Annals of Arid Zone 35(1) : 29-35, 1996

Integrated Use of Farm Yard Manure and Fertilizer N for Sustained Yield of Pearl Millet (*Pennisetum glaucum*) in an Arid Region

R.K. Aggarwal and Praveen-Kumar
Central Arid Zone Research Institute, Jodhpur 342 003, India

Abstract : Effects of organic manure (FYM) on yield of pearl millet, efficiency of applied nitrogen and soil fertility were studied under rainfed farming for seven years (1983-1989) in Jodhpur. Pearl millet yield was strongly dependent on the distribution of rainfall, particularly at the reproductive phase. Total biomass yield (grain + straw) was highest for plots receiving FYM @ 10 t ha^{-1} $annum^{-1}$, in good rainfall as well as drought years. Fertilizer nitrogen upto 80 kg ha^{-1} increased yield in good rainfall years, but in drought years, no significant effect was observed beyond 40 kg N ha^{-1}. Application of fertilizer N along with FYM further increased yield. Yield with 40 kg N ha^{-1} + FYM was nearly equal to that obtained with 80 kg fertilizer N ha^{-1} alone. FYM significantly increased the utilization efficiency of fertilizer N by crop and status of organic carbon, available N, P and micro-nutrients in soil. Residual N effects were observed for plots receiving FYM but no such residual effects were observed for fertilizer N.

Key words : Farm yard manure, nitrogen, soil fertility, pearl millet.

Rainfall in the arid regions of India is low and erratic (Ramakrishna, 1993). Therefore, crops often experience drought at various stages of growth and as a result, yields are generally low. The adverse effects of drought on crop yields are further accentuated due to the poor fertility status of the soils (Lahiri, 1978). Improvement in the fertility status of soils is considered an important strategy of drought management in these areas, as crops grown under better fertility conditions are known to withstand drought for a longer duration and are reported to yield higher (Lahiri, 1983; Kathju *et al.*, 1993).

Various studies have shown the utility of chemical fertilizers in improving crop yield under arid conditions (Lahiri, 1978; Oswal *et al.*, 1989). But, with unreliable rainfall, good grain yields and response to fertilizers is never certain. Therefore, dependency on chemical fertilizers alone may not provide a viable economic option. Further, a major part of fertilizer N applied is lost as NH_3 volatilization (Aggarwal *et al.*, 1989). Therefore, to maintain soil productivity on a sustainable basis, an integrated nutrient management approach, using both organic and inorganic sources of nutrients should be adopted (Misra and Maheshwari, 1988; Venkateswarlu, 1987). The use of manures must be given prime importance, and fertilizer use should be limited to balance the nutrient requirement of the crops (Aggarwal and Venkateswarlu, 1989; Venkateswarlu and Hegde, 1992). Animal husbandry is a major occupation of the farmers in this region (Acharya *et al.*, 1977), manures are often available.

Therefore, an experiment was conducted for seven years to quantify the long term effects of organic manures on the yield pattern of pearl millet (Pennisetum glaucum (L.) R. Br.), utilization efficiency of applied fertilizer N, and on the residual fertility of desert sandy soil.

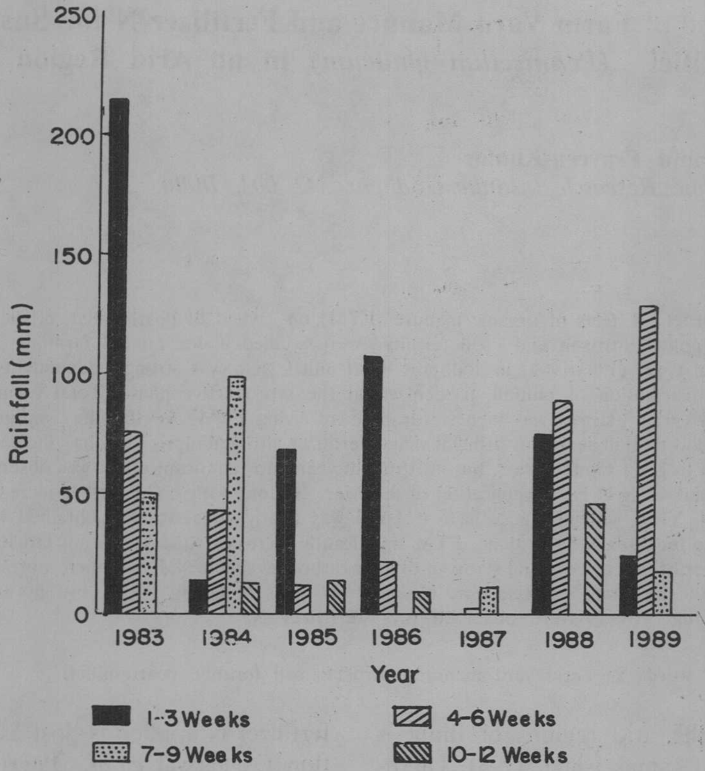

Fig. 1. The distribution of rainfall during crop period.

Materials and Methods

The study was conducted during 1983-89 at the Central Arid Zone Research Institute, Jodhpur. The soil was sandy loam (Typic Camborthid) with pH, 8.1; organic carbon, 0.27%; total N, 0.03%; available N, 140 kg ha^{-1} and available P, 6.3 ppm. The experiment was laid out in a Randomized Block Design with 3 replications. The experiment was conducted on the same piece of land with the fixed lay out. Treatments comprised farmyard manure (FYM), @ 0 and 10 t ha^{-1} (approximately 8.5 t ha^{-1} on oven dry basis), and fertilizer N, @ 0, 40 and 80 kg ha^{-1} as urea and their combinations. FYM had, on an average, 28.5% C and 1.15% N and was applied at the time of field preparation. Fertilizer N was applied in two splits, half at the time of sowing and the remaining half after a month, whenever sufficient rainfall was received. In the last year of experiment, i.e., 1989, each plot was divided in two equal parts. Half of each plot received FYM and N, where as, in the other half, no FYM or fertilizer was added to study the residual effect of their additions in previous years. The varieties used by local farmers were grown in the experiment, namely, BJ 104 in 1983 and 1984 and WCC-75 thereafter. Due to severe drought during 1987, the crop failed. N content in grain and straw at harvest was analyzed by Micro Kjeldahl method (Bremner, 1965). Blockwise soil samples were collected at the beginning and at the end of experiment and were analyzed for organic C, N, P and micro nutrients by standard methods (Jackson, 1967; Lindsay and Norvell, 1978). Available N in soil was estimated by

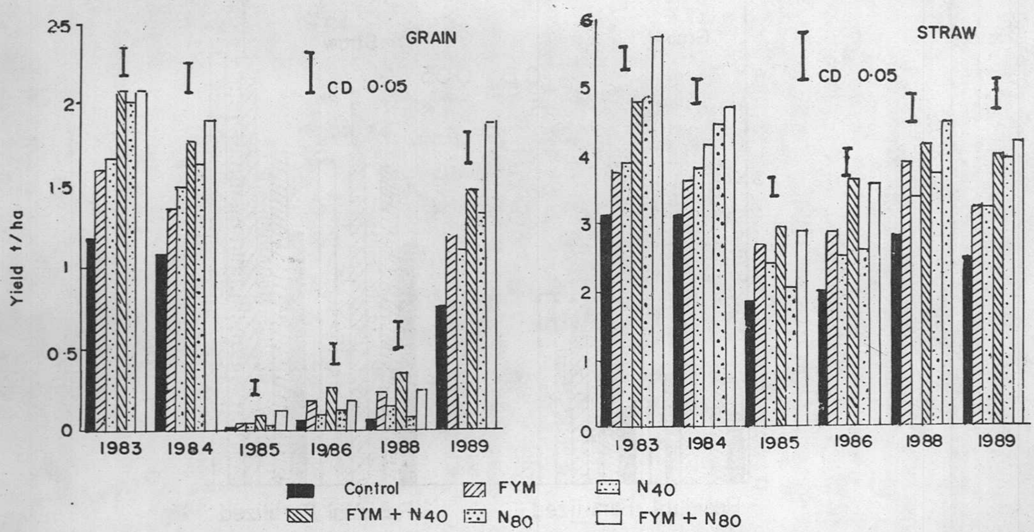

Fig. 2. Effect of FYM and N on grain and straw yield.

alkaline permanganate method (Chopra and Kanwar, 1982).

The recovery of applied N by the plants, i.e., nitrogen use efficiency (NUE) was determined by a difference as :

NUE (%) = 100 x (f-c)/a

where,

f and c are total uptake of N (kg ha^{-1}) by plant from fertilized and control plots, respectively, and a is the rate of N application (kg ha^{-1}).

The N contribution (%) from the soil was calculated by dividing N uptake in the control (kg ha^{-1}) by the initial available N content in the soil (kg ha^{-1}).

The economic returns from fertilizer and manure were approximated in terms of the price of additional grain yield (average Rs. 1700 t^{-1}) after subtracting the cost of fertilizer (average Rs. 5 kg^{-1} urea N). In this region, the straw is commonly used as the feed for farm animals, therefore, FYM used was treated as recycled on-farm waste.

Results and Discussion

Crop yield

The amount and distribution of rainfall in each growing season is shown in Fig. 1. Grain and straw yields of pearl millet varied significantly from year to year (Fig. 2) depending on the rainfall situations. Grain yields ranged from 1.18 to 2.38 t ha^{-1}, 1.08 to 1.90 t ha^{-1} and 0.77 to 1.88 t ha^{-1} in the good rainfall years of 1983, 1984 and 1989. In 1985, 1986 and 1988, low grain yields, often less than 0.30 t ha^{-1}, were recorded. However, even in these years of low grain yields, sizable straw yields, ranging from 1.25 to 4.50 t ha^{-1}, were obtained. This differential behaviour of grain and straw yields may be attributed to the adequate availability of water during the vegetative phases owing to adequate rainfall at this time in all the years (Fig. 1). But, the lack of rainfall during the reproductive phase (7-9 weeks) from 1985 to 1988 ad-

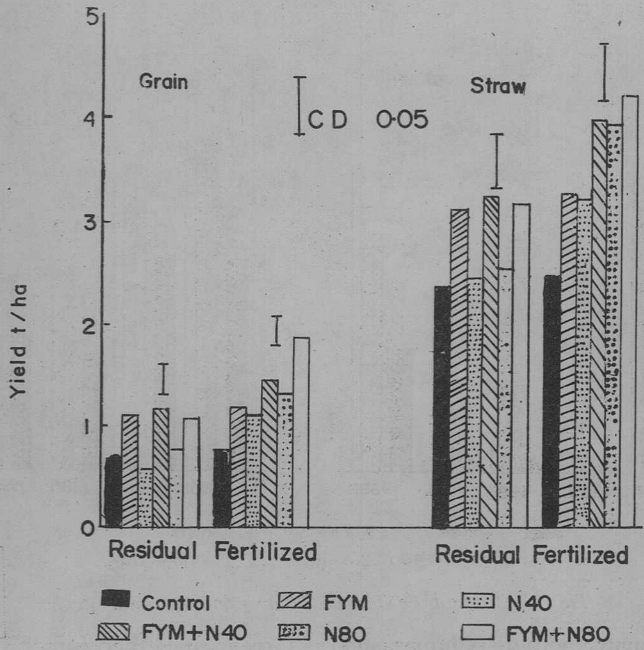

Fig. 3. Residual effect of fertilizer and manure on pearl millet yield.

versely affected the grain formation (Oswal *et al.*, 1989). To stress this point, it may be cited that although rainfall in 1984 and 1986 was almost similar, yields in 1986 were lower because there was drought during the reproductive phase.

In the years of good rainfall (1983, 1984 and 1989), the application of FYM and N individually and in combination significantly increased the yield of both the grain and straw. The effect of 40 kg fertilizer N ha^{-1} and that of FYM alone on yields were, however similar. But, the yield with 80 kg fertilizer N ha^{-1} was significantly greater than that obtained with individual application of either FYM or N, but was similar to that obtained with the combined application of 40 kg fertilizer N along with FYM. Maximum yield levels were obtained after combined application of 80 kg fertilizer N with FYM.

In contrast to years of good rainfall, in 1985 and 1986, when very low rainfall was received after the week 6 of crop growth, low grain and straw yields were recorded. In both years, the effect of FYM and fertilizer N individually and in combination on grain yield was not discernible. However, application of fertilizer N with FYM significantly increased straw yield. Straw yields obtained with both levels of N were significantly greater than for the control, but yield differences obtained with 40 and 80 kg N ha^{-1} were not significant. Further, straw yields obtained with application of FYM were greater than those obtained with 40 kg fertilizer N alone, and yield levels with the combined application of 40 kg fertilizer N with FYM were significantly greater than those obtained with 80 kg fertilizer N. These results were in contrast to those recorded in the good rainfall years and suggest that in drought years, FYM may be more effective in increasing crop yield than chemical fertilizer.

In 1988, good rainfall up to 6 week of crop growth resulted in straw yields higher

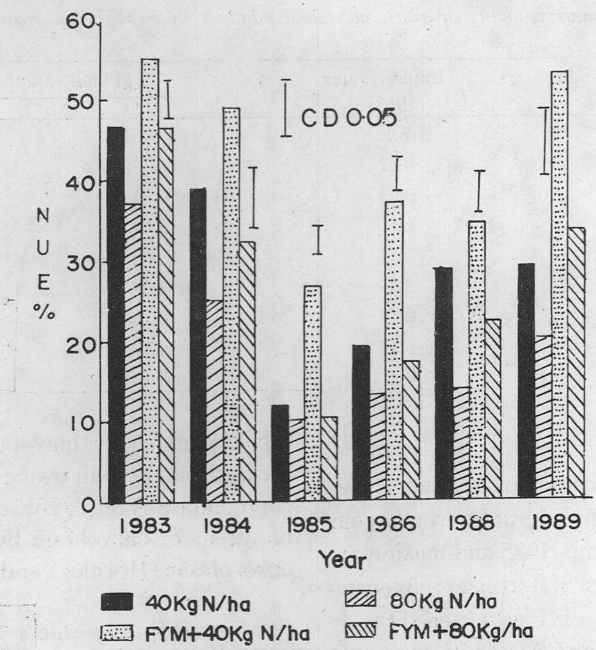

Fig. 4. Fertilizer NUE as affected by FYM in different years.

than those obtained in 1985 and 1986, even though the grain yield was very low. But, this year also, the effect of both FYM and fertilizer N on the straw yield followed the pattern observed in 1985 and 1986.

Residual effect of Fertilizers and FYM

Grain and straw yields greater than those in control were recorded in the plots where the residual effect of FYM was studied (Fig. 3). Further, there was no significant difference in the crop yield where residual effect of either FYM alone or FYM with fertilizer N was studied. The residual effect of FYM may be attributed to its slow mineralization. Mishra and Maheshwari (1988) reported that only 30% of N in FYM is available for crops in the first year of its application. On the other hand, the addition of fertilizer N, either alone or in combination with FYM, showed no residual effect. This is understandable as the fertilizer N not used by crop is generally lost from the soil either as NH_3 volatilization or NO_3 leaching (Aggarwal *et al.*, 1989).

Economic returns from fertilizer

Considering the gains and losses in the seven year period, the application of N alone, FYM or FYM + N, resulted in higher net economic returns, as compared to those for the control. Addition of FYM with either 40 or 80 kg fertilizer N ha^{-1} proved to be the most remunerative treatment with the net returns being 4 times greater than fertilizer N alone. FYM ranked next with the returns three times higher. However, in the drought years (1985-88), the application of fertilizer N, either alone or with FYM, resulted in financial loss as the cost of fertilizer N was greater than the value of additional grain yields obtained in these treatments. However, these losses were more than compensated by additional grain yields in years of good rainfall and build up of soil organic matter.

Table 1. Effect of continuous cropping of pearl millet and addition of FYM ($t\ ha^{-1}\ year^{-1}$) on fertility status of soil

Properties	Initial values (1983)	Final value (1989)	
		0	10
pH (1:2)	8.1	8.1	8.1
Organic carbon (%)	0.27	0.25	0.33
Nitrogen (%)	0.03	0.03	0.04
Available phosphorus (ppm)	6.31	5.68	8.00
Available manganese (ppm)	5.54	5.60	5.86
Available iron (ppm)	2.00	2.09	2.18
Available copper (ppm)	0.16	0.16	0.19
Available zinc (ppm)	0.31	0.37	0.45
Available nitrogen N ($kg\ ha^{-1}$)	140.0	138.6	144.3

N-use efficiency

The utilization efficiency of applied N by pearl millet varied considerably from year to year, being minimum in 1985 and maximum in 1983, at both levels of fertilizer nitrogen (Fig. 4). Comparison of Fig. 1 and Fig. 4 indicates that NUE was greater in years of good rainfall (1983, 1984 and 1989). FYM application increased the NUE in all years, but this influence was greater in years of good rainfall. The observed beneficial effect of FYM may partly be attributed to increased water availability in the plots treated with FYM (Hornick and Parr, 1987) which would have led to better plant growth and hence nitrogen utilization.

Contribution of soil available N to total N uptake

The N contribution from the soil also varied from year to year, being maximum (33%) in 1983 (a year of good rainfall) and minimum (6%) in 1985 (a drought year). These variations can also be attributed to rainfall induced changes in the microbial activity and hence mineralization of native soil N in different years. Application of FYM increased the N contribution from soil. The contribution from soil was 33% in the control in 1983 but it increased to 43% with addition of FYM. Similar trends were also observed in other years. This may be attributed to increased root growth owing to better soil physical conditions and consequent exploitation of greater soil volume by roots for nutrient absorption (Hornick and Parr, 1987).

FYM and fertility status of soil

Continuous cultivation for seven years without addition of FYM marginally decreased the status of organic carbon, available N and P in soil (Table 1). However, the status of available micro nutrients did not show any appreciable change. These results are in agreement with the observations of Aggarwal and Venkateswarlu (1989). In contrast to the above results, the overall status of organic carbon increased in plots regularly supplemented with FYM. Calculations indicated that only 8.6% of the carbon applied as FYM was retained in the soil as organic carbon. Eck (1988) and Mathers and Stewart (1984) also reported similar trends. This indicates that more than 90% of the applied organic carbon in soil was oxidized under the arid conditions probably due to prevailing high temperature. The continuous application of FYM increased the status of available N, P and micronutrients in the soil.

It is concluded that in arid areas, the responses to FYM or fertilizer N application are largely modulated by rainfall. But, the application of FYM plays a vital role in increasing or stabilizing pearl millet yield, utilization of applied fertilizer N by crop and maintenance and/or improvement of soil fertility. In contrast to low and inconsistent utilization of fertilizer N by the crops, lack of its residual effect and associated economic risk, the use of FYM alone, or its integration with fertilizer N, offers a distinct advantage in stabilizing a sustainable system of crop production in arid region.

References

Acharya, R.M., Patnayak, B.C. and Ahuja,L.D. 1977. Live-stock production-problems and prospects. In *Desertification and its Control* (Ed. P.L. Jaiswal), pp. 275-280. Indian Council of Agricultural Research, New Delhi.

Aggarwal, R.K. and Venkateswarlu, J. 1989. Long term effect of manures and fertilizers on important cropping systems of arid region. *Fertilizer News* 34: 67-70.

Aggarwal, R.K., Raina, P. and Praveen-Kumar 1989. Ammonia volatilization from urea and their possible management for increasing nitrogen use efficiency in an arid region. *Journal of Arid Environments* 13: 163-168.

Bremner, J.M. 1965. Inorganic forms of nitrogen. In *Methods of Soil Analysis, Pt. 2* (Ed. C.A. Black), pp. 1179-1237. American Society of Agronomy, Madison, Wisconsin.

Chopra, S.L and Kanwar, J.S. 1982. *Analytical Agricultural Chemistry*. Kalyani Publishers, New Delhi.

Eck, H.V. 1988. Effects of manure on dry farmed soil - 12 years after application. In *Challenges in Dryland Agriculture* (Eds. P.W. Unger, T.V. Sneed, W.R. Jordan and R. Jensen), pp. 449-451. Proceedings of the International Conference on Dryland Farming, Amarillo/Bushland, Texas, USA.

Hornick, S.B. and Parr, J.F. 1987. Restoring productivity of marginal soils by organic amendments. *American Journal of Alternative Agriculture* 2: 64-68.

Jackson, M.L. 1967. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd. New Delhi.

Kathju, S., Garg, B.K., Vyas, S.P. and Lahiri,A.N. 1993. Effects of supplemental irrigation and soil fertilization on pearl millet under drought. *Arid Soil Research and Rehabilitation* 7: 317-326

Lahiri, A.N. 1978. Relevance of soil fertility in drought evasion. In *Environment Physiology and Ecology of Plants* (Ed. D.N. Sen), pp. 277-288. Bishen Singh & Mahendra Pal Singh, Dehra Dun.

Lahiri, A.N. 1993. Drought and its effect on crop productivity. In *Desertification and its Control in the Thar, Sahara & Sahel Regions* (Eds. A.K. Sen and A. Kar), pp. 169-186. Scientific Publishers, Jodhpur.

Lindsay, W.L. and Norvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Journal of American Society of Soil Science* 42: 421-428.

Mathers, A.C. and Stewart, B.A. 1984. Manure effects on crop yield and soil properties. *Transactions of the American Society of Agricultural Engineers* 27: 1022-1026.

Misra, R.V. and Maheshwari, S. 1988. Integrated nutrient management in drylands. In *Challanges in Dryland Agriculture* (Eds. P.W. Unger, T.V. Sneed, W.R. Jordan and R. Jensen), pp. 371-374. Proceedings of the International Conference on Dryland Farming. Amarillo/Bushland, Texas, USA.

Oswal, M.C., Bakshi, R.K., Kumar, V. and Kumar, S. 1989. Response of dryland pearl millet to fertilizer under two cropping sequences. *Journal of the Indian Society of Soil Science* 37: 337-342.

Ramakrishna, Y.S. 1993. Climatological analysis of drought situations in western Rajasthan. In *Desertification and its Control in the Thar, Sahara & Sahel Regions* (Eds. A.K. Sen and A. Kar), pp. 39-48. Scientific Publishers, Jodhpur.

Venkateswarlu, J. 1987. Efficient resource management systems for drylands of India. *Advances in Soil Science* 7: 165-221.

Venkateswarlu, J. and Hegde B.R. 1992. Nutrient management for sustainable production in the coarse textured soils. In *Proceedings of the International Symposium on Sustainable Agriculture*, pp. 188-194. Punjab Agricultural University, Ludhiana.