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Effect of fertilizer and biofertilizer on pearl millet (*Pennisetum glaucum*) and pigeonpea (*Cajanus cajan)* intercropping system under rainfed conditions

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ABSTRACT

A field experiment was conducted during 3 rainy seasons of 2000–2002 at Regional Agricultural Research Station, Bijapur, in medium black soil, to study the effect of fertilizer and biofertilizer on pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] under sole and intercropping system. The grain yield of pearl millet was significantly higher under sole cropping (18.88 q/ha) compared to intercropped pearl millet (16.69 q/ha). However, pearl millet-equivalent yield, net returns and benefit : cost ratio were higher with pearl millet + pigeonpea [*Cajanus cajan* (L.) Millsp.] (2:1) intercropping system (47.38 q/ha, Rs 113,988/ha and 2.79 respectively) over sole crop of pearl millet (18.88 q/ha, Rs 4,864/ha and 2.25 respectively). Irrespective of cropping systems, application of 60 kg N + 40 kg P_2O_5/ha recorded significantly higher pearl millet-grain equivalent yield (36.17 q/ha) over absolute control, seed treatment with biofertilizer alone and application of 20 kg N+15 kg P_2O_5/ha (28.30, 31.22 and 33.42 q/ha respectively) but was on par with 40 kg N + 30 kg P_2O_5/ha + biofertilizer and recommended fertilizer dose (50 kg N + 25 kg P_2O_5/ha) of the region (35.41 and 33.71 q/ha respectively). Net monetary returns were higher with application of 60 kg N + 40 kg P_2O_5/ha (Rs 10,144/ha) and it was on a par with 40 kg N + 30 kg P_2O_5/ha + biofertilizer seed treatment (Rs 10,130/ha).

Key words : Pearl millet, Pigeonpea, Intercropping, Fertilizer, Bio-fertilizer, Yield, Economics

Pearl millet cultivation is mostly confined to poor and impoverished soils and cultivated by resource-poor farmers. Intercropping in pearl millet augments the utilization of available resources, viz. light, nutrients and moisture, with reference to the production per unit of applied inputs. Its intercropping with grain legumes is a common practice in many pearl millet-growing regions including Karnataka. With hiking input costs and the low commodity prices, the farmers are looking for low cost input alternatives like bio-farming. These alternative management techniques minimize the use of purchased inputs and exploit biological systems to improve the efficiency of applied fertilizers and thus to enhance crop yield. Due to escalation of fertilizer prices, bio-farming approach would be more remunerative and cost effective for getting higher returns with considerable fertilizer economy and better soil health. Keeping in view these factors, the present investigation was carried out to study the influence of biofertilizer application in combination with chemical fertilizers on yield and economic returns of pearl millet and pigeonpea intercropping system under rainfed conditions.

MATERIALS AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Bijapur, Karnataka, during 3 rainy seasons of 2000, 2001 and 2002 in medium black soil. The soil was low in available nitrogen (190 kg/ha) and phosphorus (19.5 kg/ha), high in available potassium (496 kg/ha) and calcium carbonate (20%), with 8.2 pH and 0.3% organic carbon. There were 16 treatments, consisting of 2 main plots of cropping system (sole pearl millet and pearl millet + pigeonpea intercropping at 2 : 1 row proportion) and 8 subplots consisting of 2 levels of fertilizer (20 kg N + 15 kg P_2O_5 and 40 kg N + 30 kg P_2O_5/ha) which were applied with and without biofertilizer (*Azospirillum* + phosphorus-solubilizing bacteria) as seed treatment and were compared with the absolute control, biofertilizer alone, 60 kg N + 40 kg P_2O_5/ha and recommended done of fertilizer (50 kg N + 25 kg P_2O_5/ha) for the region as detailed in Table 1. Pearl millet seeds were treated with *Azospirillum* and phosphorus-solubilizing bacteria biofertilizers each at 20 g/kg of seed as per treatments, and pigeonpea seeds were treated with rhizobium culture commonly in all the treatments before sowing. The experiment was laid out in split-plot design with 3 replications. The gross and net plot sizes were 5.0 m × 5.4 m, and 4.4 m × 4.5 m respectively. 'ICTP 8203' population of pearl millet and 'PT 221' variety of pigeonpea recom-

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mended for the region were used. Pearl millet was planted at 45 cm × 15 cm spacing both in sole cropping and intercropping system and pigeonpea was planted at 135 cm × 20 cm after every 2 rows of pearl millet in replacement series.

A total rainfall of 493.4, 541.4 and 509.2 mm was received during the cropping period (June to December) during 2000, 2001 and 2002, respectively, compared with the normal rainfall (average of 69 years) of 539.2 mm. Cropping seasons of 2000 and 2002 were quite normal for the growth of both crops and comparatively higher yields were obtained owing to early sowing and good distribution of rainfall. During 2001, grain yields of pearl millet and pigeonpea were lower than of 2000 and 2002, though the total rainfall was higher mainly due to late sowing (August first week) as a consequence of delayed receipt of rainy-season rains. Only the pooled data of 3 years were discussed. Input and output prices of commodities prevailed during each year of experimentation was taken for calculation of gross returns and cost of cultivation.

RESULTS AND DISCUSSION

Intercropping

Pooled data of 3 years indicated that, grain yield of pearl millet was significantly higher under sole cropping (18.88 q/ha) than intercropping system (16.69 q/ha). There was 11.6% decrease in grain yield of pearl millet due to intercropping of pigeonpea. The reduction in grain yield of pearl millet in intercropping system could be attributed to decrease in plant population due to replacement of 1 row of pearl millet by pigeonpea. Similar decrease in grain yield of pearl millet due to legume intercropping was reported by Ramulu and Gautum (1999). Though the yield-contributing characters of pearl millet, viz. ear length and effective tillers/plant, were higher under intercropping system than to sole crop (Table 1) they could not compensate the loss in plant population of pearl millet due to pigeonpea intercropping resulting in decreased grain yield.

The straw yield was significantly higher with sole crop of pearl millet (27.39 q/ha) than intercropped pearl millet (23.71 q/ha). Due to intercropping of pigeonpea, there was 15.52% reduction in straw yield. The reduction in straw yield of pearl millet under intercropping system could be attributed to decreased plant population of pearl millet rather than competition offered by the intercrop for various growth resources, as the growth attributes of pearl millet, viz. plant height and tillers/plant, showed increasing trend under intercropping system.

Pearl millet grain-equivalent yield differed significantly due to cropping systems (Table 1) and it was significantly higher with pearl millet + pigeonpea (2:1) intercropping (47.38 q/ha) than sole crop of pearl millet (18.88 q/ha). The results corroborate the findings of Kaushik *et al.* (1988), Tetarawal and Nanwal and AICPIP (2003). Higher pearl millet grain-equivalent yield owing to pearl millet + pigeonpea (2:1) intercropping system is attributed to higher gross income obtained because of additional yield of pigeonpea and its higher price in the market.

Fertilizer and biofertilizers

Grain yield of pearl millet increased significantly with increase in fertilizer level (Table 1). The response to applied biofertilizer was greater in absence of chemical fertilizer and the response decreased with increase in chemical fertilizer level. Application of biofertilizer alone resulted in 12.87% higher grain yield over absolute control. Among the treatments, application of 60 kg N + 40 kg P_2O_5/ha recorded significantly higher grain yield (20.99 q/ha) compared to 40 kg N + 30 kg P_2O_5/ha, 20 kg N + 15 kg P_2O_5/ha, application of biofertilizer alone and absolute control, but it was on par with 40 kg N +30 kg P_2O_5/ha + biofertilizer and 50 kg N + 25 kg P_2O_5/ha (19.20 and 18.70 q/ha respectively) and the latter treatments in turn were at par. Yield-attributing characters of pearl millet, viz. ear length and effective tillers/plant, followed similar trend. The results are in agreement with the findings of Tetarawal and Nanwal (2001). Higher and at par grain yield of pearl millet with 60 kg N + 40 kg P_2O_5/ha, 40 kg N + 30 kg P_2O_5/ha + biofertilizer and 50 kg N + 25 kg P_2O_5/ha could be attributed to higher growth and yield attributes over other treatments.

Straw yield increased significantly with the application of 60 kg N + 40 kg P_2O_5/ha (27.47 q/ha) compared to other treatments; however, it was on a par with 40 kg N + 30 kg P_2O_5/ha, 40 kg N + 30 kg P_2O_5/ha + biofertilizer and 50 kg N + 25 kg P_2O_5/ha. Similar results were reported from Aurangabad and Dhule in Maharashtra, Hisar in Haryana and Kalai in Uttar Pradesh, (AICPIP, 2003). Higher straw yield of pearl millet at higher levels of fertilizer could be attributed to enhanced vegetative growth with respect to plant height and tillers/plant.

Among the fertilizer and biofertilizer treatments, application of 60 kg N + 40 kg P_2O_5/ha recorded significantly higher pearl millet-equivalent yield (36.17 q/ha) compared to 40 kg N + 30 kg P_2O_5/ha, 20 kg N + 15 kg P_2O_5/ha with and without biofertilizer, application of biofertilizer alone and absolute control, but was on a par with 40 kg N + 30 kg P_2O_5/ha + biofertilizer and 50 kg N + 25 kg P_2O_5 (35.41 and 33.71 q/ha respectively). It indicates that, seed treatment of pearl millet with biofertilizer along with 40 kg N+30 kg P_2O_5/ha will save 20 kg N + 10 kg P_2O_5/ha.

Interaction effect

Grain and straw yields of pearl millet and pearl millet

Table 1. Effect of fertilizer and biofertilizer treatments on growth and yield of pearl millet with and without intercropping (pooled data of 2000, 2001 and 2002)

Treatment	Pearl millet					Pigeonpea		Pearl millet grain-equivalent yield (q/ha)	Net returns (Rs/ha)	Benefit : cost ratio
	Plant height (cm)	Effective tillers/ plant	Ear length (cm)	Straw yield (q/ha)	Grain yield (q/ha)	Seed yield (kg/ha)	Straw yield (q/ha)			
Cropping system										
Sole pearl millet	146.5	1.11	19.44	27.9	18.88			18.88	4,864	2.25
Intercropped pearl millet	149.9	1.55	20.15	23.71	16.69			47.38	13,988	2.79
CD (P=0.05)	NS	0.19	0.29	1.79	1.92			4.12	2,893	0.24
Fertilizer										
Absolute control	141.9	1.12	18.60	20.62	14.22	1,002	15.94	28.30	7,738	2.49
Biofertilizer alone (*Azospirillum* and PSB)	142.9	1.21	19.30	22.20	16.05	1,066	17.40	31.22	9,053	2.74
20 kg N + 15 kg P_2O_5/ha	146.9	1.22	19.42	25.12	17.46	1,149	18.29	33.42	9,621	2.71
20 kg N + 15 kg P_2O_5/ha + biofertilizer	149.3	1.27	19.72	25.22	17.60	1,189	18.29	33.64	9,729	2.72
40 kg N + 30 kg P_2O_5/ha	146.5	1.71	19.44	27.27	18.06	1,186	16.33	32.48	9,764	2.61
40 kg N + 30 kg P_2O_5/ha biofertilizer	151.2	1.93	20.28	25.90	19.20	1,194	16.78	35.41	10,130	2.66
60 kg N + 40 kg P_2O_5/ha	149.9	2.24	20.62	27.47	20.99	1,119	16.67	36.17	10,144	2.58
50 kg N + 25 kg P_2O_5/ha	151.5	1.93	20.42	27.38	18.70	1,142	16.44	33.71	9,341	2.54
CD (P=0.05)	3.89	0.33	0.78	2.11	2.37	115	NS	3.15	1,053	0.18

equivalent did not differ significantly due to the interaction effect of cropping system and fertilizer + biofertilizer treatments.

Pigeonpea performance in intercropping system

Seed yield of pigeonpea differed significantly due to fertilizer and biofertilizer treatments. Application of 40 kg N + 30 kg P_2O_5/ha + biofertilizer resulted in significantly higher seed yield of pigeonpea (1,194 kg/ha) over absolute control and application of fertilizer alone (1,002 and 1,066 kg/ha respectively); however, it was on a par with other treatments (Table 1). Plant height, primary branches/plant, pods/plant and straw yield of pigeonpea did not differ significantly due to various treatments.

Economics

Both net monetary returns and benefit : cost ratio were significantly higher with pearl millet + pigeonpea (2:1) intercropping (Rs 13, 988 and 2.79 respectively) compared to sole crop of pearl millet (Rs 4,864 and 2.25 respectively). This was attributed to higher gross returns realized because of additional yield of pigeonpea which also fetched higher price in the market. The results confirm the findings reported form Dhule in Maharashtra (AICPIP, 2003). Kaushik *et al.* (1998) also reported higher net monetary returns and benefit : cost ratio with pearl millet + groundnut intercropping (1:3) over sole crop of pearl millet.

Application of 60 kg N + 40 kg P_2O_5/ha resulted in higher net monetary returns (Rs 10, 144/ha) than the absolute control and application of biofertilizer alone, but it was comparable with 40 kg N + 30 kg P_2O_5/ha + biofertilizer (Rs 10,130/ha). However, benefit : cost ratio was significantly higher with application of biofertilizer alone (2.74) than the absolute control (2.49), 40 kg N + 30 kg P_2O_5/ha (2.61), 60 kg N + 40 kg P_2O_5/ha (2.58) and 50 kg N + 25 kg P_2O_5/ha (2.54), but it was on par with 40 kg N + 30 kg P_2O_5/ha + biofertilizer (2.66).

Thus application of 40 kg N + 30 kg P_2O_5/ha along with pearl millet seed treatment with biofertilizer was optimum for higher yield and economic returns in pearl millet + pigeonpea (2:1) intercropping system under rainfed conditions and would economize 20 kg nitrogen and 10 kg phosphorus/ha.

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