RESEARCH ARTICLE
Legume Research- An International Journal, Volume Issue : ()

# Foliar Nutrition with Water Soluble Macro and Micro Nutrient Fertilizers for Yield Maximization in Bush Vegetable Cowpea

R.K. Krishnasree[1], Sheeja K. Raj[1], P. Shalini Pillai[1], K. Prathapan[2], D. Jacob[3], R. Beena[1],
**10.18805/LR-4761**


## ABSTRACT

**Background:** Cowpea is a leguminous crop of indeterminate growth habit and continues to produce flowers throughout its life cycle. In order to realize the genetic yield potential of cowpea, nutrient requirements of later formed flushes also needs to be met. Hence the present study was formulated to assess the effect of foliar application of water-soluble macro nutrient fertilizers *viz*., NPK 19:19:19 and potassium nitrate and micronutrient fertilizers *viz*. zinc sulphate and solubor for yield maximization in bush vegetable cowpea.
**Methods:** The field experiment was conducted at Coconut Research Station, Balaramapuram, during *Rabi* 2020-21. The experiment was laid out in randomized block design with 13 treatments in three replications. The treatments comprised of recommended dose of conventional fertilizers (RDF) NPK 20:30:10 kg $ha^{-1}$ as control and RDF + foliar application of water-soluble fertilizers 19:19:19 (0.5%) and potassium nitrate (0.5%) with zinc sulphate (0.05%) and solubor (0.025%) in twelve different combinations.
**Result:** Results revealed that compared to RDF alone, RDF + foliar application of water-soluble macro and micro nutrient fertilizers at 45 DAS significantly improved the dry matter production, number of pods per plant and pod weight and recorded a yield enhancement of 22 to 55 per cent. Among the treatments, RDF + foliar application of 19:19:19 (0.5%) and solubor (0.025%) at 45 DAS recorded the highest dry matter production per plant (39.51 g), pods per plant (30.88 no.), pod yield (7410 kg $ha^{-1}$), net return (82651 Rs $ha^{-1}$) and B:C ratio (2.26). The treatments, RDF + foliar application of 19:19:19 (0.5%) at 45 DAS; RDF + foliar application of 19:19:19 (0.5%), zinc sulphate (0.05%) and solubor (0.025%) at 45 DAS; and RDF + foliar application of potassium nitrate (0.5%) and solubor (0.025%) at 45 DAS also recorded comparable number of pods per plant, green pod yield, net return and B:C ratio. Considering the highest green pod yield, net return and B:C ratio, RDF + foliar application of NPK 19:19:19 (0.5%) and solubor (0.025%) at 45 DAS could be recommended for yield maximization in bush type vegetable cowpea.


**Key words:** Foliar application, NPK19:19:19, Potassium nitrate, Solubor, Vegetable cowpea, Water soluble fertilizers, Zinc sulphate.

## INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp] is a leguminous crop of indeterminate growth habit continues to produce flowers throughout its life cycle grown mainly for vegetable, grain and fodder. In India, cowpea was cultivated in an area of 0.5 million ha (Rajpoot and Rana, 2016) and the leading cowpea producing states in India are Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra and Gujarat (Directorate of Pulses development, 2017). Cowpea is the major vegetable crop of Kerala cultivated in an area of 5803.05 ha (FIB, 2021). The recommended dose of fertilizers (RDF) for cowpea cultivation in Kerala was 20 kg N, 30 kg $P_2O_5$ and 10 kg $K_2O$ $ha^{-1}$ (KAU, 2016). Full dose of P and K were applied as basal and remaining half N at 30 DAS which was found inadequate to meet the nutrient requirements of later formed flowers and pods. Hence, under field condition yield potential of the crop was not achieved. In order to realize the genetic yield potential of cowpea, nutrient requirements of later formed flushes also needs to be met. Foliar application is a means of rapid correction of nutrient deficiencies as well as physiological disorders in crop plants. Foliar application was 6, 4 and 20 times more beneficial than soil application in case of N, Zn and B respectively (Dixon, 2003). Supplementary feeding of nutrients through foliage improves the plant nutrient status and crop yield (Krishnasree *et al*., 2021). A significant increase in number of fruits per plant, fruit weight and fruit diameter were observed due to foliar spray of 19:19:19 (2%) twice at vegetative stage followed by 0:52:34 (2%) during flowering stage and 13:0:45 (2%) twice at fruit development stage in comparison to no foliar spray (Narayan *et al.,* 2011). Foliar application of K 2g $L^{-1}$ favourably influenced number of fruits per plant and fruit weight in brinjal (Ramadan and Shalaby, 2016). The highest number of fruits per vine and fruit weight were recorded in foliar application of DAP (1.5%) and boric acid (0.1%) at 35 DAS followed by one more spray of boric

[1]College of Agriculture, Kerala Agricultural University, Vellayani-695 522, Kerala, India.
[2]Coconut Research Station, Balaramapuram-695 501, Kerala, India.
[3]OFR Centre, College of Agriculture, Vellayani-695 522, Kerala, India.

**Corresponding Author:** Sheeja K. Raj, College of Agriculture, Kerala Agricultural University, Vellayani-695 522, Kerala, India. Email: sheeja.raj@kau.in

**How to cite this article:** Krishnasree, R.K., Raj, S.K., Pillai, P.S., Prathapan, K., Jacob, D. and Beena, R. (2021). Foliar Nutrition with Water Soluble Macro and Micro Nutrient Fertilizers for Yield Maximization in Bush Vegetable Cowpea. Legume Research. DOI: 10.18805/LR-4761.

**Submitted:** 03-08-2021 **Accepted:** 18-10-2021 **Online:** 01-11-2021

acid (0.1%) at 45 DAS in cucumber (Mondal *et al.,* 2017). An enhancement in number of flowers per plant, number of pods per plant, pod length and pod weight were noticed in cowpea due to application of 125 per cent RDF along with 2 per cent DAP spray at flowering and pod formation stages (Kavitha *et al*., 2019). Foliar nutrition of Zn (100 mg $L^{-1}$) and B (100 mg $L^{-1}$) recorded significantly higher fruit length and number of fruits per plant in tomato receiving (Saravaiya *et al.,* 2014). Foliar feeding of Zn (0.05%) in combination with B (0.03%) recorded the highest fruit length, fruit diameter as well as fruit weight in tomato (Sultana *et al.*, 2016). With this back ground, the present study was formulated with an objective to assess the effect of foliar nutrition of water-soluble macro and micronutrient fertilizers for yield maximization in bush vegetable cowpea.

## MATERIALS AND METHODS

Field experiment was conducted during *Rabi* 2020-21 at Coconut Research Station, Balaramapuram, Thiruvananthapuram, Kerala located at 8°22′52″ North latitude and 77°1′ 47″ East longitude and at an altitude of 9 m above MSL with an objective to assess the effect of water-soluble macro and micronutrient fertilizers on yield maximization in bush vegetable cowpea. The experiment was laid out in randomized block design with 13 treatments. The treatment details are presented in the Table 1. Experimental site was prepared by ploughing the field with a garden tiller twice and was properly levelled and treatment plots having a gross plot area 3.6 m × 3.6 m were laid out. Small bunds were taken all around the treatment plots. The soil of the experimental field was strongly acidic with a pH of 4.71, normal in electrical conductivity (0.04 $dSm^{-1}$), high in organic carbon (1.29%), medium in available N (313.6 kg $ha^{-1}$), high in available P (39.23 kg $ha^{-1}$) and medium in available K (235.21 kg $ha^{-1}$). Bhagyalakshmi, a short duration, multi season, multipurpose, bush vegetable cowpea, highly resistant to anthracnose disease having a yield potential of 6.48 t $ha^{-1}$ released from College of Agriculture, Vellanikkara was used as the test crop. Seed rate adopted was 25 kg $ha^{-1}$. Before sowing, seeds were primed in 0.05 per cent zinc sulphate for 4 h and dried back to original moisture content. Seeds were dibbled at a spacing of 30 cm × 15 cm. Farm yard manure @ 20 t $ha^{-1}$ and lime @ 250 kg $ha^{-1}$was uniformly applied to all plots. Fertilizers were applied as per the treatments. All other agronomic practices were carried out as per POP recommendations of crops for Kerala (KAU, 2016). Observations on growth attributes *viz*., plant height, number of branches and dry matter production were recorded at 60 DAS and at 80 DAS (final harvest) from the five observation plants which were randomly selected and tagged. Yield attributing characters *viz*., number of pods per plant, individual pod weight, pod length and girth were also recorded from the observation plants. Tender pods were harvested from the net plot area of each treatment starting from 45 DAS and continued up to 80 DAS. Pod yield per hectare and haulm yield per hectare were calculated from the pod and haulm yield obtained from the net plot area. Economics was worked out based on the prevailing market price of the inputs and price of the tender pods (` 20 $kg^{-1}$). Analysis of variance technique for RBD (Cochran and Cox, 1965) was used for the statistical analysis of the experimental data and the significance was tested using F test. The treatment means were compared at 5 per cent probability level.

## RESULTS AND DISCUSSION

### Effect on growth attributes

Foliar nutrition of macro and micro nutrients had significant effect on growth attributes *viz*., number of branches per plant and DMP per plant. Compared to POP, foliar nutrition treatments registered higher values for number of branches per plant and DMP per plant. The treatment $T_{12}$ recorded the highest number of branches per plant both at 60 DAS and at final harvest. At 60 DAS higher dry matter production was recorded in treatment $T_2$ which was on par with $T_5$ and $T_8$. At final harvest $T_5$ registered higher DMP and was statistically at par with $T_8$, $T_{13}$ and $T_{12}$. Better expression of growth attributes in these treatments might be due to the quick access of plants to nutrients due to foliar application (Dey *et al.,* 2017). Increased availability and uptake of nutrients might have resulted in enhanced photosynthesis and translocation of photosynthates from source to the growing plant parts leading to better expression of growth attributes in these treatments. The results obtained are in consonance with the observations of Haleema *et al.* (2018) who observed that foliar application of Zn and B resulted in enhanced vegetative growth due to increase in photosynthetic and metabolic activity, cell division and cell elongation. Elhindi *et al.* (2016) reported that foliar application of $KNO_3$ improved the plant growth by enhancing the physiological process *viz*., osmoregulation, stomatal conductance, photosynthesis, protein synthesis, solute transport and nitrate metabolism. Significant increase in dry matter production was observed in chilli owing to foliar application of water-soluble fertilizers (Muthumanickam and Anburani, 2017). Banasode and Math (2018) opined that foliar application of water-soluble fertilizers significantly influenced the uptake of nutrients. Better uptake of nutrients increased the physiological process like photosynthesis, chlorophyll formation, protein synthesis, nitrate metabolism and carbohydrate synthesis which ultimately results in increased DMP. Foliar application of solubor also contributed to higher DMP in $T_5$. Boron plays an important role in increasing the permeability of cell membrane which led to better transportation of sugars and carbohydrates ultimately leading to higher DMP (Thakur *et al.*, 2019).

### Effect on yield attributes

Compared to POP recommendation of fertilizers ($T_1$), foliar application of macro and micro nutrients had significant effect on pods per plant and individual pod weight. Fageria (1992) opined that number of pods per plant is the most important yield determining character in pulses. Rapid availability of nutrients under foliar application leads to accelerated rate of physiological processes which ultimately improved the plant growth and number of pods per plant (Khanda *et al*., 1999). Krishna and Kaleeswari (2018) opined that foliar application of macro and micro nutrients increased the number of flower buds and their retention by maintaining optimum bio-physiological conditions compared to control (without foliar application). Treatment $T_5$ recorded the highest number of pods per plant and it was statistically on par with $T_2$, $T_6$ and $T_{11}$. Premsekhar and Rajashree (2009) reported that foliar application of 19:19:19 significantly enhanced the number of fruits per plant in tomato. Higher number of pods per plant observed in $T_5$ and $T_{11}$ was also due to the favorable influence of B in enhancing the fruit setting percentage by enhancing the pollen viability (Praveena *et al*., 2018), pollen germination and elongation of pollen tube (Narayanamma *et al*., 2009). Better expression of growth attributes (Table 2) and higher availability (Table 4) and uptake of nutrients also contributed to higher number of pods per plants in treatments $T_5$, $T_2$, $T_6$ and $T_{11}$. Meena *et al.* (2017) opined that foliar application of nutrients improved the source-sink relation leading to less intra plant competition for nutrients.

Foliar application of macro and micro nutrients had significant effect on individual pod weight. Treatment $T_2$ recorded significantly higher pod weight and it was on par with $T_5$, $T_6$, $T_8$, $T_9$, $T_{10}$, $T_{11}$ and $T_{13}$. Higher pod weight recorded in these treatments might be due to better partitioning of assimilate from source to sink. This was clearly evident from the data on harvest index (Table 3). Guievence and Badem (2000) reported that foliar application of nutrients promotes better uptake of nutrients and water leading to improvement in photosynthesis and better partitioning of assimilates to the edible parts. Better sugar translocation triggered by the foliar application of B (Meena, 2010) might have contributed

**Table 1:** Treatment details.

| Treatment no. | Treatment details |
|---|---|
| $T_1$ | RDF (20:30:10 NPK kg $ha^{-1}$) |
| $T_2$ | $T_1$+ foliar application of 19:19:19 (0.5%) at 45 DAS |
| $T_3$ | $T_2$ + foliar application of 19:19:19 (0.5%) at 60 DAS |
| $T_4$ | $T_2$ + foliar application of zinc sulphate (0.05%) at 45 DAS |
| $T_5$ | $T_2$+ foliar application of solubor (0.025%) at 45 DAS |
| $T_6$ | $T_2$+ foliar application of zinc sulphate (0.05%) and solubor (0.025%) at 45 DAS |
| $T_7$ | $T_6$ + foliar application of 19:19:19 (0.5%) at 60 DAS |
| $T_8$ | $T_1$ + foliar application of potassium nitrate (0.5%) at 45 DAS |
| $T_9$ | $T_8$ + foliar application of potassium nitrate (0.5%) at 60 DAS |
| $T_{10}$ | $T_8$ + foliar application of zinc sulphate (0.05%) at 45 DAS |
| $T_{11}$ | $T_8$ + foliar application of solubor (0.025%) at 45 DAS |
| $T_{12}$ | $T_8$ + foliar application of zinc sulphate (0.05%) and solubor (0.025%) at 45 DAS |
| $T_{13}$ | $T_{12}$ + foliar application of potassium nitrate (0.5%) at 60 DAS |

**Table 2:** Effect of foliar nutrition on the growth attributes of bush vegetable cowpea.

| Treatments | Plant height (cm) | | Number of branches per plant | | Dry matter production (g per plant) | |
|---|---|---|---|---|---|---|
| | 60 DAS | 80 DAS | 60 DAS | 80 DAS | 60 DAS | 80 DAS |
| $T_1$: (RDF) | 74.95 | 78.13 | 2.60 | 2.98 | 20.51 | 24.69 |
| $T_2$: ($T_1$ + 19:19:19 at 45 DAS) | 72.78 | 72.83 | 3.20 | 4.25 | 27.45 | 35.28 |
| $T_3$: ($T_2$ + 19:19:19 at 60 DAS) | 73.61 | 75.39 | 3.10 | 3.18 | 24.33 | 29.55 |
| $T_4$: ($T_2$ + $ZnSO_4$ at 45 DAS) | 71.63 | 72.73 | 3.20 | 3.25 | 24.12 | 30.12 |
| $T_5$: $T_2$ + solubor at 45 DAS) | 73.53 | 76.89 | 3.13 | 3.92 | 25.60 | 39.51 |
| $T_6$: ($T_2$ + $ZnSO_4$ and solubor at 45 DAS) | 71.59 | 72.86 | 3.08 | 3.67 | 25.79 | 34.28 |
| $T_7$: ($T_6$ + 19:19:19 at 60 DAS) | 76.52 | 80.13 | 2.87 | 3.42 | 25.57 | 31.65 |
| $T_8$: ($T_1$ + $KNO_3$ at 45 DAS) | 76.04 | 77.37 | 3.13 | 4.33 | 25.70 | 37.52 |
| $T_9$: ($T_8$ + $KNO_3$ at 60 DAS) | 70.99 | 72.21 | 2.87 | 3.00 | 26.11 | 32.60 |
| $T_{10}$: ($T_8$ +$ZnSO_4$ at 45 DAS) | 72.48 | 75.40 | 3.08 | 3.25 | 22.16 | 33.95 |
| $T_{11}$: ($T_8$ +solubor at 45 DAS) | 72.57 | 73.67 | 3.40 | 4.00 | 25.77 | 35.41 |
| $T_{12}$: ($T_8$ + $ZnSO_4$ and solubor at 45 DAS) | 70.68 | 73.19 | 3.53 | 4.50 | 25.08 | 35.61 |
| $T_{13}$: ($T_{12}$ + $KNO_3$ at 60 DAS) | 72.85 | 72.90 | 3.27 | 3.63 | 25.66 | 36.89 |
| SEm (±) | 2.373 | 2.038 | 0.146 | 0.237 | 1.135 | 1.337 |
| p= 0.05 | NS | NS | 0.428 | 0.697 | 3.333 | 3.925 |

Ns: not significant.

to higher pod weight in $T_5$, $T_6$ and $T_{11}$. The increase in pod weight observed in $T_5$, $T_6$ and $T_{11}$ are in consonance with the results of Pandav *et al.* (2016) in brinjal and Harris *et al.* (2018) in chilli. Haque *et al.* (2011) opined that higher levels of B resulted in better uptake of water, synthesis of sugars and translocation of metabolites to sink tissues. Favourable effect of Zn in sugar translocation (Singh and Tiwari, 2013), IAA synthesis (Shnain *et al.,* 2014) and reduction in flower drop (Ali *et al*., 2008) also contributed to higher individual pod weight in $T_6$, $T_{10}$ and $T_{13}$.

Foliar application of macro and micro nutrients did not contribute significantly to pod length and pod girth. This might be due to the fact that these characters are highly associated with the genetic makeup of the variety.

**Effect on yield and harvest index**

Foliar application of macro and micro nutrients significantly enhanced the pod yield compared to POP recommendation ($T_1$). Among the treatments, the highest pod yield was recorded in the treatment $T_5$ which was statistically on par with $T_2$, $T_6$ and $T_{11}$. Higher pod yield registered in these treatments was due to the production of higher number of pods per plant and pods with higher weight (Table 3). Foliar nutrition of 19:19:19 resulted in increased availability and assimilation of major nutrients (Singhal *et al*., 2015) and the favourable influence of B in various physiological processes *viz*., calcium metabolism, auxin synthesis, sugar metabolism, translocation of solutes and protein synthesis (Thakur *et al*., 2019) led to the formation of higher number of pods per plant which finally contributed to higher pod yield in $T_5$. Tariq and Mott (2007) revealed that B deficiency during flowering prevents the growth of the pollen tube leading to pollen sterility, flower drop and poor seed setting. Foliar nutrition of P enhances cell division (Reddy *et al*., 2017) leading to production of higher number of branches (Table 2) and pods per plant which finally contributed to higher yield in $T_2$. Yield enhancement in $T_{11}$ might be due to the favourable influence of K and B. Potassium promotes the water use efficiency of plants and assimilate translocation towards sink (Zhao *et al*., 2001). Vekaria *et al*. (2013) revealed that foliar nutrition of $KNO_3$ 0.4 per cent significantly increased the grain yield of green gram by 18.4 per cent compared to control. Higher yield registered in $T_6$ was due to the better expression of growth and yield attributes (Table 2 and 3). Similar observations were also made by Wasaya *et al*. (2017) in maize and Ali *et al.* (2015) in tomato.

Foliar application of macro and micro nutrients also had significant effect on haulm yield and the highest haulm yield was registered by $T_{13}$, whereas the lowest haulm yield was recorded in $T_1$. Compared to $T_1$, all the foliar nutrition treatments registered higher haulm yield. This might be due to the fact that foliar application of primary nutrients along with Zn and B enhanced the crop growth (Krishna and Kaleeswari, 2018). Adequate availability of N favours vegetative growth and formation of dark green leaves which would actively participate in photosynthesis (Thakur *et al.,* 1991). Favourable influence of boron on meristematic activity and cell division also contributed to higher dry matter production. In addition, B increases the permeability of cells thereby permitting increased translocation of sugars and carbohydrates (Thakur *et al*., 2019). Zinc had a major role in the synthesis of auxin, a plant growth promoter crucial for better growth (Singh and Tiwari, 1989). Reduced Zn availability leads to shortened internodes and chlorosis of leaves which reduces assimilatory surface area available for photosynthesis (Yadav *et al*., 2014).

The highest HI was recorded in treatment $T_7$. This was due to lower haulm yield registered in the treatment compared to other foliar treatments (Table 3). Enzyme activation and biosynthesis of enzymes, growth hormones mediated by Zn also helped in better vegetative growth of plants (Rout and Das, 2003) which in turn led to the synthesis

**Table 3:** Effect of foliar nutrition on yield attributes of bush vegetable cowpea.

| Treatments | Number of pods per plant | Individual pod weight (g) | Pod length (cm) | Pod girth (cm) |
|---|---|---|---|---|
| $T_1$: (RDF) | 17.15 | 3.23 | 16.85 | 2.24 |
| $T_2$: ($T_1$ + 19:19:19 at 45 DAS) | 27.97 | 4.16 | 17.43 | 2.22 |
| $T_3$: ($T_2$ + 19:19:19 at 60 DAS) | 21.22 | 3.64 | 16.96 | 2.16 |
| $T_4$: ($T_2$+ $ZnSO_4$ at 45 DAS) | 23.34 | 3.61 | 17.29 | 2.21 |
| $T_5$: $T_2$ + Solubor at 45 DAS) | 30.88 | 4.01 | 17.60 | 2.24 |
| $T_6$: ($T_2$ + $ZnSO_4$ and solubor at 45 DAS) | 28.38 | 3.95 | 17.29 | 2.19 |
| $T_7$: ($T_6$ + 19:19:19 at 60 DAS) | 24.85 | 3.58 | 16.89 | 2.24 |
| $T_8$: ($T_1$ + $KNO_3$ at 45 DAS) | 24.92 | 3.91 | 17.22 | 2.20 |
| $T_9$: ($T_8$ + $KNO_3$ at 60 DAS) | 20.43 | 3.79 | 17.17 | 2.24 |
| $T_{10}$: ($T_8$ + $ZnSO_4$ at 45 DAS) | 20.23 | 3.90 | 17.28 | 2.14 |
| $T_{11}$: ($T_8$ + Solubor at 45 DAS) | 28.23 | 3.81 | 17.00 | 2.20 |
| $T_{12}$: ($T_8$ + $ZnSO_4$ and solubor at 45 DAS) | 22.89 | 3.72 | 16.90 | 2.17 |
| $T_{13}$: ($T_{12}$ + $KNO_3$ at 60 DAS) | 24.22 | 3.78 | 17.44 | 2.21 |
| SEm (±) | 1.961 | 0.14 | 0.256 | 0.043 |
| p= 0.05 | 5.759 | 0.42 | NS | NS |

NS: not-significant

of greater proportion of carbohydrates through photosynthesis. Arora *et al.* (1990) has described the physiological role of Zn in effecting translocation of assimilates towards sink tissues. Deficiency of Zn causes accumulation of carbohydrates in plant leaves (Marshner and Cakmak, 1989). Boron plays a key role in translocation of sugars from leaves to pods (Thakur *et al*., 2019). Better partitioning of assimilates due to B application might have led to higher HI. Adequate supply of N, P and K through 19:19:19 and Zn and B led to better utilization of photosynthates for reproductive growth instead of excessive vegetative growth (Muthumanickam and Anburani, 2017).

### Effect on post-harvest nutrient status

Foliar application of macro and micro nutrients significantly influenced the available nutrients in the post-harvest soil. All the foliar nutrition treatments registered higher availability of N compared to $T_1$ might be due to enhanced biological N fixation as a result of better vegetative growth. The treatments $T_1$, $T_3$ and $T_9$ registered higher P availability. The reason for the increased availability of P observed in $T_3$ and $T_9$ might be due to the better root growth which would enable the crop to tap nutrients from the deeper soil layers. Addition of organic matter through FYM and decomposition of fallen leaves from the cowpea plant also paved for better availability of nutrients. Similar observations were also made by Raj (2019) in cowpea. Lower P uptake by the crop resulted in higher post-harvest P status in $T_1$. The treatment $T_6$ recorded the lowest available K might be due to higher K uptake by the crop. Similar results of reduced availability of K due to increase in uptake was reported by Kuwar *et al.* (2014) in water melon.

Foliar application of macro and micro nutrients significantly enhanced the availability of Zn and B in soil. The highest available Zn was reported in $T_{11}$ and was statistically on par with $T_8$, $T_9$ and $T_{10}$. The highest available B was registered by the treatment $T_2$ and was statistically

**Table 4**: Effect of foliar nutrition of macro and micro nutrients on post-harvest N, P, K, Zn and B status of soil.

| Treatments | Available N (kg ha$^{-1}$) | Available P (kg ha$^{-1}$) | Available K (kg ha$^{-1}$) | Available Zn (mg kg$^{-1}$ soil) | Available B (mg kg$^{-1}$soil) |
|---|---|---|---|---|---|
| $T_1$: (RDF) | 181.54 | 23.49 | 150.96 | 0.025 | 0.228 |
| $T_2$: ($T_1$+ 19:19:19 at 45 DAS) | 281.56 | 21.37 | 191.11 | 0.063 | 0.509 |
| $T_3$: ($T_2$ + 19:19:19 at 60 DAS) | 256.77 | 23.49 | 152.64 | 0.262 | 0.421 |
| $T_4$: ($T_2$ + $ZnSO_4$ at 45 DAS) | 263.04 | 19.70 | 145.20 | 0.047 | 0.353 |
| $T_5$: $T_2$ + solubor at 45 DAS) | 237.96 | 20.26 | 158.35 | 0.013 | 0.460 |
| $T_6$: ($T_2$ + $ZnSO_4$ and solubor at 45 DAS) | 237.96 | 16.75 | 136.85 | 0.074 | 0.488 |
| $T_7$: ($T_6$ + 19:19:19 at 60 DAS) | 244.23 | 20.26 | 154.32 | 0.131 | 0.427 |
| $T_8$: ($T_1$ + $KNO_3$ at 45 DAS) | 306.94 | 16.47 | 142.79 | 0.506 | 0.409 |
| $T_9$: ($T_8$ + $KNO_3$ at 60DAS) | 231.69 | 23.49 | 151.18 | 0.501 | 0.422 |
| $T_{10}$: ($T_8$ + $ZnSO_4$ at 45 DAS) | 281.86 | 22.09 | 181.93 | 0.543 | 0.434 |
| $T_{11}$: ($T_8$ + solubor at 45 DAS) | 237.96 | 18.43 | 176.50 | 0.557 | 0.490 |
| $T_{12}$: ($T_8$ + $ZnSO_4$ and solubor at 45 DAS) | 250.50 | 17.31 | 154.32 | 0.209 | 0.447 |
| $T_{13}$: ($T_{12}$ + $KNO_3$ at 60DAS) | 319.47 | 16.89 | 154.55 | 0.226 | 0.343 |
| SEm (±) | 11.89 | 0.45 | 3.11 | 0.020 | 0.029 |
| p= 0.05 | 34.904 | 1.306 | 9.140 | 0.0593 | 0.086 |

**Table 5:** Effect of foliar nutrition on yield, harvest index and economics of bush vegetable cowpea.

| Treatments | Green pod yield (kg ha$^{-1}$) | Dry haulm yield (kg ha$^{-1}$) | Harvest index | Net returns (Rs ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|---|
| $T_1$: (RDF) | 4779 | 3475 | 0.367 | 32,939 | 1.53 |
| $T_2$: ($T_1$ + 19:19:19 at 45 DAS) | 7287 | 4610 | 0.412 | 80,262 | 2.23 |
| $T_3$: ($T_2$ + 19:19:19 at 60 DAS) | 5756 | 4072 | 0.381 | 46,791 | 1.69 |
| $T_4$: ($T_2$ + $ZnSO_4$ at 45 DAS) | 6061 | 4371 | 0.374 | 53,213 | 1.78 |
| $T_5$: $T_2$ + solubor at 45 DAS) | 7410 | 5228 | 0.405 | 82,651 | 2.26 |
| $T_6$: ($T_2$ + $ZnSO_4$ and solubor at 45 DAS) | 7203 | 4562 | 0.401 | 75,982 | 2.12 |
| $T_7$: ($T_6$ + 19:19:19 at 60 DAS) | 6259 | 3868 | 0.419 | 54,248 | 1.77 |
| $T_8$: ($T_1$ + $KNO_3$ at 45 DAS) | 6803 | 5424 | 0.349 | 70,416 | 2.07 |
| $T_9$: ($T_8$ + $KNO_3$ at 60DAS) | 5808 | 4687 | 0.352 | 47,525 | 1.69 |
| $T_{10}$: ($T_8$ + $ZnSO_4$ at 45 DAS) | 5935 | 4938 | 0.345 | 53,036 | 1.81 |
| $T_{11}$: ($T_8$ + solubor at 45 DAS) | 6978 | 4573 | 0.418 | 73,861 | 2.12 |
| $T_{12}$: ($T_8$ + $ZnSO_4$ and solubor at 45 DAS) | 6246 | 5184 | 0.344 | 59,203 | 1.90 |
| $T_{13}$: ($T_{12}$ + $KNO_3$ at 60DAS) | 6465 | 5470 | 0.333 | 60,572 | 1.88 |
| SEm (±) | 194.09 | 192.38 | 0.018 | 3779 | 0.09 |
| p= 0.05 | 569.09 | 564.88 | 0.052 | 11, 097.1 | 0.254 |

comparable with $T_5$, $T_6$, $T_7$, $T_{10}$, $T_{11}$ and $T_{12}$. Similar results of increased availability of Zn and B in the soil was reported by Mini and Mathew (2019) following the foliar application of micro nutrient mixture in okra. Application of 0.25 per cent borax at flowering and fruit initiation stages of tomato recorded the highest soil available boron (Sathya *et al.,* 2013).

**Effect on economics**

Foliar nutrition of water-soluble macro and micronutrient fertilizers brought significant increase in net return and benefit cost (B:C) ratio. Foliar nutrition of water-soluble macro and micronutrient fertilizers along with RDF resulted in an increase in net return of Rs 13,852 to 49712 $ha^{-1}$. Among the treatments, treatment $T_5$ registered the highest net return (82, 651 Rs $ha^{-1}$) which was statistically on par with $T_2$, $T_6$ and $T_{11}$. Benefit cost ratio was found to be the highest in $T_5$ and it was statistically on par with $T_2$, $T_6$ and $T_{11}$. Higher net return and B:C recorded in these treatments was owing to higher green pod yield registered in the treatment (Table 5). Singhal *et al*. (2015) reported that foliar feeding of water-soluble nutrients significantly improved the okra yield and recorded higher net income. Saravaiya *et al.* (2014) observed an increase in net income and B:C ratio due to foliar application of B 100 mg $L^{-1}$ in tomato. The control treatment ($T_1$) registered the lowest net return and B:C ratio due to lesser pod yield recorded in the treatment.

## CONCLUSION

It could be concluded from the results that foliar application of water-soluble macro and micronutrient fertilizers along with RDF (N:P:K @ 20:30:10 kg $ha^{-1}$) significantly improved the growth and yield attributes of bush vegetable cowpea. Among the treatments, RDF + foliar application of 19:19:19 (0.5%) and solubor (0.025%) at 45 DAS, RDF + foliar application of 19:19:19 (0.5%) alone at 45 DAS, RDF + foliar application of 19:19:19 (0.5%), solubor (0.025%) and zinc sulphate 0.05 per cent at 45 DAS and RDF + foliar application of potassium nitrate (0.5%) and solubor (0.025%) at 45 DAS recorded higher dry matter production, number of pods per plant, green pod yield, harvest index, net return and B: C ratio. However, considering the highest green pod yield, net return and B:C ratio, the treatment $T_5$ (RDF + foliar application of 19:19:19 (0.5%) and solubor (0.025%) can be recommended for yield maximization in bush vegetable cowpea.

## REFERENCES

Ali, M.R., Mehraj, H. and Uddin, A.F.M.J. (2015). Effects of foliar application of zinc and boron on growth and yield of summer tomato. Journal of Bioscience and Agriculture Research. 6(1): 512-517.

Ali, S., Khan, A.Z., Mairaj, G., Arif, M., Fida, M. and Bibi, S. (2008). Assessment of different crop nutrient management practices for yield improvement. Australian Journal of Crop Science. 2(3): 150-157.

Arora, S.K. Pandita, M.L. and Singh, K. (1990). Response of tomato varieties to plant growth chemical and micro-nutrients during summer and rainy season. Research Development Reporter. 7(1-2): 77-85.

Bansode, C. and Math, K.K. (2018). Effect of foliar feeding of 19:19:19 and potassium nitrate water soluble fertilizers on major nutrient status of soybean in a vertisol. International Journal of Chemical Studies. 6(3): 2251-2252.

Cochran, W.G. and Cox, G.M. (1965). Experimental Designs. John Willey and Sons Inc., New York, 182 p.

Dey, S., Prasad, S., Tiwari, P. and Sharma, P. (2017). Effect of urea, KCl, zinc placement and spray on growth of cowpea. Journal of Pharmacognosy. Phytochemistry. 6(6): 971-973.

Directorate of Pulses Development. (2017). Cowpea. Available online http://dpd.gov.in [Accessed on 25 June 2021].

Dixon, R.C. (2003). Foliar fertilization improves nutrient use efficiency. Fluid Journal. 11: 11-12.

Elhindi, K., El-Hendawy, S., Abdel-Salam, E.M. and Schmidhalter, U. (2016). Foliar application of potassium nitrate affects the growth and photosynthesis in coriander (*Coriander sativum* L.) plants under salinity. Progress in Nutrition. 18(1): 63-73.

Fageria, N.K. (1992). Maximizing Crop Yields. Marcel Dekker, Inc., 274p.

FIB (Farm Information Bureau). (2021). Farm Guide. Farm Information Bureau, Thiruvananthapuram. 452 p.

Guievence, I. and Badem, H. (2000). Effect of foliar application of different sources and levels of nitrogen on growth and yield of tomato. Indian Journal of Agricultural Science. 72(2): 104-105.

Haleema, B., Rab, A. and Hussain, S.A. (2018). Effect of calcium, boron and zinc foliar application on growth and fruit production of tomato. Sarhad Journal of Agriculture. 34(1): 19-30.

Haque, M.E., Paul, A.K. and Sarker, J.R. (2011). Effect of nitrogen and boron on the growth and yield of tomato (*Lycopersicon esculentum* Mill). International Journal of Bio-resource and Stress Management. 2: 277-282.

Harris, K.D., Vanajah, T. and Puvanitha, S. (2018). Effect of foliar application of boron and magnesium on growth and yield of green chilli (*Capsicum annum* L.) [on-line]. Available: http://doi.org/10.4038/agrieast.v12i1.49 [15 Sep.2021].

KAU (Kerala Agricultural University) (2016). Package of Practices Recommendations: Crops (15th ed.) Kerala Agricultural University, Thrissur. 392p.

Kavitha, M.P., Balakumbaham, R. and Prabukumar, G. (2019). Effect of foliar spray and fertilizer levels on growth and yield of vegetable cowpea [*Vigna unguiculata* (L.) Walp. Indian Journal of Agricultural Research. 53(6): 745-748.

Khanda, C.M., Mohapatra, A.K. and Mishra, P.K. (1999). Effect of nitrogen and phosphorus fertilization on growth, yield and nutrient uptake of winter rice bean (Vigna umbiculata). Indian Journal of Agronomy. 44(4): 791-794.

Krishna, O.N. and Kaleeswari, R.K. (2018). Response of pulses to foliar application of multi nutrients on yield, quality, uptake and soil nutrient status. Madras Agricultural Journal. 105(4-6): 176-181.

Krishnasree, R.K., Chacko, S.R. and Raj, S.K. (2021). Foliar nutrition in vegetables-A Review. Journal of Pharmacognosy and Phytochemistry. 10(1): 2393-2398.

Kuwar, P., Durgude, A.G., Kadam, S.R. and Patil, A.A. (2014). Response of water melon to foliar application of different water-soluble fertilizer. Asian Journal of Horticulture. 9(2): 431-434.

Marschner, H.J. and Cakmak (1989). High light intensity enhances chlorosis and necrosis in leaves of zinc, potassium and magnesium deficient bean (*Phaseolus vulgaris*) plants. Journal of Plant Physiology. 134: 924-934.

Meena, D., Bhushan, C., Shukla, A., Chaudhary, S. and Sirazuddin. (2017). Effect of foliar application of nutrients on nodulation, yield attributes, yield and quality parameters of urd bean [*Vigna mun*go (L.) Hepper]. Bioscan. 12(1): 411-414.

Meena, R.S. (2010). Effect of boron on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill.) cv. Pusa Ruby grown under semi-arid conditions. International Journal of Chemical Engineering Research. 2(2): 167-172.

Mini, V. and Mathew, U. (2019). Yield maximization in okra through nutrient interventions in typic Ustipsamments of Kerala, India. International Journal of Plant Sciences. 14(1): 10-13

Mondal, R., Mandal, J., Mallick, R. and Mohanta, S. (2017). Study of foliar fertilization of cucumber (*Cucumis sativus* L.). Hortflora Reserach Spectrum. 6(1): 31-34.

Muthumanickam, K. and Anburani, A. (2017). Effect of combined application of inorganic and water-soluble fertilizers on growth parameters of chilli hybrid (*Capsicum annuum* L.). Asian Journal of Horticulture. 12(1): 117-120.

Narayan, K., Dubey, P, Sharma, D., Katre, V.T. and Rajhans, K.C. (2011). Effect of foliar application of water-soluble fertilizers on flowering, yield and quality attributes of tomato. The Asian Journal of Horticulture. 6(1): 225-228.

Narayanamma, M., Rani, R., Lalitha, K., Kameshwari, P. and Reddy, R.V.S.K. (2009). Effect of foliar application of micronutrients on the yield components, yield and nutrient content of bitter gourd. Orissa Journal of Horticulture. 37(2): 1-5.

Pandav, A.K., Nalla, M.K., Aslam, T., Rana, M.K. and Bommesh, J.C. (2016). Effect of foliar application of micronutrients on growth and yield parameters in eggplant cv. HLB 12. Environment and Ecology. 35(3): 1745-1748.

Praveena, R., Ghosh, G. and Singh, V. (2018). Effect of foliar spray of boron and different zinc levels on the growth and yield of Kharif green gram (*Vigna radiata*). International Journal of Current Microbiology and Applied Sciences. 7(8): 1422-1428.

Premsekhar, M. and Rajashree, V. (2009). Performance of hybrid tomato as influenced by foliar feeding of water-soluble fertilizers. American Eurasian Journal of Sustainable Agriculture. 3: 33-36.

Raj, A.B. (2019). Seed invigouration for yield enhancement in grain cowpea [*Vigna unguiculata* (L.) Walp]. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur. 155p.

Rajpoot, S.K. and Rana, D.S. (2016). Crop diversification with vegetable cowpea. Indian Farming. 66(1): 5-9.

Ramadan, M.E. and Shalaby, O.A.E-S.A.E-N. (2016). Response of egg plant (*Solanum melongena* L.) to potassium and liquorice extract application under saline conditions. Acta Scientiarum Polonorum Hortorum Cultus. 15(6): 279-290.

Reddy, T.T., Bidari, B.I. and Reddy, P.V.K. (2017). Correlation studies of quality, nutrient uptake and yield of chilli with the application of organic manures and foliar spray of water-soluble fertilizers. Journal of Research ANGRAU. 45(3): 52-55.

Rout, G.R. and Das, P. (2003). Effect of metal toxicity on plant growth and metabolism: I. Zinc. Agronomie. 23(1): 3-11.

Saravaiya, S.N., Wakchaure, S.S., Jadhav, P.B., Tekale, G.S, Patil, N.B. and Dekhane, S.S. (2014). Effect of foliar application of micronutrients in tomato (*Lycopersicon esculentum* Mill.) c.v. Gujarat tomato-2. Asian Journal of Horticulture. 9(2): 297-300.

Sathya, S., Mahendran, P.P. and Arulmozhiselvan, K. (2013). Availability of nutrients as influenced by boron application in boron deficient soil of typic haplustalf. Agricultural Science Digest. 33(4): 317-320.

Shnain, R.S., Prasad, V.M. and Saravanan.S. (2014). Effect of zinc and boron on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill.) cv. Heem Sohna under protected cultivation. European Academic Research. 2(3): 4572-4597.

Singh, H.M. and Tiwari, J.K. (2013). Impact of micronutrient spray on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill). HortFlora Research Spectrum. 2(1): 87-89.

Singh, S.S. and Tiwari, R.S. (1989). Effect of micro-nutrients on the growth characters of onion (*Allium cepa* L.) cv." Pusa Red". Haryana Journal of Horticultural Science. 18(2): 146-149.

Singhal, V.K., Patel, G.G., Patel, D.H., Kumar, U. and Saini, L.K. (2015). Effect of foliar application of water-soluble fertilizers on growth, yield and economics of vegetable cowpea production. The Ecosan. 8: 79-83.

Sultana, S., Naser, H.M., Akhter, S. and Begum, R.A. (2016). Effectiveness of soil and foliar application of zinc and boron on the yield of tomato. Bangladesh Journal of Agricultural Research. 41(3): 411-418.

Tariq, M. and Mott, C.J.B. (2007). Effect of boron on the behavior of nutrients in soil-plant systems- a review. Asian Journal of Plant Science. 6(1): 195-202.

Thakur, D., Kumar, P. and Shukla, A.K. (2019). Impact of foliar feeding of boron supplements on growth, yield contributing characters and quality of cauliflower. Biological Forum- An International Journal. 11(2): 77-82.

Thakur, O.P. Sharma, P.P. and Singh, K.K. (1991). Effect of nitrogen and phosphorus with and without boron on curd yield and stalk rot incidence in cauliflower. Vegetable Science. 18(2): 115-121.

Vekaria, G.B., Talpada, M.M., Sutaria, G.S. and Akbari, K.N. (2013). Effect of foliar nutrition of potassium nitrate on the growth and yield of green gram (*Vigna radiata* L.). Legume Research International Journal. 36(2): 162-164.

Wasaya, A., Shabir, M.S., Hussain, M., Ansar, M., Aziz, A., Hassan, W. and Ahmed, I. (2017). Foliar application of zinc and boron improved the productivity and net returns of maize grown under rainfed conditions of Pothwar plateau. Journal of Soil Science and Plant Nutrition. 17(1): 33-45.

Yadav, H.K., Dogra, P. and Yadav, V. (2014). Effect of foliar application of N and Zn on growth and yield of cauliflower (*Brassica oleracea* var. botrytis L.) cv. Snowball. Agriculture for Sustainable Development. 2(1): 56-58.

Zhao, D., Oosterhuis, D.M. and Bednarz, C.W. (2001). Influence of potassium deficiency on photosynthesis, chlorophyll content, and chloroplast ultra-structure of cotton plants. Photosynthetica. 39: 103-109.