Forage Res., **37** (4) : pp. 205-209 (2012)

BIOFERTILIZERS SUPPLEMENT TO CHEMICAL FERTILIZERS IN PEARLMILLET–A REVIEW

PARVEEN KUMAR*, KARMAL SINGH, S. K. SHARMA, SURESH KUMAR AND MEENA SEWHAG

Department of Agronomy
CCS Haryana Agricultural University,
Hisar-125 004 (Haryana), India
*(e-mail : rohilaparveen@gmail.com)

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 N_2) 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 pearlmillet 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 pearlmillet, due to *Azospirillum* inoculation. The higher yields due to inoculation of pearlmillet 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 pearlmillet 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 pearlmillet 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 pearlmillet 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 pearlmillet (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 un-inoculated 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 pearlmillet 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 (HHB-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 pearlmillet by 2 q/ha compared to uninoculated control and also 20-30 kg N/ha could be saved in pearlmillet due to seed inoculation with *Azospirillum*. Dalavi *et al.* (1993) reported that significant increase in the grain and stover yields of pearlmillet was realized when the seeds were inoculated with *A. brasilense*. Bhatnagar *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 pearlmillet were not improved either in the treatment of *Azospirillum* alone or in combination with FYM.

B. Effect of *Azotobacter* on the Performance of Pearlmillet

The encouraging role of *Azotobacter* as a biofertilizer to supplement N to pearlmillet was first reported by Gautam (1979a, b). Under dryland conditions, *Azotobacter* inoculation increased the yield of pearlmillet 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, pearlmillet 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 pearlmillet BJ-104 which responded higher to inoculation as compared to MBH-110. *Azotobacter* culture was not only effective in pearlmillet 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 pearlmillet were inoculated with *Azotobacter* culture as compared to 7.29 q/ha when uninoculated.

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

Earlier some workers have reported that

Azospirillum and *Azotobacter* produced similar pearlmillet 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 pearlmillet 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 P_2O_5/ha. Jadhav *et al.* (1994) reported that seed inoculation of pearlmillet with a combination of *A. chroococuum* 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. chroococuum* (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 pearlmillet 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 Pearlmillet

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 pearlmillet. 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 partioning 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 Pearlmillet

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, P_2O_5/ha+*Azotobacter* > 25 kg N+12.5 kg P_2O_5/ha > 5 t FYM/ha > control (No fertilizer, no manure, no inoculation). Nanwal (1991) also reported the additional yields from pearlmillet 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 P_2O_5/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+P_2O_5+*A. brasilense* in the pearlmillet based cropping system. It was revealed that application of N and *Azospirillum* resulted in the marked improvement in yield and yield attributes of rainfed pearlmillet (Gautam *et al.*, 1985). Rathore and Gautam (2003) found that use of biofertilizers significantly improved the number of earheads/m^2, length of earhead and 1000-grain weight over the control. The maximum increase in yield attributes was recorded with 60 kg N+45 kg P_2O_5/ha; which was at par with 40 kg N+30 kg P_2O_5/ha+biofertilizers. Bhargava *et al.* (1981) observed that grain yield of rainfed pearlmillet increased due to seed

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 pearlmillet 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 pearlmillet than absolute control, 75 and 100 per cent recommended dose of nitrogen. Hooda *et al* (2004) reported that biofertilizers inoculation (*Azospirillium*+PSB) alone and their application with different levels of chemical fertilizers produced higher yields than chemical fertilizers. Kumar *et al.* (2009) reported that use of *Azospirillum* along with fertilizer and farm yard manure gave higher grain and stover yield than control in pearlmillet. Neelam *et al.* (2009) 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), Kalaghatagi *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 pearlmillet, 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 pearlmillet yield.

REFERENCES

Anonymous, 2011 : *Consumption, Production and Import of Fertilizers*. Department of Agriculture and Cooperation, Ministry of Agriculture, GOI.

Bhag Chand, and R. C. Gautam, 2000 : *Indian J. Agron.*, **45** : 658-661.

Bhargava, S. S., K. S. Rathore, R. K. Siag, and M. Lal, 1981 : *Agric. Sci. Digest*, **1** : 133-134.

Bhatnagar, S. K., Yadav, O. P. and R. C. Gautam, 1998 : *Indian J. agric. Sci.*, **68** : 423-430.

Bhattacharya, P., and M. K. Paliwal, 1996 : *Indian Farmer Time*, **14** : 19.

Bouton, J. H., R. L. Smith, S. C. Schank, G. W. Burton, M. E. Tyler, R. C. Littell, R. N. Gallaher, and K. H. Quesenberry, 1979 : *Crop Sci.*, **19** : 12-16.

Dalavi, N. D., V. G. Patil, A. S. Jadhav, and G. Harinarayana, 1993 : *J. Maharashtra Agric. Univ.*, **18** : 466-467.

Dart, P. J., and S. P. Wani, 1982 : *Symposia Papers*, **1** : 3-27.

De, R. and R. C. Gautam, 1987 : In : Proc. Intern. Pearlmillet Workshop held at ICRISAT, Hyderabad, from 7-11 April, 1986.

Gautam, R. C. 1979a : *Madras agric. J.*, **66** : 839-840.

Gautam, R. C. 1979b : *Madras agric. J.*, **66** : 809-811.

Gautam, R. C. 1984 : *Indian Fmg.*, **34** : 7-13.

Gautam, R. C. and S. K. Kaushik, 1988 : *Indian J. Agron.,* **33** : 196-197.

Gautam, R. C., S. K. Kaushik, and V. Ramulu 1988 : *Indian J. Agron.*, **43** : 382-386.

Gautam, R. C., M. M. Kutty, and S. K. Kaushik, 1985 : *Indian J. agric. Sci.*, **55** : 269-273.

Hooda, R. S., Anil Khippal, and R. P. Narwal, 2004 : *Haryana J. Agron.*, **20** : 29-30.

Jadhav, A. S., A. A. Shaikh, and N. S. Dukare, 1994 : *J. Maharashtra agric. Univ.*, **19** : 485-486.

Jha, Deepa, and R. S. Mathur, 1993 : *Intern. J. Trop. Agric.*, **11** : 31-35.

Joshi, N. L., and A. V. Rao, 1989 : *Ann. Arid Zone*, **28** : 291-297.

Kalaghatagi, S. B., C. J. Itnal, D. I. Jirali, and M. S. Nagod, 1996 : *J. Maharashtra Agric. Univ.*, **21** : 28-30.

Kapulnik, Y., S. Sarig, I. Nur, Y. Okon, J. Kigel, and Y. Henis, 1981 : *Exptl. Agric.*, **17** : 171-178.

Kohire, O. D., R. S. Raut, R. G. Deshmukh, G. U. Malewar, and S. S. Mane, 1996 : *Nature and Biosphere*, **1** : 58.

Kumar, Anil, R. S. Hooda, H. P. Yadav, L. K. Chugh, Manoj Kumar, and Rajesh Gera, 2009 : *Indian J. agric. Sci.*, **79** : 767-771.

Kumar, Parveen, Harbir, Singh, R. S. Hooda, and V. P. Singh, 2007 : *Res. on Crops*, **8** : 72-76.

Kumar, R., and R. C. Gautam, 1992 : *Ann. Agric. Res.*, **13** : 434-436.

Kumar, Rajender, Surender Singh, and D. P. Singh, 1993 : *Haryana agric. Univ. J. Res.*, **23** : 191-197.

Kutty, M. M. 1983 : M. Sc. thesis, Div. Agron., IARI, New Delhi.

Mane, S. S., A. K. Hadgaonkar, A. P. Suryawanshi, and S. D. Salunke, 2000 : *J. Indian Soc. Soil Sci.*, **48** : 617-619.

Nanwal, R. K. 1991 : Ph. D. thesis, Division of Agronomy, IARI, New Delhi.

Narula, N., D. C. Nijhawan, K. Lakshminarayana, R. L. Kapoor, and O. P. S. Verma, 1991 : *Indian J. agric. Sci.*, **61** : 484-487.

Neelam, V. P. Singh, and Anil Kumar, 2009 : *Haryana J. Agron*., **25** : 71-72.

Neelam, V. P. Singh, and Anil Kumar, 2009 : *Forage Res*., **35** : 121-123.

Neelam, V. P. Singh, and Anil Kumar, 2011 : *Res. on Crops*, **12** : 701-703

Pareek, M., and M. S. Shekhawat, 1988 : *Indian J. Agron.*, **33** : 322-324.

Raghuwanshi, K. S., K. B. Pawar, and J. D. Patil, 1997 : *Madras Agric. J.*, **84** : 656-658.

Randhawa, Nirmal Singh, Jagrup Singh, and M. S. Sidhu, 1989 : *Forage Res.*, **15** : 128-131.

Rathore, B. S., V. P. Singh, R. S. Hooda, Kapila Shekhawat, and Rakesh Kumar, 2003 : *Haryana J. Agron.*, **19** : 148-149.

Rathore, S. S., and R. C. Gautam, 2003 : *Indian J. Agron.*, **48** : 153-155.

Reddi, M. R., and G. B. Reddy, 1981 : *Indian J. Agron.*, **26** : 408-412.

Sadhu, A. C., J. R. Patel, P. C. Patel, and B. G. Patel, 1991 : *Forage Res.*, **17** : 59-64.

Sarig, S., Y. Kapulnik, I. Nur, and Y. Okon, 1984 : *Exptl. Agric.*, **20** : 59-66.

Singh, D. V., A. Saxena, and N. L. Joshi, 1997 : In : Proc. Symposium on Recent Advances in Management of Arid Ecosystem held at Jodhpur during March 3-5.

Singh, D. V., A., Saxena, A. S., Faroda, H. L., Joshi, S. Kathju and Amalkar, 1999 : Recent advances in management of arid ecosystem procedding of symposium held in India. pp. 283-286.

Subba Rao, N. S. 1982 : *Biofertilizers in Agriculture.* Oxford and IBH Publishing Co., New Delhi.

Subba Rao, N. S., K. V. B. R., Tilak, C. S. Singh, and R. C. Gautam, 1982 : Proc. National Symposium on Biological Nitrogen Fixation held at IARI, New Delhi, Feb. 25-27. pp. 507-516.

Tandon, H. L. S. 1991 : *Fertil. News*, **36** : 69-79.

Tilak, K. V. B. R. 1991 : In : *Bacterial Fertilizers.* ICAR Pub. pp. 40-46.

Tilak, K. V. B. R., and G. Singh, 1994 : *Fertil. News*, **39** : 11-17.

Tilak, K. V. B. R., and N. S. Subba Rao, 1987 : *Biol. Fert. Soils*, **4** : 97-102.

Tiwana, M. S., G. S. Chela, I. S. Thind, K. P. Puri, and Kanwaljit, Kaur, 1992 : *Ann. Biol.*, **8** : 29-32.

Venkataraman, G. C. and K. V. B. R. Tilak, 1990 : In : *Soil Fertilizer and Fertilizer Use, Vol. IV.* IFFCO Pub. pp. 137-148.

Venkateswarlu, B., and A. V. Rao, 1983 : *Plant and Soil*, **74** : 379-386.

Verma, L. N. 1995 : In : *Organic Agriculture. Pee Kay Tree Crops Development Foundation, Cochin, India*, Thampan, P. K. (ed.). pp. 101-143.

Wani, S. P., S. Chandrapalaiah, M. A. Zambre, and K. K. Lee, 1989 : In : *Nitrogen Fixation with Non-legumes*. pp. 249-262.

Wani, S. P., S. Chandrapalaih, and P. J. Dart, 1985 : *Exptl. Agric.*, **21** : 175-182.

Wani, S. P., P. J. Dart, and M. N. Upadhyaya, 1983 : *Can. J. Microbiol.*, **29** : 1063-1069.

Yandagoudar, B. A., and H. D. Mohan Kumar, 1994 : *Karnataka J. Agric. Sci.*, **7** : 491-493.