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Productivity and nutrient uptake of pigeonpea (*Cajanus cajan*) in pigeonpea based intercropping systems as influenced by planting pattern and nutrients levels applied to intercrops

FATEHJEET SINGH SEKHON[1], THAKAR SINGH[2] and K S SAINI[3]

Punjab Agricultural University, Ludhiana, Punjab 141 004

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ABSTRACT

The experiment was conducted at students' research farm, Punjab Agricultural University, Ludhiana during 2015 and 2016 to study the effect of planting pattern and levels of nutrient applied to intercrops on growth, yield and nutrient uptake in pigeonpea [*Cajanus cajan* (L.) Millsp.] based intercropping systems. Pigeonpea seed yield and biological yield were not significantly influenced by different planting pattern and nutrient level applied to intercrops under different intercropping systems during both the years. Pigeonpea equivalent yield was significantly affected by planting pattern and nutrient levels. Highest pigeonpea equivalent yield (1.84 and 1.90 tonnes/ha) was observed under planting pattern of pigeonpea (50 cm × 25 cm) + maize fodder during during both the years. Pigeonpea equivalent yield increased with increase in levels of nutrient to intercrops and maximum pigeonpea equivalent yield of 1.63 and 1.73 tonnes/ha was obtained with 100% of recommended dose of nutrients applied to intercrop. N, P and K uptake by pigeonpea was not affected by different planting pattern but N (75.3 and 80.8 kg/ha), P (16.0 and 17.2 kg/ha) and K (70.0 and 78.4 kg/ha) uptake was maximum with 100% nutrients applied to intercrops during both the years, respectively. Similar trend was observed with available N, P and K in soil at harvest.

Key words: Intercropping system, Nutrient levels, Nutrient uptake, Pigeonpea, Planting pattern, Productivity

Pulses are second to cereals in importance for human and animal dietary needs. Deep rooting characteristics, ability to fix atmospheric nitrogen and huge leaf fall makes pulses an important component in cropping systems. Pigeon-pea ranked second most important pulse crop of India which was grown at a large scale after chickpea. Pigeonpea is a nutritious, high protein crop with high digestible protein (68%), low in fat and sodium with no cholesterol and has high dietary fibres (Wilson *et al* 2012). Pigeonpea [*Cajanus cajan* (L.) Millsp.] is commonly known as red gram or *arhar* or *tur*. It is the pulse crop which is predominantly grown during the *kharif* season, both as a sole and intercrop. Intercropping is potentially beneficial system showing sustainable yield advantage over sole cropping and reduced risk. Intercropping is an intensive land use system for increasing the productivity by utilizing the spaces left between the rows of main or base crop. Intercropping of short duration cereals and pulses provides an opportunity to utilize of available resources more efficiently with enhancement of productivity and profitability of system. There is possibility of growing crops like cowpea fodder and maize fodder with pigeonpea due to its initial slow growth rate. Demand of fodder has been increased in Punjab due to increase in dairy units during last few decadeds. To feed the present population 6.24 million adult animals are to be provided with sufficient amount of good quality fodder. Per day supply of fodder is about 30.1 kg/animal with 67.9 mt annual production of fodder. About 91.1 million tonnes of green fodder is required to meet the basic demand of 40 kg green fodder per adult animal per day (Anonymous 2017). So, there is possibility of growing crops like cowpea fodder and maize fodder with pigeonpea due to its initial slow growth rate to solve the problem of fodder scarcity. Nutrient management is the key issue in obtaining potential yield of both component crops in any intercropping system.

MATERIALS AND METHODS

A field experiment was conducted at students' research farm, Punjab Agricultural University, Ludhiana, Punjab on loamy sand soil during *kharif* season of 2015 and 2016. The soil of experimental site had a pH of 7.2 and 7.1, containing 0.32 and 0.31% organic carbon, 196 and 197.5 kg/ha available N, 18.8 and 20.5 kg/ha available P and 213.2 and 216.0 kg/ha available K during both years, respectively. Total rainfall received during crop season was 562.5 and 518.9 mm during 2015 and 2016, respectively.

[1]e mail: fatehjeetsingh@pau.edu, [2]e mail: thakarsingh@pau.edu, [3]e mail: sainiks@pau.edu, Department of Agronomy.

The treatment combinations comprised six intercropping systems with different planting pattern, viz. T_1: Pigeonpea (50 cm × 25 cm) + cowpea fodder, T_2: Pigeonpea (50 cm × 25 cm) + maize fodder, T_3: Pigeonpea (50 cm × 25 cm) + groundnut, T_4: Pigeonpea (100 cm × 12.5 cm) + cowpea fodder, T_5: Pigeonpea (100 cm × 12.5 cm) + maize fodder and T_6: Pigeonpea (100 cm × 12.5 cm) + groundnut in main plot, keeping the plant population same in all treatments and three nutrients level of recommended dose applied to intercrop, viz. T_1: 0 (Control), T_2: 50% NPK and T_3: 100% NPK in sub-plots replicated thrice in a split-plot design. Recommended dose of nutrients to pigeonpea was applied at 15 kg N/ha, 40 kg P_2O_5 and 30 kg K_2O through urea, single super phosphate and muriate of potash, respectively at the time of sowing. All the NPK to cowpea fodder and groundnut was applied at time of sowing. However, in maize fodder half dose of nitrogen and full doses of phosphorus and potash were applied at time of sowing and remaining half dose of nitrogen was applied after first irrigation. Application of nutrients to intercrops was done according to treatments on area basis during both the years. Pigeonpea (PAU 881) was grown in additive series intercropping with cowpea fodder (Cowpea 88), maize fodder (J 1006) and groundnut (SG 99), one row of intercrop was sown between two rows of pigeonpea. Sowing of the crops was done on 29 May 2015 and 26 May 2016 and fodder crops were harvested after 45 days of sowing and pigeonpea and groundnut was harvested on 2 November 2015 and 26 October 2016. Pigeonpea equivalent yield (PEY) was worked out by converting the yield of intercrops to yield of pigeonpea on the basis of prevailing market prices of each crop. Grain and stover sample were collected at harvest and were dried, processed and analyzed for N, P, and K uptake. Soil samples were also collect at harvest, oven dried and sieve for analysis of N, P, and K using kjeldhal, colorimeter and flame photometer, respectively. Efficiency of N/P/K was calculated as ratio of dry matter yield at harvest (kg/ha) to N/P/K accumulation in crop at harvest and physiological efficiency index of absorbed N/P/K of the treatment was calculated as ratio of kg seed produce to kg of N/P/K absorbed in above ground dry matter at harvest.

RESULTS AND DISCUSSION

Productivity of pigeonpea

Seed yield and biological yield of pigeonpea were not significantly influenced by different planting pattern in different intercropping systems. This might be due to the absence of competition between pigeonpea and intercrops for growth resources such as nutrients, moisture, solar raditation because fodder crops, viz. cowpea fodder and maize fodder were harvested before the initiation of grand growth period of pigeonpea and groundnut being leguminous crops show no competition of resources. These results are close conformity with the findings of Kumar *et al.* (2013). Different levels of nutrients applied to intercrops did not significantly influence the seed yield of pigeonpea. However, increasing trend was observed with increasing the levels of

Table 1 Seed and biological yield of pigeonpea, intercrop yield and pigeonpea equivalent yield as influenced by different intercropping systems and levels of nutrients applied to intercrops

Treatment	Seed yield (t/ha)		Biological yield (t/ha)		Intercrop yield (t/ha)		PEY (t/ha)	
	2015	2016	2015	2016	2015	2016	2015	2016
Pigeonpea (50 cm × 25 cm) + cowpea fodder	1.21	1.27	7.61	8.22	11.65	15.08	1.48	1.65
Pigeonpea (50 cm × 25 cm) + maize fodder	1.19	1.22	7.58	8.17	23.02	23.07	1.84	1.90
Pigeonpea (50 cm × 25 cm) + groundnut	1.22	1.30	7.60	8.22	0.22	0.16	1.36	1.43
Pigeonpea (100 cm × 12.5 cm) + cowpea fodder	1.21	1.29	7.52	8.20	8.79	9.33	1.45	1.52
Pigeonpea (100 cm × 12.5 cm) + maize fodder	1.17	1.27	7.62	8.19	13.17	13.68	1.53	1.67
Pigeonpea (100 cm × 12.5 cm) + groundnut	1.28	1.32	7.67	8.28	0.15	0.08	1.31	1.37
SEm±	0.05	0.05	0.08	0.05			0.06	0.05
CD (P = 0.05)	NS	NS	NS	NS			0.18	0.17
Nutrients levels applied to intercrops (% of recommended NPK)								
0	1.16	1.21	7.63	8.19	7.39	8.14	1.37	1.44
50	1.20	1.28	7.58	8.18	9.20	10.05	1.49	1.60
100	1.28	1.33	7.59	8.26	11.91	12.53	1.63	1.73
SEm±	0.04	0.03	0.05	0.03			0.03	0.04
CD (P = 0.05)	NS	NS	NS	NS			0.09	0.11

Table 2 Total uptake of nutrient as influenced by intercropping systems and levels of nutrients applied to intercrops

Treatment	Total N uptake (kg/ha)		Total P uptake (kg/ha)		Total K uptake (kg/ha)	
	2015	2016	2015	2016	2015	2016
Pigeonpea (50 cm × 25 cm) + cowpea fodder	70.7	74.5	14.8	15.7	68.1	74.9
Pigeonpea (50 cm × 25 cm) + maize fodder	68.4	72	14.3	15.5	67.3	74
Pigeonpea (50 cm × 25 cm) + groundnut	71.1	77.6	15.1	16	68.2	75.3
Pigeonpea (100 cm × 12.5 cm) + cowpea fodder	71.3	77.5	14.9	15.6	68	75
Pigeonpea (100 cm × x12.5 cm) + maize fodder	70.1	75.7	14.2	15	67.7	74.8
Pigeonpea (100 cm × 12.5 cm) + groundnut	72.5	78.5	15.5	16	68.5	76.9
SEm±	1.94	2.35	0.35	0.45	0.98	1.13
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Nutrients levels applied to intercrops (% of recommended NPK)						
0	65.8	71.5	13.6	14.2	66	71.9
50	71	75.6	14.8	14.7	67.9	75.1
100	75.3	80.8	16	17.2	70	78.4
SEm±	0.81	1.39	0.27	0.21	0.49	0.75
CD (P = 0.05)	2.4	4.1	0.8	0.6	1.2	2.2

nutrients from zero to 100% of recommended dose, though the differences failed to reach the level of significance. Nagar *et al.* (2015) also reported similar effect of intercropping and different nutrient levels on seed yield of pigeonpea.

Intercrop yield was higher with planting pattern of pigeonpea (50 cm × 25 cm) from pigeonpea (100 cm × 12.5cm) which may be due to increase in number of row in narrow planting patterns which help in increase in yield of intercrop. Increased in levels of nutrient applied to intercrop, increase the yield of intercrops.

Pigeonpea equivalent yield

The highest PEY (1.84 and 19 t/ha) was computed in pigeonpea (50 cm× 25 cm) + maize fodder intercropping system during both the years, respectively, whereas it was lowest in pigeonpea (100 cm × 12.5cm) + groundnut intercropping system (13.1 and 13.7 t/ha). The highest PEY obtained from pigeonpea (50 cm× 25 cm) + maize fodder intercropping system might be due higher yield of maize fodder intercrop as compared to other intercrops and yield of pigeonpea was also not affected by maize fodder crop. The significant effect was observed with different levels of nutrients applied to intercrops. Application of 100% recommended dose of nutrients to intercrops recorded higher PEY of 1.63 and 1.74 t/ha during 2015 and 2016, respectively. This was mainly due to increase in growth and development of intercrops with increase in dose of nutrients from control to 100%. A similar result was reported by Pandey *et al.* (2013) and Tiwari *et al.* (2011).

Uptake of nutrients by pigeonpea

Total uptake of plant nutrients was not significantly

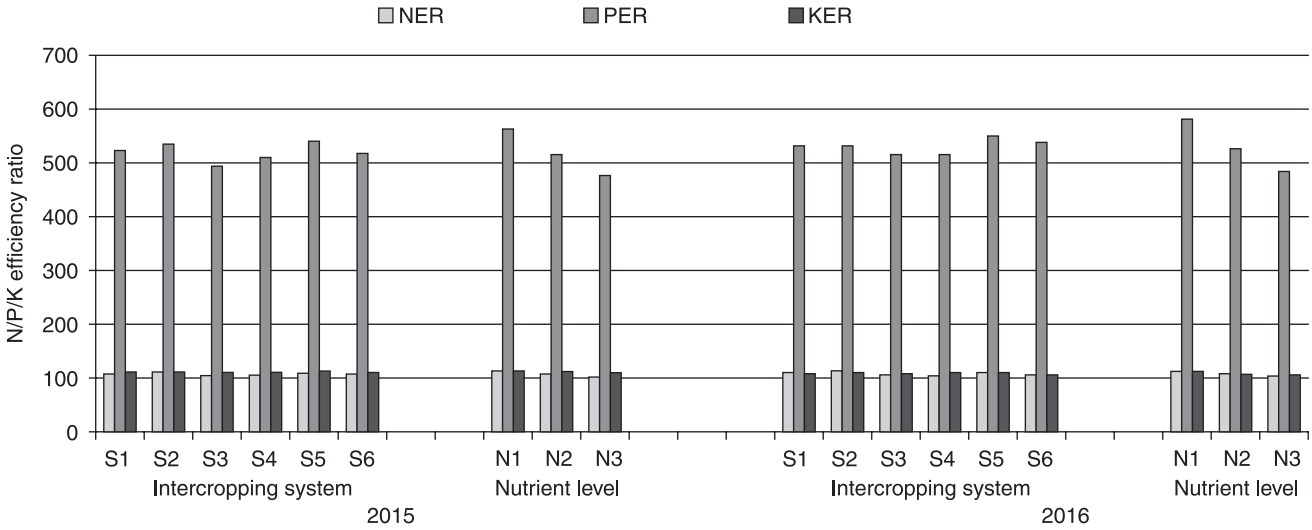

Fig 1 N-P-K efficiency ratio as influenced by different intercropping systems and nutrients levels applied to intercrops during 2015 and 2016.

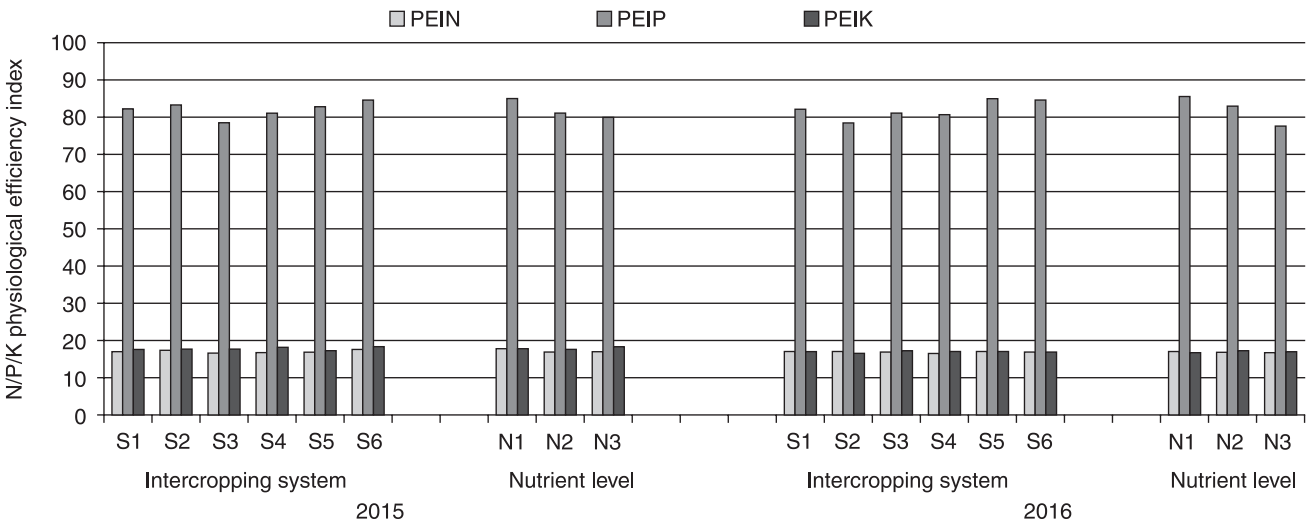

Fig 2 N-P-K physiological efficiency index as influenced by different intercropping systems and nutrients levels applied to intercrops during 2015 and 2016.

Table 3 Available soil nutrient status of soil as influenced by intercropping systems and levels of nutrients applied to intercrops

Treatment	Available N (kg/ha)		Available P (kg/ha)		Available K (kg/ha)	
	2015	2016	2015	2016	2015	2016
Pigeonpea (50 cm × 25 cm) + cowpea fodder	212.2	213.7	19.9	21.4	218.6	223.4
Pigeonpea (50 cm × 25 cm) + maize fodder	211.8	211.5	20.0	21.2	217.2	220.8
Pigeonpea (50 cm × 25 cm) + groundnut	213.1	213.4	20.0	21.5	218.9	222.5
Pigeonpea (100 cm × 12.5 cm) + cowpea fodder	212.4	214.2	20.1	21.6	219.4	222.2
Pigeonpea (100 cm × x12.5 cm) + maize fodder	211.0	211.9	19.9	21.2	217.6	221.6
Pigeonpea (100 cm × 12.5 cm) + groundnut	212.1	214.1	20.2	21.7	219.7	225.6
SEm±	1.14	1.47	0.29	0.19	2.51	1.83
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Nutrients levels applied to intercrops (% of recommended NPK)						
0	208.4	210.3	19.0	20.7	216.3	218.6
50	211.8	213.4	19.9	21.4	218.6	222.9
100	214.9	216.1	21.0	22.1	220.8	226.6
SEm±	1.05	0.60	0.14	0.13	1.49	1.12
CD (P = 0.05)	2.7	2.4	0.7	0.4	2.1	3.6
Initial status	196.0	197.5	18.8	20.5	213.2	216.0

influenced by different intercropping systems during both the years. This might be due the fact that after the harvest of fodder crops competition reduced and nutrient availability was not affected. Among the different levels of fertilizer applied to intercrops, 100% recommended dose showed significantly higher total N, P and K uptake than the 50% recommended dose and control which may be due to higher availability of N, P and K at higher nutrients levels. Kumawat *et al.* (2015) and Singh *et al.* (2013) reported the similar results with different intercropping systems and different levels of nutrients applied in pigeonpea crop.

N/P/K efficiency ratio and physiological ratio

Efficiency ratio: Among different intercropping systems, the higher N efficiency ratio was observed with pigeonpea (50 cm× 25 cm) + maize fodder, whereas P and K efficiency ratio were observed highest with pigeonpea (100 cm× 12.5 cm) + maize fodder during 2015. However during 2016, maximum N and K efficiency ratio were recorded with pigeonpea (50 cm × 25 cm) + maize fodder and higher P efficiency ratio was recorded with pigeonpea (100 cm × 12.5 cm) + maize fodder intercropping systems. Application of 100% recommended dose of nutrient to intercrop recorded lowest N, P, and K efficiency ratio during both the years.

Physiological efficiency index: The lowest N and K physiological efficiency index was recorded with pigeonpea (100 cm× 12.5 cm) + maize fodder intercropping system.

Pigeonpea (50 cm× 25 cm) + groundnut intercropping system resulted in lowest P physiological efficiency index during 2015. Whereas during 2016, pigeonpea (100 cm × 12.5 cm) + cowpea fodder intercropping system recorded lowest N physiological efficiency index and pigeonpea (50 cm × 25 cm) + maize fodder intercropping system recorded lowest P and K physiological efficiency index. Higher N physiological efficiency index were observed with control during 2015 and with 50% of nutrient applied to intercrops during 2016. P physiological efficiency index was lowest with 100% application of nutrients to intercrops and higher with control during both the years. During 2015, K physiological efficiency index was higher with 100% of nutrient applied to intercrops and it was recorded maximum with 50% and 100% in 2016. These results are conformity with the findings of Rana *et al.* (2006)

Soil fertility

Availability of nutrient increased from its initial status, however, pigeonpea based intercropping systems failed to show any significant effect on available N, P, and K status of soil during both the years. Available N (214.9 and 216.1 kg/ha), P (21 and 22.1 kg/ha) and K (220.8 and 226.6 kg/ha) in soil was observed maximum with the application of 100% recommended dose of nutrients to intercrops during both the years, which was significantly superior over 50% recommended dose and control. This may be attributed to reduction in competition effect after harvest of fodder crops and the pigeonpea was applied with full recommended dose and its leguminous nature helped in fixing atmospheric nitrogen, which might helped in increasing the nutrient availability in soil. Singh *et al.* (2016) and Kumawat *et al.* (2015) also reported that available K in soil was increased with the increase in doses of nutrients applied to pigeonpea.

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