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Response of Vegetable Cowpea to Complete Nutrient Supply Through Foliar Application

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In vegetable cowpea, pot culture experiments were conducted to study effect of crop response to complete nutrient supply through foliar application of nutrients in randomized block design with three replications and eight treatments including, Control (no nutrients), Soil application of nitrogen (N), phosphorus (P), potassium (K) alone and along with micronutrients (MN), Foliar application of 2% N alone, P alone, K alone, and in combination of 2% of N, P, K each and 0.5% MN. Soil

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application of recommended dose (RD)of NPK and MN done at 4 Days After Sowing (DAS). Foliar application of nutrients done at 30 DAS, 40 DAS and 50 DAS. Results revealed, soil application of recommended dose of fertilizers (RDF) NPK + MN recorded highest growth parameters like plant height, number of leaves per plant and highest yield parameters like dry weight per plants, number of pods per plant, fresh pod yield per plant and was comparable with foliar application of 2% N + 2% P + 2% K + 0.5% MN. Post-harvest soil sample analysis for soil nitrogen, phosphorus and potassium status, the soil nitrogen status was highest in foliar application of 2% N + 2% P + 2% K + 0.5% MN and lowest in soil application RDF NPK, soil phosphorus was highest in RDF NPK and soil potassium status was higher in control.

Keywords: Foliar application; nitrogen; phosphorus; potassium; micronutrient.

1. INTRODUCTION

Cowpea *Vigna unguiculata* L. Walp is one among the most important food legume crops in semiarid tropics. In many developing countries, it constitutes more than half the plant protein in diets. It also contributes 60 – 70 kg N per ha into the soil due to its nitrogen fixing properties and as a residue which benefits succeeding crops (Rachie, 1985). In addition, it grows well in poor soils with more than 85% sand and less than 0.2% organic matter and low levels of phosphorus (Singh et al. 2011). The little leaves and yeasty pods are eaten as vegetables. Vegetable cowpea being a legume fixes atmospheric nitrogen in the root zone. Nitrogen fixation by this plant is considered as an important role especially when the soil suffers from a lack of nitrogen (Dugjie et al. 2009).

Nitrogen supply in the world is expected to increase by 3.7% annually between 2014 and 2018, whereas demand is projected to increase by 1.4% in the same period. The world phosphate (H_3PO_4 based P_2O_5) supply is expected to increase by 2.7% per annum between 2014 and 2018, whereas demand is projected to increase by 2.3% in the same period. The demand for potash is projected to increase by 2.6% between 2014 and 2018. The world potash supply is expected to increase by 4.2% during the same period. According to FAO the Asia region is the largest consumer of fertilizer in the world. Total fertilizer nutrient consumption in Asia is 58.5% of the world total, the bulk of which is in East Asia and South Asia. The share of Asia in world consumption of nitrogen is 62.1%, phosphate 57.6% and potash 46.4%. To bridge the gap between demand and supply, we can reduce the consumption of the fertilizers, by applying major and micro nutrients through foliar instead of soil application.

Foliar application can provide nutrients for plants quickly to obtain high performance guarantee. From an ecological perspective, foliar fertilization is more passable, because of small amounts of nutrients used for rapid use by plants. Foliar feeding, using foliar fertilizer, is an effective method for correcting soil deficiencies and overcoming the soil's inability to transfer nutrients to the plant. Tests have shown that up to 60% of a foliar fed nutrient solution can be found in the smallest root of a plant within 60 minutes of application. The absorption takes place through stomata of the leaves and also through the epidermis. Movement of elements is usually faster through the stomata, but the total absorption may be as great through the epidermis. Plant is also able to absorb nutrients through their stem. Although crops use low amounts of micronutrients (< 2.4 kg per ha), about half of the cultivated world's soils are deficient in plant bioavailable micronutrients, due to their slow replenishment from the weathering of soil minerals, soil cultivation for thousands of years and insufficient crop fertilization. Relevant micronutrients deficiencies occur more frequently in neutral to alkaline soils, under anaerobic conditions and in arid or semiarid regions.

In recent days, more use of inorganic fertilizers than the required amount causes environmental pollution. The production and utilization of these fertilizers in excess amounts causes emission of greenhouse gases, leading to accelerated climate change. In order to reduce the environmental hazards, by excess use of these fertilizers an alternate method is looked upon and foliar application finds its way as best method, where comparatively meagre quantity of fertilizers is required. With this view, a study was programmed to study the effect of crop response to complete nutrient supply through foliar application in vegetable cowpea.

2. MATERIALS AND METHODS

Pot culture experiments with an objective of evaluating the crop response to complete nutrient supply through foliar application in vegetable cowpea were conducted during Summer, 2022 at Eastern Block Farm, Tamil Nadu Agricultural University, Coimbatore geographically located in North Western agro-climatic zone of Tamil Nadu at 11^o North latitude, 77^o East longitude and at an altitude of 426.7 metres above MSL. The range of maximum temperature recorded during the cropping season was 35.9^{o}C and minimum temperature19.1^{o}C. Optimum temperature requirement of vegetable cowpea is 20-30^{o}C for proper growth and development. The RH during entire crop season ranged between 56.0 and 73.0%. The relative humidity during March (65.8%) was higher than average relative humidity; as a result, there was an incidence of aphids, which was controlled effectively by spraying Imidacloprid 17.8% SL @ 1 ml for 5 litres of water. The rainfall was uneven during the crop period. The rainfall received during the crop period was 99.6 mm in 11 rainy days. It was uniform towards the end of the crop season and was scarce during the initial period. The scarce period was supported with irrigation @1 litre per pot. The physico-chemical characteristics of the experimental soil was sandy clay loam in texture, Bulk Density (1.19 g/cm^3) pH (7.3), EC (0.38 d S/m), low in available nitrogen (191.6 kg ha^{-1}), medium in phosphorus (11.2 kg ha^{-1}) and high in potassium (449.8 kg ha^{-1}).

The vegetable cowpea variety PKM1 was used. The experiment was laid out in Randomized Block Design (RBD) with eight treatments and three replications.

Table 1. Experiment of Randomized Block Design (RBD) with eight treatments and three replications

Treatments	
T_1	Control
T_2	Soil application of NPK
T_3	Soil application of NPK + MN
T_4	Foliar application of 2% N
T_5	Foliar application of 2% P
T_6	Foliar application of 2% K
T_7	Foliar application of 2% N + 2% P + 2% K
T_8	Foliar application of 2% N + 2% P + 2% K + 0.5% MN

Table 2. Fertilizer application schedule

Sl. No.	Treatment	DAS	Fertilizer	Quantity (g/pot)
1.	Control (T_1)		-	-
2.	Soil application of NPK (T_2)	4	Urea	0.32
			SSP	1.88
			MOP	0.50
3.	Soil application of NPK + MN (T_3)	4	Urea	0.32
			SSP	1.88
			MOP	0.50
			$FeSO_4$	0.15
			$ZnSO_4$	0.15
4.	Foliar application of 2% N (T_4)	30,40,50	Urea	0.10
5.	Foliar application of 2% P (T_5)	30,40,50	SSP	0.62
6.	Foliar application of 2% K (T_6)	30,40,50	MOP	0.16
7.	Foliar application of 2% N + 2% P + 2% K (T_7)	30,40,50	Urea	0.10
			SSP	0.62
			MOP	0.16
8.	Foliar application of 2% N + 2% P + 2% K + 0.5% MN (T_8)	30,40,50	Urea	0.10
			SSP	0.62
			MOP	0.16
			$FeSO_4$	0.15
			$ZnSO_4$	0.15

The nutrients, Nitrogen (N), Phosphorus (P), Potassium (K), Iron (Fe), Zinc (Zn) were supplied through commercial fertilizers namely, Urea (46%), Single Super Phosphate (16%), Muriate of Potash (60%), $FeSO_4$ (19%), $ZnSO_4$ (36%), respectively.

Plastic pots were filled with 25 kg of weighed soil without clods and dirt and arranged according to the layout. Vegetable cowpea treated seeds were sown in pots. First irrigation was given immediately after sowing and life irrigation was given at 3 DAS. There after irrigation was given every alternate day @1 lit. /pot. Thinning was done on 15 DAS leaving one healthy seedling per pot. Imidacloprid 17.8% SL @ 1 ml for 5 lit. of water was sprayed on the plants whenever aphid infestation was noticed. The Recommended Dose Fertilizer (RDF) for vegetable cowpea is 25:50:50 kg NPK ha^{-1}. The fertilizer application schedule was worked out based on the RDF (Table 2).

Growth characters *viz.,* plant height, number of leaves, were recorded at 30, 40, 50 DAS. Plant Dry matter was analysed after the harvest. Yield parameters like number of green pods per plant and green pod yield per plant were recorded at harvest. Post-harvest soil samples were collected treatment wise from the pots and analysed for physico-chemical characteristics. The data on various parameters studied during the course of investigation were statistically analysed, applying the technique of analysis of variance. Wherever the treatment differences were found significant (‘F’ test), critical difference was worked out at five per cent probability level and the values were furnished. The data produced was used to interpret the results.

3. RESULTS AND DISCUSSION

Results of the pot culture experiments conducted during 2022, at Eastern Block Farm, TNAU, Coimbatore were statistically analysed for significance and tabulated. The interpolation of results along with discussion are detailed below

3.1 Growth Parameters

3.1.1 Plant height (in cm) (Table 3)

Vegetable cowpea demands large quantity of plant nutrients during flowering and pod formation stages. Absorption of all required nutrients during the peak period may not be possible. Hence, foliar application benefitted crop growth with increase in plant height and number of leaves per plant and indirectly influences yield. Plant height was recorded at 30 DAS, 40 DAS, 50 DAS. At 30 DAS, significantly higher plant height was recorded in soil application of RD NPK + MN (T_3) (10.3 cm) and least with foliar application of 2% K (T_6) and foliar application of 2% N + 2% P + 2% K (T_7). At 40 DAS, significantly highest plant height was recorded with soil application of RD NPK + MN (T_3) (25 cm). Lowest plant height was observed in control (T_1), foliar application of 2% P (T_5) and foliar application of 2% K (T_6). At 50 DAS, significantly highest plant height observed in soil application of RD NPK + MN (T_3) (46.2 cm) and least in control (T_1) and foliar application of 2% P (T_5). This might be due to continuous supply of nutrients with soil application of fertilizers and possibly washing away of foliar applied nutrients due to rainfall. The above results are in accordance with the work carried out by Fan Ling and Moshe Silbarbush (2002).

3.1.2 Number of leaves per plant (Table 3)

The number of leaves per plant were counted at 30, 40, 50 DAS of vegetable cowpea. Foliar nutrient application had significant influence on number of leaves per plant. At 30 DAS, there was significant difference on number of leaves per plant. More number of leaves per plant was observed in soil application of RD NPK + MN (T_3) (4.3 nos.) and foliar application of 2% K (T_6) (4.3 nos.). However, at 40 DAS control (T_1) recorded significantly lowest number of leaves (5.3 nos.) per plant and all the other treatments recorded higher number of leaves per plant and were on par with each other. At 50 DAS, soil application of RD NPK + MN (T_3) recorded (11.3 nos.) significantly higher number of leaves per plant.

3.1.3 Dry weight per plant (in g) (Table 4)

Dry weight per plant produced has positive correlation to plant height and number of leaves per plant. The plant dry weight of vegetable cowpea recorded ranged from 12.8 g per plant to 32.2 g per plant. Significantly, highest dry weight was recorded in soil application of RD NPK + MN (T_3) (32.2 g per plant) and on par with soil application of RD NPK (T_2) (31.2 g per plant). The lowest dry weight per plant was recorded with foliar application of 2% P (T_5) (12.8 g per plant). Application of macro nutrients and micro nutrients in soil might have facilitated more availability and absorption of nutrients

Table 3. Effect of complete nutrient supply through foliar application on plant height (in cm) and number of leaves per plant

Treatment		Plant height (in cm)			Number of leaves per plant		
		30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS
T_1	Control	8.20	19.10	37.20	3.60	5.30	9.30
T_2	Soil application of NPK	9.30	23.60	44.80	3.60	6.60	10.60
T_3	Soil application of NPK + MN	10.30	25.00	46.20	4.30	8.00	11.30
T_4	Foliar application of 2% N	8.30	23.20	44.80	3.60	6.60	9.60
T_5	Foliar application of 2% P	8.40	19.20	37.00	3.30	5.30	8.30
T_6	Foliar application of 2% K	7.80	19.10	38.10	4.30	5.60	7.60
T_7	Foliar application of 2% N + 2% P + 2% K	7.80	23.30	44.60	2.60	6.30	8.30
T_8	Foliar application of 2% N + 2% P + 2% K + 0.5% MN	8.30	23.20	44.90	3.30	6.30	8.60
S Ed		**0.31**	**4.12**	**7.60**	**0.77**	**1.13**	**1.54**
CD (0.05)		**0.66**	**8.83**	**16.31**	**1.66**	**2.42**	**3.29**

Table 4. Effect of complete nutrient supply through foliar application on number of pods per plant, yield per plant (in g), dry matter per plant (in g) and post-harvest nitrogen, phosphorus and potassium (kg ha^{-1}) in soil

Treatment		Pods per plant	Yield per plant (in g)	Dry matter per plant (in g)	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
					Initial	Final	Initial	Initial	Final	Initial
T_1	Control	15.3	72.5	16.80	192	152	11.2	6.3	450	445
T_2	Soil application of NPK	22.0	101.2	31.20	192	160	11.2	9.7	450	421
T_3	Soil application of NPK + MN	24.0	110.6	32.20	192	170	11.2	7.4	450	436
T_4	Foliar application of 2% N	17.3	74.2	24.70	192	166	11.2	6.1	450	419
T_5	Foliar application of 2% P	15.3	66.6	12.80	192	171	11.2	8.3	450	413
T_6	Foliar application of 2% K	15.0	70.6	17.40	192	176	11.2	6.3	450	403
T_7	Foliar application of 2% N + 2% P + 2% K	19.3	94.6	27.20	192	187	11.2	6.9	450	426
T_8	Foliar application of 2% N + 2% P + 2% K + 0.5% MN	18.3	102.2	26.10	192	188	11.2	6.5	450	431
S Ed		**0.8**	**3.3**	**17.57**		**29**		**1.6**		**72**
CD (0.05)		**1.7**	**7.0**	**37.68**		**62**		**3.5**		**154**

throughout the crop period. This paved way for production of more biomass leading to higher dry weight per plant. The same conclusion was derived by Andre Bationo and Ntare (2000); Fritz, (1978).

3.2 Yield Parameters

3.2.1 Number of pods per plant (Table 4)

Number of pods per plant is an important parameter to obtain higher yield in vegetable cowpea. The number of pods per plant ranged between 15.0 and 24.0 pods per plant. Soil application of RD NPK + MN (T_3) recorded significantly higher number of pods per plant(24 nos.). As the temperature recorded during the experimental period was in the required optimum range, it helped in good vegetative cover and reproductive development. Foliar application of 2% K (T_6) recorded least number of pods per plant (15 nos.). This was in accordance with the results reported by Manivannan et al*.* (2002); Ganapathy et al., (2008).

3.2.2 Yield per plant (in g) (Table 4)

Fresh pod yield of vegetable cowpea ranged from 66.6 g per plant to 110.6 g per plant. Soil application of RD NPK + MN (T_3) recorded significantly highest fresh pod yield of 110.6 g per plant and was on par with foliar application of 2% N + 2% P + 2% K + 0.5% MN (T_8) (102.2 g per plant) followed by soil application of RD NPK (T_2) (101.2 g per plant). Least fresh pod yield of 66.6 g per plant was recorded with foliar application of 2% P (T_5). The results were supported by studies of Daramy et al*. (*2017). However, comparatively higher yield was also observed in foliar application of 2% N + 2% P + 2% K + 0.5% MN (T_8) and foliar application of 2% N + 2% P + 2% K (T_7) 2% N + 2% P + 2% K (T_7) and may be due to increased absorption of nutrients through leaves and efficient translocation of photosynthates from source to sink, thus enlarging the size of the yield structure. The findings of Raghuwanshi et al*.* (1993), Hamayun and Chaudhary (2004) and Hamayun et al. (2011) have also confirmed the results of the present study. Higher yield due to complete nutrient supply through foliar application in later stages of the crop growth may have resulted in faster absorption and utilization of nutrients. Nutrient elements which are normally absorbed through roots can also be effectively absorbed through foliage. Foliar fertilization assumes greater importance because the nutrient is brought in the immediate vicinity of the metabolic area *viz.,* foliage without the process of being first mineralized in the soil, absorbed through the roots and then transported to the leaf for assimilation. The results obtained are in accordance with Jagannathan et al. (1990); Girma et al., (2007).

3.3 Post-harvest Soil Nitrogen, Phosphorus and Potassium Status (kg ha^{-1}) (Table 4)

The post - harvest NPK status of the soil showed significant variations according to the treatments imposed. The highest soil nitrogen status was observed with foliar application of 2% N + 2% P + 2% K + 0.5% MN (T_8) (188.1 kg ha^{-1}) and was on par with foliar application of 2% N + 2% P + 2% K (T_7) (186.9 kg ha^{-1}). It can be due to efficient use of foliar applied fertilizers and soil nitrogen fixation by vegetable cowpea. Soil application of RD NPK (T_2) recorded lowest post-harvest soil nitrogen content which can be correlated with its high uptake and yield. Similar trend was observed in post-harvest soil nitrogen content of the treatment soil application of RD NPK + MN (T_3). The post-harvest soil phosphorus content was highest in soil application of RD NPK (T_2) (9.7 kg ha^{-1}) and on par with foliar application of 2% P (T_5) and lowest in foliar application of 2% N (T_4) (6.1 kg ha^{-1}). This might be due to the phosphorus loving nature of legume crop. Similar result was drawn by Bagayoko et al*.* (2000). The soil potassium status was higher in control (T_1) (445.2 kg ha^{-1}) which could be due to lesser uptake by the crop resulting in lower yield. The second highest value for post-harvest soil potassium content was observed in soil application of RD NPK + MN (T_3) and foliar application of 2% N + 2% P + 2% K + 0.5% MN (T_8). The reason can be attributed towards efficient utilization of soil applied and foliar applied nutrients, respectively for translocation of photosynthates. Lowest soil potassium was recorded in foliar application of 2% K (T_6) (402.8 kg ha^{-1}) Haq and Mallarino (2000); Kaya et al., (2001).

4. CONCLUSION

Finally, to conclude from the experimental results, soil application of recommended dose of nitrogen, phosphorus and potassium on 4 DAS along with micronutrient recorded the highest pod yield per plant and it was comparable with foliar application of 2% of nitrogen, 2% phosphorus and 2% potassium along with 0.5% of micronutrient in three equal splits on 30 DAS, 40 DAS and 50 DAS.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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