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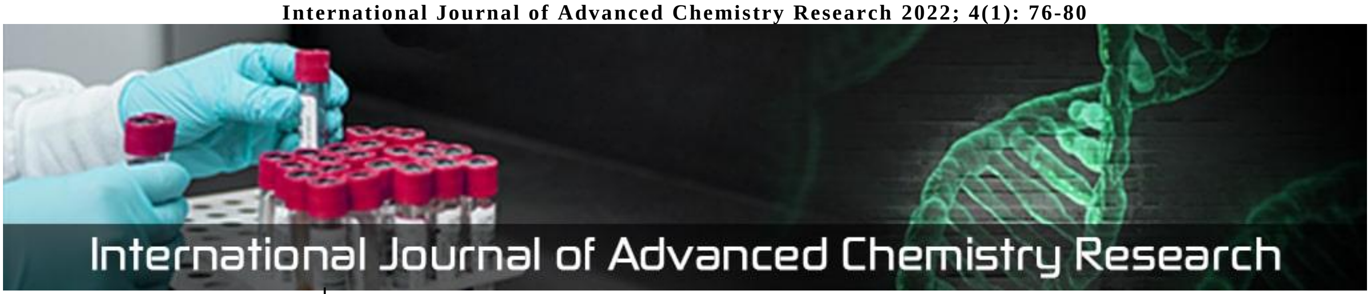

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Effect of integrated nutrient management on growth and yield of Pigeonpea in Chhattisgarh Plain

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Abstract
India is the largest producer and consumer of pulses in the world accounting for about 29 per cent of the world area and 19 per cent of the world's production. In order to achieve self-sufficiency in pulses, the projected requirement by the year 2025 is estimated at 27.5 MT. To meet this requirement, the productivity needs to be enhanced to 1000 kg ha^{-1}, and an additional area of about 3-4 M ha has to be brought under pulses besides reducing post-harvest losses. The yield levels of pulses have remained low and stagnant, also area and total production. Among the pulses major constraints in pigeon pea production is mostly grown in marginal lands under rainfed agriculture and without nutrient management, hence are prone to abiotic stresses. Therefore it is essential for higher production and productivity of pigeonpea, use of high yielding varieties with best nutrient management practices. A field experiment was conducted at Barrister Thakur Chhedilal College of Agriculture and Research Station Bilaspur C.G. find out the effect of integrated nutrient management on growth and yield of pigeonpea (*Cajanus cajan* (L.) Millsp.). The experiment was laid out in Randomized Block Design (RBD) with three replications. There were 8 treatment combinations. Application of 150 per cent RDF + FYM @ 5 t ha^{-1} significantly increased the yields of pigeonpea crops over control and other lower doses of fertilizers and FYM. The maximum pigeonpea equivalent yield (16.75 and 16.21 q ha^{-1}), stalk yield (55.68 q ha^{-1} and 54.63 q ha^{-1}), Harvest index (23.12 % and 22.97 %), gross returns (₹ 105504 and ₹ 102123 ha^{-1}), net returns (₹ 61297.70 and ₹ 59633 ha^{-1}) and benefit cost ratio (1.40 and 1.38) were recorded when full recommended dose of fertilizer was applied to pigeonpea crop (T_6 and T_5, respectively).

Keywords: Production, productivity, nutrient, pigeonpea

Introduction
Pigeonpea (*Cajanus cajan* (L.) Millsp.) is a very old crop in this country, also known as red grams, arhar, or tur. It is most frequently consumed as 'dal,' a split pulse. Pigeonpea was India's second-most important pulse crop after chickpea. It is commonly used as a pulse, green vegetable, and fodder for a number of other things. It occupies an area of about 3.90 m ha with a total production of 3.17 MT with an average productivity of 813 kg ha^{-1} (Tiwari, 2016) [16]. The low yield of pigeon pea is not only due to its cultivation on sub-marginal lands, but also because of inadequate and imbalance fertilization as well as continuous use of inorganic fertilizers which decreased the productivity, sustainability, soil health and finally affecting environment (Singh, 2007) [18]. Intensive agriculture using exhaustive high yielding varieties of crops had led to heavy withdrawal of nutrients from the soil during past few years and fertilizer consumption remained much below in comparison to removal in India. This gap between nutrient removal and supply cannot be bridged by fertilizer alone. It can only be achieved by integrated nutrient approach. To avoid negative environmental effects by fertilizer application, eco-friendly management practices can be adopted at farm level. Development and application of such a system appears to be an alternative to maintain sustainable agricultural system. Adequate maturing not only improves the crop yield but also sustains the soil health and productivity. Moreover, chemical fertilizers are becoming costlier input in agriculture. Therefore, it is right time to evaluate the feasibility and efficiency of organic waste not only for improving and build-up of soil fertility but also to increase efficiency of chemical fertilizer. The productivity of pigeonpea is controlled by many factors, i.e. varieties, time of sowing, nutrient management, etc. out of which mineral nutrition plays an important role, but heavy and imbalance use of chemical fertilizers has led to think about the use of organic manures in intensively growing areas for sustainable production. Integrated nutrient management is the supply of the required plant nutrients for sustaining.

The desired crop productivity with minimum/no deleterious effect on soil health and environment through use of judicious combination of organic, inorganic and bio fertilizers. Thus, integrated management of the nutrients is needed for proper plant growth, together with effective crop, water, soil, and land management.

The effect of chemical fertilizer, FYM and bioinoculant on the growth and yield attribute of pigeonpea

Singh *et al.*, (2008) [19], Integrating organic and inorganic fertilizers increases crop yield while improving soil health over time. The increased seed yield can be attributed to the release of adequate plant nutrients from organic and inorganic sources, which is essential for improved crop growth and yield. Rathore *et al*., (2010) [20] revealed that 20 kg N + 40 kg P_2O_5 ha^{-1} resulted in considerably higher seed and haulm yield, yield components, nutrient content, and nitrogen and phosphorus uptake (N and P) of urdbean than 10 kg N + 20 kg P_2O_5 ha^{-1} + *Rhizobium* + PSB and 0 N: 0 P_2O_5 + *Rhizobium* + PSB. Similar findings were reported by Singh and Singh (2004) [21] and Kumar and Elamathi (2004) [22]. Sharma *et al*., (2010) [22] reported that application of RDF + 15 kg $ZnSO_4$ recorded significantly higher number of pods $plant^{-1}$, number of seeds pod^{-1}, 100-seed weight and seed yield of pigeonpea (13.78 q ha^{-1}) followed by RDF + 25 kg $ZnSO_4$ (13.53 q ha^{-1}) and RDF + seed treatment with sodium molybdate @ 4 g kg^{-1} (12.42 q ha^{-1}) as compared to control (7.78 q ha^{-1}). Stephen *et al*., (2014) [23] Ambrose Alli University's Teaching and Research Farm in Ekpoma, Nigeria, conducted an experiment to study the influence of different rates of phosphorus fertilizer on pigeonpea growth, yield, nodulation, and nutrient uptake (*Cajanas cajan*). Increasing the amount of P fertilizer above 25 kg ha^{-1} had no significant effect on pigeonpea yield therefore, 25 kg ha^{-1} is the recommended rate. The increase in yield might be attributed to the beneficial impact of coupling organics with balanced inorganic fertilization to the extent of with FYM @ 3t ha^{-1} with 'Harit-Harvardan' @5 kg ha^{-1} + RDF + seed inoculation of biofertilizer over RDF alone. These observations complemented the findings of Kumar and Gautam (2004) [24], Patil and padmani (2007) [26] In pigeonpea, application of 100 per cent RDF ha^{-1} combined with FYM @ 5 t ha^{-1} resulted in significantly higher grain yield (1,436 kg ha^{-1}), number of pods $plant^{-1}$ (178.96), and number of grains pod^{-1} (4.13), although 75 per cent RDF ha^{-1} along with FYM @ 5 t ha^{-1} was significantly superior to control. Patil and Padmani (2007a) [11] Researchers in Junagadh, Gujarat, reported that using 100 per cent RDF (25 N + 50 P_2O_5 + K_2O 0.0 kg ha^{-1}) significantly increased plant height, branches $plant^{-1}$, and nodule counts compared to control and 50 per cent RDF, though it was on par with 75 per cent RDF. Singh (2007) [27] field experiment was conducted at BHU, Varansi, and it was discovered that application of 50 per cent RDF + 5 per cent FYM ha^{-1} considerably enhanced plant height, number of branches, and dry matter $plant^{-1}$ of pigeonpea while remaining at par with 10 per cent FYM and 100 per cent RDF. Nagaraju and Mohan kumar (2009) [28] it was reported that applying prescribed nitrogen and potassium, as well as 100 per cent P_2O_5, via activated mussorie rock phosphate (cow dung + urine + silt), resulted in increased plant height, pods $plant^{-1}$, and yield (185 cm, 193 and 1949 kg ha^{-1}) of pigeonpea. Pandey and kushwaha (2009) [10] reported that interaction effect of *rhizobium* + PSB with 100 per cent RDF produced maximum seed yield (2150 kg ha^{-1}) of pigeonpea followed by *Rhizobium* + PSB inoculation with 50 per cent RDF (1909 kg ha^{-1}). Arjun Sharma *et al*., (2009) [29] revealed that application of FYM @ 5 t ha^{-1} + seed inoculation with *Rhizobium* + $ZnSO_4$ @ 15 kg ha^{-1} + crop residues @ 5 t ha^{-1} recorded significantly higher plant height (184.09 cm), primary branches per plant (12.34), secondary branches per plant (7.86), seed yield (15.81 q ha^{-1}) of pigeonpea and was on par with the treatment receiving FYM + seed inoculation with *Rhizobium* + $ZnSO_4$ @ 15 kg ha^{-1} during *kharif* season at ARS, Gulbarga. Deshbhratar *et al*. (2010) [4] observed significant increase in grain yield (14.81 q ha^{-1}) and straw yield (41.26 q ha^{-1}) of pigeonpea with 20 kg S $ha^{-1}$and 50 kg P_2O_5 ha^{-1} with common dose of nitrogen @ 30 kg ha^{-1}. The increase in grain and straw yield was 102.77 and 52.87 per cent over control. Maximum number of pods $plant^{-1}$, maximum number of grains pod^{-1} and test weight was also observed in this treatment. Rathod *et al.* (2016) [13] In a field experiment in Gulbarga, it was observed that applying RDF + $ZnSO_4$ @ 15 kg ha^{-1} increased plant height, number of main branches, and secondary branches of pigeonpea, albeit it was on par with RDF + $ZnSO_4$ @ 25 kg ha^{-1} and significantly superior to the other treatments. Pal *et al*., (2016) [9] revealed that among the nutrient management practices, application of 100 per cent recommended dose of fertilizer + 2.5 t vermicompost recorded significantly higher growth characters i.e. plant height, no. of branches, dry matter accumulation $plant^{-1}$, leaf area index nodule $plant^{-1}$, dry weight of nodule $plant^{-1}$ as compared to rest of nutrient management practices. Singh *et al*., (2016a) [30] a field experiment conducted in Ranchi, Jharkhand, the application of 200 per cent RDF (30:60:30:30 kg NPKS ha^{-1}) resulted in significantly higher growth characteristics, including plant height, the number of primary and secondary branches $plant^{-1}$, leaf area index, the number of nodules $plant^{-1}$, and the dry weight of nodules $plant^{-1}$, but it was on par with 150 per cent RDF and superior to 100 per cent RDF. Pigeonpea equivalent yield is significantly influenced by fertility levels. Vermicompost application at 2.5 t ha^{-1} + 50 per cent RDF resulted in significantly higher pigeonpea equivalent yield of 19.36 q ha^{-1}, which was comparable to phosphor-compost application at 2.5 t ha^{-1} + 50 per cent RDF (18.43 q ha^{-1}). This was mainly because applying vermicompost and phosphocompost increased the growth and development characteristics, which increased the production of both crops. Sharma reported a similar result (2009) [29].

Effect of integrated nutrient management on economics

Shivran *et al*., (2000) [14] discovered that the cropping system produced a maximum net return of ₹ 22,675 when pigeonpea was fertilized with 60 kg P_2O_5 ha^{-1}. Kumar and Rana (2007) [6] revealed that application of 40 kg P_2O_5 + 25 kg S ha^{-1} + PSB resulted in a significantly higher net return and B:C ratio than using 40 kg P_2O_5 ha^{-1} and a control that was comparable to using 40 kg P_2O_5 + 25 kg S ha^{-1}. Patil and Padmani (2007b) [26], the highest net returns were obtained with 100 per cent RDF (25 N + 50 P_2O_5+ K_2O 0.0 kg ha^{-1}), but the highest net ICBR was obtained with 75 per cent RDF over 50 per cent RDF and control. Singh (2007) [27] observed that net returns of pigeonpea were observed with the application of 50 per cent RDF + 5 t FYM ha^{-1} over other treatments. Pandet and Khuswaha (2009) [31] found that pigeonpea seed inoculation with *Rhizobium* + PSB +100 per cent RDF produced significantly higher net returns (38,233 ha^{-1}) than *Rhizobium* + PSB inoculation with 50 per cent RDF (32437 ha^{-1}). Sharma *et al*., (2010a) [12] observed that At 15 and 30 days after harvest, the pigeonpea + green gram intercropping system with RDF + 2 per cent urea spray produced significantly higher pigeonpea equivalent (19.53 and 18.99 q ha^{-1}), gross return (31,439 and 30,576 ha^{-1}), net return (23,984 and 22,928 ha^{-1}), and B:C ratio (3.81 and 3.63, respectively). Sharma *et al.*, (2010b) [22] from Karnataka revealed that application of 100 per cent RDF + 15 kg $ZnSO_4$ ha^{-1} resulted in the highest gross return, net return, and B: C ratio compared to the control. Tiwari *et al.*, (2011) [17] concluded that pigeonpea + urdbean cultivation with application of PSB + FYM @ 2.5 t ha^{-1} produced greater net returns (₹ 27,911 ha^{-1}) and B:C ratio (1.58) than pigeonpea + maize cropping with B:C ratio of 0.70. Meena *et al.*, (2012) [8] reported that adoption of induced defoliation in pigeonpea couple with NPK+ FYM gave the highest system productivity whereas significantly higher net returns (₹32,400 ha^{-1}) was found under NPK + induced defoliation over the other treatment. Vishwanatha *et al.*, (2012) [32] concluded that the application of 100 per cent RDF TH pigeonpea + 100 per cent RDPK and 50 per cent RDN to sunflower as basal dose + 50 per cent RDN as top dress at 45 DAS to sunflower based on population was noted to produce the highest gross returns (80,302 and 77,448 ha^{-1}), net returns (62,308 and 59,718 ha^{-1}), and B: C ratios (3.46 and 3.37), respectively**.**

Material and method

Details of experimental site

The experiment was performed at Barrister Thakur Chhedilal College of Agriculture and Research Station, Sarkanda, Bilaspur. It is situated in the middle region of the state of Chhattisgarh. The soil of experimental field was clayey. During the crop period the maximum temperature ranges from 33.4 ˚C to 33 ˚C at 40th standard meteorological week while, minimum temperature ranges from 4.4 ˚C to 6.4 ˚C at 4th standard meteorological week. The relative humidity varied from 96.3 to 45 percent at its highest and lowest point on 41st standard meteorological week and 6th standard meteorological week. The maximum rainfall recorded on 9th August to 15th August which is 841.6 mm on 32th standard meteorological week. The pigeonpea variety was selected for the study purpose. It is developed from Indira Gandhi Krishi Vishwavidyalaya Raipur in 2011. Duration is about 180-190 days. This variety is resistant to wilt and sterility mosaic disease. The average yield is 18-19 q ha^{-1}.The experiment was laid out in randomized block design (RBD) with three replications and Eight Integrated nutrient management treatments. T_1 : 100 % RDF, T_2: 125 % RDF, T_3 : 150 % RDF, T_4 : 100 % RDF + FYM @ 5 t ha^{-1}, T_5 : 125 % RDF + FYM @ 5 t ha^{-1}, T_6 : 150 % RDF + FYM @ 5 t ha^{-1}, T_7 : 100 % RDF + *Rhizobium culture*, T_8 : Control plot. Pigeonpea was sown on 12th July 2021 and Harvested on 05th February 2022.

Result and Discussion

In this experiment different crop growth period number of plant population observed non-significant. Treatment T_6 shows significantly highest growth parameters and yield attributes i.e., plant height, number of primary and secondary branches $plant^{-1}$, number of functional leaves $plant^{-1}$, number of root nodules and dry weight of root nodules $plant^{-1}$, dry matter accumulation (g), crop growth rate, relative growth rate and number of pods $plant^{-1}$, pod length in cm, number of seed pod^{-1}, seed weight $plant^{-1}$ and it was at par with T_5. Significantly maximum seed yield and stalk yield recorded in this treatment. While lowest was found under T_8 (control plot). Highest cost of cultivation (44206.30 ₹ ha^{-1}), gross return (105504 ₹ ha^{-1}) and net return (61297.70 ₹ ha^{-1}) observed in T_6 followed by T_5.While lowest was recorded under T_8 (control plot). Maximum benefit: cost ratio (1.82) found in T_7 (100% RDF+ *Rhizobium culture*) followed by T_2 (1.81) and T_3 (1.78).

Table 1: Effect of integrated nutrient management on pod length in cm, number of pods $plant^{-1}$, number of seeds pod-seed weight $plant^{-1}$ of pigeonpea.

	Treatment details	Seed yield (q ha^{-1})	Stalk yield (q ha^{-1})	Biological yield (q ha^{-1})	Test weight (gm)	Harvest index (%)
T_1	RDF 100% (20:50:20) kg ha^{-1} $N:P_2O_5:K_2O$	13.83	51.13	64.97	90.51	21.29
T_2	RDF 125 % (25:62.5:25) kg ha^{-1} $N:P_2O_5:K_2O$	14.50	52.33	66.82	90.88	21.69
T_3	RDF 150% (30:75:30) kg ha^{-1} $N:P_2O_5:K_2O$	15.12	53.56	68.68	91.39	22.01
T_4	RDF 100% + FYM @ 5t ha^{-1}	15.50	53.03	68.53	92.33	22.61
T_5	RDF 125% + FYM@ 5t ha^{-1}	16.21	54.33	70.54	92.87	22.97
T_6	RDF 150% + FYM@ 5t ha^{-1}	16.75	55.68	72.53	93.17	23.12
T_7	RDF 100% + *Rhizobium culture*	14.11	53.15	66.36	92.08	21.29
T_8	Control plot	10.79	43.52	54.31	88.31	19.87
	S.Em ±	0.45	2.19	1.99	2.33	0.99
	CD (5%)	1.36	6.66	6.04	7.05	3.00

Table 2: Effect of integrated nutrient management on seed yield, stalk yield, biological yield, test weight and harvest index of pigeonpea

	Treatment details	Pod length (cm)	No of pod $plant^{-1}$	No. of seed pod^{-1}	Seed weight $plant^{-1}$
T_1	RDF 100% (20:50:20) kg ha^{-1} $N:P_2O_5:K_2O$	4.91	129.10	3.52	53.33
T_2	RDF 125 % (25:62.5:25) kg ha^{-1} $N:P_2O_5:K_2O$	5.01	130.13	3.68	54.56
T_3	RDF 150% (30:75:30) kg ha^{-1} $N:P_2O_5:K_2O$	5.32	133.72	3.77	54.67
T_4	RDF 100% + FYM @ 5t ha^{-1}	5.96	135.66	3.86	58.08
T_5	RDF 125% + FYM@ 5t ha^{-1}	6.08	137.33	4.37	58.19
T_6	RDF 150% + FYM@ 5t ha^{-1}	6.31	138.38	4.49	59.54
T_7	RDF 100% + *Rhizobium culture*	5.42	135.48	4.23	57.25
T_8	Control plot	4.48	126.93	2.99	48.13
	S.Em ±	0.26	1.11	0.24	0.42
	CD (5%)	0.80	3.35	0.72	1.29

Conclusion

It is concluded that on the basis of growth parameter were significantly higher under Treatment T_6 (150 % RDF + FYM @ 5 t ha^{-1}) in pigeonpea. It was at par with Treatment T_5 (125 % RDF + FYM @ 5 t ha^{-1}). On the basis of yield attributes, seed yield T_6 (150 % RDF + FYM @ 5 t ha^{-1}) recorded highest (16.75 q ha^{-1}) however, it was significantly at par T_5 (135 % RDF + FYM @ 5 t ha^{-1}) and T_4. Treatment T_8 (Control plot) recorded lowest yield compare to all other treatments. On the basis of benefit: cost ratio maximum (1.82) observed treatment T_7 (100 % RDF + *Rhizobium culture*) followed by T_2 (2.81) and T_1 (1.78).

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