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Research Paper

Effect of nutrient and pest management on productivity and profitability of pigeonpea (*Cajanus cajan*)

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2017 and 2018 at the Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh, India, to study the impact of nutrient and pest management on productivity and profitability of pigeonpea [*Cajanus cajan* (L) Millsp.]. The experiment consisted 8 treatments of nutrient and pest management, replicated thrice in randomized block design. Pods/plant were found markedly superior in recommended dose of fertilizer (RDF) + multimicronutrient @ 2 ml/L at 50% flowering + indoxacarb spray at flowering + 1 systemic insecticide at 15 days after the first spray. However, 1000-seed weight (65.19 g) was significantly higher in RDF + multimicronutrient @ 2 ml/L at 50% flowering + indoxacarb spray at flowering + 1 systemic insecticide at 15 days after first spray. Grain yield (1.07 t/ha) was significantly superior under RDF + multimicronutrient @ 2 ml/L at 50% flowering + indoxacarb spray at flowering + 1 systemic insecticide at 15 days after the first spray. The stover yield (6.13 t/ha) was recorded significantly higher (17.92%) in RDF + 0.5% borax spray at 50% flowering. Harvest index was estimated significantly superior in RDF + indoxacarb spray at 50% flowering + 1 systemic insecticide (Dimethoate) at 15 days after first spray followed by RDF + multimicronutrinent @ 2 ml/L at 50% flowering + indoxacarb spray at flowering + 1 systemic insecticide at 15 days after the first spray (17.53%). Gross returns (69.3 × 10^3 ₹/ha) and net returns (69.3 × 10^3 ₹/ha) of pigeonpea were recorded significantly higher under RDF + multimicronutrient @ 2 ml/L at 50% flowering + Indoxacarb spray at flowering + 1 systemic insecticide at 15 days after the first spray, while benefit : cost ratio (3.68; 3.49) was found significantly more in RDF + 2% urea spray at 50% flowering and RDF + 0.5% $ZnSO_4$ spray at 50% flowering than the other treatments.

Key words: Borax, Indoxacarb, Multimicronutrient, Pigeonpea, Systemic insecticides, Urea and $ZnSO_4$

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is the most versatile food legume of India. It ranks second in both acreage (4.80 million ha) and production (4.32 million tonnes) among the pulses in India, with average productivity of 900 kg/ha (AICRPP, 2020–21). It is grown in a vast rainfed area of India. However, the productivity of pigeonpea is low in the farmer's field because of low dose of nutrient application, scarcity of moisture, no use of plant-protection measures etc.

Nutrient management is the most basic factor and exerts a great influence on growth, yield attributes and yield. Among all nutrients, nitrogen, phosphorus and potassium are the prime ones which have direct effect on metabolism of plant and contribute to proper growth and yield of crop plant. The crop productivity can be sustained by maintaining soil fertility through use of all possible plant nutrients in an integrated manner (Roy and Ange, 1991). Optimum plant nutrition helps in early establishment of rainfed crop by developing right crop canopy structure and root- system.

Pigeonpea yield has remained stagnant for the past 3 to 4 decades, largely due to damage inflicted by insect-pests (Basandria *et al.,* 2011). Lateef and Reed (1983) reported that, the low yield in pigeonpea was due to several reasons of which insect-pests and diseases are of major concern. In India, the avoidable losses due to insect-pests in pigeonpea were recorded to an extent of 78%. The pigeonpea pod-borer complex comprises gram pod-borer, [*Helicoverpa armigera* (Hubner)] plume moth, [*Exelastis atmosa* (Walshingham)] and pod fly [*Melanagromyza obtusa* (Molloch)]. Considerable loss of grain yield is inflicted on account of their association with fruiting bodies. *Helicoverpa armigera* alone contributes loss up to 50% for

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management of pod-borer complex (Thakare, 2001; Dodia *et al.,* 2009). Insecticides are most commonly recommended and preferred, especially for crops with high remunerative prices like pigeonpea. Hence, chemical measures are often termed as necessary evil in present scenario of pigeonpea pest management. Farmers use chemical pesticides indiscriminately, which leads to increased cost of plant protection resulting in lower profitability. Newer insecticides with novel mode of action were evaluated to find out an effective and economical insecticide for enhancing productivity and profitability of pigeonpea.

MATERIALS AND METHODS

The field experiment was conducted at Agriculture farm of the Mahatma Gandhi Chitrakoot Gramodaya Viswavidayalaya Chitrakoot, Satna, Madhya Pradesh during the rainy (*kharif*) season of 2017 and 2018. The farm is situated under Kymore Plateau of Northern Madhya Pradesh (25°10' N and 80° 32' E at an altitude of 190–210 m above mean sea-level). Agro-ecological Chitrakoot is characterized by semi-arid and sub-tropical climate with hot summer and cold winters. The total mean annual rainfall of Chitrakoot is 950 mm, while the crop received 800 mm from July to December 2017 and 670 mm rainfall from July to December 2018, with 26 and 23 rainy days during the crop seasons. The soil was sandy loam, with slightly alkaline *p*H 7.9 and 7.8, low in organic carbon (0.24 and 0.27%) and available nitrogen (110.25 and 126.75 kg/ha) and available phosphorus 8.75 and 13.28 kg/ha/g and medium in available potash (144 and 160 kg/ha) during 2 consecutive years.

The experiment consisted 8 treatments, replicated 3 times in randomized block design. The treatments were: T_1, Recommended dose of fertilizers (RDF); T_2, RDF + 2% urea spray at 50% flowering; T_3, RDF + 0.5% borax spray at 50% flowering; T_4, RDF + 0.5% $ZnSO_4$ spray at 50% flowering; T_5, RDF + 1% urea + 0.25% $ZnSO_4$ + 0.25% borax spray at 50% flowering; T_6, RDF + multimicronutrient spray @ 2 ml/litre at 50% flowering; T_7, RDF + indoxacarb at flowering + 1 systemic insecticide (Dimethoate) 15 days after the first spray; and T_8, RDF + multimicronutrient spray @ 2 ml/litre at 50% flowering + indoxacarb at flowering + 1 systemic insecticide 15 days after the first spray. The recommended dose of fertilizers (RDF) for pigeonpea was 20 : 60 : 30 kg N : P_2O_5 : K_2O/ha which supplied through diammonium phosphate and muriate of potash. The entire quantity of nitrogen, phosphorous and potassium were applied basal in the furrows uniformly in all treatments. The seed was treated with thiram @ 2.5 g/kg seed for protecting from fungal infection before seed inoculation. Thereafter, it was inoculated with *Rhizobium* culture @ 20 g/kg seed followed by phosphorus-solubilizing bacteria (PSB) @ 40 g/kg seed. Pigeonpea cv. 'UPAS 120' (short duration) was sown in rows, 60 cm apart on 19 July 2017 and 23 July 2018 using a seed rate of 20 kg/ha. The plant-to-plant spacing was maintained 15 cm by thinning at 20 days after sowing. The crop was grown as per recommended package and practices and harvested on 8 December 2017 and 13 December 2018. Observations were recorded at appropriate time by use of standard procedures (Castellanos–Navarrete *et al.,* 2013). The economics of both the years was calculated as per prevailing price of the market. The data obtained were subjected to statistical analysis as outlined by Gomez and Gomez (1984). The treatment differences were tested by using F test and critical differences 5% probability.

RESULTS AND DISCUSSION

Yield attributes

The pods/plant (47.96) were observed numerically higher under RDF + multimicronutrient + indoxacarb at flowering + 1 systemic insecticide 15 days after the first spray (T_8), followed by treatment T_6, i.e. RDF + multimicronutrient spray @ 2 ml/litre at 50% flowering (47.17 pods/plant). However, 1,000-seed weight obtained was significantly superior (65.19g) under T_8, treatment in pooled data as well as first and second year experiment (Table 1). However, pod length was noted numerically higher in T_5 (RDF + 1% urea + 0.25 % $ZnSO_4$ + 0.25% borax spray at 50% flowering) followed by T_8, treatments. The grains/pod were more in T_6 treatment (Table 1). The higher yield attributes of pigeonpea might be owing to foliar application of micronutrient, viz. $ZnSO_4$, borax or multimicronutrient as well as pest control at flower and pod-filling stage. Kumar and Sharma (2020) observed that, application RDF + multimicronutrient @ 2 ml/litre + indoxacarb at 50% flowering followed by Dimethoate 30 EC @ 0.03% after 15 days after the first spray resulted in the maximum pods/plant in pigeonpea. These results are in agreement with the findings of Elumle *et al*., (2019) and Mishra *et al*., (2021).

Yield

The treatment T_8 (RDF + multimicronutrient + indoxacarb at flowering + 1 systematic insecticide 15 days after the first spray) resulted in significantly superior grain yield of pigeonpea (1.07 t/ha) compared to rest of the treatments (Table 2). The yield of pigeonpea was low because of short-duration variety, 'UPAS 120' was used in experimentation. All the treatments gave higher yield than the control. Stover yield was significantly better (6.10 t/ha) under RDF + 0.5% borax spray at 50% flowering (T_3) in pooled data as well as in the first year. While in the second year it was significantly higher in T_2 (RDF + 2% urea spray

Table 1. Effect of nutrient and pest management on yield attributes of pigeonpea (pooled for 2 years)

Treatment	Yield attributes			
	Pods/plant	Pod length (cm)	Grains/pod	1000-seed weight (g)
T_1, Recommended dose of fertilizer	41.33	4.71	3.39	59.92
T_2, T_1 + 2% urea spray at 50% flowering	44.70	4.77	3.61	60.53
T_3, T_1 + 0.5% borax spray at 50% flowering	39.67	4.91	3.67	64.29
T_4, T_1 + 0.5% $ZnSO_4$ spray at 50% flowering	44.73	4.84	3.63	62.68
T_5, T_1 + 1% urea + 0.25% $ZnSO_4$ + 0.25% borax spray at 50% flowering	42.83	5.24	3.63	64.99
T_6, T_1 + multimicronutrient spray @ 2 ml/litre at 50% flowering	47.17	4.87	3.68	64.71
T_7, T_1 + indoxacarb at flowering + 1 systemic insecticide 15 days after the first spray	42.83	4.94	3.58	63.45
T_8, T_6 + indoxacarb at flowering + 1 systemic insecticide 15 days after the first spray	47.96	5.18	3.47	65.19
SEm±	4.62	0.32	0.12	1.06
CD (P=0.05)	NS	NS	NS	3.04

Table 2. Effect of nutrient and pest management on yield and harvest index of pigeonpea

Treatment	Yield						Harvest index (%)		
	Seed (t/ha)			Stover (t/ha)					
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T_1, Recommended dose of fertilizer	0.83	0.87	0.85	6.31	4.87	5.59	11.75	15.12	13.43
T_2, T_1 + 2% urea spray at 50% flowering	0.94	1.03	0.98	6.89	5.30	6.10	12.04	16.31	14.18
T_3, T_1 + 0.5% borax spray at 50% flowering	0.83	0.94	0.89	6.99	5.26	6.13	10.41	15.25	12.83
T_4, T_1 + 0.5% $ZnSO_4$ spray at 50% flowering	0.93	0.94	0.93	6.90	4.74	5.82	11.96	16.66	14.31
T_5, T_1 + 1% urea + 0.25% $ZnSO_4$ + 0.25% borax spray at 50% flowering	0.86	0.89	0.87	6.01	4.59	5.30	12.71	16.37	14.54
T_6, T_1 + multimicronutrient spray @ 2 ml/litre at 50% flowering	0.87	0.91	0.89	5.34	4.64	4.99	13.80	16.43	15.11
T_7, T_1 + indoxacarb at flowering + 1 systemic insecticide 15 days after the first spray	1.01	1.02	1.02	4.79	4.59	4.69	17.63	18.21	17.92
T_8, T_6 + indoxacarb at flowering + 1 systemic insecticide 15 days after the first spray	1.05	1.09	1.07	5.43	5.06	5.24	17.23	17.82	17.53
SEm±	0.03	0.04	0.03	0.41	0.16	0.35	0.98	0.59	0.90
CD (P=0.05)	0.09	0.12	0.09	1.27	0.50	1.01	2.97	1.80	2.57

at 50% flowering), followed by T_5 (RDF + 1% urea + 0.25% $ZnSO_4$ + 0.25% borax spray at 50% flowering). Pigeonpea yield also depends upon physiological disorder, i.e. shedding of flowers. This physiological disorder could be controlled effectively by foliar spray. It is known that, nutrients modify the source-sink relationship and increase the translocation, photosynthetic efficiency resulting in increased flower retention and pod setting (Ganapathy *et al.,* 2008). The crop was attacked by various insect-pest *Maruka vitrata* Fabricius) at the time of flowering. The application of RDF + indoxacarb at flowering + 1 systemic insecticide (Dimethoate) 15 days after first spray (T_7) and RDF + multimicronutrient + indoxacarb at flowering + 1 systemic insecticide 15 days after the first spray (T_8) besides varied nutrient-management practices had controlled these insect pests which resulted in higher yield attributes and seed yield of pigeonpea. Indoxacarb is an oxadiazine insecticide that blocks the sodium channels in insect nerve cells, causing Lepidoptera larvae to stop feeding within 4 hours, it becomes paralyzed and die within 2 to 5 days. Rathod *et al.,* (2014) found that, the bio-efficacy of indoxacarb 15 EC (KN 128) was more or less dose related, i.e. with increase of dose, there was corresponding decrease in larvae population of *H. armigera,* and increase in grain yield of pigeonpea. However, Indoxacarb 15 EC (KN 128) @ 50 g a.i./ha was found effective for the control of *H. armigera* in pigeonpea. Similar results were reported by Meena *et al*., (2020) and Mishra and Rai (2021).

Harvest index of pigeonpea was significantly higher (19.92%) under RDF + indoxacarb spray at 50% flowering

+ 1 systemic insecticide at 15 days after the first spray (T_7). Treatment T_8 was statistically at par with T_7, and the remaining treatments had almost similar harvest index. The superior harvest index of pigeonpea under T_8 and T_7 treatments could be ascribed to higher grain yield compared to stover yield of respective treatment.

Economics

The cost of cultivation was varied with treatment, and it was maximum of 20.5 × 10^3 ₹/ha under RDF + multimicronutrient + indoxacarb at flowering + 1 systemic insecticide 15 days after the first spray (T_8), while the minimum cost (17.2 × 10^3 ₹/ha) was found in RDF (T_1). This variation was associated due to variable treatment cost. Gross returns (69.3 × 10^3 ₹/ha; 66.3 × 10^3 ₹/ha) and net returns (48.6 × 10^3 ₹/ha; 48.4 × 10^3 ₹/ha) were significantly maximum under treatment T_8, followed by T_2 (Table 3). The higher net returns was obtained as a result of higher gross returns as well as greater cost of cultivation of respective treatment. Application RDF+ multimicronutrient @ 2 ml/litre + indoxacarb at 50% flowering followed by Dimethoate 30 EC @ 0.03% at 15 days after the first spray resulted in the maximum net returns in pigeonpea (Jadhav and Kute, 2019). Similar results were also reported by Meena *et al*., (2020) and Mishra *et al*., (2021).

Benefit: cost ratio (B:C) was significantly higher and statistically at par under T_2, (RDF + 2% urea spray at 50% flowering) and T_4, (T_1 + 0.5% $ZnSO_4$ spray at 50% flowering) treatments. This trend could be owing to lower cost of cultivation in T_2 and T_4 treatments. The moderate B : C ratio was obtained under T_8 owing to higher cost of cultivation of applied pesticide. The results are in agreement with the findings of Baldev and Punia (2018) and Singh *et al*., (2022).

Thus, it can be concluded that application of RDF + multimicronutrient 50% flowering + indoxacarb at flowering + 1 systemic insecticide 15 days after the first spray (T_8) was the best treatment for higher grain yield, gross returns and net returns under rainfed conditions of Kymore Plateau of Madhya Pradesh.

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Table 3. Effect of nutrient and pest management on economics of pigeonpea (pooled for 2 years)

Treatment	Economics			
	Cost of cultivation (× 10^3 ₹/ha)	Gross returns (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio
T_1, Recommended dose of fertilizer	17.4	58.0	40.5	3.32
T_2, T_1 + 2% urea spray at 50% flowering	18.0	66.3	48.4	3.68
T_3, T_1 + 0.5% borax spray at 50% flowering	18.2	61.1	42.8	3.35
T_4, T_1 + 0.5% $ZnSO_4$ spray at 50% flowering	18.1	63.3	45.1	3.49
T_5, T_1 + 1% urea + 0.25% $ZnSO_4$ + 0.25% borax spray at 50 % flowering	18.2	59.3	40.6	3.23
T_6, T_1 + multimicronutrient spray @ 2 ml/litre at 50% flowering	18.0	59.1	41.1	3.28
T_7, T_1 + indoxacarb at flowering + 1 systemic insecticide 15 days after first spray	20.5	65.5	45.0	3.19
T_8, T_6 + indoxacarb at flowering + 1 systemic insecticide 15 days after first spray	20.6	69.3	48.6	3.35
SEm±	–	1.85	1.77	0.10
CD (P=0.05)	–	5.31	5.07	0.28

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