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Short communications

Nutrient management in short duration pigeon pea [*Cajanus cajan* (L.) Millsp.] in the southern laterites of Kerala

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Abstract
The field experiment to standardise the nutrient management practice in pigeon pea (APK1) was conducted in randomised block design with eight treatments comprising of different nutrient sources and methods of application, at College of Agriculture, Vellayani, Thiruvananthapuram. Significant variations were recorded in growth parameters, yield attributes, yield, nitrogen uptake and protein content of seeds. The treatment involving application of 100 % N + 50 % P + 50 % K + P solubiliser + K solubiliser in soil resulted in the significantly tallest plants (109.70 cm) and maximum number of branches per plant (6.5) at harvest, average pod weight (0.62 g) and seed yield (1.48 t ha^{-1}). Seed protein content was also maximum in the treatment, indicating that the integrated package of 100 per cent recommended dose of nitrogen and substitution of 50 per cent each of phosphorus and potassium with P solubiliser (*Bacillus megaterium*) and K solubiliser (*Bacillus sporothermodurans*) can be recommended for pigeon pea cultivation in the southern laterites of Kerala.

Key words: INM, Pigeon pea, Seed protein, Solubilisers, Uptake, Yield

Pigeon pea [*Cajanus cajan* (L.) Millsp.] is a globally important legume crop, mostly cultivated in Asia, Africa, Latin America and in the Caribbean region. It is an important source of protein for the poor communities in many tropical and subtropical regions of the world, and the seeds contain nearly 20 - 30 per cent protein (Snapp et al., 2003). The deep root system, growth habit and high nitrogen (N) fixing ability strengthen its potential as a component in cropping systems. Although an integral component of the daily diet in Kerala, the crop has not come up on a commercial scale in the state. Cultivation is confined to 266 ha covering areas in Palakkad district. Short duration varieties are more popular on account of its early maturation and suitability in inter and sequential cropping systems. Keeping this in view, a field experiment was conducted in the southern laterites of Kerala to ascertain the integrated nutrient management practice suited for the short duration variety of pigeon pea, APK 1, based on the NPK dose of 40: 80:40 kgha^{-1} found most suitable in the two year study at College of Agriculture, Vellayani (Devaraj, 2021).

The field experiment was conducted at the Instructional Farm of College of Agriculture, Vellayani, Thiruvananthapuram, Kerala (8^{o}30’ N latitude, 76^{o}54’ E longitude and at an altitude of 29 m above mean sea level). The soil falling in southern laterites, AEU 8, was sandy clay loam with moderately acidic pH(5.75), high in organic C (1.00%), low in available N (111.02 kg ha^{-1}), high in available P (67.14 kg ha^{-1}) and available K (385.33 kg ha^{-1}). The experiment was laid out in RBD with eight treatments and three replications. The treatments were T_1: 100 % NPK as chemical fertilizers, T_2: 100 % N + 50 % P + 100

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% K as chemical fertilizers + P solubiliser, T_3: 100 % N + 100 % P + 50 % K as chemical fertilizers + K solubiliser, T_4: 100 % N + 50 % P + 50 % K as chemical fertilizers + P solubiliser + K solubiliser, wherein the entire dose of N were given in soil. The treatments T_5 to T_8, followed the similar package as T_1 to T_4, except that 50 per cent N was applied in soil and the remaining 50 per cent as foliar spray with urea at 2 per cent concentration as the N source, 30 and 45 days after sowing (DAS). An absolute control (without fertilizers) was also maintained (C) for comparison. The quantity of lime and chemical fertilizers (Urea, Rajphos and Muriate of Potash) were computed based on the soil test data and the recommendations based on the ratings (KAU, 2016), and were applied as per treatments. Farmyard manure was applied uniformly in all plots @ 12.5 t ha^{-1}(TNAU, 2014). Seeds (@ 15 kg ha^{-1} were inoculated with *Rhizobium* isolated from the root nodules of pigeon pea plants, @ 50 g per kg seed. The P and K solubilisers (formulation of *Bacillus megaterium* and *Bacillus sporothermodurans* respectively procured from the Department of Microbiology, CoA Vellayani) were applied @ 10 g mixture (dry cow dung and solubiliser mixed in the ratio, 50:1) per plant, one week after basal fertilizer application to substitute 50 per cent P and K dose. The biometric observations were recorded periodically and the crop was harvested manually when the pods turned brown colour. Threshing and winnowing were also done manually to separate seeds and yields were recorded.Sample seeds in each treatment were oven dried, ground and analysed for the N content (Micro-kjeldhal distillation and digestion method) and crude protein computed based on the conversion factor (Simpson et al., 1965).

The data on growth parameters, yield attributes,yield and seed protein contentwere statistically analysed with ANOVA using the F-test and wherever found significant, the critical differences were calculated for comparison of the treatments.

The effect of nutrient management practices on the growth and seed yields in pigeon pea are presented in Tables 1 and 2. Plant height and number of branches at 30 and 60 DAS did not record any significant variations with the integrated nutrient management practices evaluated (Table 1) whereas at harvest, the plants differed significantly in heights and were the tallest in T_4, in which the P and K doses were reduced to 50 per cent with biofertilizers and applied in soil. The treatment $T_4$was on par with T_1, T_2 and T_6. With respect to the number of branches per plant, the treatment $T_4$was on par with T_2. The lower values of plant height and number of branches confirm the poor vegetative growth in absolute control.

Among the yield parameters, the variations were found significant for the average pod weight alone

Table 1. Effect of INM practices on plant height and number of branches per plant

Treatments	Plant height (cm)			Number of branches		
	30 DAS	60 DAS	At harvest	30DAS	60 DAS	At harvest
T_1: 100 % NPK as chemical fertilizers	52.20	106.67	107.17	3.3	5.3	6.3
T_2: 100 % N + 50 % P +100 % K + P solubiliser	52.45	106.40	108.60	3.1	5.7	6.4
T_3: 100 % N + 100 % P +50 % K + K solubiliser	50.32	104.67	106.00	2.9	5.4	6.0
T_4: 100 % N + 50 % P +50 % K + P solubiliser +K solubiliser	52.00	107.15	109.70	2.8	5.6	6.5
(T_1 to T_4 – N as soil application, basal and 30 DAS)						
T_5: 100 % NPK as chemical fertilizers	52.60	103.00	106.33	3.3	4.9	6.0
T_6: 100 % N + 50 % P +100 % K + P solubiliser	52.75	104.25	107.63	2.9	5.2	6.2
T_7: 100 % N + 100 % P +50 % K + K solubiliser	49.98	101.00	103.50	3.1	4.8	5.7
T_8: 100 % N + 50 % P +50 % K + P solubiliser + K solubiliser	52.90	102.83	104.75	2.7	5.0	6.3
(T_5 to T_8 – ½ N in soil and remaining as foliar spray)						
SEm±	2.07	1.44	1.08	0.44	0.54	0.03
CD (0.05)	ns	ns	3.301	ns	ns	0.084
T_9: Absolute control	45.55	87.33	90.00	2.6	4.1	5.3

(Table 2). The highest pod weights were recorded in T_4 (0.62 g) and was on par with T_2 and T_8 (0.60 g each). Seed yield in pigeon pea was also maximum in T_4 (1.48 t ha^{-1}), on par with the treatments, T_8 (1.46 t ha^{-1}) and T_2 (1.40 t ha^{-1}). Haulm yields followed a similar trend, but were comparable. The seed yield realised inabsolute control was nearly 51 per cent less than the highest yield (T_4), highlighting the need for external nutrient input additions despite the soil being high in P and K, and the crop being a N fixer.

It is evident that the inclusion of P and K solubilisers could enhance the nutrient availability to pigeon pea as the growth and yields realised were either on par or higher than that with 100 per cent chemical fertilizer application. In the absolute control, plants were shorter with poor branching habit as they had to survive on the native soil fertility. The better growth realized is ascribed to the integrated nutrient management strategy adopted. Nitrogen fixation and the chemical fertilizer, urea ensured N requirement of the crop, whileP and K solubilisers, *Bacillus megaterium* and *Bacillus sporothermodurans* respectively, along with P and K chemical fertilizers increased the availability of these nutrients for uptake by pigeon pea. Similar findings of increased availability and uptake resulting in profused growth and higher number of primary branches per plant have been reported (Singh, 2007). Further, *Bacillus* has the ability to produce growth hormones, especially indole acetic acid (Sheng and Huang, 2001), and siderophores (Hu and Boyer, 1996) which would also have contributed to the enhanced growth. Seed yields corresponded to the better growth expressed in the treatments indicating a positive source -sink relation with the inclusion of biofertilizers. Tiwari et al. (2016) explored the soil properties in bulk and rhizosphere soils of red gram and reported higher bacterial counts, indole acetic acid and siderophores in the latter. The exudates from plant roots provided carbon source and supported microbial growth. In addition, augmentation of the rhizosphere microbial activity with biofertilizer addition would also have created a favourable environment for root growth, nodulation and increased nutrient availability. However, despite the rhizospheric effects plausible in pigeon pea, the control treatment could not realize the beneficial effects as observed in the integrated nutrient management practice,because in the latter, the direct effect of the nutrient inputs and / biofertilizer and that of the rhizospheric processes resulted in the enhanced growth and yields. This could also be the reason for the better yields in INM over sole chemical fertilizer application.

Perusal of the data on seed protein content revealed it to be higher in P and K biofertilizer included treatments (T_4 and T_8), the values being 21.59 and 21.33 per cent respectively. The lowest value (17.3 %) was recorded in control. It is inferred that the higher protein contents are sequel to the better uptake and hence higher nutrient contents,

Table 2. Effect of INM practices on yield attributes, seed yield and economics in pigeon pea

Treatments	Average pod weight (g pod^{-1})	Number of seeds per pod	Seed yield tha^{-1}	Haulm yield tha^{-1}	Seed protein %	Benefit : Cost ratio
T_1: 100 % NPK as chemical fertilizers	0.51	4.7	1.35	4.58	18.78	1.99
T_2: 100 % N + 50 % P +100 % K + P solubiliser	0.60	4.8	1.40	5.01	20.77	2.00
T_3: 100 % N + 100 % P +50 % K + K solubiliser	0.54	4.7	1.37	4.73	19.37	1.97
T_4: 100 % N + 50 % P +50 % K + P solubiliser + K solubiliser	0.62	4.8	1.48	5.07	21.59	2.05
T_5: 100 % NPK as chemical fertilizers	0.53	4.8	1.32	4.47	18.32	1.94
T_6: 100 % N + 50 % P +100 % K + P solubiliser	0.58	4.7	1.39	5.00	20.52	1.97
T_7: 100 % N + 100 % P +50 % K + K solubiliser	0.52	4.8	1.32	4.71	18.55	1.87
T_8: 100 % N + 50 % P +50 % K + P solubiliser + K solubiliser	0.60	4.8	1.46	5.00	21.33	2.01
SEm±	0.01	0.03	0.03	0.16	0.11	-
CD (0.05)	0.023	ns	0.088	ns	0.324	-
T_9: Absolute control	0.40	4.5	0.98	3.97	17.30	1.65

especially N in seed. Choudhary et al. (2001) documented that with efficient photosynthesis in plants, carbohydrates synthesized are diverted to seeds to form more of proteins.

Taking into account the economics of input management, T_4 was found to be more economical followed by T_8, as evident from the benefit cost ratios presented Table 2 and is attributed to the higher cost involved in foliar nutrition.

The study revealed the significance of integrated nutrient management in pigeon pea variety APK 1, and the application of chemical fertilizers at 40:40:20 kg NPK ha^{-1} along with P and K solubilisers @ 10 g mixture per plant (dry cow dung and solubiliser mixed in the ratio, 50:1) along with the basal dose of FYM (@12.5 t ha^{-1}) and *Rhizobium* treatment of seeds, was found to be the most suited for higher seed yields in the southern laterites of Kerala. The N dose may be applied as urea in two splits in soil, or in three splits, basal dose in soil and foliar sprays, 30 and 45 DAS.

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