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Integrated nutrient management for improving growth and yield of cowpea

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ABSTRACT

A field experiment was conducted to study different sources of fertilizer nutrients in different combinations and their effect on growth and yield of cowpea in kharif 2018 and 2019. The results revealed that 100% recommended dose of fertilizers (RDF) + 1% 19:19:19 NPK fertilizer spray at 30 days after sowing (DAS) recorded higher plant height (36.33 and 38.3 cm), number of branches (5.93 and 8.8), pods plant^{-1} (16.8 and 17.68), seeds pod^{-1} (15.4 and 16.9), seed yield (1519 and 1688 kg ha^{-1}), which ultimately fetched higher gross return of Rs. 45,570 and 55,704 ha^{-1}, net return of Rs. 19,220 and 28,774 ha^{-1} and benefit:cost ratio of 1.73 and 2.07 in the first and second year, respectively. The same treatment was found as effective as 100% RDF + seed treatment (Rhizobium + phosphate solubilizing bacteria) + 2% urea spray at 30 DAS in respect of all the observations.

Keywords: Cowpea, foliar spray, seed treatment, 19:19:19 fertilizer, seed yield

Cowpea (*Vigna unguiculata*) is an important pulse crop as a rich source of protein, minerals and energy. The crop fits well into the cropping system for its initial fast growth, extensive root development, early establishment, short duration, soil-enriching capacity, and increased profitability in the wake of drought-like situation. Since cowpea contains about approximately 4.3 g protein, 2.0 g fibre, 8.0 g carbohydrate and 84.6 g water along with a higher amount of fats and minerals (Dey *et al*., 2020), it is often recognised as vegetable meat. India covers an area of about 6.5 million hectares under cowpea with an annual production of about 5.9 million tonnes and average productivity of 916 kg ha^{-1} (Anon., 2015). In general, the area under pulses has been increased over the years although the level of productivity is not much satisfactory due to intensive cropping and injudicious use of chemical fertilisers. Conventionally the crop is cultivated with the use of straight fertilizers and without using bio-fertilizers or any other supplementary sources of nutrients. As a way of supplementary nourishment, foliar nutrition can be considered as an effective method which plays a vital role in the successful cultivation of legumes. Foliar nutrition enhances nodulation, root growth and development, energy transformation as well as various metabolic reactions in plants which improve the yield potential through enhanced nutrient recovery (Dey *et al*. 2020). Since cowpea is a legume crop, having the capacity to fix atmospheric nitrogen, seed treatment with nitrogen-fixing bacteria and phosphorous solubilizing bacteria (PSB) can improve the nitrogen fixation and phosphorous uptake capacity of the plant from the soil. Nitrogen and phosphorous are the basic nutrient elements for healthy plant growth and root development which promotes nodulation process whereas phosphorous increases protein content probably by increasing fixed N in plants. However, still there is a dearth of information related to the compatibility of the agronomic practices to mitigate the changing climatic situation, adverse impact of greenhouse gases, global warming, biotic and abiotic stresses, escalating costs of agricultural inputs, etc. This study would possibly come out with a recommendation for improving production and profits with the use of cheaper sources of nutrients which would ensure balanced nutrition, food security, and living standard of common people (Sebetha *et al*. 2010).

MATERIALS AND METHODS

A field experiment was conducted to study the influence of different integrated nutrient management (INM) practices on the growth and yield of cowpea during *kharif* 2018 and 2019 at Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India. Cowpea variety KBC-2 is mutant variety of V16, released from University of Agricultural Sciences, Bangalore during 2001. It has semi-determinate, light brown seeds, matures in 95 to 100 days. It is suited for *kharif, rabi* and summer seasons (it can be grown throughout the year). The soil of the experimental site was acidic (pH 6.1) with medium fertility status (available nitrogen 267 kg ha^{-1}, available phosphorous 38 kg ha^{-1} and available potassium 154 kg ha^{-1}). Eight treatments were assigned

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in a completely randomized block design with three replications. The treatments included 100% recommended dose of fertilizers (RDF) (control), 100% RDF + water spray, 100% RDF + seed treatment with Rhizobium + phosphate solubilizing bacteria (PSB), 100% RDF + seed treatment + 2% urea spray, 100% RDF + seed treatment + 1% 19:19:19 NPK fertilizer spray, 50% RDF + 2.5 t FYM ha^{-1}, 50% RDF + 2.5 t FYM ha^{-1} + 2% urea spray, 50% RDF + 2.5 t FYM ha^{-1} + 1% 19:19:19 NPK fertilizer spray. Urea, single super phosphate (SSP) and muriate of potash (MOP) were used as sources of NPK (25:50:25 kg ha^{-1}). The full dose of nitrogen, phosphorus and potassium were applied at the time of sowing. FYM was applied at the rate of 3 t ha^{-1} before two weeks of sowing. According to the treatments, microbial inoculants were seed treated before 3 hours of sowing and nutrients were sprayed 30 days after sowing. Individual plot size was 4.5 m × 4.0 m. Single seed was sown in each hill at a depth of 5 cm and spacing of 45 cm (row to row) and 10 cm (plant to plant) was maintained. All sorts of plant protection measures along with water and weed management practices were followed in all the treatments as per recommendation.

Observations recorded

Growth parameters

Plant height: The plant height at harvest stage was measured from the ground level to the tip of the fully opened leaves in main shoot of the selected five plants from each net plot. Average values from each plot were computed and expressed in cm.

Number of branches $plant^{-1}$: The randomly selected five plants were used for recording the number of branches $plant^{-1}$ at harvest stage. Total numbers of secondary branches $plant^{-1}$ were counted and average values from each plot were worked out and recorded.

Yield parameters

Number of pods $plant^{-1}$: Five plants from each treatment in all replications were harvested separately and counted number of pods per plant.

Pod length and number of seeds pod^{-1} : Five pods from five plants in each treatment were harvested separately and pod length was measured separately and mean value was mentioned in cm. Similarly from the same pod, number of seeds were counted.

Seed yield (kg ha^{-1}): Grain yield obtained from each net plot area was used for calculating grain yield and mentioned in kg ha^{-1}.

Economics

Cost of cultivation: The cost of cultivation (Rs. ha^{-1}) of each treatment was worked out by considering the price of inputs, charges for cultivation, labour, land and other charges.

Gross returns: The gross returns ((Rs. ha^{-1}) occurred due to different treatments in the present study were worked out by considering market prices of economic product, by product and crop residues.

Net returns: The net returns (Rs. ha^{-1}) of each treatment was worked out by deducting the mean cost of cultivation (Rs. ha^{-1}) of each treatment from the gross returns (Rs. ha^{-1}) gained from the respective treatments.

Benefit: Cost ratio (B:C): The benefit: cost ratio of each treatment was calculated by dividing the gross returns with the mean cost of cultivation.

Statistical analysis

The experimental data pertaining to each character were analyzed statistically by using the technique of Analysis of Variance for Factorial Randomized Block Design. The significance was tested by "Variance ratio" (F), standard error of mean (S.Em. ±) and critical difference (C.D.) were worked out for each character studied to evaluate differences between the treatments and interaction effect at 5 per cent level.

RESULTS AND DISCUSSION

Effect on crop growth

The plant height of cowpea was significantly influenced by different treatments. Application of 100% RDF in combination with seed treatment and foliar spray of NPK fertilizer (19:19:19) at 30 DAS recorded an improved plant height (36.33 and 38.3 cm in first and second year, respectively), which remained at par with 100% RDF + seed treatment with or without foliar spray of 2% urea solution (Table 1). Higher plant height of cowpea with the conjoint application of chemical fertilizer and bio-fertilizer was earlier reported by Hossain *et al*. (2017). Number of branches $plant^{-1}$ did not differ due to different treatments although it was numerically higher in 100% RDF + seed treatment + 1% 19:19:19 NPK fertilizer spray (5.93 and 8.88 in first and second year, respectively). These results were in consonance with the observations of Chauhan *et al*. (2016). Seed treatment with the beneficial microorganisms was found effective since Rhizobium could help in biological fixation of atmospheric nitrogen in the plants and PSB could convert the unavailable form of phosphorous into available form which might be attributed to the increased uptake of the phosphorous. These beneficial microorganisms not only could help in the uptake of the nutrients from the soil, they did contribute to the overall growth and development of the crop plants through secretion of several growth promoting substances such as IAA, lumichrime, riboflavin, gibberlins, cytokinins, jasmonates and many

Table 1: Effect of different treatments on growth of cowpea

Treatment	Plant height (cm)		Branches plant^{-1}	
	2018	2019	2018	2019
Control (100% RDF)	26.63	28.9	4.33	5.46
100% RDF + water spray	28.07	30.17	4.4	5.78
100% RDF + seed treatment	35.63	36.61	5.27	6.92
100% RDF + seed treatment + 2% urea spray	36.03	37.93	5.57	8.17
100% RDF + seed treatment + 1% 19:19:19 spray	36.33	38.3	5.93	8.88
50% RDF + FYM $^{-1}$	31.4	32.94	5.00	6.08
50% RDF + FYM $^{-1}$ + 2% urea spray	32.07	34.87	5.07	6.13
50% RDF + FYM + 1% 19:19:19 Spray	34.97	35.77	5.13	6.31
SEm(±)	1.5	2.05	0.35	0.96
LSD (0.05)	4.55	6.05	NS	NS

NS: Not significant, RDF: Recommended dose of fertilizers

more which finally helped in tapping the full potential of the crop (Dal Cartivo *et al*. 2020). Because of indeterminate growth habit, the crop responded well to the availability of more amounts of nutrients, which could increase the plant height. Foliar application of NPK could improve the crop growth because of the fact that the absorption of nutrients through stomata was rapid when fertilizers were applied directly on the foliage. Combined application of 100% RDF + seed treatment + 1% 19:19:19 NPK fertilizer spray could provide sufficient amount of NPK to the crop plants. In this treatment combination, nitrogen played an important role to improve the plant height, phosphorous could stimulate the growth of the lateral buds, leading to more number of branches in the plant, and potassium could help in activating metabolic enzymes which improved the overall growth and development of the crop. It was observed that application of water soluble fertilizers significantly increased the N, P and K contents in leaves (Singhal *et al*., 2016). Bute *et al*. (2019) reported that foliar nutrition of 2% urea and 19:19:19 NPK fertilizer was equally effective to improve number of branches as well as plant height. Similar results were also reported with higher number of branches and plant height when supplied with 2% urea (Dey *et al*., 2017). The plants supplied with NPK (19:19:19) as foliar application along with RDF (basal dose) recorded higher plant height due to adequate availability of NPK (in 100% RDF treatments), which might have helped in better harvesting of solar energy whereas the increased uptake of nutrients promoted plant height probably by increasing the cell division, elongation and photosynthetic activities (Rajasingh and Lourduraj, 2014).

Effect on crop yield and ancillary parameters

The influence of treatments on the seed yield and ancillary parameters was found significant in both the years of experimentation (Table 2). Higher seed yields were recorded with the application of 100% RDF + seed treatment + 1% 19:19:19 NPK (1519 and 1688 kg ha^{-1}), which was, however, on par with the treatments viz. 100% RDF + seed treatment + 2% urea spray (1472 and 1598 kg ha^{-1}) and 100% RDF + seed treatment (1413 and 1502 kg ha^{-1}) in first and second year, respectively. Similarly higher number of pods plant^{-1} (16.8 and 17.68) and pod length (16.73 and 16.83 cm) were recorded with 100% RDF + seed treatment + 1% 19:19:19 spray in first and second year, respectively. Higher yields under these treatments were attributed to the improved yield attributes viz. number of pods plant^{-1} as well as pod length. The main reasons for the improvement in yield parameters were higher plant height which helped in better utilization of the sunlight and increased number of branches with more number of leaves and pods plant^{-1} which led to an increase in total dry matter accumulation of the crop and thereby helped in achieving higher seed yield. Higher yield with the foliar application of 0.5% NPK (19:19:19) was reported earlier by Singhal *et al*. (2016), and it was explained due to higher nutrient uptake in seed and plant. Number of seeds pod^{-1} did not significantly vary due to different treatments although it was numerically higher in 100% RDF + seed treatment + 1% 19:19:19 NPK fertilizer spray, which increased the pod length, accommodating more number of seeds pod^{-1}. Chatterjee and Bandyopadhyay (2017) reported improved yield and yield parameters due to seed treatment with bio-fertilizers along with molybdenum in cowpea. Meena *et al*. (2016) observed similar results in greengram where higher yield and yield parameters were recorded with higher doses of fertilizer application and seed treatment with Rhizobium. Pandey *et al*. (2019) also found similar results in greengram. Higher seed yield of cowpea was

Table 2: Effect of different treatments on yield parameters and seed yield of cowpea

Treatment	Pods plant^{-1}		Seeds pod^{-1}		Pod length (cm)		Seed yield (kg ha^{-1})	
	2018	2019	2018	2019	2018	2019	2018	2019
Control (100% RDF)	12.87	13.07	13.03	14.13	12.77	12.99	969	1008
100% RDF + water spray	13.27	13.87	13.3	14.54	13.6	13.15	1054	1167
100% RDF + seed treatment	14.5	16.65	15.07	16.18	15.37	15.23	1413	1520
100% RDF + seed treatment + 2% urea spray	15.19	17.02	15.13	16.53	15.6	15.79	1472	1598
100% RDF + seed treatment + 1% 19:19:19 spray	16.8	17.68	15.4	16.9	16.73	16.83	1519	1688
50% RDF + FYM $^{-1}$	13.53	14.75	13.87	15.01	13.9	13.98	1144	1214
50% RDF + FYM $^{-1}$ + 2% urea spray	14.17	15.31	14.53	15.52	14.27	14.39	1210	1330
50% RDF + FYM + 1% 19:19:19 Spray	14.3	15.99	14.9	15.71	14.8	14.68	1261	1387
S.Em. (+)	0.65	0.55	0.7	0.57	0.65	0.87	78.7	82.57
LSD (p=0.05)	1.98	1.65	NS	NS	1.98	2.52	235.1	247.7

NS: Not significant, RDF: Recommended dose of fertilizers

Table 3: Production economics as influenced by different treatments

Treatment	Cost of cultivation (Rs. ha^{-1})		Gross return (Rs. ha^{-1})		Net return (Rs. ha^{-1})		BCR	
	2018	2019	2018	2019	2018	2019	2018	2019
Control (100% RDF)	24592	24592	29070	33264	4478	8672	1.18	1.35
100% RDF + water spray	24842	25042	31620	38511	6778	13469	1.27	1.54
100% RDF + seed treatment	25092	25592	42390	50160	17298	24568	1.69	1.96
100% RDF + seed treatment + 2% urea spray	25692	26392	44160	52734	18468	26342	1.72	2.00
100% RDF + seed treatment + 1% 19:19:19 spray	26350	26930	45570	55704	19220	28774	1.73	2.07
50% RDF + FYM $^{-1}$	26692	27730	34320	40062	7628	12332	1.29	1.44
50% RDF + FYM $^{-1}$ + 2% urea spray	27116	29100	36300	43890	9184	14790	1.34	1.51
50% RDF + FYM + 1% 19:19:19 Spray	27512	29312	37830	45771	10318	16459	1.38	1.56

BCR: Benefit/cost ratio NS: Not significant, RDF: Recommended dose of fertilizers

reported due to supply of NPK (19:19:19) through foliar application along with RDF (Rajasingh and Lourduraj, 2014).

Effect on production economics

Application of 100% RDF + seed treatment + foliar spray of 1% 19:19:19 at 30 DAS fetched higher gross return of Rs. 45,570 and 55,704 ha^{-1}, net return of Rs. 19,220 and 28,774 ha^{-1} and B : C ratio of 1.73 and 2.07 in first and second year, respectively. Higher gross return, net return and B : C ratio were mainly attributed to the higher seed yield in the treatment. Bhagariya *et al*. (2020) reported higher gross income and net return with the application of 100% RDF along with 5 t FYM ha^{-1}. Similar results were reported earlier by Yadav *et al*. (2012). Higher B:C ratio with Rhizobium and 75% RDF over other treatment combinations was due to higher yield (Chauhan *et al*., 2016).

CONCLUSION

Application of 100% RDF + seed treatment + foliar spray of 1% 19:19:19 NPK at 30 DAS in cowpea recorded higher yield and economic returns. From this experiment we conclude that pulse crop requires nutrients at 30 days after sowing for good establishment of plants and similarly seed treatment with nutrients enhanced the plant stand establishment.

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