of nitrogen fixing and phosphorus solubilizing bacteria such as Azotobacter, Azospirillum and Pseudomonas, etc. within the rhizosphere of plants of economic importance is being recently harnessed in Indian agriculture. Inoculation of these bacteria has synergic and additive effects on plant growth, besides reducing the cost of cultivation. Hence, it is imperative to popularize the use of biofertilizers, which is a low-cost input technology to reduce the dependence on inorganic fertilizers and contribute to pollution-free atmosphere, which is the need of the day.

Key words: Biofertilizers, pearlmillet, Azospirillum, Azotobacter

Pearlmillet, being an important dual-purpose kharif crop, plays a vital role in the integrated agricultural and animal husbandry economy of the drier region of the nation. It responds favourably to the application of nutrients particularly nitrogen and phosphorus, which are supplied mostly through chemical fertilizers and farm yard manure (FYM). Nitrogen (inert gas N₂) constitutes about 78% per cent of the atmosphere in elemental form; however, as such it is not useful for higher plants. Hence, nitrogen demand of the plants is generally met by the use of chemical fertilizers. Poor economic conditions of the farmers in the arid regions prevent them to use costly fertilizers. Moreover, continuous and sole use of chemical fertilizers has resulted in numerous problems like micronutrients deficiencies, nutrient imbalance in soil and plant system, pest infestation, environmental degradation and deterioration of soil health. In India, the total production of nitrogenous fertilizer is 263.78 lakh tonnes against the consumption of 281.22 lakh tonne (Anonymous, 2011). This gap is likely to be widened further and perhaps can be narrowed down through the use of nitrogen that is naturally available in nature through continuous biological nitrogen fixation. The use of potential biological systems would provide 15-20 lakh tonnes of nitrogen for crop production in India, while the equivalent urea fertilizer needed is around 33-34 lakh tonnes. Moreover, the biofertilizers also help in maintaining the long term soil fertility and ecological sustainability required for increasing crop productivity. In such condition, there is need to assess the effect of biofertilizers in increasing the yield and decreasing the amount of chemical fertilizer required by pearlmillet crop. Here, an attempt has been made to review the pertinent research work done by various workers under different agro climatic conditions on pearlmillet crop in respect of biofertilizers under the following headings:

A. Effect of Azospirillum on the Performance of Pearlmillet

B. Effect of Azotobacter on the Performance of Pearlmillet

C. Effect of Azotobacter and Azospirillum on the Performance of Pearlmillet

D. Effect of biomix biofertilizers on the Performance of Pearlmillet

E. Effect of biofertilizers along with chemical fertilizers on the Performance of Pearlmillet

A. Effect of Azospirillum on the Performance of Pearlmillet

Free living N fixer Azospirillum has been found effective in fixing nitrogen, when seeds of pearlmillet are inoculated with it under rainfed situation. The
association between cereal plants and nitrogen fixing bacteria, as shown by increased nitrogenase activity, is well established (Dart and Wani, 1982; Wani et al., 1983). *Azospirillum* or *Azotobacter* either singly or in combination have been used to study inoculation responses with various cereals/millets (Bouton et al., 1979; Kapulnik et al., 1981; Narula et al., 1991). Wani et al. (1985) reported 26 per cent increase in pearl millet yield due to *Azospirillum* inoculation compared to control at ICRISAT, Hyderabad. Venkataraman and Tilak (1990) found that *Azospirillum* inoculation increased grain productivity of cereals by 5-20 per cent, of millets by 30 per cent and of fodder by over 5 per cent. Bhattacharya and Paliwal (1996) observed 11 per cent increase in the yield of pearl millet, due to *Azospirillum* inoculation. The higher yields due to inoculation of pearl millet with *Azospirillum* were also reported by Subba Rao (1982) and Subba Rao et al. (1982). In the studies of Kutty (1983), bio-fertilization with *Azospirillum* was found to be an advantageous practice as it contributed approximately 10 kg N/ha to the N uptake of pearl millet crop, which was equivalent to 20 to 25 kg N/ha in terms of fertilizer-nitrogen depending upon the recovery of applied fertilizer. De and Gautam (1987) reported markedly increase in yield of pearl millet by the seed inoculation with *Azospirillum brasilense*. Similarly, Tilak and Subba Rao (1987) also found that the seed inoculation with *A. brasilense* significantly increased the grain yield of pearl millet and noticed that the effects of inoculation were more pronounced at lower levels of nitrogen than at the higher levels. *Azospirillum* inoculation along with 20 kg N/ha increased the grain yield of pearl millet (Gautam and Kaushik, 1988). Joshi and Rao (1989) reported that inoculation with *Azospirillum* favourably improved the yield of *bajra* by 39.4 per cent over uninoculated control. They also reported that there was an increase of 37.9 per cent in tillers, 44.3 per cent in earheads and 31.2 per cent in test weight of pearl millet with *Azospirillum* inoculation. The inoculation response in terms of increase in grain yield was equivalent to about 30 kg N/ha. Singh et al. (1999) studied the effects of seed inoculation with biofertilizers (nitrogen fixing bacteria and phosphate solubilizing bacteria) on the performance of pearl millet (HBB-67) and found that the inoculation with biofertilizers increased grain yield by 26 per cent over untreated control. Tilak (1991) reported that *A. brasilense* inoculation increased the grain yield of pearl millet by 2 q/ha compared to uninoculated control and also 20-30 kg N/ha could be saved in pearl millet due to seed inoculation with *Azospirillum*. Dalavi et al. (1993) reported that significant increase in the grain and stover yields of pearl millet was realized when the seeds were inoculated with *A. brasilense*. Bhattacharya et al. (1998) reported that *A. brasilense* was among free living bacteria, which showed associated symbiosis when present in the rhizosphere. Seed inoculation with *A. brasilense* in conjunction with N application was found to save nitrogen to the extent of 10-20 kg/ha. Conversely, Bhag Chand and Gautam (2000) reported that the yield attributing characters of pearl millet were not improved either in the treatment of *Azospirillum* alone or in combination with FYM.

B. Effect of *Azotobacter* on the Performance of Pearl Millet

The encouraging role of *Azotobacter* as a biofertilizer to supplement N to pearl millet was first reported by Gautam (1979a, b). Under dryland conditions, *Azotobacter* inoculation increased the yield of pearl millet by 0-27 over control (Venkataraman and Tilak, 1990). Narula et al. (1991) observed better performance of *Azotobacter chroococcum* compared to *A. brasilense* or *Azospirillum lipoferum*. Reddi and Reddy (1981) observed that yield attributing characters like effective tillers per metre row length, length of earhead and test weight were significantly increased due to inoculation of seeds with *Azotobacter* culture. Further, pearl millet seed inoculation with *Azotobacter* also increased grain yield by 10.7-12.1 per cent over control. They also reported that mean increase in productive tillers was 12 per cent and in the length of earhead was 5.5 per cent due to use of culture over no culture. Wani et al. (1985) observed that there was significant interaction between varieties and bacterial culture for grain yield of pearl millet BJ-104 which responded higher to inoculation as compared to MBH-110. *Azotobacter* culture was not only effective in pearl millet but also effective in other cereals like wheat, maize and rice, etc. They demonstrated that highest yield of 8.23 q/ha was obtained when seeds of pearl millet were inoculated with *Azotobacter* culture as compared to 7.29 q/ha when uninoculated.

C. Effect of *Azotobacter* and *Azospirillum* on the Performance of Pearl Millet

Earlier some workers have reported that
*Azospirillum* and *Azotobacter* produced similar pearl millet yields (Sarig *et al.*, 1984; Pareek and Shekhawat, 1988; Tandon, 1991; Tiwana *et al.*, 1992). Singh *et al.* (1997) while studying the effect of inoculation with biofertilizers on the performance of pearl millet crop grown without chemical fertilizer reported that inoculation with biofertilizer increased the grain yield by 26 per cent over uninoculated control during one season, but in the next season inoculated as well uninoculated treatments produced similar grain yields, but use of biofertilizers increased the stover yield by 27 and 14 per cent over control during both the seasons. They further observed that the grain and stover yields obtained by inoculation were almost similar to those produced with the application of 20 kg N and 10 kg P₂O₅/ha. Jadhav *et al.* (1994) reported that seed inoculation of pearl millet with a combination of *A. chroococcum* and *A. lipoferum* increased grain yield by 21.4 per cent compared to control. Tiwana *et al.* (1992) reported that biofertilizers alone had no effect on green and dry matter yield and further found that *Azospirillum* and *Azotobacter* produced similar yield of green and dry matter. Yandagoudar and Mohan Kumar (1994) found that among the three bacterial cultures used, the highest grain yield of 1449 kg/ha was obtained by seed inoculation with *A. brasilense* followed by *A. lipoferum* (1379 kg/ha) and *A. chroococcum* (1310 kg/ha). Kalaghatagi *et al.* (1996) found that seed treatment alone with biofertilizers recorded 37 per cent higher grain yield over control. Tilak and Subba Rao (1987) found increase in grain yield of pearl millet with or without application of nitrogen in the presence of *Azospirillum* or *Azotobacter* under field conditions.

### D. Effect of Biomix Biofertilizers on the Performance of Pearl Millet

Rathore *et al.* (2003) observed that inoculation of seed with the mixed biofertilizer significantly increased the grain and stover yields over control. Gautam *et al.* (1988) also observed the significant effect of biofertilizers on the yield of pearl millet. Use of biofertilizers (*Azotobacter, Azospirillum,* phosphate solubilizing bacteria and their mixtures) in combination with nitrogen application has also been observed to improve the yield attributing characters of bajra. The improvement in yield attributing characters under various combinations of nitrogen and biofertilizers was probably due to adequate supply of nutrients, particularly nitrogen and phosphorus and helped in the process of photosynthesis and partitioning of photosynthates (sink filling process). Neelam *et al.* (2009) reported that grain and stover yields with *Azotobacter* inoculation were 10.5 and 5.8 per cent higher over control. However, grain and stover yields with Biomix (*Azotobacter*+PSB) application were 14.7 and 10.8 per cent higher, respectively, over control. The inoculation of seed with mixed biofertilizers significantly increased the uptake of phosphorus from 4.74 kg/ha (control) to 6.66 kg/ha (biofertilizers) in grain and 6.90 kg/ha (control) to 8.33 kg/ha (biofertilizers) in stover.

### E. Effect of Biofertilizers along with Chemical Fertilizers on the Performance of Pearl Millet

Gautam (1984) noticed that the effectiveness of the bacterium increased considerably, when it was applied in addition to low rates of N ranging from 10 to 40 kg/ha. While studying the response of *bajra* to inorganic, organic, biofertilizers alone and in combinations, Kumar and Gautam (1992) observed yield responses in order of 25 kg N+12.5 kg P₂O₅/ha+Azotobacter > 25 kg N+12.5 kg P₂O₅/ha > 5 t FYM/ha > control (No fertilizer, no manure, no inoculation). Nanwal (1991) also reported the additional yields from pearl millet and castor with the inoculation of *Azospirillum*, which also increased the gross returns/ha of rainfed farming appreciably and also maximum N uptake was noticed with *Azospirillum* inoculation when it was accompanied by 25 kg N+12.50 kg P₂O₅/ha. Jha and Mathur (1993) concluded that *A. brasilense* increased the grain yield and N uptake when 40 or 80 kg N/ha was applied before sowing. Kumar *et al.* (1993) reported that gross and net returns were the highest with N+P₂O₅+A. *brasilense* in the pearl millet based cropping system. It was revealed that application of N and *Azospirillum* resulted in the marked improvement in yield and yield attributes of rainfed pearl millet (Gautam *et al.*, 1985). Rathore and Gautam (2003) found that use of biofertilizers significantly improved the number of earheads/m², length of earhead and 1000-grain weight over the control. The maximum increase in yield attributes was recorded with 60 kg N+45 kg P₂O₅/ha; which was at par with 40 kg N+30 kg P₂O₅/ha+biofertilizers. Bhargava *et al.* (1981) observed that grain yield of rainfed pearl millet increased due to seed inoculation with biofertilizers.
inoculation with *Azotobacter* culture and was the highest (17.3 q/ha) at 60 kg N/ha + *Azotobacter* culture. It was also reported by Mane *et al.* (2000) that pearl millet had responded better to biofertilizers compared to chemical fertilizers for higher production. Kumar *et al.* (2007) found that inoculation of PSB and *Azospirillum* along with 75 and 100 per cent recommended dose of fertilizer gave significantly higher grain and stover yield of pearl millet than absolute control, 75 and 100 per cent recommended dose of nitrogen. Hooda *et al.* (2009) reported that use of *Azospirillum* along with fertilizer and farm yard manure gave higher grain and stover yield than control in pearl millet. Neelam *et al.* (2011) found that plant height, total numbers of tillers per plant, dry matter production and leaf area per plant at harvest were maximum with application of biomix along with fertilizer application. Similarly, Neelam *et al.* (2011) reported that the uptake of nitrogen in grain and stover increased significantly with the increasing level of nitrogen and phosphorus in association with biomix. An overall improvement in the yield attributes of bajra crop due to application of nitrogen in combination with biofertilizers has also been reported by Gautam and Kaushik (1988), Pareek and Shakhawat (1988), Randhawa *et al.* (1989), Sadhu *et al.* (1991), Kalaghanatagi *et al.* (1996), Kohire *et al.* (1996), Raghuwanshi *et al.* (1997), Raghuwanshi *et al.* (1997) and Rathore *et al.* (2003).

**CONCLUSION**

Beneficial effect of biofertilizers may be realized by combining their application with chemical fertilizers. In pearl millet, applications of biofertilizers in association with nitrogenous fertilizers were found to be significantly superior in terms of growth characters, yield attributes and yield. Biofertilizers are effective in reducing the dependence on the chemical fertilizers along with increase in the pearl millet yield.

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