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Nutrient status of cowpea [*Vigna unguiculata* (L.)] influenced by foliar nutrition under different management systems

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Abstract

An investigation entitled "Foliar nutrition of cowpea [*Vigna unguiculata* (L.)] under different management systems" was carried out at College of Agriculture, Padannakkad and Regional Agricultural Research Station (RARS), Pilicode, during 2018 - 20 with an objective to evaluate the effect of foliar nutrition under organic and integrated nutrient management practices in cowpea. The field experiment was carried out in randomized block design with 12 treatments, combinations of management system and six foliar nutrition. Management system includes KAU adhoc organic POP recommendations (2017) (S_1) and KAU POP recommendations (2016 (S_2). Six foliar nutrition, *viz*. 'Sampoorna- KAU multi nutrient mix' (F_1), micro nutrient solution (F_2), jeevamrutham (F_3), humic acid (F_4), fulvic acid (F_5) and a control without foliar spray (F_0), were tested in the study. Nitrogen, potassium and magnesium contents of the plant were significantly enhanced by S_2 at flowering and at harvesting stage compared to S_1. Foliar nutrition of humic acid enhanced the phosphorous content of plant at flowering stage. Interaction effects S_1F2, S_1F_3, S_1F_4 and S_1F_5 were on par and significantly superior to other treatment combinations with respect to P content of plant at flowering stage. Jeevamrutham enhanced the K content of plant at flowering stage and was on par with humic acid and fulvic acid spray. At harvesting stage, S_1F_1 enhanced the calcium content of plant and was on par with all treatments except S_1F_5 and S_2F_2. Foliar nutrition of fulvic acid and humic acid increased the magnesium content of plant at both stages. Micro nutrient solution increased the Fe content of plant and was on par with F_1, F_3 and F_5 at flowering and F_1 and F_5 at harvesting stage. Sampoorna enhanced the Zn content of plant at harvesting stage and was on par with jeevamrutham and fulvic acid.

Keywords: Cowpea, fulvic acid, jeevamrutham, micronutrients, organic, sampoorna

Introduction

Cowpea is most commonly known as lobia in India, and as Vellappayar in Kerala. Cowpea is an annual herb with a strong principal tap root and many lateral roots. The feeding lateral roots are more confined to the surface soil. Cowpea being a leguminous crop has the capacity to fix atmospheric nitrogen. The bacteria, *Rhizobium leguminosarum* in association with cow pea can fix nitrogen most efficiently. In major parts of Kerala, micronutrient deficiencies are severe, which also contribute to causes low yield in productivity in cowpea. As per the GPS-aided analysis of more than 2 lakh soil samples, Zn (36.5%) as identified as the major deficient element followed by Fe (12.8%), Cu (4.2%), Mn (7.1%), B (23.4%) and scattered deficiency of Mo has been observed in acid soils (Shukla *et al*., 2019). Deficiency is mostly due to enhanced crop uptake, which is triggered by intensified agricultural practices. Inorganic micronutrient formulations are available to supplement the micronutrients to alleviate deficiencies in crops.

Application of nutrients as foliar spray increases the absorption of nutrients which in turn reflect on growth, yield, and quality of the produce. Research conducted by Anitha *et al*. (2005) under AICRP on arid legumes during kharif seasons found that foliar application of micronutrients like iron and zinc has significant influence on the yield of cowpea. Kerala Agricultural University has developed a "micro nutrient solution" and a micro nutrient mixture 'KAU nutrient multi mix –Sampoorna' to solve the problem of micro nutrient deficiencies in crops.

Hence a field experiment was conducted to assess the direct and indirect effect of liquid organic formulations and micronutrient combinations along with normal recommendations of organic and integrated nutrient management on nutrient status of plant in cowpea.

Materials and Methods

The field experiment was conducted at Regional Agricultural Research Station (RARS), Pilicode at an altitude of 15 m above mean sea level. The region has a warm tropical humid climate. The type of soil present in the experimental site was red loam. The field experiment was conducted during rabi season from October to December, 2019. Highest rainfall obtained during the initial stage of crop at that stage relative humidity of the atmosphere was also high.

The seeds of cowpea var. PGCP 6 procured from the Regional Agricultural Research Station, Pattambi were sown at the rate of 60 kg ha^{-1} with a spacing of 30 cm between the rows and 25 cm between the plants.

Design of the experiment was randomized block design with 12 treatment and 3 replications. These treatments were the combination of management system and foliar nutrition.

Treatment details

T_1: KAU Adhoc organic POP Recommendations (S_1F_0)
T_2: KAU Adhoc organic POP Recommendations+ Sampoorna (S_1F_1)
T_3: KAU Adhoc organic POP Recommendations+ Micronutrient solution (S_1F_2)
T_4: KAU Adhoc organic POP Recommendations+ Jeevamrutham (S_1F_3)
T_5: KAU Adhoc organic POP Recommendations+ Humic acid (S_1F_4)
T_6: KAU Adhoc organic POP Recommendations+ Fulvic acid (S_1F_5)
T_7: KAU POP Recommendations (S_2F_0)
T_8: KAU POP Recommendations + Sampoorna (S_2F_1)
T_9: KAU POP Recommendations + Micronutrient solution (S_2F_2)
T_{10}: KAU POP Recommendations + Jeevamrutham (S_2F_3)
T_{11}: KAU POP Recommendations + Humic acid (S_2F_4)
T_{12}: KAU POP Recommendations + Fulvic acid (S_2F_5)

Farmyard manure was applied uniformly to all the plots @ 20 t ha^{-1} as basal dose and well mixed with top soil. In addition, in plots T_1, T_2, T_3, T_4, T_5 and T_6, farmyard manure (2 t ha^{-1}) and rock phosphate at the rate of 100 kg ha^{-1} was applied as nutrient supplements based on KAU adhoc organic POP Recommendation (2017). Fertilizers like urea, rajphos and MOP were applied in plots T_7, T_8, T_9, T_{10}, T_{11} and T_{12} based on KAU package of practice recommendation (2016) at the rate of 20:30:10 kg N: P_2O_5: K_2O ha^{-1}. Nitrogen was applied in two equal doses, first as basal dose and second dose at 15 DAS. Phosphorus and potassium were applied full as basal in all the plots.

Multi nutrient mixture 'Sampoorna- KAU multi mix' @ 5 g L^{-1} and micro nutrient solution (2%) were applied as foliar spray at 15, 30, and 45 DAS. Fulvic acid @ 2 g L^{-1}, humic acid @ 1000 ml $acre^{-1}$ and jeevamrutham (100%) as foliar spray were given at weekly interval up to 45 DAS.

Biometric observations were taken during flowering and harvesting stage. The major biometric observations included are plant height (cm), number of branches per plant, number of nodules per plant, leaf area (cm^2) and total dry matter production (kg ha^{-1}). Yield and yield attributes such as number of pods per plant, number of seeds per pod, pod weight per plant (g), test weight (100 seed weight), pod yield (kg ha^{-1}) and seed yield (kg ha^{-1}) were recorded at harvesting stage.

Fully matured pods were harvested for grain purpose. First harvesting was done at 60 DAS. Three harvests were obtained from the field. After harvesting, the pods were dried, threshed and cleaned to obtain the seeds.

Results

Nitrogen content in plant at flowering and at harvesting stage responded significantly to management systems and higher N content was obtained in treatment S_2 (3.13% and 2.81% at flowering and harvesting stage respectively). Nitrogen content of the plant was not significantly influenced by foliar application at both stages. Among the interaction effects, S_2F_2 recorded maximum N content at flowering and S_2F_1 at harvesting stage without any significant differences.

Nutrient management systems, foliar nutrition and their interaction significantly influenced the phosphorous content of plant at flowering stage and at harvesting stage no significant differences were observed. Nutrient management based on KAU adhoc organic POP (S_1) enhanced the P content of plant (0.303%) at flowering stage. Highest phosphorous content (0.346%) was observed with foliar nutrition F_4 (humic acid) which was significantly superior to all other foliar nutrition treatments. The treatment combination S_1F_4, where KAU adhoc organic POP and humic acid were combined, significantly increased the P content in plant and was on par with S_1F_2, S_1F_3 and S_1F_5.

Potassium content of plant was significantly influenced by the management system at flowering and at harvesting stage. The treatment S_2 recorded maximum K content at flowering (2.48%) and at harvesting stage (1.89%) compared to S_1.Foliar nutrition had significant influence on plant K at flowering stage only. Highest K content was observed in F_3 which was on par with F_4 and F_5. Interaction effects of nutrient management system and foliar nutrition was not significant with K content in plant at both stages.

Calcium content in plant was not significantly influenced by any of the treatment or their combinations except treatment interaction at harvesting stage. At harvesting stage KAU organic POP along with Sampoorna (S_1F_1) significantly increased the Ca content of plant (3.04%) which was on par with S_1F_3, S_1F_0, S_1F_2, S_1F_4, S_2F_0, S_2F_1, S_2F_3, S_2F_4 and S_2F_5.

Nutrient management system and foliar nutrition had a significant influence on Mg content in plant both at flowering and at harvesting stages Interaction of nutrient management system and foliar nutrition produced a significant effect in Mg content of plant at flowering stage and failed to produce a significant effect at harvesting stage. KAU POP recommendation (S_2) enhanced the Mg content in plant at flowering and at harvesting stage. Foliar application of fulvic acid (F_5) enhanced the Mg content (0.94%) in plant at flowering stage and was on par with application of humic acid F_4 (0.89%). At harvesting stage humic acid (F_4) increased the Mg content which was on par with fulvic acid. At harvesting stage, application of KAU POP along with fulvic acid (S_2F_5) application enhanced the Mg content of plant which was on par with S_2F_1, S_2F_2, S_2F_3, S_2F_4 and S_1F_5 and significantly superior to other treatment combinations.

At flowering stage, S content was significantly enhanced by KAU POP recommendation (S_2) compared to S_1. In the case of foliar nutrition, application of fulvic acid (F_5) increased the S content (0.400%) and was significantly superior to other treatments. Application of KAU POP along with fulvic acid spray (S_2F_5) significantly enhanced the S content of plant at flowering stage and was on par with S_2F_0, S_2F_1 and S_1F_4. Management system, foliar nutrition and their interaction effect failed to produce any significant effect on S content in plant at harvesting stage.

At flowering and at harvesting stages, management system and interaction effects failed to produce significant influence on Fe content while foliar nutrition significantly influenced the Fe content at both stages. Foliar nutrition F_2, where micronutrient solution was sprayed, recorded maximum Fe content (352.84 mg kg^{-1}) at flowering stage and which was on par with F_5, F_3 and F_1 and significantly superior to F_0 and F_4. Foliar nutrition F_2 significantly increased the Fe content (352.84 mg kg^{-1}) of plant and was on par with F_1 and F_5 at harvesting stage.

Management systems, foliar nutrition and their interaction effects on Mn was found to be insignificant both at flowering and at harvesting stage. Zinc content in plant (Table 12) was not significantly influenced by management system, foliar nutrition and their interaction effects at flowering stage. At harvesting stage only foliar nutrition showed significant difference and the treatment F_1 recorded highest Zn content (74.46 mg kg^{-1}) which was on par with F_3 and F_4 and superior to other treatments. Copper content in plant was significantly influenced by foliar nutrition only (Table 12). At flowering stage highest Cu content was observed with foliar nutrition F_4 (28.33 mg kg^{-1}) and was on par with F_3 and F_5.

Discussions

KAU POP Recommendation includes the application of major nutrients *viz.* nitrogen, phosphorus and potassium through inorganic fertilizers while KAU adhoc organic POP recommendations follow the application of nutrients through organic manures. Nitrogen content in plant, grain and N uptake was highest in treatment with KAU POP recommendation both at flowering and harvesting stage. This may be due to the increased availability of N from inorganic fertilizer like urea and efficient translocation of N from vegetative parts to reproductive parts. Similar results were reported by Pandya and Bhatt, 2007 [6]; Verma *et al.* (2015) [10]. High N content and dry matter production may lead to higher N uptake compared to KAU adhoc organic POP. Foliar application of fulvic acid enhanced the N content and it was in line with the findings of Khalil, *et al.* (2011) [3]. They concluded that fulvic acid application enhanced the protein content in cucumber.

Phosphorous content was highest in KAU adhoc organic POP at flowering stage and this may be due to the application of farm yard manure. Minhas and Sood (1994) [12] confirms this result.

KAU POP Recommendation significantly increased the K content in plant. This may be due to the increased availability of K from inorganic fertilizer like MOP and efficient translocation of K from vegetative parts to reproductive parts

Maximum K content of plant was recorded in jeevamrutham foliar spray, which was on par with application of humic acid and fulvic acid at flowering stage. Sutar *et al*. (2017) [9] and Palekar (2006) [5] found that jeevamrutham foliar spray has enhanced plant K content. El-Bassiony *et al.* (2010) [1] recorded that the application of humic acid enhanced the potassium content of plant in snap bean.

Even though individual effect of foliar nutrition and management system were not significant with respect to Ca content of plant, interaction effects except KAU POP along with fulvic acid and KAU POP along with micro nutrient solution were significant at harvesting stage.

Individual effect of management system and foliar nutrition were significant in the case of Mg content in plant. KAU POP enhanced the S content of plant. Foliar nutrition fulvic acid enhanced the S content of plant because the fulvic acid contains 0.25% S. KAU organic POP with humic acid, KAU POP without foliar application, KAU POP along with Sampoorna and KAU POP with fulvic acid were on par and significantly superior over other treatments.

Maximum Fe content was observed with inorganic micro nutrient formulation both at flowering and at harvesting stage and was on par with Sampoorna and fulvic acid at both stages. Micro nutrient formulation and Sampoorna contains Fe as a constituent. The findings are in accordance with the results obtained by Jhon (2019) [2].

Sampoorna, jeevamrutham and fulvic acid were on par and significantly enhanced the Zn content of plant at harvesting stage. Sampoorna consists of Zn 3.5-5% and due to this, application of Sampoorna as foliar spray increased the Zn content in plant. Rauthan and Schnitzer (1981) [7] found that application of fulvic acid enhanced the Zn uptake in cucumber.

Copper content of the plant was influenced by the foliar nutrition at harvesting stage. Foliar nutrition with humic acid recorded maximum Cu content and was on par with jeevamrutham and fulvic acid. Sharif *et al.*, (2002) [8] also reported similar results with respect to humic acid in maize. Humic acid attracts Cu ions due to chelation and prevent them from leaching and make it more available for plants thus increases the accumulation (Yingei, 1988) [11] similar effects were also observed with fulvic acid and jeevamrutham. In grain, Cu content was highest for KAU POP recommendation. All foliar nutrition except control influenced the Cu content.

Table 1: Effect of management system, foliar nutrition, and their interaction effects on N, P and K content in plant at flowering and harvesting stage

Treatment	N (%)		P (%)		K (%)	
Management systems (S)	**Flowering stage**	**Harvesting stage**	**Flowering stage**	**Harvesting stage**	**Flowering stage**	**Harvesting stage**
S_1	2.38	2.13	0.303	0.193	1.97	1.39
S_2	3.13	2.81	0.270	0.196	2.48	1.89
S.Em (±)	0.136	0.135	0.003	0.004	0.137	0.108
CD (0.05)	0.403	0.398	0.008	NS	0.405	0.320
Foliar nutrition (F)						
F_0	2.44	1.72	0.241	0. 167	1.65	1.19
F_1	3.01	2.08	0.276	0.175	1.99	1.45
F_2	3.19	2.55	0.289	0.183	1.94	1.75
F_3	2.89	2.50	0.294	0.218	2.79	1.97
F_4	2.56	1.85	0.346	0.221	2.53	1.78
F_5	2.57	2.08	0.274	0.204	2.42	1.72
S.Em (±)	0.236	0.234	0.005	0.004	0.238	0.188
CD (0.05)	NS	NS	0.015	NS	0.702	NS
Interaction effects (SxF)						

S_1F_0	1.90	1.72	0.221	0.150	1.72	0.89
S_1F_1	2.54	2.08	0.262	0.220	1.74	1.38
S_1F_2	2.75	2.55	0.316	0.210	1.75	1.48
S_1F_3	2.50	2.50	0.305	0.204	2.50	1.70
S_1F_4	2.30	1.85	0.318	0.181	2.05	1.52
S_1F_5	2.32	2.08	0.304	0.194	2.02	1.42
S_2F_0	2.98	3.21	0.261	0.113	1.58	1.48
S_2F_1	3.48	3.23	0.290	0.200	2.23	1.52
S_2F_2	3.64	3.02	0.261	0.155	2.13	2.02
S_2F_3	3.28	2.90	0.283	0.231	3.07	2.24
S_2F_4	2.82	2.36	0.283	0.261	3.01	2.03
S_2F_5	2.57	2.15	0.245	0.213	2.82	2.03
S.Em (±)	0.334	0.331	0.007	0.009	0.336	0.188
CD (0.05)	NS	NS	0.021	NS	NS	NS

S_1- KAU Adhoc organic POP Recommendations S_2- KAU POP Recommendations F0 – Without foliar application F_1 – Sampoorna F_2 – Micronutrient solution F_3 – Jeevamrutham F_4 – Humic acid F_5 – Fulvic acid

Table 2: Effect of management system, foliar nutrition and their interaction effects on Ca, Mg and S content in plant at flowering and harvesting stage

Treatment	**Ca (%)**		**Mg (%)**		**S (%)**	
Management systems (S)	**Flowering stage**	**Harvesting stage**	**Flowering stage**	**Harvesting stage**	**Flowering stage**	**Harvesting stage**
S_1	3.09	2.72	0.78	0.80	0.32	0.235
S_2	3.10	2.70	0.89	0.85	0.367	0.245
S.Em (±)	0.101	0.063	0.014	0.007	0.004	0.012
CD (0.05)	NS	NS	0.041	0.022	0.012	NS
Foliar nutrition (F)						
F_0	2.97	2.63	0.73	0.75	0.307	0.217
F_1	3.30	2.82	0.81	0.82	0.325	0.274
F_2	3.09	2.59	0.86	0.82	0.308	0.266
F_3	3.25	2.85	0.81	0.80	0.352	0.225
F_4	2.95	2.72	0.89	0.87	0.375	0.229
F_5	3.02	2.66	0.94	0.86	0.400	0.230
S.Em (±)	0.175	0.110	0.024	0.013	0.007	0.021
CD (0.05)	NS	NS	0.071	0.038	0.010	NS
Interaction effects(SxF)						
S_1F_0	3.04	2.60	0.61	0.69	0.200	0.250
S_1F_1	3.47	3.04	0.75	0.79	0.228	0.260
S_1F_2	3.10	2.68	0.80	0.80	0.310	0.263
S_1F_3	3.37	3.00	0.74	0.79	0.376	0.183
S_1F_4	2.79	2.67	0.85	0.89	0.416	0.229
S_1F_5	2.81	2.33	0.92	0.83	0.385	0.226
S_2F_0	2.89	2.65	0.85	0.81	0.413	0.184
S_2F_1	3.13	2.60	0.87	0.84	0.422	0.288
S_2F_2	3.09	2.50	0.93	0.84	0.306	0.269
S_2F_3	3.14	2.70	0.87	0.82	0.327	0.268
S_2F_4	3.10	2.77	0.93	0.89	0.321	0.229
S_2F_5	3.23	2.99	0.96	0.89	0.430	0.230
S.Em (±)	0.247	0.155	0.034	0.018	0.010	0.030
CD (0.05)	NS	0.458	0.100	NS	0.028	NS

S_1- KAU Adhoc organic POP Recommendations S_2- KAU POP Recommendations F_0 – Without foliar application F1 – Sampoorna F_2 – Micronutrient solution F_3 – Jeevamrutham F_4 – Humic acid F_5 – Fulvic acid

Table 3: Effect of management system, foliar nutrition and their interaction effects on Fe and Mn content in plant at flowering and harvesting stage

Treatment	**Fe (mg kg^{-1})**		**Mn (mg kg^{-1})**	
Management systems (S)	**Flowering stage**	**Harvesting stage**	**Flowering stage**	**Harvesting stage**
S_1	301.79	277.06	235.26	201.04
S_2	324.06	295.12	252.39	191.14
S.Em (±)	8.677	8.691	7.248	9.348
CD (0.05)	NS	NS	NS	NS
Foliar nutrition (F)				
F_0	300.03	264.46	221.52	182.40
F_1	310.90	286.56	247.20	217.86
F_2	352.84	326.60	258.46	171.26
F_3	309.23	263.46	240.30	190.70
F_4	279.43	267.61	247.16	199.06
F_5	325.13	307.86	248.33	215.28
S.Em (±)	15.029	15.053	12.554	16.192

CD (0.05)	44.363	44.433	NS	NS
Interaction effects (SxF)				
S_1F_0	312.66	244.60	187.44	164.26
S_1F_1	293.13	287.40	241.33	260.00
S_1F_2	330.95	313.46	264.73	162.46
S_1F_3	298.46	266.27	243.13	201.33
S_1F_4	247.73	234.20	227.60	201.66
S_1F_5	327.80	316.46	247.36	216.56
S_2F_0	287.40	284.33	255.60	200.53
S_2F_1	328.66	285.73	253.06	175.73
S_2F_2	374.73	339.73	252.20	180.06
S_2F_3	320.00	266.67	237.46	180.06
S_2F_4	311.13	301.02	266.73	196.46
S_2F_5	322.46	299.26	249.30	214.00
S.Em (±)	21.254	21.288	17.753	22.899
CD (0.05)	NS	NS	NS	NS

S_1- KAU Adhoc organic POP Recommendations S_2- KAU POP Recommendations F_0 – Without foliar application F_1 – Sampoorna F_2 – Micronutrient solution F_3 – Jeevamrutham F_4 – Humic acid F_5 – Fulvic acid

Table 4: Effect of management system, foliar nutrition and their interaction effects on Zn and Cu content in plant at flowering and harvesting stage

Treatment	Zn (mg kg^{-1})		Cu (mg kg^{-1})	
Management systems (S)	**Flowering stage**	**Harvesting stage**	**Flowering stage**	**Harvesting stage**
S_1	77.61	59.74	23.58	22.79
S_2	78.46	61.93	24.19	22.87
S.Em (±)	2.756	2.593	1.287	1.006
CD (0.05)	NS	NS	NS	NS
Foliar nutrition (F)				
F_0	76.63	59.00	19.10	19.70
F_1	84.96	74.46	20.60	21.36
F_2	76.76	53.43	21.29	23.53
F_3	80.96	65.40	27.02	23.56
F_4	77.33	55.53	28.33	24.09
F_5	71.56	62.60	26.98	21.72
S.Em (±)	4.773	4.491	2.229	1.742
CD (0.05)	NS	13.258	6.580	NS
Interaction effects (SxF)				
S_1F_0	74.73	65.13	18.69	20.39
S_1F_1	92.86	78.66	23.77	20.03
S_1F_2	73.00	53.06	21.30	25.63
S_1F_3	82.33	57.06	24.02	23.02
S_1F_4	73.06	52.73	28.81	23.20
S_1F_5	69.66	51.80	24.92	24.46
S_2F_0	78.53	52.86	19.51	19.02
S_2F_1	77.06	70.26	17.44	22.70
S_2F_2	80.53	53.80	21.28	21.42
S_2F_3	79.60	73.73	30.01	24.10
S_2F_4	81.60	58.33	27.8	24.98
S_2F_5	73.46	62.60	29.05	18.98
S.Em (±)	6.75O	6.352	3.153	2.464
CD (0.05)	NS	NS	NS	NS

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