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Comparing the Feasibilities of Pearlmillet-Based Intercropping Systems Supplied with Varying Levels of Nitrogen and Phosphorus

O. P. Sharma and A. K. Gupta

Authors' address: Dr O. P. Sharma (corresponding author) and Dr A. K. Gupta, Department of Agronomy, SKN College of Agriculture, Jobner 303 329, Rajasthan, India

With 3 tables

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Abstract

To compare the feasibilities of pearlmillet-based intercropping systems, field experiments were carried out for 2 years on loamy sand soils in the semi-arid plain zone of Rajasthan, India. Results showed that the pooled yields of pearlmillet from the single crop (1525 kg ha^{-1}) and from the crop intercropped with legumes (1528, 1498 or 1540 kg ha^{-1}) were statistically the same. The yields from intercrop legumes were obtained as a bonus. The highest value of land equivalent ratio (1.21) was recorded for the pearlmillet + clusterbean system, which gave significantly better results than the pearlmillet + cowpea system. It was also found that the dose of nitrogen can be reduced by up to 25 % when pearlmillet is grown with legumes. However, intercrop legumes required the recommended dose of fertilizer to produce their optimal yields. The practice of intercropping without fertilizer proved disadvantageous.

Key words: intercropping — legumes — LER — monetary advantage — nitrogen — pearlmillet

Introduction

Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] is a staple food crop of the semi-arid tropics. It is grown in harsh climates where no other cereal can be successfully cultivated. Its grains are rich in protein, fat and minerals. Pearlmillet (PM) stalks have good fodder value. It is grown both in pure and in complex mixed systems. Cereal–legume intercropping has attracted the attention of agronomists, possibly as a result of the established and theoretical advantages of intercropping systems (Ofori and Stern 1987). The primary reason for intercropping is that it is thought to give higher total yields than monocropping (Clark and Myers 1994). Nevertheless, very little chemical fertilizer is applied to cereal–legume intercropping systems, and then only to the main crop, the assumption being that the legume component can fulfil its own requirement. Roy and Barun (1983) suggested that the yield of an intercropping system can be increased by supplying the recommended dose of fertilizer to both the component crops. They further stated that the fertilizer needs of a component crop in a cereal–legume intercropping system are likely to be very different from their individual requirements, which seems logical as two crops grown in association may or may not exploit the growth resources fully. However, massive application of nitrogen (N) is neither economic nor ecologically desirable. Cereal–legume intercropping may offer the opportunity to reduce the dose of N applied to cereal as the soluble nitrogenous compounds secreted by legumes may be utilized by the adjoining porous root walls of non-legumes (Lipman 1913). With this background, the present investigation was conducted with the following objectives: (i) to compare the yields of PM obtained from single and mixed stands; (ii) to explore the possibility of reducing N applied to PM when grown in association with legumes; (iii) to determine the fertilizer requirement of intercrops for economic yields, and (iv) to assess the effect of intercropping on selected parameters.

Materials and Methods

The field experiment was conducted at the Agronomy farm, SKN College of Agriculture, Jobner (26°05′ N, 75°28′ E) over 2 consecutive years. The soil of the experimental site was a loamy sand with a pH value of 7.9 and an organic carbon content of 0.16 %. The amounts of available N, P and K were 143, 7.1 and 142 kg ha^{-1}, respectively. The single crop of PM was raised in lines 45 cm apart, but in the intercropping system PM was sown in paired rows 30 or 60 cm apart to accommodate an additional row of a legume crop. One row of clusterbean (CB) or cowpea (CP) or mungbean (MB) was inserted in the 60-cm gap between the two adjacent paired rows of PM. Thus, the density of the intercrop plots was 33 % higher than that of the single PM crop. Legume crops were planted at their usual spacing of 30 cm × 10 cm. The fertility levels consisted of seven treatments including a control (without any fertilizer) and different proportions of the recommended doses of N. For PM and legumes the recommended quantities of N were 60 and 15 kg ha^{-1}, respectively. In the treatment allocation, M denotes the main crop of PM and I the intercrop (clusterbean, cowpea or mungbean). $M_{100}I_{100}$ plots were those receiving 100 % of the full dose of nitrogen, and the intercrop also received the full dose of N. The other fertility combinations were $M_{100}I_0$, $M_{75}I_{100}$, $M_{75}I_0$, $M_{50}I_{100}$, $M_{50}I_0$ and M_0I_0 (control). A uniform basal dose of 30 kg P_2O_5 ha^{-1} was applied to all the rows of PM and to intercrops only where N fertilizer was applied. The experiment was conducted under rainfed conditions. The amounts of rainfall received in 1995 and 1996 were 555 and 690 mm, respectively, but the rainfall distribution in 1995 was quite erratic and most of the rain fell in a few events. The crops were harvested at maturity and grain was separated manually. Grain yield recorded in kg plot^{-1} was converted to kg ha^{-1}. The parameters used to evaluate the effects of intercropping in this study were land equivalent ratio (LER), pearlmillet equivalent yield (PMEQ) and monetary advantage. LER, as defined by Willey and Osiru (1972), is the total land area required under single cropping to give the yields obtained in the intercropping mixture. The LER values were calculated as per the formula given by Fisher (1977). For a valid comparison of yield data, yields of intercrops were converted into pearlmillet grain equivalents based on market prices at the time of harvest and added to the PM yield to obtain the relative yield potential of different intercrop combinations. The monetary advantage was worked out using the following expression given by Willey (1979):

$$\text{Monetary advantage} = \text{value of combined intercrop yield} \times (\text{LER} - 1)/\text{LER}.$$

Results and Discussion

Significant differences were observed in the yields of crops in the two seasons of the experiment. The results showed that the grain yield of PM during 1996 was higher than that during 1995. However, the opposite trend was noticed for intercrops. The reason for this anomaly was the high cloud cover experienced in 1995 during the early growth stage and terminal drought, which adversely affected the PM yield but not the yield of the selected legumes which, being short-duration plants, escaped these ill effects. In 1996, favourable weather in terms of distribution of rainfall and sunshine led to luxuriant growth of the main crop from the start, which perhaps resulted in shading of the legume plants growing between the paired rows of the main crop. Singh and Bishnoi (1983) and Bar et al. (1988) also obtained large variations in the yields of pearlmillet due to seasonal variability of rainfall.

Effect of intercrop

The results shown in Table 1 revealed that the grain yields of PM were statistically the same from single and mixed stands receiving the recommended doses of fertilizers. Paired planting of PM and legumes slightly improved the grain yield of the main crop in 1996. The results further indicated that the differences in the yields of PM in association with different species of legumes were marginal. The yield from the intercrop legumes can be considered a bonus arising from the higher density (33 % of that of the single crops). The highest value of LER was obtained with the PM + CB system, which was significantly better than the PM + CP system (Table 2). Clark and Myers (1994) also recorded a

Table 1: Effect of fertility levels on grain yield (kg ha^{-1}) of pearlmillet grown in pure and mixed stands

	Yield of pearlmillet grown in association with:								
	Clusterbean			Cowpea			Mungbean		
Treatments	1995	1996	Pooled	1995	1996	Pooled	1995	1996	Pooled
M_0I_0	587	1597	1092	555	1529	1082	583	1601	1092
$M_{50}I_0$	664	1769	1216	648	1777	1212	691	1825	1238
$M_{50}I_{100}$	728	1879	1303	685	1883	1264	726	1979	1352
$M_{75}I_0$	794	1925	1359	746	1896	1321	804	2003	1403
$M_{75}I_{100}$	848	2069	1458	742	1932	1357	856	2040	1448
$M_{100}I_0$	867	2090	1478	832	1997	1414	895	2103	1499
$M_{100}I_{100}$	912	2145	1528	963	2093	1498	929	2151	1540
S.E.M. ±	29	69	37	29	69	37	29	69	37
LSD (P = 0.05)	82	194	105	82	194	105	82	194	105
Single crop	936	2114	1525	–	–	–	–	–	–

Table 2: Effect of intercropping systems and fertilizer levels on LER, pearlmillet equivalent yield and monetary advantage (pooled over 2 years)

System	LER	Pearlmillet equivalent yield ($kg\,ha^{-1}$)	Monetary advantage ($INR\,ha^{-1}$)
PM + CB	1.21	2031	1942
PM + CP	1.15	1733	1374
PM + MB	1.18	2220	1932
S.E.M. ±	0.01	17	24
LSD (P = 0.05)	0.028	48	66

Treatments	CB	CP	MB	CB	CP	MB	CB	CP	MB
M_0I_0	0.99	0.93	0.95	1694	1416	1819	− 93	− 545	− 418
$M_{50}I_0$	1.09	1.06	1.06	1869	1615	2036	948	682	829
$M_{50}I_{100}$	1.23	1.18	1.22	2109	1788	2375	2190	1682	2362
$M_{75}I_0$	1.20	1.13	1.17	2001	1714	2156	1831	1234	1837
$M_{75}I_{100}$	1.32	1.24	1.29	2227	1867	2434	2991	2158	2959
$M_{100}I_0$	1.25	1.17	1.24	2062	1769	2234	2369	1618	2571
$M_{100}I_{100}$	1.36	1.32	1.34	2262	1965	2488	3357	2787	3385
S.E.M. ±	0.028	0.028	0.028	48	48	48	63	63	63
LSD (P = 0.05)	0.079	0.079	0.079	136	136	136	174	174	174

INR = Indian Rupees.
Price ($INR\,kg^{-1}$) adopted for calculating pearlmillet equivalent yield: pearlmillet, 4; clusterbean, 9; cowpea, 7; mungbean, 12.

higher value of LER with intercropping in pearlmillet. Furthermore, the highest PMEY (2220 $kg\,ha^{-1}$) was recorded with PM + MB because of the higher price of mungbean grains. It can be seen from Table 1 that PM yielded only 1525 $kg\,ha^{-1}$ when grown as single crop. Similar results were reported by Ramulu et al. (1998), who obtained a higher pearlmillet grain equivalent with PM + pigeonpea than with a monocrop of PM planted at uniform row spacing.

Effect of fertility levels

The highest yield of PM was obtained from plots receiving the full amount of the recommended dose ($M_{100}I_{100}$), but the yields were comparable to those in which the amount of N was curtailed by 25 %

Table 3: Effect of fertilizer levels on grain yields ($kg\,ha^{-1}$) of legumes grown in pure and mixed stands

	Yield of associated legumes								
	Clusterbean			Cowpea			Mungbean		
Treatments	1995	1996	Pooled	1995	1996	Pooled	1995	1996	Pooled
M_0I_0	354	181	267	242	185	213	248	237	242
$M_{50}I_0$	372	208	290	258	202	230	272	260	266
$M_{50}I_{100}$	465	251	358	340	258	299	364	317	340
$M_{75}I_0$	379	191	285	253	196	224	254	247	250
$M_{75}I_{100}$	453	230	341	334	249	291	353	304	328
$M_{100}I_0$	332	186	259	229	175	202	252	238	245
$M_{100}I_{100}$	428	223	325	298	236	267	345	286	315
S.E.M. ±	23	12	13	18	13	11	25	18	15
LSD (P = 0.05)	68	36	37	52	38	32	74	52	43
Single crop	949	824	886	798	778	788	1075	859	967

($M_{75}I_{100}$). This was true for all the intercropping systems. Thus it can be inferred that the dose of N can be reduced by up to 25 % when PM is grown with legumes. Further reductions in the level of N applied to PM significantly reduced the yield even when the intercrop was given the full dose of fertilizer. It is interesting to note from the data (Table 3) that fertilization applied at 100 % of the recommended dose to the intercrop legumes is essential to optimize the yields of legumes grown between the paired rows of PM.

The level of fertilizer applied to the intercrop cannot be reduced in parallel with the increase in the amount supplied to the main crop. Similar findings were also reported by Yadav et al. (1994) for PM grown under an intercropping system with CP and MB. The practice of intercropping without fertilizer is disadvantageous, as indicated by the value of LER (< 1.0), and confirmed by negative values of monetary advantage. Singh et al. (1994) also reported that LER, crop equivalent yield and net return were increased with increasing fertilizer doses applied to both the crop components. The values of all parameters used in the study to evaluate the suitability of intercropping increased with increasing levels of fertilization and the highest numerical values were obtained for $M_{100}I_{100}$, closely followed by $M_{75}I_{100}$. This again confirms that N can be reduced by up to 25 % by mixing short-duration legumes with pure pearlmillet.

Conclusions

The study has demonstrated the superiority of intercropping to single cropping of pearlmillet, as the yield of pearlmillet was not adversely affected by inserting legumes between the paired rows of pearlmillet. The highest yield of pearlmillet was obtained when the crop was fertilized with 100 % doses of nitrogen and phosphorus ($M_{100}I_{100}$), but the yields were comparable to those obtained when the amount of N was reduced by 25 % ($M_{75}I1_{00}$). Thus it can be concluded that the dose of N can be reduced by up to 25 % when pearlmillet is grown with legumes. Fertilization of legumes at the recommended dose (I_{100}) is essential to optimize yields of legume grown between the paired rows of pearlmillet. The highest value of LER was recorded for the pearlmillet + clusterbean system, which gave significantly better results than the pearlmillet + cowpea system.

Zusammenfassung

Ein Vergleich der Eignung eines auf Perlhirse basierenden Mischanbausystems mit unterschiedlichen Stickstoff- und Phosphorsäuremengen

Um die Eignung der Perlhirse auf der Basis eines Mischanbausystems zu überprüfen, wurden Feldexperimente für zwei Jahre auf einem lehmigen Sandboden in der semiariden Ebene von Rajastan, Indien durchgeführt. Die Ergebnisse zeigten, dass der Gesamtertrag von Perlhirse in einem Reinanbau (1525 kg ha^{-1}) und in einem Mischanbau mit Leguminosen (1528, 1498 bzw. 1540 kg ha^{-1}) statistisch gleich war. Die Erträge der Leguminosen im Mischanbau waren ein zusätzlicher Gewinn. Die höchsten Werte von LER (1,21) wurden im Mischanbau von Perlhirse + Klusterbohnenanbau nachgewiesen, wobei eine signifikante Überlegenheit gegenüber Perlhirse + Kuhbohnenanbausystemen nachzuweisen war. Die Ergebnisse weisen ferner darauf hin, dass bei der Stickstoffanwendung bis zu 25 % eingespart werden können, wenn Perlhirsen zusammen mit Leguminosen angebaut werden. Allerdings, der Mischanbau mit Leguminosen erfordert eine zu empfehlende Anwendungsmenge von Dünger, um optimale Erträge zu produzieren. Die Praxis des Mischanbaus ohne zusätzliche Düngung erwies sich als ungünstig.

References

Bar, A. K., R. C. Gautam, and S. K. Kaushik, 1988: Performance of pearlmillet genotypes in sole and intercropping system under rainfed conditions. Indian J. Agron. **33,** 52—55.

Clark, K. M., and R. L. Myers, 1994: Intercrop performance of pearlmillet, amaranth, cowpea, soybean and guar in response to planting pattern and nitrogen fertilization. Agron. J. **86,** 1097—1102.

Fisher, N. M., 1977: Studies in mixed cropping. I. Seasonal differences in relative productivity of crop mixtures and pure stands in Kenya Highlands. Exp. Agric. **13,** 169—177.

Lipman, J. G., 1913: A further discussion on certain methods used in the study of the associative growth of legumes and non legumes. J. Am. Soc. Agron. **5,** 70—72.

Ofori, F., and W. R. Stern, 1987: Cereal–legume intercropping system. Adv. Agron. **41,** 41—90.

Ramulu, V., R. C. Gautam, and S. K. Kaushik, 1998: Intercropping in pearlmillet (*Pennisetum glaucum*) with grain legumes and oilseed crops under rainfed conditions. Indian J. Agron. **43,** 382—386.

Roy, R. N., and H. Barun, 1983: Fertilizer use under multiple cropping systems: an overview. FAO Fert. Plant Nutr. Bull. **6,** 9—23.

Singh, R., and O. P. Bishnoi, 1983: Effect of rainfall variability on crop maturity in arid region of Haryana: a case study. Int. J. Trop. Agric. **1,** 317—324.

Singh, R. A., A. K. Singh, and U. N. Singh, 1994: Nitrogen economy in pearlmillet and blackgram intercropping system under rainfed condition of Vindhyan plateau. Indian J. Agric. Sci. **64,** 252—254.

Willey, R. W., 1979: Intercropping – its importance and research needs. Part 1. Competition and yield advantages. Field Crop Abstr. **32,** 1—10.

Willey, R. W., and D. S. O. Osiru, 1972: Studies on mixtures of maize and beans (*Phaseolus vulgaris*) with particular reference to plant population. J. Agric. Sci. **79,** 519—529.

Yadav, S. K., B. R. Singh, S. Kumar, and O. P. S. Verma, 1994: Correlations and economic studies on growth and yield parameters of pearlmillet under intercropping system with cowpea and mungbean. Int. J. Trop. Agric. **12,** 33—35.