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Research Paper

Effect of fertility levels and foliar nutrition in fieldpea (*Pisum sativum*) under south - eastern Rajasthan

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ABSTRACT

An experiment was conducted during the winter (*rabi*) season of 2016–17, 2017–18 and 2018–19 at the Agriculture University, Kota, Rajasthan, to evaluate the effect of fertility levels and foliar nutrition on fieldpea (*Pisum sativum* L.). The experiment consisted of 3 recommended dose of fertilizers (RDF) levels (75%, 100% and 125%) and 5 foliar sprays [water spray, neem-coated urea 2%, NPK (19 : 19 : 19) 0.5%, NPK (17 : 44 : 0) 0.5% and NPK (0 : 0 : 50) 0.5%] at pre-flowering and pod-initiation stages. Result revealed, that the maximum and significantly higher plant height (168.21 cm), branches/plant (3.12), nodule count (23.75), nodule dry weight (35.87 g/plant), pods/plant (61.90), seeds/pod (3.78), grain yield (2350 kg/ha), net returns (₹52,889/ha) and benefit : cost ratio (3.02) were recorded with application of 125% RDF (25 kg N + 50 kg P + 25 kg K + 25 kg S + 6.25 kg Zn/ha) with 7.32, 10.64, 13.54, 11.40, 15.81, 12,17, 26.82, 32.18 and 16.60% increase over 75% RDF. Application of 125% RDF recorded the maximum nutrient content (N : P : K : S 3.30 : 0.54 : 1.18 : 0.40% in seed and 1.69 : 0.48 : 1.51 : 0.31% in straw) and uptake (N : P : K : S 77.57 : 12.59 : 27.68 : 9.42 kg/ha in seed and 58.14 : 16.35 : 51.99 : 10.67 kg/ha in straw) over the other treatments. Among foliar applications, NPK (19 : 19 : 19) @ 0.5% at pre-flowering and pod- initiation stage resulted in the maximum and significantly higher plant height (167.76 cm), branches/plant (3.14), nodule count (23.77), nodule dry weight (36.36 g/plant), pods/plant (63.43), seeds/pod (3.89), grain yield (2,250 kg/ha), net returns (₹50,835/ha) and benefit: cost ratio (3.06) over rest of treatments with 9.69, 12.95, 8.69, 10.06, 23.38, 18.24, 12.84, 17.19 and 15.47% increase over the control; however, it recorded at par results with NPK (17 : 44 : 0) @ 0.5% at pre-flowering and pod-initiation stage. Similarly, higher NKS uptake in seed and straw was observed under foliar application of NPK (19 : 19 : 19) @ 0.5% and P uptake under NPK (17 : 44 : 0) @ 0.5% than the other treatments.

Key words: Economics, Fieldpea, Foliar spray, NPK, RDF, Yield

India is the largest producer and consumer of pulses in the world, contributing to around 25–26% to global basket. The country grows a variety of pulse crops under wide range of agro-climate conditions. During 2019–20 the total pulse production in country was 23.02 million tonnes (GoI, 2021). In our country the majority of pulses are grown under rainfed, resource poor and harsh environments, frequently prone to drought and other abiotic stress conditions.

Fieldpea (*Pisum sativam* L.) is one of the most important pulse crops among the various grain legumes grown in India. India is the largest producer as well as consumer of fieldpea. It is third most important pulse crop globally, after dry bean and chickpea (*Cicer arietinum* L.) and the third most popular winter (*rabi*) pulse of India after chickpea and lentil (*Lens culinaris* Medikus). The major fieldpea producing state in India are Uttar Pradesh, Madhya Pradesh, Bihar, Assam and Odisha. In India it grown in 0.64 million (m) ha, with annual production of 0.88 m tonnes with average productivity of 1,375 kg/ha. In Rajasthan, it produced 14,240 tonnes in 585 ha area (IIPR, 2022). A 100 g dried edible portion of grains contains 1.8 g fat, 62.1 g carbohydrates, 21–25% protein,

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0.15 g riboflavin, 0.72 mg thiamine, 2.4 mg niacin, 64 mg calcium, 4.8 mg iron, 11% moisture, vitamin A and vitamin C (Bhat *et al*., 2013). Among the different pulse grown in the country, fieldpea is inherited with the maximum yield potential, which has not yet been exploited.

Fertilizer management is very important and can greatly affects the growth and yield of fieldpea. Nitrogen and phosphorus are among the major yield-limiting factors and these nutrients are almost deficient in most soils in India. Fieldpea is a highly efficient nitrogen-fixing crop; however, due to the lag period between rhizobium root colonization and the onset of nodule functioning, the young legume plants require an additional N to achieve vigorous growth.

Foliar applications of fertilizers are one of the ways of using fertilizers more efficiently and economically. Foliar application of major plant nutrients like nitrogen was found to be a good as soil application (Subramanian and Palaniappan, 1981; Gohil *et al*., 2019). Nitrogen is a necessary component of several vitamins. Increase in N fertilizer significantly increases the seed yield, vegetative growth, total carbohydrate, soluble sugars and NPK content of plants (Das and Jana, 2015). Phosphorus has stimulating effect on the growth parameters, total carbohydrate and soluble sugars and minerals contents. Potassium is an important macronutrient and the most abundant cation in higher plants. Potassium is essential for enzyme activation such as enzyme of essential oil synthesis. Therefore, an experiment was conducted to evaluate the effect of fertility levels and foliar nutrition on fieldpea.

MATERIALS AND METHODS

An experiment was conducted during the winter (*rabi*) seasons of 2016–17, 2017–18 and 2018–19 at Agricultural Research Station, Agriculture University, Kota, Rajasthan. The experiment consisted of 3 levels of recommended fertilizers, viz. 75% (15 kg N + 30 kg P + 15 kg K + 15 kg S + 3.75 kg Zn/ha), 100% (20 kg N + 40 kg P + 20 kg K + 20 kg S + 5 kg Zn/ha) and 125% (25 kg N + 50 kg P + 25 kg K + 25 kg S + 6.25 kg Zn/ha). The recommended dose of fertilizers (RDF) was applied as per treatments at the time of sowing. Five foliar sprays, viz. water spray (control), neem-coated urea 2% at pre-flowering and pod-initiation, NPK (19 : 19 : 19) 0.5% at pre-flowering and pod-initiation, NPK (17 : 44 : 0) 0.5% at pre-flowering and pod-initiation and NPK (0 : 0 : 50) 0.5% at pre-flowering and pod-initiation. The total treatment combinations were 15 with 3 replications and the experiment was laid out in factorial randomized block design. Fieldpea variety 'IPFD 10-12' was sown with seed rate of 80 kg/ha in 5.4 m × 4.0 m plot, with planting geometry of 30 cm × 10 cm. The soil of experimental site was clay loam, slightly saline, low in available nitrogen, medium in phosphorus and high in potassium. The nodule count and nodule dry weight were recorded 45 days after sowing. The plant height (cm), branches/plant, pods/plant and seeds/pod were recorded at harvesting from 5 random plants and averaged. The seed and straw yield of each plot was recorded in kg/plot after cleaning and threshed the produce and was converted to kg/ha. Net returns were calculated using current input and output prices during the crop season. Benefit : cost ratio was calculated by dividing net returns from the cost of cultivation. At maturity, seed and straw samples of fieldpea were collected for chemical analysis of nitrogen, phosphorus, potassium and sulphur content. Nitrogen was estimated by colorimetric method (Snell and Snell, 1949), phosphorus by vanado-molybdate yellow colour method (Jackson, 1973), potassium by flame-photometer method (Jackson, 1973) and sulphur by Tabatabai and Brenner (1970) method. The nutrient uptake was computed as:

Nutrient uptake (kg/ha) = Nutrient content (%) in seed/straw × seed/straw yield (kg/ha)/100

The data were analysed using standard ANOVA and the significance of differences in treatment means was compared to critical differences at the 5% level of probability.

RESULTS AND DISCUSSION

Growth and yield attributes

The plant height, nodules count and nodules dry weight of fieldpea increased significantly with the increasing levels of RDF up to 125% RDF. Application of 125% RDF resulted in the maximum and significantly higher plant height (168.21 cm), nodules count (23.75/plant) and dry weight of nodules (35.87 g/plant) over 75% RDF; however, it was at par with 100% RDF. Among foliar nutrition, an application of NPK (19 : 19 : 19) @ 0.5% at pre-flowering and pod-initiation stage resulted in significantly higher plant height, nodules count and nodules dry weight over the other treatments but remained at par with rest of the treatments for plant height (Table 1). Similarly, application of 125% RDF resulted in significantly higher number of branches/plant (3.12) over rest of treatments (100% and 75% RDF). Among the foliar nutrition, an application of NPK (19 : 19 : 19) @ 0.5% at pre-flowering and pod-initiation stage revealed the maximum number of branches/plant, being at par with NPK (17 : 44 : 0) @ 0.5% at pre-flowering and pod-initiation stage over rest of the treatments.

The interaction effect of fertility levels and foliar spray was found significant in respect of branches/plant. The NPK (17 : 44 : 0) @ 0.5% at pre-flowering and pod-initiation and 125% RDF (3.24) showed the maximum and significantly higher branches/plant over rest of treatment combinations, being at par with NPK (19 : 19 : 19) @ 0.5% at pre-flowering and pod-initiation stage with 75% RDF,

Table 1. Effect of fertility levels and foliar spray on growth and yield attributes of fieldpea (pooled data of 3 years)

Treatment	Plant height at harvesting (cm)	Branches/ plant	Nodule count at 45 DAS	Nodule dry weight/ plant (mg)	Pods/ plant	Seeds/ pod
Fertility levels						
75% RDF	156.74	2.82	20.92	32.20	53.45	3.37
100% RDF	165.55	2.96	23.45	34.98	59.56	3.57
125% RDF	168.21	3.12	23.75	35.87	61.90	3.78
SEm±	1.46	0.03	0.11	0.26	1.06	0.05
CD (P=0.05)	4.11	0.09	0.30	0.72	2.99	0.13
Foliar nutrients spray						
Water spray (control)	152.94	2.78	21.87	33.03	51.41	3.29
NCU 2% at PF and PI	164.81	2.96	23.20	34.75	58.70	3.50
NPK (19 : 19 : 19) 0.5% at PF and PI	167.76	3.14	23.77	36.36	63.43	3.89
NPK (17 : 44 : 0) 0.5% at PF and PI	169.80	3.09	22.68	34.17	62.87	3.74
NPK (0 : 0 : 50) 0.5% at PF and PI	162.20	2.86	22.03	33.44	55.11	3.45
SEm±	1.88	0.04	0.14	0.33	1.37	0.06
CD (P=0.05)	5.30	0.11	0.39	0.93	3.87	0.16

#DAS, Days after sowing; RDF, recommended dose of fertilizers, PF, pre-flowering; PI, pod-initiation stage; NCU, neem-coated urea 75% RDF (15 kg N + 30 kg P + 15 kg K + 15 kg S + 3.75 kg Zn/ha); 100% RDF (20 kg N + 40 kg P + 20 kg K + 20 kg S + 5 kg Zn/ha); 125% RDF (25 kg N + 50 kg P + 25 kg K + 25 kg S + 6.25 kg Zn/ha)

100% and 125% RDF and neem-coated urea 2% at pre-flowering and pod-initiation stage with 125% RDF (Table 2).

The improvement in soil environment resulted in encouraged root growth of plants, which helped in drawing more water and nutrients from larger area and deeper layers and thus owing to higher availability of nutrients, synthesis of more carbohydrate and their translocation to different plant parts resulted in increased vegetative growth including the reproductive structures. These results confirm with the findings of Kumar (2011) and Choudhary and Yadav (2011). Foliar application of nutrients promotes the apical dominance, cell elongation and shoot development and enhances the synthesis of carbohydrate and protein thereby increases the height and branches of plant (Sarvari *et al*., 2019; Bahadari *et al*., 2020). Karpagam *et al*. (2004) recorded that, foliar application of NPK 19 : 19 : 19 along with the recommended dose of fertilizer resulted in the maximum plant height and number of branches/plant.

Table 2. Interaction effect of fertility and foliar nutrition on branches/ plant of fieldpea (pooled data of 3 years)

Fertility and foliar nutrition	75% RDF	100% RDF	125% RDF
Water spray (control)	2.41	2.92	3.01
NCU 2% at PF and PI	2.86	2.94	3.08
NPK (19 : 19 : 19) 0.5% at PF and PI	3.07	3.13	3.23
NPK (17 : 44 : 0) 0.5% at PF and PI	3.02	3.01	3.24
NPK (0 : 0 : 50) 0.5% at PF and PI	2.73	2.81	3.04
SEm±		0.07	
CD (P=0.05)		0.20	

RDF, recommended dose of fertilizers, PF, pre-flowering; PI, pod-initiation stage; NCU, neem-coated urea

Maximum and significantly higher number of pods/ plant (61.90) and seeds/pod (3.78) were recorded with 125% RDF, being at par with 100% RDF over 75% RDF. Among the foliar nutrition, an application of NPK (19 : 19 : 19) @ 0.5% at pre-flowering and pod-initiation stage recorded the maximum and significantly higher number of pods/plant (63.43) and seeds/pod (3.89) over rest of the treatments; however, it was at par with NPK (17 : 44 : 0) @ 0.5% at pre-flowering and pod-initiation.

Grain and straw yield

The increasing levels of RDF significantly increased the grain and straw yield of fieldpea (Table 3). The application of 125% RDF resulted in the maximum grain yield (2,350 kg/ha) and straw yield (3,433 kg/ha) of fieldpea over 100 and 75% RDF. The grain yield obtained from 125% RDF was 7.95 and 26.82% higher than that of 100% and 75% RDF respectively. Among the foliar nutrition, an application of NPK (19 : 19 : 19) @ 0.5% at pre-flowering and pod-initiation resulted in significantly higher grain yield (2,250 kg/ha) and straw yield (3,277 kg/ha) than the other treatments except NPK (17 : 44 : 0) @ 0.5% at pre-flowering and pod-initiation (2185 kg/ha). This treatment recorded 12.84, 8.07 and 6.08% higher grain yield over water spray, NCU 2% and NPK (0 : 0 : 50) @ 0.5% at pre-flowering and pod-initiation.

Phosphorus is the important constituent of co-enzymes which are important for photosynthesis and protein synthesis, and it plays important role in metabolism which ultimately increases the pods and grain yield. The results confirm with the finding of Lal (2004).

Table 3. Effect of fertility levels and foliar spray on yield and economics of fieldpea (pooled data of 3 years)

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Net returns (₹/ha)	Benefit : cost ratio
Fertility levels				
75% RDF	1,853	2,735	40,014	2.59
100% RDF	2,177	3,148	48,706	2.95
125% RDF	2,350	3,433	52,889	3.02
SEm±	24	30	730	0.04
CD (P=0.05)	68	85	2,054	0.12
Foliar nutrients spray				
Water spray (control)	1,994	2,957	43,380	2.65
NCU 2% at PF and PI	2,121	3,094	47,144	2.87
NPK (19 : 19 : 19) 0.5% at PF and PI	2,250	3,277	50,835	3.06
NPK (17 : 44 : 0) 0.5% at PF and PI	2,185	3,147	48,865	2.94
NPK (0 : 0 : 50) 0.5% at PF and PI	2,082	3,052	45,792	2.75
SEm±	31	39	942	0.06
CD (P=0.05)	88	110	2652	0.16

RDF, recommended dose of fertilizers, PF, pre-flowering; PI, pod-initiation stage; NCU, neem-coated urea

Application of nutrients through foliar sprays along with soil application has several advantages in supplementing the nutritional requirements of crops. Foliar nutrition is designed to eliminate the problems like fixation and immobilization of nutrients. These results confirm the finding of Mamathashree *et al*., (2014).

Nutrient content and uptake

Nutrient content and uptake pattern of fieldpea significantly differed with different RDF levels (Table 4 and 5). The maximum and significantly higher N, P, K and S content and uptake in fieldpea seed and straw were observed under 125% RDF over 100 and 75% RDF. The increased availability of these nutrients in the root zone coupled with increased metabolic activity at cellular levels might have synthesized more nutrients and their accumulation in various plant parts (Yaseen *et al*., 2014; Meena *et al*., 2021; Yadav *et al*., 2016). The increased uptake of nitrogen, phosphorus and potassium content in seed and straw seems to be owing to the fact that, uptake of nutrient is a product of biomass and nutrient content. The nutrient accumulation in plant is dependent on dry-matter accumulation in plant and concentration of nutrient at cellular level. Balai *et al*., (2017) also reported the increased content and uptake of nutrients owing to increased fertility levels.

The nutrient content and uptake were differed significantly among foliar nutrition over the control. The maximum and significantly higher N content in seed and straw was recorded under application of NCU 2% followed by NPK (19 : 19 : 19) @ 0.5% and NPK (17 : 44 : 0) @ 0.5%

Table 4. Effect of fertility levels and foliar spray on nutrient content of seed and straw of fieldpea (pooled data of 3 years)

Treatment	Nutrient content of seed				Nutrient content of straw (%)			
	N	P	K	S	N	P	K	S
Fertility levels								
75% RDF	3.11	0.49	1.07	0.31	1.52	0.42	1.36	0.25
100% RDF	3.27	0.52	1.13	0.39	1.67	0.45	1.45	0.28
125% RDF	3.30	0.54	1.18	0.40	1.69	0.48	1.51	0.31
SEm±	0.024	0.004	0.010	0.003	0.019	0.004	0.011	0.003
CD (P=0.05)	0.068	0.011	0.029	0.009	0.053	0.012	0.030	0.009
Foliar nutrients spray								
Water spray (control)	3.05	0.47	1.02	0.33	1.47	0.41	1.30	0.25
NCU 2% at PF and PI	3.33	0.51	1.09	0.37	1.73	0.44	1.38	0.29
NPK (19 : 19 : 19) 0.5% at PF and PI	3.30	0.53	1.19	0.40	1.70	0.47	1.51	0.32
NPK (17 : 44 : 0) 0.5% at PF and PI	3.26	0.56	1.10	0.38	1.68	0.50	1.40	0.28
NPK (0 : 0 : 50) 0.5% at PF and PI	3.20	0.50	1.22	0.35	1.56	0.43	1.60	0.26
SEm±	0.031	0.005	0.013	0.004	0.024	0.006	0.014	0.004
CD (P=0.05)	0.088	0.014	0.037	0.011	0.068	0.016	0.039	0.011

RDF, recommended dose of fertilizers, PF, pre-flowering; PI, pod-initiation stage; NCU, neem-coated urea

Table 5. Effect of fertility levels and foliar spray on nutrient uptake of seed and straw of fieldpea (pooled data of 3 years)

Treatment	Nutrient uptake of seed (kg/ha)				Nutrient uptake of straw (kg/ha)			
	N	P	K	S	N	P	K	S
Fertility levels								
75% RDF	57.81	9.06	19.81	5.78	41.80	11.60	37.34	6.83
100% RDF	71.14	11.25	24.55	8.42	52.49	14.20	45.49	8.86
125% RDF	77.57	12.59	27.68	9.42	58.14	16.35	51.99	10.67
SEm±	0.98	0.14	0.37	0.12	0.73	0.21	0.48	0.11
CD (P=0.05)	2.75	0.41	1.05	0.35	2.05	0.60	1.34	0.31
Foliar nutrients spray								
Water spray (control)	61.08	9.48	20.36	6.58	43.71	12.24	38.53	7.55
NCU 2% at PF and PI	70.72	10.81	23.21	7.95	53.46	13.68	43.06	8.86
NPK (19 : 19 : 19) 0.5% at PF and PI	74.39	11.93	26.96	9.02	56.12	15.38	49.90	10.43
NPK (17 : 44 : 0) 0.5% at PF and PI	71.20	12.23	24.08	8.44	53.15	15.75	43.87	9.03
NPK (0 : 0 : 50) 0.5% at PF and PI	66.82	10.38	25.44	7.37	47.62	13.21	49.35	8.06
SEm±	1.26	0.19	0.48	0.16	0.94	0.28	0.62	0.14
CD (P=0.05)	3.54	0.53	1.36	0.45	2.64	0.78	1.73	0.40

RDF, recommended dose of fertilizers, PF, pre-flowering; PI, pod-initiation stage; NCU, neem coated urea

over the other treatments. The significantly higher P content in seed and straw was recorded with the application of NPK (17 : 44 : 0) @ 0.5%, being at par with NPK (19 : 19 : 19) @ 0.5% over the other treatments. However, the maximum and significantly higher K content in seed and straw was recorded under foliar application of NPK (0 : 0 : 50) @ 0.5% and the maximum S content was observed under foliar application of NPK (19 : 19 : 19) @ 0.5% over the other treatments. The maximum and significantly higher N, K and S uptake of fieldpea seed and straw was recorded under foliar application of NPK (19 : 19 : 19) @ 0.5% over the other treatments; however, the higher P uptake of fieldpea seed and straw was observed in foliar application of NPK (17 : 44 : 0) @ 0.5% over the other treatments. It is evident from significant correlation between dry-matter accumulation and uptake of nutrients (Meena *et al*., 2021). A repeated application of small units of foliar fertilizers stimulates plant metabolism and increases nutrient content and uptake. Result confirms the findings of Yadav and Choudhary (2012).

Economics

Application of 125% RDF showed significantly higher net returns (₹52,889/ha) and benefit: cost ratio (B : C) (3.02) over application of 100% and 75% RDF but found statistically at par with 100% RDF for benefit: cost ratio (Table 2). The net returns and benefit: cost ratio obtained from 125% RDF was 32.18% and 16.60% higher than 75% RDF respectively. Among the foliar nutrition, an application of NPK (19 : 19 : 19) @ 0.5% at pre-flowering and pod-initiation stage resulted in the maximum and significantly higher net returns (₹50,385/ha) and benefit : cost ratio (3.06) over rest of treatments but at par with NPK (17 : 44 : 0) @ 0.5% at pre-flowering and pod-initiation (₹48,865/ha and 2.94). Foliar application of NPK (19 : 19 : 19) recorded 17.19 and 15.47% higher net returns and benefit : cost ratio over the control. The higher net returns under 125% RDF and foliar spray of NPK (19 : 19 : 19) @ 0.5% at pre-flowering and pod-initiation stage were owing to higher seed yield of fieldpea recorded in these treatments.

The fieldpea crop should be fertilized with 125% RDF (25 kg N + 50 kg P + 25 kg K + 25 kg S + 6.25 kg Zn/ha) at the time of sowing and subsequently foliar spray of NPK 19 : 19 : 19 @ 0.5% at pre-flowering and pod-initiation for higher yield and profits.

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