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Production potential of sorghum (*Sorghum bicolor*) intercropped with pigeonpea (*Cajanus cajan*) under varying fertility levels in the rainfed environment of Bundelkhand region

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Abstract

A field experiment was conducted during rainy seasons of 2004-05 and 2005-06 at Agriculture Research Farm, Nehru P.G. College, Lalitpur (U.P.) in sandy loam soil, to find out optimum NPK fertilizer requirement of sorghum + pigeonpea intercropping system. The seed yield of intercrop sorghum was significantly superior at sorghum with 75% NPK + pigeonpea with RDF (1.76 t/ha). Plant height, length and width/panicle, seeds/ panicle of intercrop sorghum were also distinctly higher with these treatment combinations. Sorghum equivalent yield was 108.13% higher at sorghum 75% NPK + pigeonpea RDF over sole sorghum at RDF with LER value of 1.80. Protein content of sorghum seed did not significantly vary due to intercropping system. . However, N,P,K uptake was 5.32, 16.36 and 14.22 % higher with sorghum + pigeonpea at sorghum 75% NPK + pigeonpea RDF over sole sorghum at RDF.

Key words : Sorghum, pigeonpea, intercropping, NPK levels, protein content, nutrient uptake, productivity, efficiency.

Sorghum [*Sorghum bicolor* (L.) Moench] is a prime food and fodder crops of dryland agriculture, where it is grown sole as well as intercrop. The intercropping of sorghum + pigeonpea is common and could ensure the fulfillment of dietary requirement, enhanced productivity of crops per unit area per unit time (Anonymous, 2004).

Nitrogen needs of cereals intercropped with legumes are reported to be less than for sole cropping due to transfer of some of the fixed nitrogen by legumes to the associated cereal during the growing season (Willey, 1979). In general, intercropping system may not require additional P, if only one component needs it, when there is little competition for P between component crops, especially on neutral soils with medium P availability. However, there is necessity for higher levels of P in intercropping systems than in sole crop situation to get near normal yields of component crops, particularly in P deficient soil (Srinivasan and Ahlawat, 1990). Since most Indian soils are considered adequate in native K, its application did not receive due attention. Mining of native K under intensive cropping and continuous neglect of replenishment through fertilizers led to K deficiency in many soils and responses to its application became spectacular in different cropping systems. In fact, study on nutrient requirement and nutrient competitions in intercropping hardly receive any due attention. Therefore, the present study was under taken to explore the optimum doses of NPK for higher productivity of sorghum with pigeonpea

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intercropping system under rainfed situation of Bundelkhand region.

Materials and Methods

The field experiment was carried out at the Agriculture Research Farm, Nehru P.G. College, Lalitpur (U.P.) India (latitude 24° 10'N, longitude 79° 00'E and about 400m asl) during 2004-05 and 2005-06. The experimental site is located in a semi-arid and sub-tropical climate with hot dry summers and cold winters with average annual rainfall is 802.9 mm. while experimental field received 806.1 and 927.4 mm rainfall during two respective years. The soil of experimental field was sandy loam (Raker) with P^H of 7.5 and 7.3, total N 152 and 164 kg/ha, available P 5.6 and 4.7 kg P/ha and available K 233 and 220 kg K/ ha, respectively during 2004-05 and 2005-06. Total eight treatments comprised 6 fertility levels in intercropping system (sorghum+ pigeonpea) Viz. F_1 (sorghum 100% NPK+ Pigeonpea no NPK), F_2 [sorghum no NPK + Pigeonpea RDF(20 : 26.2 : 25 kg N:P:K/ha)], F_3 (Sorghum 25% NPK + Pigeonpea RDF), F_4 (Sorghum 50% NPK + Pigeonpea RDF), F_5 (Sorghum 75% RDF + Pigeonpea NPK), F_6 (Sorghum 100% NPK + Pigeonpea RDF) and 2 control for sole sorghum (control and RDF *i.e.* 120 : 17.5 : 25 kg N:P:K/ha) were laid out in a randomized block design with three replications.

The sorghum and pigeonpea seeds were treated with thiram 75% WP @ 2.5 g/kg seed. However, pigeonpea seed was also uniformly treated with *Rhizobium* species culture @ 200 g/ 10 kg seed and phosphate soluble mobilizer (PSM) culture @ 400 g/10 kg seed. Row to row distance was maintained 45 cm for sole sorghum and 75 cm for sole pigeonpea. However, in intercropping system one line of sorghum was adjusted between two rows of pigeonpea (1:1). The lines were marked at the desired distance and shallow furrow were opened with the help of deshi plough. The seeds were drilled manually in the furrow using the recommended seed rate of sorghum (cv. CSV-15) @ 12 kg/ha and pigeonpea (cv. Amar) @ 15 kg/ha. Full NPK for pigeonpea was applied as basal while, for the sorghum, the 1/3 doses of N with full doses of P and K were applied as basal and remaining one was applied in two equal split doses at 30 and 50 days stages of crop close to sorghum rows. Urea, single super phosphate and muriate of potash were used to supply N, P and K, respectively. The sowing of sorghum and pigeonpea were done on 15th July in both the years and harvested on 6th October, 20th February in first year and 11th October, 1st March in second year, respectively. The necessary plant protection and weed control practices were followed during crop growth.

The yield advantage of intercropping was calculated in term of land equivalent ratio (LER) and crop equivalent yield (CEY) (Panda, 2004). Sorghum equivalent yields (t/ha) = yield of sorghum (t/ha) + [yield of intercrop (t/ha) x unit price of intercrop (Rs./t)]/ unit price of sorghum (Rs./t). The productivity and economics were calculated on the basis of prevailing market prices.

Results and Discussion

Growth and yield attributes:

The growth parameters viz. plant height, leaves/plant and yield attributes viz. panicles/ plant , length/ panicle, width/ panicle, seeds/ panicle and 100 seed weight of sorghum recorded significantly higher under sorghum sole with RDF than that of sorghum sole with no NPK (Table 1). The improvement in NPK status in soil with increasing fertility levels resulted in greater synthesis of chlorophyll in the leaves. Further, phosphorus fertilization also improves the various metabolic and physiological processes in the plant system (Patidar and Mali, 2004). In sorghum + pigeonpea system, plant height, length/ panicle, width/panicle, seeds/panicle and 100 seed weight were registered significantly higher under sorghum 75% NPK + pigeonpea RDF treatment. However, leaves/plant of intercrop sorghum was significantly superior at sorghum 100% NPK + pigeonpea no NPK. This may be due to the fact that nitrogen was involved in increasing the protoplasm constituents and accelerating the process of cell division and elongation which in turn gives luxuriant vegetative growth for higher productivity. These findings are in conformity to those of Ram and Singh (2003). However, plant

Table 1. Effect of intercropping and fertility levels on growth and yield attributes of sorghum under sorghum + pigeonpea system (Pooled data of 2 years).

Treatment	Plant height (cm) 60 DAS	Leaves/ plant 60 DAS	Panicles/ Plant	Length / panicle (cm)	Width / panicle (cm)	Seeds/ panicle	100-seed weight (g)
Sorghum sole @ no NPK	91.2	8.17	0.85	9.35	1.32	235	0.25
Sorghum sole @ RDF	226.2	12.50	1.00	22.79	6.24	2189	1.60
S. (100% NPK) + P. (No NPK)	206.9	12.00	1.00	19.04	5.42	1116	1.37
S. (No NPK) + P. (RDF)	149.9	9.84	1.00	13.09	2.90	223	0.62
S. (25% NPK) + P. (RDF)	191.7	9.34	1.00	17.94	5.15	930	1.17
S. (50% NPK) + P. (RDF)	198.0	10.17	1.00	19.22	5.89	1110	1.25
S. (75 % NPK) + P. (RDF)	224.0	10.17	1.00	23.92	6.47	2181	1.39
S. (100 % NPK) + P. (RDF)	205.7	10.50	1.00	21.75	6.32	2173	1.27
LSD (P = 5%)	8.4	1.91	0.10	1.76	0.74	194	0.25

S- sorghum, P- pigeonpea, DAS- days after sowing

height and yield attributes of intercrop sorghum with 75% NPK + pigeonpea RDF were statistically at par with sorghum sole @ RDF treatment. This might be due to better utilization of nutrients and resources by sorghum on account of least competition faced by sorghum in association with slow growth of intercrop pigeonpea.

Yield and harvest index

Seed yield of sole sorghum with RDF was recorded 112.34% higher than that of no NPK to sorghum sole (Table 2). Such increased yield was evident from significant enhance in yield attributes i.e. panicle/plant, length/panicle, width/panicle, seeds/panicle and 100-seed weight (Table 1). Further, higher seed yield was also because of balanced nutrition to sorghum crop grown in field having low N and P and medium K status. Similar findings were also reported by Kushwaha *et al*. (2007). Significantly higher stover yield was noted under sorghum @ RDF than sorghum with no NPK application. This could be associated with higher growth parameters i.e. plant height and leaves/plant. Among the intercrop in association with pigeonpea, seed yield of sorghum was found significantly superior and gave 46.06% higher under sorghum 75% NPK + pigeonpea RDF than sorghum no NPK + pigeonpea RDF and statistically at par with sole sorghum @ 100% RDF owing to better yield attributes.

When intercrop compared with sole system, sorghum 75% NPK + pigeonpea RDF gave 2.32 and 5.03% higher intercrop seed and stover yield of sorghum than sorghum sole with RDF, respectively . It showed that growth and reproductive formation of sorghum did not affect in association with pigeonpea because of least competition faced by sorghum plant. This effect might be reduced due to adequate supply of NPK as well as beneficial effect of associated pigeonpea crop. (Verma *et al*., 2005)

Harvest index of sorghum sole with RDF was significantly higher (61.25%) than that of no NPK to sorghum sole However, intercrop sorghum was noted greater harvest index at sorghum no NPK + Pigeonpea RDF followed by sorghum 75 % NPK + Pigeonpea RDF fertility levels. When sole system compared with intercropping, harvest index of intercrop sorghum with sorghum no NPK + pigeonpea RDF and sorghum 75% NPK + pigeonpea RDF were either higher or statistically at par with sorghum sole with RDF. This was because of more proportional increase in seed yield as compared to stover yield .

Protein content

Protein content of sorghum was 11.08% higher under sorghum sole with RDF than no NPK to sole sorghum (Table 2). Nitrogen has the key role in growth of cereals and was the most limiting nutrient in experimental soil. Nitrogen application increased the seed yield and improved the quality of grain, particularly the protein content. In intercropping system,

Table 2. Effect of intercropping and fertility levels on yield, quality, productivity and efficiency of sorghum under sorghum + pigeonpea system.

Treatment	Seed yield (t/ha)			Stover yield (t/ha)			Harvest index (%)	Protein content (%)	Sorghum equivalent yield (SEY) (t/ha)	LER
	2004-05	2005-06	Pooled data	2004-05	2005-06	Pooled data				
Sorghum sole @ no NPK	0.81 (0.32)	0.81 (0.38)	0.81 -0.35	1.61	1.58	1.60	33.84	9.84	0.81	1.00
Sorghum sole @ RDF	1.65 (0.97)	1.78 (1.16)	1.72 -1.07	2.52	2.63	2.58	39.98	10.93	1.72	1.00
S. (100% NPK) + P. (No NPK)	1.46 (0.44)	1.80 (0.40)	1.63 -0.42	2.78	2.85	2.82	36.49	10.90	2.61	2.22
S. (No NPK) + P. (RDF)	1.15 (0.78)	1.26 (1.03)	1.21 -0.91	1.31	1.46	1.39	46.50	10.43	3.30	2.37
S. (25 % NPK) + P. (RDF)	1.26 (0.73)	1.39 (0.52)	1.33 -0.63	2.00	2.07	2.04	39.37	9.97	2.82	1.40
S. (50 % NPK) + P. (RDF)	1.42 (0.72)	1.51 (0.59)	1.47 -0.66	2.70	2.46	2.58	36.26	10.43	2.98	1.51
S. (75 % NPK) + P. (RDF)	1.70 (0.71)	1.82 (0.78)	1.76 -0.75	2.70	2.71	2.71	39.37	10.90	3.58	1.80
S. (100%NPK) + P. (RDF)	1.59 (0.57)	1.64 (0.93)	1.62 -0.75	2.60	2.59	2.60	38.23	10.74	3.30	1.64
LSD (P = 5%)	0.38	0.37	0.38	0.46	0.15	0.31	4.57	NS	0.17	-

S- Sorghum, P- pigeonpea. In bracket yield of sole and intercropped pigeonpea are given.

protein content in intercrop sorghum was found maximum in sorghum 75% NPK + pigeonpea RDF and sorghum 100% NPK + pigeonpea no NPK treatments which were statistically at par with pure sorghum. The higher protein content might be due to increase in N uptake with increasing levels of N. These results are in agreement with the findings of Ram and Singh (2003).

Nutrient uptake

Nutrient uptake of sorghum viz. nitrogen, phosphorus and potassium was significantly superior under sorghum sole with RDF than that of no NPK to sorghum sole owing to better growth and yield of sorghum sole (Table 3). Increased nitrogen levels significantly increased the nutrient uptake (Ramesh and Reddy, 2004). In varied fertility levels, intercrop sorghum at sorghum 75% NPK + pigeonpea RDF noted significantly higher N, P and K uptake than rest of fertility levels except sorghum 100% NPK + pigeonpea no NPK which was statistically at par (Table 3). This might be due to higher N, P and K content in sorghum seeds and more dry matter yield in association with pigeonpea because of increase N, P and K supply in this system. Intercrop sorghum 75% NPK + pigeonpea 100 % NPK also exhibited significant higher K uptake and statistically at par N and P uptake with of sorghum sole at RDF owing to statistically at par grain and stover yield of sorghum because of greater NPK supply. These results confirmed with the findings of Ram and Singh (2003).

Productivity and efficiency

Sorghum equivalent yield (SEY) of intercropping system was significantly higher than sole sorghum because of addition yield of intercrop pigeonpea. The similar result was reported by Ahlawat *et al*. (2005). In different fertility levels, SEY was higher at 75% NPK to sorghum + pigeonpea RDF owing to higher grain yield of sorghum. Although pigeonpea yield was marginally reduced with increasing fertility levels but comparative increase in sorghum yield was much more which resulted in such higher sorghum equivalent yield.

LER of sorghum + pigeonpea system were higher than sole system of sorghum. The yield advantage in intercropping system may be due to crop complementaries. In varied fertility treatments, LER was higher with no NPK to sorghum + RDF to pigeonpea (2.39) followed by 100% NPK to sorghum + no NPK to pigeonpea (2.22). Such yield advantage owing to inter-cropping might be attributed to the combined effect of better utilization of natural resources than sole cropping of companion crops, resulting in higher productivity per unit area (Dutta and Bandyopathyay, 2006).

From the two year study, it may be

Table 3. Effect of intercropping and fertility levels on nutrient uptake of sorghum under sorghum + pigeonpea intercropping system.

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	2004 -05	2005 -06	Pooled data	2004 -05	2005 -06	Pooled data	2004 -05	2005 -06	Pooled data
Sorghum sole @ no NPK	2.32	1.83	2.08	0.66	0.65	0.66	6.32	6.11	6.22
Sorghum sole @ RDF	22.89	26.67	24.78	4.68	5.22	4.95	20.25	25.45	22.85
S. (100% NPK) + P. (No NPK)	20.12	20.66	20.39	5.88	4.57	5.23	22.07	24.45	23.26
S. (No NPK) + P. (RDF)	9.87	15.46	12.67	3.02	3.18	3.10	6.08	11.84	8.96
S. (25 % NPK) + P. (RDF)	8.29	10.11	9.20	1.90	2.03	1.97	11.32	12.85	12.09
S. (50 % NPK) + P. (RDF)	16.54	15.02	15.78	3.84	3.70	3.77	21.42	18.30	19.86
S. (75 % NPK) + P. (RDF)	25.09	27.10	26.10	5.90	5.61	5.76	25.51	26.69	26.10
S. (100 % NPK) + P. (RDF)	19.87	20.85	20.36	5.70	3.80	4.75	19.47	21.13	20.30
LSD (P = 5%)	2.45	2.53	2.52	1.09	0.79	0.94	2.04	2.05	2.07

S- Sorghum, P- pigeonpea.

concluded that sorghum in association with pigeonpea at 75% NPK to sorghum + RDF to pigeonpea were found to be most optimum dose of nutrient and efficient intercrops of the system. This treatment was identified as a most compatible combination for rainfed areas of Bundelkhand region.

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