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Original Research Article

Effect of Fertilizer Levels and Pigeonpea Based Intercropping Systems on Yield, Nutrient Removal and Economics in Chhotanagpur Region under Rainfed Condition

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A B S T R A C T

An experiment on the effect of fertilizer levels in pigeonpea based intercropping systems under rainfed conditions was conducted to find out the most remunerative pigeonpea based intercropping systems, their optimum fertilizer requirements, total nutrient uptake and net change in fertility status of soil after harvest of the crops under rainfed condition of Chhotanagpur region.. Pigeonpea intercropped with groundnut (1: 3) at 100 per cent recommended dose of fertilizer applied to pigonepa and 50 per cent recommended dose of fertilizer to groundnut recorded maximum grain yield (18.0 q/ha), stalk yield (54.80 q/ha), net return (Rs. 34,692/ha), benefit: cost ratio (2.84) than any other combination of pigeonpea based intercropping systems and fertilizer levels. It was also found that the nitrogen, phosphorus and potassium uptake under pigeonpea + groundnut intercropping system was significantly superior to the value of total uptake of nitrogen, phosphorus and potassium recorded under pigeonpea + rice intercropping system and the maximum uptake was obtained at 100 per cent recommended dose of fertilizer applied to pigeonpea and 50 per cent to companion crops which was statistically alike with the value of uptake recorded at 100 per cent recommended dose of fertilizer applied to both crops. Net change in soil fertility at the end of the two years of experimentation with respect to available nitrogen, phosphorus and potassium showed positive trend when 100 per cent recommended dose of fertilizer applied to both crops and the maximum value of nutrient balance was recorded under pigeonpea + groundnut intercropping system.

Keywords

Pigeonpea based intercropping system, yield, economics, fertility change, rainfed

Introduction

The plateau region of Jharkhand is distinctly different from other parts of the country in respect of agroclimatic conditions and cropping pattern. The entire region is almost rainfed. The rainfed uplands which are presently placed under short duration rice, millets, pulses and oilseeds in *kharif* are not in a condition to support a second crop in sequence. The strategy for increasing agricultural production in a dominant monocropping system of this region has to be scientific adoption of intercropping system and thus, from 'survival oriented' to "production oriented" agriculture over space and time. The importance of intercropping in farming practice has long been recognized but it is only very recently that it has awakened real interest. The main reason for this, undoubtedly, is increasing evidence that intercropping can provide substantial

yield advantage over sole cropping. These advantages have mainly been identified as higher yields in a given season but it has also been suggested that intercropping may give greater stability of yields over different seasons (Willey, 1979) and this is the primary reason for its prevalence in farming practices. In case of higher yields in a given season, the major ways in which they can be brought about are better use of resources and improved nitrogen economy in presence of legume. There may be possible difficulties in practical management of intercropping and actual yield decrease may occur because of adverse competitive effect (Donald, 1963) and allelopathic effect (Risser, 1969 and Rices 1974). Hence, selection of main and intercrops is important so that competition between component crops is reduced to the minimum for achieving maximum intercropping advantage as it plays a vital role for the success of any intercropping system. Pigenopea [*Cajanus cajan* (L) Millsp] is an important rainfed crop grown in *Kharif* season under plateau region of Jharkhand. Its initial slow growth and very little horizontal spread till 60-65 days after seeding provide good scope for growing short duration cereals, pulses and oilseeds in the inter row space of the pigeonpea. Selection of suitable intercrops for pigeonpea based intercropping for better use of resources is one of the prime objectives of the present investigation for achieving yield advantages. Under such circumstances, the increased demand of grain, legume and oilseeds can be fulfilled up to some extent by intercropping of pigeonpea with rice, maize and groundnut. Research on identification of cropping pattern for different agroclimatic and soil conditions had been initiated about 25 years ago but the effect of such cropping on soil fertility and nutrient management to maintain and possibly to improve the soil fertility status have not been given adequate attention. Determining the fertilizer schedule for sole crops itself is a complex problem because of many factors affecting availability, fixation and loss of applied nutrients and the difficulties in estimating the contribution from soil. The problem becomes more complex in intercropping systems with additional factors like, possible effect of legumes in the system and complementary and competitive interference from the component crops. Moreover, the associate crops in intercropping system are of different nature of growth and nutrients needs. Fertilizer recommendation for intercropping system have been generally based on schedules recommended for the sole crops. There could be considerable saving in the total quantity of fertilizer applied to the system because of varying mobilizing power of the component crops and possible contribution of nitrogen from the root nodules of legumes. Hence, there is a need to determine the optimum fertilizer application for its efficient utilization by intercropping system. Keeping the above points in view and realizing the needs of this region, an experiment was conducted in rainfed upland to study the nutrient management in intercropping system.

Materials and Methods

The experiment was conducted at Birsa Agricultural University Farm, Kanke, Ranchi during the *kharif* season of 1998 and 1999. The soil of the experimental plot was sandy loam (sand 58.3 %, silt 25.1% and clay 17.8%), acidic in reaction (pH 6.2), low in available nitrogen (242.0 kg/ha), phosphorus (9.82 kg/ha) and medium in potassium (170.2 kg/ha). The experiment was laid out in randomised block design with three replications. The treatments consisted of three intercropping systems [C_1-pigeonpea + groundnut (1: 3), C_2-pigeonpea + rice (1: 3) and C_3-pigeonpea +

maize (1: 1)] and three fertilizer levels (F_1-100 per cent recommended dose of fertilizer to both pigeonpea and companion crops, F_2-100 per cent recommended dose of fertilizer to pigeonpea and 50 per cent recommended dose to companion crops and F_3-100 per cent recommended dose of fertilizer to pigeonpea and no fertilizer to companion crops) with four sole crops i.e. pigeonpea (S_1), groundnut (S_2), rice (S_3) and maize (S_4) for comparison. Fertilizer levels of 100 per cent recommended dose of fertilizer for sole crops of pigeonpea, groundnut, rice and maize were 20: 40: 20, 25: 50: 20, 40: 30: 20 and 100: 50: 25 kg N, P_2O_5 and K_2O per hectare, respectively. Total rainfall during crop periods were 1446.1 and 1802.4 mm in 1998 and 1999 respectively. All the package of practices for different crops were followed properly.

Results and Discussion

The highest value of grain (16.37 q/ha) and stalk yield of pigeonpea (49.36 q/ha), net return (Rs. 29288/ha), and benefit: cost ratio (2.38) were recorded under pigeonepa + groundnut intercropping systems (Table 1) than rest of the systems which might be attributed to the effective weed control by early coverage of field by groundnut, best compatibility of pigeonpea and groundnut and additional supply of nitrogen to the system by groundnut than rest of the component crops tested. The higher yield with increasing fertilizer levels was owing to the best interplay of growth and yield attributing characters of both component crops as a result of adequate nutrition Among the intercropping systems, the maximum pigeonpea yield (16.37 q/ha) was recorded by pigeonpea + groundnut intercropping system. It might be due to fixation of nitrogen by groundnut. Such additional supply of nitrogen was not observed in rest of the intercropping systems. Other reason for the same may be due to the utilization of resources efficiently by groundnut due to rapid growth and larger canopy coverage in the early season. These findings are in agreement with the findings of Giri *et al.,* (1980) and Rao and Willey (1980). It was observed that reduction in pigeonpea yield as compared to sole pigeonpea was 22.8 and 40.2 per cent in pigeonpea + groundnut and pigeonpea + maize intercropping systems, respectively. The reduction in yield might be due to competition offered by component crops for light, nutrient, moisture and space in intercropping systems. Data on fertilizer levels revealed that application of 100 per cent recommended dose of fertilizer to pigeonpea and 50 per cent recommended dose to companion crops recorded maximum yield of pigeonpea than rest of the fertilizer levels but it was found to be at par with the treatment which received 100 per cent recommended dose of fertilizer by both crops.

Both these levels were significantly superior to the level where 100 per cent recommended dose of fertilizer was applied to pigeonpea and no fertilizer to companion crops which recorded the lowest pigeonpea yield. The reason may be competition exerted by the component crops for nutrients. Similar observation was recorded for stalk/straw yield of the component crops in the systems. The higher level of pigeonpea yield in both these treatments might be due to the fact that the basal dose of fertilizer meets the initial demands of the cereal and legume and thereafter legume meets its requirement for nitrogen produced by itself. The slight variation in the yield of pigeonpea might be due to luxuriant growth of pigeonpea receiving 100 per cent recommended dose of fertilizer by both crops and adverse effect on nodulation in pigeonpea.

Table.1 Effect of Fertilizer levels in pigeonpea based intercropping systems on yield, nutrient removal and economics

Treatments	Grain yield (q/ha)		Stalk/straw yield (q/ha)		Total nutrient uptake (kg/ha)			Total nutrient removal (kg/ha)	Net return (Rs/ha)	B: C ratio
	Pigeon-pea	Compan-ion crops	Pigeon-pea	Compan-ion crops	N	P	K			
Sole crops										
S1: Pigeon pea	21.20		58.66		128.0	38.0	96.0	162.0	23445	3.76
S2: Ground nut		21.30		52.35	126.1	19.1	99.5	244.8	11024	1.07
S3: Rice		17.20		29.31	36.1	7.2	60.1	103.7	435	0.05
S4: Maize		27.20		31.53	55.3	9.0	34.5	98.5	11236	1.36
Intercropping systems										
C1	16.37	16.15	49.36	47.78	214.8	50.2	170.2	435.2	29288	2.38
C2	13.27	9.35	40.36	15.36	109.0	30.7	98.5	237.7	14683	1.36
C3	12.63	11.90	39.69	15.13	114.1	30.0	82.0	226.2	18447	1.77
CD (P=0.05)	0.87		2.74		8.8	2.3	5.4	14.3	2117	0.19
Fertilizer levels (Kg/ha)										
F1	15.23	15.40	46.32	27.88	157.9	40.1	125.8	324.8	23048	1.93
F2	15.53	13.45	47.86	30.45	163.0	42.3	133.2	338.7	24036	2.14
F3	11.50	9.30	35.26	19.93	115.4	28.6	91.6	235.7	15318	1.45
CD (P=0.05)	0.8		2.74		8.8	2.3	5.4	14.3	2117	

Table.2 Effect of Fertilizer levels in pigeonpea based intercropping systems on soil fertility after harvest of crops

Treatments	Initial fertility status of soil (kg/ha)			Fertility status of soil after harvest of crops (kg/ha)			Net change in soil fertility after harvest of crops (kg/ha)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Sole crops									
S1: Pigeon pea	242	22.5	205	247.3	25.8	212.5	5.3	3.3	7.5
S2: Ground nut	242	22.5	205	249	25.2	212.3	7	2.7	7.3
S3: Rice	242	22.5	205	237.3	23.4	208.2	-4.7	0.9	3.2
S4: Maize	242	22.5	205	232	21.6	205.9	-10	-0.9	0.9
Pegeonpea + Groundnut									
F1	242	22.5	205	254.3	27.1	214.4	12.3	4.6	9.4
F2	242	22.5	205	248.7	25.8	213.5	6.7	3.3	8.5
F3	242	22.5	205	242.7	23.2	206.8	0.7	0.7	1.8
Pigeonpea + Rice									
F1	242	22.5	205	247.3	24.9	213.2	5.3	2.4	8.2
F2	242	22.5	205	243.7	23.7	211.5	1.7	1.2	6.5
F3	242	22.5	205	235	21.8	206.6	-7	-0.7	1.6
Pigeonpea + Maize									
F1	242	22.5	205	243.3	24.5	211.5	1.3	2.8	6.5
F2	242	22.5	205	236.3	21.8	209.2	-5.7	-0.7	4.2
F3	242	22.5	205	232.3	19.7	202.8	-9.7	-2.8	-2.2

Table.3 Grain yield, Stalk yield, net return and benefit: cost ratio of cropping systems as influenced by intercropping systems x Fertilizer levels

Fertilizer levels ⇨ / Intercropping Systems ⇩	100% recommended dose to both crops				100% recommended dose to pigeonpea + 50% to companion crops				100% recommended dose to pigeonpea and no fertilizer to companion crops			
	Grain yield of pigeonpea (q/ha)	Stalk yield of pigeonpea (q/ha)	Net return (Rs/ha)	Benefit: cost ratio	Grain yield of pigeonpea (q/ha)	Stalk yield of pigeonpea (q/ha)	Net return (Rs/ha)	Benefit: cost ratio	Grain yield of pigeonpea (q/ha)	Stalk yield of pigeonpea (q/ha)	Net return (Rs/ha)	Benefit: cost ratio
Pigeonpea + groundnut	17.1	51.78	29538	2.27	18	54.8	34692	2.84	14.01	44.22	23634	2.03
Pigeonpea + rice	13.49	40.61	15367	1.36	15.55	47.56	18362	1.71	10.76	36.35	10318	1.02
Pigeonpea + maize	15.1	46.56	24285	2.16	13.05	41.2	19043	1.86	9.73	31.32	12004	1.31
CD (P=0.05)	1.51	4.74	3685	0.32	1.51	4.74	3685	0.32	1.51	4.74	3685	0.32

Table.4 Total N, P, Kuptake and available after crop harvest of cropping systems as influenced by intercropping systems x Fertilizer levels

Fertilizer Levels ⇨ / Intercropping Systems ⇩	100% recommended dose to both crops						100% recommended dose to pigeonpea + 50% to companion crops						100% recommended dose to pigeonpea and no fertilizer to companion crops					
	Total N uptake (kg/ha)	Available N (kg/ha) after crop harvest	Total P uptake (kg/ha)	Available P (kg/ha) after crop harvest	Total K uptake (kg/ha)	Available K (kg/ha) after crop harvest	Total N uptake (kg/ha)	Available N (kg/ha) after crop harvest	Total P uptake (kg/ha)	Available P (kg/ha) after crop harvest	Total K uptake (kg/ha)	Available K (kg/ha) after crop harvest	Total N uptake (kg/ha)	Available N (kg/ha) after crop harvest	Total P uptake (kg/ha)	Available P (kg/ha) after crop harvest	Total K uptake (kg/ha)	Available K (kg/ha) after crop harvest
Pigeonpea + groundnut	223	252.1	51.7	26.35	172.1	213.2	247.3	247.7	58.6	25.5	203	210.7	174.2	242.5	40.3	23.3	135.3	206.6
Pigeonpea + rice	115	246.6	32.5	24.6	106.5	212.1	125.8	242.7	36.5	23.4	111	210.2	86.3	236.5	23.2	22.1	82.8	206.5
Pigeonpea + maize	140.3	242.6	36.2	24.2	98.8	210.3	116	237	32	22.1	85.6	207.2	86	234.3	22.2	20.7	61.7	202.6
CD (P=0.05)	15.2	6.5	4.2	1.5	9.3	6.2	15.2	6.5	4.2	1.5	9.3	6.2	15.2	6.5	4.2	1.5	9.3	6.2

However, considering intercroping systems as a whole, it was found that the maximum grain yield (18.09 q/ha) and pigeonpea equivalent yield were recorded under pigeonpea + groundnut intercropping system at 100 per cent recommended dose of fertilizer applied to pigeonpea and 50 per cent recommended dose to companion crops (Table.3). Similar observations were recorded for stalk yield of pigeonpea. This might be attributed to the fact that the basal dose of fertilizers meets the initial demand of component crops legume and the legume thereafter meets its requirement from the nitrogen produced by itself. These results were supported by Pathak *et al.,* (1968), Waghmare *et al.,* (1984) and Pandey *et al.,* (2012).

Results regarding nutrient uptake (Table. 1) revealed that the total uptake of nitrogen (214.8 kg/ha), phosphorus (50.2 kg/ha) and potassium (170.2 kg/ha) by component crops was maximum in pigeonpea + groundnut intercropping system which was significantly higher than the uptake recorded under pigeonpea + rice and pigeonpea + maize intercropping systems. This was mainly due to the production of higher biomass by the system. It was further observed that 100 per cent recommended dose of fertilizer applied to pigeonpea and 50 per cent to companion crops recorded maximum nitrogen (163.0 kg/ha) and potassium (133.2 kg/ha) uptake which was followed by the treatment receiving 100 per cent recommended dose of fertilizer by both crops. These results were in agreement with the findings of Wahua (1983); Waghmare and Singh (1984) and Mason *et al.,* (1986).

The pooled data (Table. 2) revealed that the maximum value of available nitrogen (247.5 kg/ha), phosphorus (24.06 kg/ha) and potassium (210.8 kg/ha) were recorded in pigeonpea + groundnut intercropping system followed by pigeonpea + rice intercropping system. This could mainly be accounted for nitrogen fixation by both pigeonpea and groundnut, decomposition of fallen leaves, root nodules and roots of the component crops. Since legume has a unique property of having CEC double to that of cereals and has also the capacity to utilize phosphorus from relatively insoluble sources. Being legume + legume intercropping system, absorption of phosphorus and potassium was more by component crops. Decomposition of fallen leaves, root nodules and roots might have increased the level of phosphorus and potassium. This result confirms the findings of Dalal (1974), Waghmare *et al.,* (1984) and Ae *et al.,* (1990). Maximum available nitrogen (247.2 kg/ha), phosphorus (25.08 kg/ha) and potassium (21.9 kg/ha) were recorded at 100 per cent of recommended dose of fertilizer applied to both the crops which might be due application of higher doses of fertilizers (Table.4).

The economic analysis of intercropping system revealed that the highest gross return net return (Rs.29,288/ha) and benefit: cost ratio (2.38), were recorded under pigeonpea + groundnut intercropping system (Table. 1).

This was due to the highest grain and stralk/straw yield of both crops. These findings were in agreement with the observation reported by Singh *et al.,* (1981), Rafey *et al.,* (1988), Jha *et al.,* (1991), Reddy *et al.,* (1994), Sarkar *et al.,* (1995) and Shankaranarayana *et al.,* (2000). Among fertilizer levels, 100 per cent recommended dose of fertilizer applied to pigeonpea and 50 per cent recommended dose to companion crop recorded maximum net return (Rs.24,036/ha) and benefit: cost ratio (2.14) which were found to be statistically alike with the treatment receiving 100 per

cent recommended dose of fertilizer by both crops except benefit: cost ratio (1.93). Both these treatments showed its superiority over the treatment receiving 100 per cent recommended dose of fertilizer by pigeonpea only. This was mainly due to higher grain and stalk/straw yield of component crops recorded in both the above mentioned treatments.

The results obtained was supported by the findings of Sharma and Rajput (1996) and Reddy *et al.,* (1994). When intercropping system and fertilizer level is considered as a whole, it was found that maximum gross return net return (Rs. 34,692/ha), and benefit: cost ratio (2.84) were recorded under pigeonpea + groundnut intercropping system at 100 per cent recommended dose of fertilizer applied to pigeonpea and 50 per cent recommended dose to companion crops, which might be attributed to higher grain and straw yield, higher market price of groundnut and low cost of cultivation.

On the basis of two years of experimental findings, it can be concluded that the combination of pigeonpea + groundnut intercropping system and 100 per cent recommended dose of fertilizer applied to pigeonpea and 50 per cent recommended dose to groundnut was found to be the most stable, productive and profitable combination under rainfed conditions of Chotanagpur region.

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