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Evaluation of Micronutrient Mixture as Seed Treatment and Foliar Nutrition in Grain Cowpea

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ABSTRACT

Background: Micronutrient formulation is a liquid mixture of micronutrients which can be used as a fertilizer. It is a mixture of two solutions *viz*., solution A and solution B. Solution A is a mixture of zinc sulphate (50 gL^{-1}), boric acid (10 gL^{-1}), copper sulphate (20 gL^{-1}), manganous sulphate (0.5 gL^{-1}), ferrous sulphate (10 gL^{-1}) and ammonium molybdate (0.5 gL^{-1}) whereas solution B is an organic acid which act as a chelate. The mixture can be diluted to specific concentrations for application. The objective of the study was to evaluate the effect of micronutrient formulation as seed treatment and foliar nutrition.

Methods: The study was conducted at College of Agriculture, Padannakkad, Kerala Agricultural University and Regional Agricultural Research Station, Pilicode during 2018–19. The investigation was carried out in three parts: (i) standardization of micronutrient formulation for cowpea (ii) seed treatment study (iii) field experiment. The proportion of mixing micronutrient formulation and the duration for seed treatment was standardized in experiment I. In experiment II, a seed treatment study was carried out in a completely randomised design with seven treatments and three replications which included seed treatment with micronutrient formulation @ 0.25, 0.50, 0.75, 1, 1.5 and 2 percent as T_1, T_2, T_3, T_4, T_5 and T_6 respectively. T_7 (seed treatment with water) was the control. Three, a field experiment was carried out in randomized block design (factorial) with twelve treatments and three replications. The treatment consisting of combination of four levels of seed treatment - factor A (no seed treatment (S_1), seed treatment with rhizobium (S_2), seed treatment with best concentration from experiment 1 (S_3) and second best seed treatment from experiment 1 (S_4)) and three levels of foliar application of micronutrient - factor B (no foliar application (F_1), one foliar application at 15 DAS (F_2) and two foliar applications at 15 and 30 DAS (F_3).

Result: Through lab experiments, solution B was standardized and the formulation was developed by mixing solution A and solution B in the ratio 1:2. Duration for seed treatment was also standardized as 6 hours. Thus micronutrient formulation was standardized. In seed treatment study, seeds treated with 2% micronutrient formulation (T_6) showed highest plant height at three leaf stage (24.23 cm) and seedling vigour index (2423). In the field experiment seed treatment with 2% micronutrient formulation (S_3), foliar spray at 15 and 30 days after sowing (F_3) and their interaction (S_3F_3) was found to be highly effective to the crop in terms of plant height, stem diameter, number of pods per plant, pod weight per plant, grain yield and nutrient content in grain. These results clearly indicate the role of micronutrient formulation in enhancing the growth, yield and nutrient content of cowpea.

Key words: Foliar spray, Cowpea, Micronutrient formulation, Seed treatment, Yield.

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp] is an important pulse crop grown annually in warm climate with adequate rainfall. It can thrive well in temperate zones as well as humid tropics. Cowpea is rich in fibre, protein, iron and potassium but low in fat and calorie. It is also referred as vegetable meat because of its high protein content. Inclusion of cowpea in diet prevents cancer, anaemia and repair of muscle tissues. Pulses are an important group of crops which has the capacity to provide high quality protein complementing cereal proteins in vegetarian diet. The Recommended Dietary Allowances (RDA) for adult male and female is 60 g and 55g per day respectively. In India, pulses are cultivated in an area of 25.26 million ha with production potential of 16.47 million tonnes and yield of 652 kg/ha (Government of India, 2016). In Kerala it is cultivated in an area of 1738 ha with a production of 1433 tonnes (Government of Kerala, 2016-2017).

Micronutrients are essential elements in growth required by plants only in small quantities. In spite of its lower requirement in plants these are equally formidable as primary and secondary nutrients. The deficiency of micronutrients become prevalent quite recently affecting the productivity and stability of soils (Bell and Dell, 2008). A major portion of Kerala soils lack boron since it is formed from acid igneous rocks (SSO, 2007). A study conducted by Suresh *et al*. (2014) in the Northern district of Kerala, Kasaragod revealed that the soils are deficient in boron by 78 per cent, zinc by 8 and copper by 3 per cent. Hence

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supplementing micronutrients is essential for improving the growth and yield of crops.

Foliar nutrition is the most advanced method in supplementing nutrition to plants. It gains attention due to its efficiency as well as cost effectiveness. Application of micronutrients in the appropriate mineral form enhances its availability in plants (Alloway, 1986). Formulations containing micronutrients when supplied to plants as foliar spray are found effective in correcting deficiencies and thereby increases the yield (Mona *et al*., 2012). Foliar application of nutrients helps the plants to absorb nutrients through the stomatal openings in leaves and results in most effective use of fertilizers in a most economical way (Manasa *et al*., 2015). Efficiency of fertiliser use and quick response of the applied nutrients results in growth enhancement as well as yield. It also reduces the chance of toxicity in plants compared to the supplementation of fertilizers through conventional methods.

Micronutrient fertilizers can also be supplied as seed treatment so that the wastage of fertilizers during soil application can be significantly reduced. Application of micronutrient through seed treatment improves growth, yield and enhances the phenological events (Farooq *et al*., 2012). In economical perspective seed treatment is the better option for which less micronutrient is needed, it is ease in application and improves seedling growth (Singh *et al*., 2003).

MATERIALS AND METHODS

The whole study was conducted in three parts: (i) standardization of micronutrient formulation for cowpea was carried out during February - April 2018 (ii) seed treatment study during June - July 2018 (Experiment I) and (iii) field experiment during October – February 2018 to 2019 (Experiment II).

Micronutrient formulation is a mixture of two solutions *viz*., solution A and solution B. Solution A is a mixture of zinc sulphate, boric acid, copper sulphate, manganous sulphate, ferrous sulphate and ammonium molybdate whereas solution B is an organic acid which act as a chelate. These two solutions have to be mixed in a specific ratio at the time of application because of the poor shelf life of micronutrient mixture. Attempt was being made to increase the shelf life of this micronutrient formulation in the combined form of both solutions A and B.

For standardizing the micronutrient formulation, several trials were done and a combination of Solution A and Solution B (2:1) were prepared so that it can be supplied to farmers as micronutrient mixture which reduces the difficulty of mixing solutions during field application. The micronutrient formulation can be diluted to different concentrations for seed treatment and foliar spray. To standardize the time for seed treatment several trials were conducted. Cowpea seeds were treated with micronutrient mixture at different concentrations at the rate of 0.25, 0.50, 0.75, 1, 1.5 and 2 percentages for different durations (1 hr, 2hrs, 4 hrs, 6hrs, 8 hrs, 10 hrs and 12 hrs).

Laboratory study was carried out at College of Agriculture, Padannakkad, Kerala Agricultural University to standardize the concentration of micronutrient formulation for cowpea. Different concentrations of the standardized micronutrient formulation were used for seed treatment study (Experiment 1). The experiment was carried out in completely randomized design with 7 treatments and 3 replications which included seed treatment with micronutrient formulation @ 0.25, 0.50, 0.75, 1, 1.5 and 2 percent as T_1, T_2, T_3, T_4, T_5 and T_6 respectively. T_7 (seed treatment with water) was the control. Observations on germination percentage (placing seeds in moistened filter paper for three days and recorded the number of seeds germinated on fourth day), number of days taken for germination (counting the number of days taken for germination from the start day it kept for germination), seedling length at three leaf stage (average length of five plants were taken at three leaf stage) and seedling vigour index (calculated by multiplying seedling length with germination percentage) were recorded.

The field experiment was conducted at Regional Agricultural Research Station, Pilicode, (Kasaragod, Kerala) during the period October to December 2018. Geographically, the experimental site lies in tropic region, at 12º 12' N latitude and 75º 10' E longitude and at an altitude of 15m above mean sea level with a warm humid tropical climate.

The experiment was conducted in randomized block design (factorial) with 12 treatments replicated three times. The randomized block design was set up in such a way that the experimental field had been divided into 36 plots, each of 2 m length and 1.5 m width. Thus each replication contains 12 uniform plots to carry out different treatment applications. The crop production was done by following all the cultural practices starting from the land preparation to the harvest. The treatment consisting of combination of four levels of seed treatment – Factor A (no seed treatment (S_1), seed treatment with rhizobium (S_2), seed treatment with best concentration from experiment 1 (S_3) and second best seed treatment from experiment 1 (S_4)) and three levels of foliar application of micronutrient – Factor B (no foliar application (F_1), one foliar application at 15 DAS (F_2) and two foliar applications at 15 and 30 DAS (F_3)). The treatments interactions include no seed treatment and no foliar application (S_1F_1), no seed treatment + one foliar application (S_1F_2), no seed treatment + two foliar application (S_1F_3), Seed treatment with rhizobium + no foliar application (S_2F_1), Seed treatment with rhizobium + one foliar application (S_2F_2), Seed treatment with rhizobium + two foliar application (S_2F_3), Seed treatment with best treatment from experiment 1 + no foliar application (S_3F_1), Seed treatment with best treatment from experiment 1 + one foliar application (S_3F_2), Seed treatment with best treatment from experiment 1 + two foliar application (S_3F_3), Seed treatment with second best treatment from experiment 1+ no foliar application (S_4F_1), Seed treatment with second best treatment from experiment 1+ one foliar

Table 1: Composition of Solution A (1 litre).

Nutrients composition	Amount (g)
$ZnSO_4.7H_2O$	50
$CuSO_4.5H_2O$	20
$FeSO_4.7H_2O$	10
H_3BO_3	10
$MnSO_4.H_2O$	0.5
(NH_4) $6Mo7O_{24}.4H_2O$	0.5

application (S_4F_2) and Seed treatment with second best treatment from experiment 1+ two foliar application (S_4F_3).

Observations on different yield attributes were taken to study the effect of treatments on growth and development of the crop. Five plants were randomly selected and tagged from each plot to record the periodical observations. Growth parameters such as plant height (taken as the average value of the tagged plant), stem diameter (average of five plants from each plot), number of branches and dry matter production (average of five plants from each plot) were recorded. Yield parameters included number of pods per plant (number of pods obtained from five index plants from each plot were recorded and average was taken), number of seeds per pod (ten pods from index plants were selected and average number of seeds were recorded), pod weight per plant (ten pods from index plants were selected and average weight was recorded) and grain yield (calculated in kg per hectare). The incidence of pest and disease were recorded during the course of investigation. The data obtained from the seed treatment study and field experiment was analysed statistically using Analysis of Variance (ANOVA) for completely randomized design and factorial randomized block design proposed by Panse and Sukhatme in 1985. It was then tested for its significance using standard statistical tools.

RESULTS AND DISCUSSION

Standardization of micronutrient formulation for cowpea

The different concentrations of micronutrient formulation and time required for seed treatment in cowpea was standardized by soaking cowpea seeds with micronutrient mixture at different concentrations (0.25%, 0.50%, 0.75%, 1%, 1.5% and 2%). Seeds were soaked in each of these solutions for seven different durations (1 hr, 2hrs, 4 hrs, 6hrs, 8 hrs, 10 hrs and 12 hrs). Observations on seed germination and its emergence showed that the seeds treated with micronutrient mixture for 6 hours showed better shoot and root growth for the different concentration of micronutrient formulation as compared to other duration of seed treatment. Time for seed treatment was standardized in papaya for boron. Seeds treated with 2 ppm boron solution for six hours showed increased germination and growth of seedlings (Deb *et al*., 2010).

Seed treatment study

The different concentrations of micronutrient mixture in seed treatment study had no significant influence on germination percentage and days taken for germination whereas seedling length at three leaf stage and seedling vigour index (germination percentage x seedling length) was significantly influenced by the treatments (Table 2). The treatment T_6 showed maximum seedling length at three leaf stage (24.23 cm) and seedling vigour index (2423) which might be due to the beneficial effect of micronutrients in enhancing cell elongation and cell division of meristematic tissues. The increased seedling length of cowpea contributed to considerable increase in seedling vigour index in the treatment receiving 2% concentration of micronutrient mixture. Thus T_6 was considered as the best concentration for seed treatment study. This treatment was followed by T_5 which recorded the second highest values in seedling length at three leaf stage (22.31) and seedling vigour index (2231). The treatments T_6 (best seed treatment) and T_5 (second best) were selected for the field experiment to evaluate the performance of micronutrient formulation in cowpea. Masuthi *et al*. 2009 had reported that cowpea seeds treated with zinc sulphate showed higher vigour index and Deb *et al*. 2010 reported that papaya seeds treated with boron at 2ppm showed better growth of seedlings.

Field experiment: Effect of seed treatment, foliar spray of micronutrient formulation and their interaction on growth attributes

Effect of seed treatment, foliar spray and their interaction on plant height, stem diameter, number of branches and dry matter production is given in the Table 3.

Table 2: Effect of seed treatment with micronutrient formulation on germination and seedling characters of cowpea.

Treatment	Germination percentage (%)	Days taken for germination	Seedling length at three leaf stage (cm)	Seedling vigour index
T_1	96.70	1.66	18.80	1817.96
T_2	96.76	1.66	19.81	1881.95
T_3	97.77	1.67	19.84	1939.75
T_4	97.77	1.66	19.94	1949.53
T_5	100.00	1.33	22.31	2231.00
T_6	100.00	1.00	24.23	2423.00
T_7	95	1.77	18.75	1814.25

T_1 – Micronutrient formulation at the rate of 0.25% ; T_2 – Micronutrient formulation at the rate of 0.50% ; T_3 – Micronutrient formulation at the rate of 0.75% ; T_4 – Micronutrient formulation at the rate of 1% ; T_5 – Micronutrient formulation at the rate of 1.5% ; T_6 – Micronutrient formulation at the rate of 2% ; T_7 – Control (Seed treatment with water).

Table 3: Effect of seed treatment, foliar spray and their interaction on growth and yield parameters of cowpea.

Treatment and inter--actions	Plant height (cm)		Number of branches $plant^{-1}$		Stem diameter (cm)		Dry matter production (kg ha^{-1})	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	Pod weight $plant^{-1}$	Grain yield (kg ha^{-1})
	Flower bud initiation	Harvest	Flower bud initiation	Harvest	Flower bud initiation	Harvest					
S_1	20.86	35.97	9.87	9.97	2.11	4.16	2000.06	16.73	15.46	24.92	1969
S_2	23.11	38.41	9.89	9.99	2.35	4.58	2172.62	17.97	15.73	29.73	1977
S_3	24.31	39.75	10.34	10.45	2.43	4.65	2292.91	21.02	15.13	36.14	2224
S_4	23.53	38.63	10.38	10.40	2.44	4.26	2220.94	19.44	14.80	31.90	2168
SEm (±)	0.27	0.35	0.17	0.16	0.06	0.01	16.37	0.91	0.43	2.28	16
CD (0.05)	**0.81**	**1.05**	**NS**	**NS**	**0.17**	**0.05**	**48.33**	**2.68**	**NS**	**4.26**	**48**
F_1	21.26	36.57	9.85	9.89	2.06	3.91	2042.53	16.71	15.53	26.43	1979
F_2	21.61	36.92	10.12	10.15	2.40	4.49	2099.46	18.63	14.93	27.80	2101
F_3	25.98	41.08	10.10	10.15	2.54	4.85	2372.92	20.97	15.38	33.49	2173
SEm (±)	0.23	0.30	0.15	0.15	0.05	0.01	14.18	0.78	0.37	0.79	14
CD (0.05)	**0.70**	**0.90**	**NS**	**NS**	**0.15**	**0.04**	**41.85**	**2.32**	**NS**	**2.33**	**41**
S_1F_1	18.66	34.33	9.87	9.98	1.73	3.58	1804.07	16.00	15.46	24.64	1820
S_1F_2	21.73	36.40	9.88	9.89	2.32	4.58	2068.19	16.67	15.33	25.00	2000
S_1F_3	22.20	37.20	9.99	9.98	2.29	4.34	2127.92	15.53	15.60	25.91	2113
S_2F_1	21.93	36.60	10.11	10.12	2.19	4.38	2037.39	13.40	15.80	26.00	1843
S_2F_2	21.40	36.63	10.13	10.14	2.02	4.06	2193.57	18.53	15.26	26.51	2000
S_2F_3	26.00	42.00	10.11	10.12	2.86	5.30	2286.90	20.20	16.13	30.00	2059
S_3F_1	21.06	37.73	9.98	9.99	2.24	4.38	2104.28	18.40	15.53	28.32	2133
S_3F_2	22.06	37.40	9.97	9.98	2.66	4.72	2161.21	19.67	14.73	29.98	2220
S_3F_3	29.80	44.13	10.12	10.13	2.39	4.86	2613.24	25.00	15.13	38.11	2320
S_4F_1	23.40	37.63	10.12	10.13	2.07	3.30	2224.37	17.06	15.33	27.24	2120
S_4F_2	21.26	37.26	9.98	9.99	2.62	4.60	1974.86	19.93	14.40	28.00	2186
S_4F_3	25.93	41.00	9.99	10.00	2.64	4.90	2463.60	21.01	14.66	31.23	2200
SEm (±)	0.47	0.61	0.30	0.30	0.10	0.02	28.36	1.57	0.75	2.38	28
CD (0.05)	**1.40**	**1.81**	**NS**	**NS**	**0.30**	**0.08**	**83.71**	**4.72**	**NS**	**7.15**	**83**

Levels of seed treatment showed significant difference in plant height at flower bud initiation and at harvest. At flower bud initiation S_3 recorded maximum plant height (24.31 cm) which was on par with seed treatment with 1.5% micronutrient formulation, S_4 (23.53 cm). At the time of harvest S_3 recorded maximum height of 39.75 cm which was significantly superior to all other treatments. Levels of foliar spray of micronutrients showed significant difference in plant height at flower bud initiation and at harvest. Maximum height was observed in F_3 treatment both at flower bud initiation (25.98 cm) and at harvest (41.08 cm). In the interaction effect maximum plant height was recorded in the treatment S_3F_3 at both the stages given as 29.80 cm and 44.13 cm, which were significantly different from all other treatments. The beneficial effect of micronutrients in growth and development of plants might be the reason for increase in plant height compared to control treatment receiving no seed treatment and no foliar spray. Micronutrients has the capacity to increase the auxin content and chlorophyll content of tissues thus promoting plant growth and yield. It helps in the growth of cells by promoting cell elongation and cell division of meristematic regions. The micronutrients zinc and boron plays a crucial role in growth and development of new cells in plants. The findings are in accordance with the results obtained by Suryanarayana and Reddy (1978). They reported that plant height of French bean was increased by the application of 0.01 percent Zn and B. Cowpea seeds treated with borax showed highest plant height at 30 and 60 days after sowing (Masuthi *et al*., 2009).

Significant difference was not observed in the number of branches at flower bud initiation and at harvest in seed treatment, foliar spray and their interaction.

Stem diameter showed significant difference with variation in seed treatment. Maximum diameter was observed in treatment S_4 (2.44 cm) at flower bud initiation which was on par with S_3 (2.43 cm) and seed treatment with rhizobium, S_2 (2.35). At the time of harvest treatment S_3 recorded the highest stem diameter (4.65 cm) which was significantly different from all other treatments. Levels of foliar spray showed significant difference in stem diameter at flower bud initiation. F_3 recorded maximum stem diameter (2.54 cm) which was on par with single spray of micronutrient formulation, F_2 (2.40 cm). At the time of harvest, F_3 (4.85 cm) recorded maximum stem diameter which was significantly different from all other treatments. Interaction effect of treatments also showed significant difference among the treatments. At flower bud initiation maximum stem diameter was recorded in S_2F_3 (2.86 cm) which was on par with S_3F_2 (2.66 cm), S_4F_3 (2.64 cm) and S_4F_2 (2.62 cm). At harvest S_2F_3 (5.30 cm) showed maximum stem diameter which showed significant difference from all other treatments. These findings were in accordance with Mathur (2000) reported that seeds of garden pea inoculated with rhizobium showed enhanced growth characters and yield. Suryanarayana and Rao (1981) reported that foliar spray of micronutrient solution containing zinc, copper, manganese, magnesium, boron and molybdenum resulted in enhanced growth of okra. Bukvic *et al*. (2003) reported the similar increasing trend in stem diameter with zinc application.

Dry matter production recorded was maximum in S_3 (2292.91 kg ha^{-1}) which was superior over other seed treatments. Dry matter production was lowest in S_1 (2000.06 kg ha^{-1}). Foliar spray F_3 showed maximum dry matter production per plant (2372.92 kg ha^{-1}) which was superior over other levels of foliar spray. Interaction of main treatments showed significant difference in dry matter production with S_3F_3 (2613.24 kg ha^{-1}) produced highest amount which was superior over other interactions. Seed treatment with micronutrients have the capacity to enhance dry matter production. Seed treatment might had resulted in increased seed vigour. Increased seed vigour might be the reason for maximum dry matter production in plants. Similar results were obtained in barley. Seeds of barley treated with micronutrients showed increased dry matter production (Ajouri *et al*., 2004).

Effect of seed treatment, foliar spray of micronutrient formulation and their interaction on yield and yield attributes of cowpea

The data on yield and yield attributes are given in Table 3.

Levels of seed treatment showed significant difference in the number of pods per plant with maximum number recorded in S_3 (21.02) which was on par with S_4 (19.44). The lowest number of pods per plant was observed in S_1 (16.73). Levels of foliar spray showed significant difference in the number of pods per plant with maximum number recorded in F_3 (20.97). F_1 recorded the lowest number (16.71). The interaction effect also showed significant difference in number of pods per plant with maximum number recorded in S_3F_3 (25.84) which was on par with seed treatment with 1.5% micronutrient formulation + two foliar sprays, S_4F_3 (21.01). S_1F_1 (16) recorded the least value. Treatments did not show any significant difference in the number of seeds per pod.

Levels of seed treatment showed significant difference in pod weight per plant. S_3 recorded highest pod weight per plant (36.14 g) which was on par with S_4 (31.90 g). It was then followed by S_2 (29.73 g) and control recorded the least (24.92 g). Levels of foliar spray showed significant difference in pod weight per plant with F_3 (33.49 g) recorded the highest value which was superior over all other treatments. The treatment F_1 showed lowest value (26.43 g). Interaction effect of seed treatment and foliar spray of micronutrient in pod weight was found to be significant with S_3F_3 (38.11 g) recorded maximum pod weight per plant which was on par with S_4F_3 (31.23 g). Treatment S_1F_1 (24.64 g) recorded the lowest value.

Levels of seed treatment showed significant difference in yield with highest value was obtained in S_3 (2224 kg ha^{-1}) superior over all other seed treatments. Lowest yield was obtained in S_1 (1969 kg ha^{-1}). Levels of foliar spray showed significant difference in yield with highest was recorded in F_3 (2173 kg ha^{-1}) which was superior over all other treatments and the lowest yield was recorded in F_1 (1979 kg ha^{-1}). Interaction of seed treatment and foliar spray also showed significant difference in the yield with highest was recorded in S_3F_3 (2320 kg ha^{-1}) which was superior over other treatment interactions. It was followed by S_3F_2 (2220 kg ha^{-1}) which was on par with S_4F_3 (2200 kg ha^{-1}). Lowest yield was recorded in S_1F_1 (1820 kg ha^{-1}).

The role of micronutrients in enhancing the yield and its attributes are evident. Seed treatment with micronutrients had positive influence on yield of cowpea. Seed treatment with micronutrients might had increased the seed vigour resulting in better growth and yield of plants. It is also involved in hormonal metabolism, pollination and fertilization and enhancement of cell division which ultimately leads to increase in number and weight of pods. By enhancing the cell division and expansion vegetative growth can also be increased. It also helps in increased production of assimilates and its proper partitioning. Pranakrishna (1976) reported that pulse crops treated with sodium molybdate increased the seed yield by 45 percentage compared to the control. Common beans treated with zinc increased the yield of crops (Kaya *et al*., 2007). Pod yield in pea was found to be higher in seeds treated with 0.5 percent boron solution (Kumar *et al*., 2008). Foliar application of micronutrient mixture (zinc, copper, boron and iron) at two percentage resulted in increased yield in okra (Datire *et al*., 2010).

Nitrogen, phosphorus, potassium content in grain

Nutrient content in grain is given in the Table 4.

S_2 (3.71) recorded highest nitrogen in grain which was superior over other seed treatments. F_3 (3.76) in foliar spray and S_2F_3 (3.91) in interaction were found to be superior over other treatments. Phosphorus content in grain was found to be non significant with respect to treatments and their interactions. S_3 (1.18) in seed treatment and F_3 (1.08) in foliar spray recorded highest potassium content. Interaction effect showed that S_3F_3 (1.25) and S_4F_3 (1.19) were found to be on par with each other.

Nitrogen content in grain was maximum in S_2 (seed treatment with rhizobium). This might be due to the positive effect of rhizobia on increasing the nitrogen content in grain. Thilakaratna *et al*. (2019) reported that in common bean, seed treatment with rhizobium showed increased nitrogen content in grain. Considering the potassium concentration in grain, seed treatment with micronutrient mixture at 2% showed highest concentration. The presence of boron in the micronutrient mixture might be the reason for increase in potassium content of grain as it enhances the potassium uptake by plants. The application of micronutrient spray could be beneficial in increasing the grain concentration of nitrogen and potassium. Since it increases the uptake of nutrients, the concentration of nutrients in plant tissues might be increased. Gad (2012) reported that application of

Table 4: Effect of seed treatment, foliar spray and their interaction on nutrient content in cowpea grain.

Treatments and interactions	N (%)	P (%)	K (%)	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	B (mg kg^{-1})	Mo (mg kg^{-1})
S_1	3.43	0.32	0.81	103.54	7.74	48.63	5.23	74.80	1.05
S_2	3.71	0.32	1.01	105.86	8.96	51.13	5.53	75.11	1.06
S_3	3.50	0.36	1.18	120.91	14.30	56.90	6.50	86.80	1.07
S_4	3.41	0.36	1.00	109.50	10.74	52.82	6.06	79.13	1.06
SEm (±)	0.02	0.02	0.01	0.03	0.01	0.01	0.001	0.01	0.02
CD (0.05)	**0.07**	**NS**	**0.04**	**0.09**	**0.03**	**0.02**	**0.003**	**0.04**	**NS**
F_1	3.38	0.34	0.96	105.35	9.21	50.94	5.45	76.20	1.04
F_2	3.41	0.33	0.96	106.85	9.38	52.19	5.60	77.25	1.05
F_3	3.76	0.36	1.08	117.65	12.71	53.98	6.45	83.42	1.05
SEm (±)	0.02	0.02	0.01	0.02	0.01	0.009	0.001	0.01	0.02
CD (0.05)	**0.06**	**NS**	**0.03**	**0.07**	**0.03**	**0.025**	**0.002**	**0.04**	**NS**
S_1F_1	3.30	0.27	0.72	94.83	5.55	45.06	4.50	69.50	0.77
S_1F_2	3.40	0.32	0.77	100.83	5.56	48.10	4.71	70.30	0.69
S_1F_3	3.61	0.37	0.93	114.96	12.11	52.73	6.50	84.61	1.30
S_2F_1	3.30	0.35	0.94	104.90	8.56	50.30	5.21	74.50	1.49
S_2F_2	3.31	0.34	0.96	103.86	9.06	50.90	5.41	75.50	1.54
S_2F_3	3.91	0.34	1.13	108.83	9.26	52.21	6.01	75.31	0.89
S_3F_1	3.71	0.35	1.01	112.86	12.86	55.81	6.20	84.61	1.52
S_3F_2	3.62	0.37	1.10	117.90	12.96	55.92	6.32	86.61	1.25
S_3F_3	3.81	0.40	1.25	131.96	17.08	59.21	7.02	89.23	1.56
S_4F_1	3.23	0.37	0.99	108.83	9.89	52.61	5.91	76.21	1.24
S_4F_2	3.31	0.34	1.00	104.83	9.94	53.86	6.01	76.60	1.35
S_4F_3	3.72	0.38	1.19	114.83	12.39	52.00	6.30	84.61	1.45
SEm (±)	0.01	0.02	0.02	0.05	0.02	0.01	0.002	0.02	0.03
CD (0.05)	**0.02**	**NS**	**0.07**	**0.15**	**0.06**	**0.05**	**0.004**	**0.08**	**NS**

molybdenum increased the concentration of nitrogen and potassium in groundnut seeds. Nitrogen concentration was found to be highest in S_2F_3. Seed treatment with rhizobium might be the reason for increase in nitrogen content which is enhanced by the foliar spray of micronutrient mixture. Potassium content in grain was found to be highest in S_3F_3 which was on par with S_4F_3. Micronutrients, especially boron help in the uptake and translocation of potassium in plants. This might be the reason for increased potassium content in grains supplied with micronutrient seed treatment and foliar spray. Pattanayak *et al*. 2000, Thiyageswari and Ramanathan, (2001) and Hanwate *et al*. (2018) reported similar results.

Micronutrient content in grain

Seed treatment S_3 (120.91), foliar spray F_3 (117.65) and interaction S_3F_3 (131.96) were found to be superior in the respective treatments and their combinations in iron content of grain. Manganese content in grain was superior in treatments. Among the seed treatments, S_3 (14.30) recorded significantly higher value. F_3 (12.71) and S_3F_3 (17.08) showed superior value in the respective treatments and interaction. Zinc content in grain showed the same trend of iron and manganese with S_3 (56.90), F_3 (53.98) and S_3F_3 (59.21) recorded superior values. Copper content in grain also showed significant difference among treatments with S_3 (6.50), F_3 (6.45) and S_3F_3 (7.02) showed copper content superior over other treatments. S_3 (86.80), F_3 (83.42) and S_3F_3 (89.23) showed highest boron content over other treatments. Molybdenum was found to be non significant with respect to seed treatment, foliar spray and their interaction.

Seed treatment showed significant difference in the concentration of iron, manganese, zinc, copper and boron content in grain and were found to be highest in seeds receiving 2% micronutrient formulation. Hence it is revealed that micronutrient seed treatment has the capacity to increase the nutrient concentration in grain. Similar results were obtained by Pattanayak *et al*., 2000. Maize seeds treated with micronutrient increased the concentration of iron, manganese and zinc content in grains (Harris *et al*., 2007).

Foliar application of micronutrient mixture also showed significant difference in the amount of iron, manganese, zinc, copper and boron concentration in grain. Treatments receiving foliar spray of micronutrient mixture at 15 and 30 days after sowing showed higher concentration of these micronutrients. Divyasree, 2018 reported that foliar application of micronutrient mixture containing Fe, Mn, Zn, Cu and B significantly increased the respective nutrient concentrations in grains of mung bean.

Similar results were obtained in the interaction effects. Seed treatment with the best micronutrient formulation and two foliar spray recorded highest value of micronutrients in grain except in the case of molybdenum. The combined effect of the individual treatments might be the reason for this. The economic analysis of the field experiment given in

Table 5: Benefit – cost ratio of the field experiment.

Treatments	Cost of cultivation	Gross return	B:C Ratio
T_1	83947	127600	1.52
T_2	100000	160000	1.60
T_3	107988	180340	1.67
T_4	86671	131740	1.52
T_5	100000	160000	1.60
T_6	104036	170620	1.64
T_7	105712	183940	1.74
T_8	110333	198600	1.80
T_9	110441	199900	1.81
T_{10}	104971	181600	1.73
T_{11}	106198	181600	1.71
T_{12}	113953	196000	1.72

Table 5 shows that plants receiving seed treatment with 2 per cent micronutrient formulation and two foliar sprays showed higher benefit cost ratio compared to other treatments.

CONCLUSION

The results obtained from the investigation revealed that the application of micronutrient formulation as foliar spray (15 and 30 DAS) along with seed treatment (2% micronutrient formulation) was found to be highly effective in increasing the growth and yield characters of cowpea. The nutrient content in grain was also found to increase with the application of micronutrient formulation enhancing the nutritional quality of grain. Considering the benefit cost ratio plants receiving seed treatment with 2 per cent micronutrient formulation and two foliar sprays showed higher yield compared to the cost incurred. Thus it was found to be the most effective and profitable method.

REFERENCES

Ajouri, A., Asgedom, H. and Becker, M. (2004). Seed priming enhances germination and seedling growth of barley under conditions of P and Zn deficiency. J. Plant Nutr. Soil Sci. 167: 630-636.

Alloway, W.H. (1986). Soil-plant-animal and human interrelation--ships in trace element nutrition. In: Trace elements in Human and Animal nutrition. [Mertz, W.(ed.)], Academic press, Oriando, San Diego, New York, Austin, London, Montreal, Sydeney, Tokyo, Toronto. pp. 465-488.

Bell, R.W. and Dell, B. (2008). Micronutrients for Sustainable Food, Feed, Fibre and Bioenergy Production (1st Ed.). IFA, Paris, France.

Bukvic, G., Antunovic, M., Popovic, S. and Rastija, M. (2003). Effect of P and Zn fertilization on biomass yield and its uptake by maize lines (*Zea mays* L.). Plant Soil Environ. 49(11): 505–510.

Choudhary, S.K., Jat, M.K. and Mathur, A.K. J. (2017). Effect of micronutrient on yield and nutrient uptake in sorghum. Pharmacognosy and Phytochemistry. 6(2): 105-108.

Datire, R.B., Laware, S.L. and Apparao, B.J. (2010). Effect of

Organically Chelated Micronutrients on Growth and Productivity in Okra. Asian J. Exp. Biol. Sci. Spec. 200: 115-117.

Deb, P., Das, A., Ghosh, S.K. and Suresh, C.P. (2010). Improvement of seed germination and seedling growth of papaya (*Carica papaya* L.) through different pre-sowing seed treatments. Acta Hort. 851: 313-316.

Divyashree, K.S. (2018). Effect of different methods of micro--nutrients mixture application on growth and yield of mungbean in Cauvery command area. J. Pharmacognosy Phytochemistry. 7(3): 3578-3582.

Farooq, M., Wahid, A. and Siddique, K.H.M. (2012). Micronutrient application through seed treatments-A review. J. Soil Sci. Plant Nutr. 12(1): 125-142.

Gad, N. (2012). Influence on molybdenum on groundnut production under different nitrogen levels. World J. Chem. 7(2): 64-70.

GOI [Government of India]. (2016). Agricultural Statistics at a glance 2016 [online]. Available: http://eands.dacnet.nic.in [11 January 2018].

GOK [Government of Kerala]. (2016-2017). Agricultural Statistics 2016-2017 [online]. Available:www.ecostat.kerala.gov.in/images/pdf/publications/Agriculture/.../rep_agristat_1516.pdf [11 January 2018].

Hanwate, G.R., Giri, S.N. and Yelvikar, N.V. (2018). Effect of foliar application of micronutrients on nutrient uptake by soybean crop. Int. J. Pure App. Biosci. 6(5): 261-265.

Harris, D., Rashid, A., Miraj, G., Arif, M., Shah, H. (2007). A on-farm seed priming with zinc sulphate solution - A cost-effective way to increase the maize yields of resource-poor farmers. Field Crops Res. 10: 119-127.

Kaya, M., Atak, M., Khawar, K.M., Ciftci, C.Y. and Ozcan, S. (2007). Effect of pre-sowing seed treatment with zinc and foliar spray of humic acids on yield of common bean (*Phaseolus vulgaris* L.). Int. J. Agric. Biol. 7: 875-878.

Kumar, R., Kumar, S.S. and Pandey, A.C. (2008). Effect of seed soaking in nitrogen, phosphorus, potassium and boron on growth yield of garden pea *(Pisum sativum* L.). Ecol. Environ. Conserv. 14: 383-386.

Manasa, V., Hebsur, N.S., Malligawad, L.H., Kumar, L.S. and Ramakrishna, B. (2015). Effect of water soluble fertilizers on uptake of major and micronutrients by groundnut and post-harvest nutrient status in a vertisol of Northern transition zone of Karnataka. *Ecoscan* 9(1-2): 1-5.

Masuthi, D.A., Vyakaranahal, B.S. and Deshpande, V.K. (2009). Influence of pelleting with micronutrients and botanical on growth, seed yield and quality of vegetable cowpea. Karnataka J. Agric. Sci. 22(4): 898-900.

Mathur, K. (2000). Effect of Rhizobium inoculation and various sources of nitrogen on growth and yield of summer greengram [*Vigna radiata* (L.) Wilckzek.] M. Sc. (Ag) thesis, CCS HAU, Hisar, India, 132p.

Mona, E., Eleiwa, Ibrahim, S.A. and Mohamed, F. 2012. Combined effect of NPK levels and foliar nutritional compounds on growth and yield parameters of potato plants (*Solanum tuberosum* L.) Afr. J. Micro. Res. 6(24): 5100–5109.

Panse, V.G. and Sukhatme, P.V. (1985). Statistical Methods for Agricultural Workers (4th Ed.). Indian Council of Agricultural Research, New Delhi, p.347.

Pattanayak, S.K., Dash, V., Jena, M.K. and Nayak, R.K. (2000). Seed treatment of green gram with molybdenum and cobalt: Effect on nodulation, biomass production and N uptake in an acid soil. J. Indian Soc. Soil Sci. 48: 769-773.

Pranakrishna, S. (1976). Effect of nitrogen micronutrients and rhizobium culture on cowpea and blackgram. M.Sc. (Ag) thesis, Orissa University of Agriculture and Technology, 56p.

Ravi, S., Channal, T., Hebsur, N.S. and Dharamtti. (2008). Effect of sulphur, zinc and iron nutrition on growth, yield, nutrient uptake and quality of safflower (*Carthamus tinctorius* L.). Karnataka J. Agric. Sci. 21: 3.

Singh, M.V. (2003). Issues and challenges in promoting safe use of micronutrients in agriculture during new millennium: Interface on micronutrients, MCEAR, Pune. pp.241.

SSO [Soil Survey Organization]. (2007). Benchmark Soils of Kerala. Agriculture (SC Unit) Department, Govt. of Kerala, Thiruvananthapuram, 623p.

Suresh, P.R., Govindan, M., Gladis, R. and Joseph, B. (2014). Soil Fertility status of Kasargod district. College of Agriculture, Padannakad. 32p.

Suryanarayana, V. and Rao, S.K.V. (1981). Effect of growth regulators and nutrient sprays on the yield of okra. Veg. Sci. 8: 12-14.

Suryanarayana, V. and Reddy, P.E. (1978). Effect of growth regulators and micronutrients on French bean. Veg. Sci. 6(1): 130-134.

Thilakarathna, M.S., Chapagain, T., Ghimire, B., Pudasaini, R., Tamang, B.B., Gurung, K., Choi, K., Rai, L., Magar, S., Bishnu, B.K., Gaire, S. and Raizada, M.N. (2019). Evaluating the effectiveness of rhizobium inoculants and micronutrients as technologies for Nepalese common bean smallholder farmers in the real-world context of highly variable hillside environments and indigenous farming practices. Agric. 9(20): 23-26.

Thiyageshwari, S. and Ramanathan, G. (2001). Uptake of nutrients as influenced by application of micronutrients and cytozyme to soybean in inceptisol. J. Soil Crops. 11(1): 1-6.