Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 493-498
Received: 01-05-2020
Accepted: 03-06-2020

Kiran SK
Student, University of Agricultural Sciences, Bangalore, Shivamogga, Karnataka India

Dr. Prakash SS
Professor and Head, Department of Soil Science and Agricultural Chemistry, College of Agriculture, V.C. Farm, Mandya, Karnataka, India

Dr. Krishnamurthy R
Associate Professor, Department of Soil Science and Agricultural Chemistry, GKVK, UAS, Bangalore, Karnataka, India

Dr. Yogananda SB
Associate Professor, Department of Agronomy, College of Agriculture, V.C. Farm, Mandya, Karnataka, India

Dr. Shivakumar KV
Professor and Head, Department of Crop Physiology, College of Agriculture, V.C. Farm, Mandya, Karnataka, India

Corresponding Author:
Kiran SK
Student, University of Agricultural Sciences, Bangalore, Shivamogga, Karnataka India

Effect of humic acid and multi-micronutrient mixture with STCR fertilizer dose on nutrient content and uptake by cowpea in southern dry zone (Zone 6) of Karnataka

Kiran SK, Prakash SS, Krishnamurthy R, Yogananda SB and Shivakumar KV

Abstract
The STCR equation developed on cowpea for Zone 5 has been tested for its performance and accessed for its efficiency in Zone 6. A field experiment was conducted at College of Agriculture, VC farm, Mandya with thirteen treatments including control, RDF+FYM, STCR (no FYM), STCR (no P), STCR (50% RDP) and STCR (50% RDP) with foliar application of HA (500, 1000 ppm) and MM (1 & 2) alone and their combinations at 30 and 45 DAS. Results revealed that yield target of 15 q ha^{-1} was achieved with application of STCR (50% RDP) based fertilizers. Significantly higher grain and haulm yield of 1550.61 and 3096.29 kg ha^{-1}, respectively was obtained in the treatment with STCR (50% RDP)+HA @ 500 ppm and MM2. Higher concentration of nitrogen (4.58%) and potassium (2.64%) in cowpea grain was recorded in T_{12} and phosphorous content (0.47%) was highest in T_2 which received RDF + FYM compared to all the other treatments. The concentration and uptake of all the micronutrients (Fe, Cu, Mn, Zn and B) in grain and haulm were significantly higher in treatments having combination of humic acid and MM, followed by MM alone compared to all the other treatments.

Keywords: STCR, Humic acid (HA), Multi-micronutrient mixture (MM)

Introduction
Pulses are gaining worldwide importance as they are the cheap source of protein in human diet. Hence, there is a need to enhance the total pulse production to provide sufficient amount of protein to the increasing population. Several factors contribute towards low productivity of pulses. Pulses have been traditionally grown under rainfed condition in marginal lands and in soils of low fertility in contrast to cereal crops which have been grown in more fertile lands with assured water supply. The nutrient management involving technological innovations brings out a definite improvement in utilization of nutrient with increased nutrient use efficiency and will certainly improve the productivity.

India is the largest producer and consumer of pulses in the world accounting for about 29 and 19 per cent of the world's area and production, respectively. Even more importantly India is also the largest importer and processor of pulses in the world. Ironically, the country's pulse production has been hovering around 14-15 m t coming from a near stagnated area of 22-23 m ha, since 1990-91 (Singh and Bhatt, 2013) [13].

Nitrogen requirement of pulses is much lower than cereals mainly because of biological nitrogen fixation but requires higher amount of phosphorous. However, pulse crops responds favourably to higher doses of fertilizer nutrients than generally applied or even recommended. But less productivity is mainly because they are grown on marginal lands in rainfed condition and with lower doses of fertilizers leading to sub-optimal nutrient uptake and abiotic stresses during the growth period.

Since fertilizer is a costly input, the scientific and efficient utilization of this input is very important. In this input utilization, STCR approach plays a vital role as a comprehensive approach of fertilizer utilization, wherein fertilizer will be applied based on the yield target, to a particular soil test values.

Micronutrients have a major role in cell division and development of meristematic tissues, photosynthesis, respiration and acceleration of plant maturity (Zeidan *et al*., 2006) [16]. In addition, Iron (Fe), Boron (B), Zinc (Zn), Copper (Cu), and Manganese (Mn) are considered essential micronutrients for plants and humans (Kaya *et al*., 1999; Asad and Rafique, 2000 and Hao *et al*., 2007) [7, 2, 6] and micronutrients maintain the crop-physiological balance.

Humic acid (HA) is a principal component of humic substances, which are the major organic constituents of soil (humus), peat and coal. Humic substances are formed by the microbial degradation of dead plant matter such as lignin and charcoal. HA can be used as a cheap organic fertilizer source to improve plant growth and yield and enhance stress tolerance as well as to improve soil physical properties and complex metal ions.

Material and methods

A field experiment was conducted at "A" Block, College of Agriculture, V.C. Farm, Mandya which comes under Agro Climatic Zone-6, Southern Dry Zone, Karnataka in Kharif 2016. It lies between 76°49'08" E longitude and 12°34'03" N latitude with 697 m above mean sea level.

The soil was sandy loam in texture with 87.17, 1.5, and 9.75 per cent sand, silt and clay, respectively and bulk density of 1.4 Mg m^{-3}. The soil was neutral in reaction (pH 6.85) and low in soluble salts (0.14 dS m^{-1}). The soil was medium in organic carbon (6.8 g kg^{-1}) content, low in available nitrogen (Alkaline KMnO4 method) (200.7 kg ha^{-1}) and high in available P_2O_5 (chloromolybdic blue colour method)(68.32 kg ha^{-1}), while it was medium in K_2O (Flame photometric method) (179.5 kg ha $^{-1}$) and high in sulphur (turbidometric method) (12.75 mg kg^{-1}). The exchangeable calcium and magnesium content by complexometric titration was 4.80 and 1.60 cmol kg^{-1}, respectively. The DTPA extractable micronutrient content (by AAS) *viz.*, zinc, iron, copper, manganese and boron were 1.86, 11.82, 0.52, 11.8 and 0.38 mg kg^{-1}, respectively.

The experiment was carried out with 13 treatment combinations with T1: Absolute control, T2: RDF + FYM, T3: STCR only (P maintenance dose i.e. 50% RDP), T4: STCR actual dose (no P), T5: STCR (50% RDP) + FYM, T6: T5 + HA (500 ppm foliar spray at 30 and 45 DAS), T7: T5 + HA (1000 ppm foliar spray at 30 and 45 DAS), T8: T5 + MM1 (Foliar spray at 30 and 45 DAS), T9: T5 + MM2 (Foliar spray at 30 and 45 DAS), T10: T5 + HA (500 ppm) + MM1 (Foliar spray at 30 and 45 DAS), T11: T5 + HA (1000 ppm) + MM1 (Foliar spray at 30 and 45 DAS), T12: T5 + HA (500 ppm) + MM2 (Foliar spray at 30 and 45 DAS), T13: T5 + HA (1000 ppm) + MM2 (Foliar spray at 30 and 45 DAS).

The quantity of fertilizer through STCR approach was calculated by using STCR equations for a cowpea yield target of 15 q ha^{-1}.

F.N. = 11.02 T- 0.43 S.N ($KMnO_4$ - N)

$F.P_2O_5$ = 10.77 T- 2.725 $S.P_2O_5$ (Olsen's - P_2O_5)

$F.K_2O$ = 8.48 T- 0.466 $S.K_2O$ (NH_4OAC - K_2O)

The recommended dose of fertilizer i.e. 25-50-25 kg NPK per hectare was applied with 7.5 tonnes of FYM. For STCR treatments, the following fertilizer dose was applied based on the treatment details. Humic acid and micronutrient mixture was applied upon dilution according to treatment details. Agritone (4% HA) was diluted in water to get 500 and 1000 ppm, respectively. The foliar application of HA and MM was carried out @ 30 and 45 DAS.

Nutrient	Initial status (kg ha^{-1})	Actual STCR dose	Applied STCR dose *
N	200.7	79	50
P_2O_5	68.32	-24.62	25
K_2O	179.5	43.553	43.5

Micronutrient carrier and quantity used for foliar application

Micronutrient	MM1 (g ha^{-1})	MM2 (g ha^{-1})
$Fe_2SO_4.7H_2O$	210	420
$MnSO_4.5\ H_2O$	66	66
$ZnSO_4.7H_2O$	380	760
$CuSO_4.7H_2O$	84	50
Borax	190	190

The micronutrient salts were dissolved in water using citric acid and pH of the solution was adjusted to 6.5 using KOH.

Total nitrogen content of plant samples was determined by Kjeldahl's digestion distillation method. Powdered sample of 0.5 g was digested using concentrated H_2SO_4 in presence of digestion mixture (containing K_2SO_4 and $CuSO_4$. $5H_2O$ and selenium in the ratio 100: 20: 1) and distilled in alkaline medium (Piper, 1966) [11]. One gram of the powdered plant sample and grain sample of cowpea were pre-digested with conc. HNO_3 overnight and then digested with di-acid mixture containing HNO_3 and $HClO_4$ in the proportion of 9:4 (Di-acid digestion). The volume of the digest was made to 100 ml with distilled water and used for total elemental analysis (except N). Micronutrient content of cowpea seed was analyzed in atomic absorption spectrophotometer after digesting sample using di-acid mixture. Soil available micronutrients (Fe, Mn, Cu and Zn) were determined by Lindsay and Norvell (1978) [14] method. Hot water soluble B was estimated using azomethine- H in spectrophotometer (Truog, 1960) [15].

Results

Table 1: Effect of STCR based fertilizer recommendation along with foliar application of humic acid and multi-micronutrient mixture on grain and haulm yield of cowpea

Treatment	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1 - Absolute control	1015.66	1992.22
T_2 - RDF + FYM	1422.22	2513.33
T_3 - STCR	1522.09	2875.92
T_4 - STCR (no P)	1239.90	2337.03
T_5 - STCR (50% RDP) + FYM	1522.22	2907.40
T_6 - T_5 + HA 500 ppm	1526.67	3007.40
T_7 - T_5 + HA 1000 ppm	1529.90	3016.29
T_8 - T_5 + MM1	1532.93	3029.26
T_9 - T_5 + MM2	1537.32	3036.29
T_{10} - T_5 + HA 500 ppm + MM1	1541.92	3061.11
T_{11} - T_5 + HA 1000 ppm + MM1	1545.25	3081.85
T_{12} - T_5 + HA 500 ppm + MM2	1550.61	3096.29
T_{13} - T_5 + HA 1000 ppm + MM2	1547.80	3060.74
S.Em±	66.21	141.95
CD (P=0.05)	193.24	414.32

The grain yield of cowpea in control was 1015.66 kg ha^{-1}, which increased significantly due to application of RDF + FYM (1422.22 kg ha^{-1}) fertilizers. While application of STCR based fertilizer dose (50% RDP) only or along with foliar spray of HA and MM (T_3 and T_5-T_{13}) significantly increased the seed yield of cowpea compared to control (1015.66 kg ha^{-1}) and T_4 (1239.90 kg ha^{-1}) but they were statistically at par with each other. The maximum seed yield of 1550.61 kg ha^{-1} was recorded in the treatment that received STCR based fertilizer dose (50% RDP) along with foliar spray of HA @

500 ppm and MM2 at 30 and 45 DAS (T_{12}). Significantly higher haulm yield of 3096.29 kg ha^{-1} was obtained due to T_{12} followed by 3081.85 kg ha^{-1} in T_{11}. These treatments were significantly superior than control (1992.22 kg ha^{-1}), RDF + FYM (2513.33 kg ha^{-1}) and T_4 (2337.03 kg ha^{-1}). (Table 1)

Nutrient content

The application of humic acid and micronutrients mixture with STCR prescribed fertilizer dose showed significant difference in all the major nutrient content of grain and haulm. Higher nitrogen content of 4.58 and 2.31 per cent in grain and haulm, respectively was recorded in T_{12} (STCR (50% RDP) + HA 500 ppm + MM2) treatment followed by 4.52 and 1.83 per cent, respectively with T_7 (STCR 50% RDP + HA 1000 ppm). (Table 2)

The phosphorous content in grains varied from 0.37 per cent to 0.47 per cent due to treatments. P content was highest in T_2, T_{12} and T_{13} (0.47%) which were significantly higher than T_4 (0.40%) and control (0.37%). The effect of different treatments showed a significant difference on P content in haulm. The Highest P concentration of 0.26 per cent was recorded in T_2 treatment with RDF + FYM followed by STCR based fertilizer dose (50% RDP) i.e. T_{13} (0.24%) and T_{12}, T_8 and T_9 (0.23%). The potassium content significantly increased from 2.24 per cent in control to 2.64 per cent in T_{12} and T_{13} with STCR based fertilizer dose (50% RDP) + foliar application of HA and MM2 which were on par with each other but significantly superior than control (2.24%) and T_2 (2.45%). The potassium concentration in haulm varied from 1.75 to 2.83 per cent. The highest concentration was observed in T_{11} (2.83%) due to STCR prescribed fertilizers (50% RDP) with foliar application of HA 1000 ppm + MM1 followed by T_{10} (2.82%) which was significantly higher than control (1.75%), T_2 (2.32%), T_3 (2.29%), T_4 (2.31%), T_5 (2.54%), T_6 (2.56%) and T_7 (2.49%).

The calcium content in grain was highest in T_3, T_4, T_7 and T_8 with 0.4 per cent which were significantly higher than all other treatments except T_6 and T_{13} (0.35%). In haulm higher concentration of calcium was observed in T_2 with RDF + FYM (3.05%) followed by T_9 (2.93%). Highest magnesium concentration in grain was seen in treatments having STCR based fertilizer dose (50% RDP) with humic acid i.e. T_6 and T_7 (1.60%). Higher concentration of magnesium in haulm was observed in T_8 (3.88%) followed by T_7 (3.75%) which were significantly higher than all other treatments except T_2 and T_{10} (3.35%). Significantly higher concentration of sulphur in grain was recorded in T_9 (0.227%) while in haulm it was 0.182 per cent due to STCR based fertilizer dose (50% RDP) with foliar application of MM2.

Application of micronutrients mixture alone and in combination with humic acid besides NPK significantly influenced the micronutrient content in grain and haulm of cowpea. Iron content in grain was significantly increased from 88.36 mg kg^{-1} in control to 153.84 mg kg^{-1} in T_{13} , however in haulm highest concentration of iron was recorded in T_{12} (387.30 mg kg^{-1}), followed by T_9 (385.57 mg kg^{-1}) and T_{13} (385.23 mg kg^{-1}) which were significantly higher than that observed in T_1 to T_7 treatments. The highest concentration of manganese was observed in T_{11} (38.93 mg kg^{-1}) followed by T_{10} (38.87 mg kg^{-1}) which were significantly higher as compared to the values recorded in T_1 to T_7 treatments. In haulm, highest concentration of manganese was noticed in T_8 (78.83 mg kg^{-1}) followed by T_{10} (78.73 mg kg^{-1}). Significantly higher zinc content in grain was seen in T_{12} (32.35 mg kg^{-1}) and T_{13} (32.27 mg kg^{-1}) due to application of STCR based fertililzer dose with humic acid and MM2 compared to T_1, T_2, T_3, T_4, T_5, T_6 and T_7. Highest concentration of zinc in haulm was recorded in T_{12} (18.77 mg kg^{-1}) followed by T_{13} (18.65 mg kg^{-1}) and these were significantly higher than all other treatments without MM. copper content of grain in control was 8.90 mg kg^{-1} which increased significantly to 12.84 mg kg^{-1} in T_{11} due to application of STCR based fertilizer dose (50% RDP) with 1000 ppm HA and MM1, followed by T_{10} (12.65 mg kg^{-1}). Copper content in haulm significantly increased from 8.60 mg kg^{-1} in control to 12.56 mg kg^{-1} in T_{11} (STCR 50% RDP + HA 1000 ppm + MM1) followed by T_8 (12.36 mg kg^{-1}) which were significantly higher than T_1, T_2, T_3, T_4, T_5, T_6 and T_7. Boron concentration in grain varied significantly due to treatments. Highest concentration of 28.82 mg kg^{-1}was recorded in T_{13}, followed by 28.72 mg kg^{-1} in T_{10} (STCR based fertilizer dose with FA of HA 500 ppm and MM1) which were significantly higher than T_1, T_2, T_3, T_4, T_5, T_6 and T_7. In haulm, highest concentration of 44.58 mg kg^{-1} was recorded in T_{11} followed by T_{10} (44.35 mg kg^{-1}) which were significantly higher than treatments T_1 to T_7. (Table 3)

Among the treatments, the treatment T_{12} which received STCR N and K with 50% RDP along with foliar application of HA and MM recorded higher concentration of primary nutrients (N and K) both in grain and haulm compared to all other treatments. Whereas the P content was higher in RDF + FYM treatment. Such improvements were possibly due to the enhanced absorption of nutrients due to higher availability of N and K with higher dose. While P content was higher in RDF as the recommended P dose was higher in RDF than STCR treatment.

Addition of HA and MM as foliar application along with major nutrients further increased the nutrient concentration in both grain and haulm. This may be due to humic acid acts as an additional source of nutrients besides it improved the root and shoot growth of the plant and there by enhanced the uptake of nutrients. Along with HA, addition of MM increased the efficient utilization of macronutrients and accumulation of these macronutrients in economical part. The increased concentration of N, P and K due to foliar application of HA was in line with the results obtained by Ehab *et al*. (2015) [3] in bean, Mahmoud *et al*. (2011) [10] in soybean and Ananthi and Mallika (2014) [1] in green gram. However, significantly lower concentration of primary nutrients (N, P and K) and secondary nutrients (Ca, Mg and S) were noticed in the treatment T_1. This may be due to decrease in the availability of nutrients due to non-application of any fertilizers or manures to soil.

The concentrations of all the micronutrients (Fe, Cu, Mn, Zn and B) were significantly higher in the treatments which received MM along with STCR based fertilizers. The higher concentration of nutrient observed may be due to enhanced nutrient supply as a result of application of micronutrients which ensured higher efficiency of macro and micronutrients and also enhanced better root growth, shoot growth and chlorophyll content thus increasing the plant ability to absorb the nutrients from the increased supply. Addition of MM along with HA further increased the concentration which might be due to the chelating property of the humic acid which complexed with micronutrient and increased the absorption and translocation of the nutrients within the crop.

The increased content of micronutrients by HA evidenced by the findings of Khaled and Hassan (2011) [8] in corn, Singravel *et al*. (1998) [14] in sesame, Ananthi and Mallika (2014) [1] in green gram, El-Azab (2016) [5] in cowpea. Similar increase in the micronutrient content by the application of MM were confirmed by Salih (2013) [12] and Daniel and Patrick (2014) in cowpea.

Table 2: Nitrogen, phosphorus, potassium, calcium, magnesium and sulphur content in grain and haulm of cowpea as influenced by STCR based fertilizer dose with foliar HA and MM application

Treatment	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		S (%)	
	Grain	Haulm	Grain	Haulm	Grain	Haulm	Grain	Haulm	Grain	Haulm	Grain	Haulm
T_1 - Absolute control	4.04	1.83	0.37	0.16	2.24	1.75	0.34	2.38	1.33	2.83	0.116	0.094
T_2 - RDF + FYM	4.42	2.24	0.47	0.26	2.45	2.32	0.35	3.05	1.53	3.35	0.164	0.159
T_3 - STCR	4.27	2.25	0.44	0.18	2.62	2.29	0.40	2.55	1.47	3.07	0.183	0.164
T_4 - STCR (no P)	4.31	2.08	0.40	0.17	2.55	2.31	0.40	1.97	1.35	2.43	0.175	0.159
T_5 - STCR (50% RDP) + FYM	4.48	2.28	0.44	0.21	2.62	2.54	0.30	2.56	1.45	3.05	0.163	0.164
T_6 - T_5 + HA 500 ppm	4.34	2.29	0.44	0.19	2.63	2.56	0.35	2.87	1.60	3.13	0.160	0.147
T_7 - T_5 + HA 1000 ppm	4.52	2.30	0.46	0.18	2.58	2.49	0.40	2.35	1.60	3.75	0.183	0.156
T_8 - T_5 + MM1	4.48	2.30	0.45	0.23	2.59	2.77	0.40	2.65	1.40	3.88	0.188	0.165
T_9 - T_5 + MM2	4.50	2.30	0.46	0.23	2.61	2.81	0.30	2.93	1.65	3.15	0.227	0.182
T_{10} - T_5 + HA 500 ppm + MM1	4.37	2.24	0.46	0.22	2.60	2.82	0.33	2.25	1.57	3.35	0.161	0.160
T_{11} - T_5 + HA 1000 ppm + MM1	4.41	2.28	0.46	0.20	2.61	2.83	0.32	2.70	1.50	3.20	0.177	0.146
T_{12} - T_5 + HA 500 ppm + MM2	4.58	2.31	0.47	0.23	2.64	2.77	0.33	2.62	1.55	3.17	0.194	0.148
T_{13} - T_5 + HA 1000 ppm + MM2	4.41	2.30	0.47	0.24	2.64	2.76	0.35	2.42	1.40	3.18	0.196	0.164
S.Em±	0.09	0.06	0.02	0.01	0.07	0.06	0.02	0.17	0.09	0.19	0.008	0.007
CD (P=0.05)	0.27	0.16	0.05	0.03	0.19	0.19	0.06	0.50	NS	0.55	0.022	0.021

Table 3: Iron, manganese, zinc, copper and boron content in cowpea as influenced by STCR based fertilizer dose with foliar HA and MM application

Treatment	Fe (mg kg^{-1})		Mn (mg kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})		B (mg kg^{-1})	
	Grain	Haulm	Grain	Haulm	Grain	Haulm	Grain	Haulm	Grain	Haulm
T_1 - Absolute control	88.36	159.27	30.31	41.77	23.90	9.47	8.90	8.60	16.46	24.79
T_2 - RDF + FYM	103.28	226.70	31.33	58.22	27.10	11.90	10.05	9.07	20.29	30.29
T_3 - STCR	103.31	260.80	33.57	61.81	27.40	11.45	10.17	8.75	21.77	31.57
T_4 - STCR (no P)	101.64	286.00	33.03	51.55	27.80	13.15	10.28	9.15	18.41	26.45
T_5 - STCR (50% RDP) + FYM	104.59	282.03	32.40	63.12	27.85	14.05	10.28	9.65	21.85	32.51
T_6 - T_5 + HA 500 ppm	106.58	290.57	32.50	59.05	27.18	14.03	10.29	9.10	22.09	32.85
T_7 - T_5 + HA 1000 ppm	108.66	296.47	32.20	54.26	27.53	14.37	10.63	8.95	22.57	33.01
T_8 - T_5 + MM1	136.29	365.87	38.39	78.83	31.30	17.85	12.58	12.36	28.64	44.30
T_9 - T_5 + MM2	146.83	385.57	37.90	76.10	31.70	18.55	12.48	11.20	28.55	44.23
T_{10} - T_5 + HA 500 ppm + MM1	139.01	368.50	38.87	78.73	31.53	18.07	12.65	11.80	28.72	44.35
T_{11} - T_5 + HA 1000 ppm + MM1	149.75	372.57	38.93	78.03	31.62	18.10	12.84	12.56	28.68	44.58
T_{12} - T_5 + HA 500 ppm + MM2	145.70	387.30	38.27	76.23	32.35	18.77	12.54	11.47	28.64	44.31
T_{13} - T_5 + HA 1000 ppm + MM2	153.84	385.23	38.33	76.73	32.27	18.65	12.57	11.68	28.82	44.15
S.Em±	4.20	11.83	0.47	3.44	0.87	0.70	0.43	0.39	0.59	1.18
CD (P=0.05)	12.25	34.54	1.36	10.03	2.53	2.03	1.26	1.13	1.73	3.43

Table 4: Uptake of nitrogen, phosphorous and potassium by cowpea as influenced by STCR based fertilizer dose with foliar HA and MM application

Treatment	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})		
	Grain	Haulm	Total	Grain	Haulm	Total	Grain	Haulm	Total
T_1 - Absolute control	41.03	36.37	77.40	3.77	3.13	6.90	22.73	35.09	57.82
T_2 - RDF + FYM	62.86	56.25	119.11	6.75	6.62	13.37	34.86	58.31	93.18
T_3 – STCR	64.87	64.17	129.04	6.65	5.12	11.77	39.95	65.79	105.74
T_4 - STCR (no P)	53.42	48.51	101.93	4.94	3.89	8.83	31.58	54.19	85.77
T_5 - STCR (50% RDP) + FYM	68.26	66.01	134.27	6.66	6.01	12.68	39.93	73.91	113.84
T_6 - T_5 + HA 500 ppm	66.48	68.90	135.38	6.78	5.58	12.36	40.41	77.09	117.50
T_7 - T_5 + HA 1000 ppm	69.65	69.30	138.94	7.12	5.51	12.63	39.81	75.06	114.88
T_8 - T_5 + MM1	67.72	69.63	137.35	6.76	7.07	13.83	39.07	83.94	123.01
T_9 - T_5 + MM2	68.24	69.94	138.18	7.08	7.04	14.12	39.72	85.26	124.98
T_{10} - T_5 + HA 500 ppm + MM1	67.35	68.53	135.87	7.15	6.74	13.89	40.21	86.21	126.42
T_{11} - T_5 + HA 1000 ppm + MM1	68.17	70.21	138.38	7.15	6.05	13.20	40.29	87.33	127.62
T_{12} - T_5 + HA 500 ppm + MM2	71.01	71.57	142.58	7.25	7.26	14.51	40.90	85.71	126.61
T_{13} - T_5 + HA 1000 ppm + MM2	68.21	70.36	138.57	7.29	7.29	14.58	40.93	84.38	125.31
S.Em±	3.93	2.90	4.55	0.48	0.44	0.50	2.65	4.33	4.57
CD (P=0.05)	11.48	8.48	13.29	1.39	1.29	1.47	7.73	12.65	13.34

Table 5: Uptake of calcium, magnesium and sulphur by cowpea as influenced by STCR based fertilizer dose with foliar HA and MM application

Treatment	Ca (kg ha^{-1})			Mg (kg ha^{-1})			S (kg ha^{-1})		
	Grain	Haulm	Total	Grain	Haulm	Total	Grain	Haulm	Total
T_1 - Absolute control	3.47	46.66	50.13	13.41	56.75	70.15	1.19	1.85	3.04
T_2 - RDF + FYM	4.97	76.68	81.66	21.80	84.28	106.08	2.33	3.99	6.32
T_3 - STCR	6.09	73.28	79.36	22.19	87.53	109.72	2.78	4.68	7.47

T_4 - STCR (no P)	4.96	45.85	50.81	16.71	56.70	73.41	2.18	3.70	5.88
T_5 - STCR (50% RDP) + FYM	4.57	60.44	65.01	22.12	88.28	110.40	2.48	4.81	7.29
T_6 - T_5 + HA 500 ppm	5.34	86.07	91.41	24.53	94.09	118.63	2.45	4.43	6.89
T_7 - T_5 + HA 1000 ppm	6.16	70.96	77.12	24.51	113.03	137.54	2.82	4.71	7.53
T_8 - T_5 + MM1	6.04	80.58	86.62	21.27	117.73	139.00	2.84	4.98	7.82
T_9 - T_5 + MM2	4.55	89.10	93.64	25.00	95.57	120.57	3.36	5.52	8.88
T_{10} - T_5 + HA 500 ppm + MM1	5.16	69.10	74.27	24.26	102.41	126.67	2.48	4.89	7.37
T_{11} - T_5 + HA 1000 ppm + MM1	4.99	82.97	87.97	23.14	98.96	122.10	2.73	4.53	7.26
T_{12} - T_5 + HA 500 ppm + MM2	5.07	81.16	86.23	24.03	98.33	122.37	3.01	4.58	7.59
T_{13} - T_5 + HA 1000 ppm + MM2	5.42	73.67	79.09	21.67	96.54	118.21	3.03	5.03	8.06
S.Em±	0.40	5.59	5.60	1.76	6.51	7.20	0.13	0.31	0.33
CD (P=0.05)	1.15	16.30	16.35	5.13	19.00	21.01	0.37	0.92	0.97

Table 6: Uptake of iron, manganese, zinc, copper and boron by cowpea as influenced by STCR based fertilizer dose with foliar HA and MM application

Treatment	Fe (g ha^{-1})			Mn (g ha^{-1})			Zn (g ha^{-1})			Cu (g ha^{-1})			B (g ha^{-1})		
	Grain	Haulm	Total	Grain	Haulm	Grain	Grain	Haulm	Total	Grain	Haulm	Total	Grain	Haulm	Total
T_1	89.55	317.86	407.41	30.80	83.01	113.81	24.33	18.70	43.02	8.99	17.27	26.26	16.64	48.68	65.32
T_2	146.85	569.07	715.92	44.58	146.18	190.77	38.55	30.03	68.58	14.30	22.79	37.09	28.87	76.22	105.09
T_3	158.87	758.00	916.86	51.08	177.20	228.28	39.32	33.15	72.47	15.48	25.26	40.73	33.13	90.13	123.27
T_4	125.95	666.09	792.05	40.97	120.67	161.64	34.44	30.69	65.14	12.74	21.41	34.15	22.83	61.71	84.55
T_5	158.52	818.52	977.03	49.33	184.49	233.82	39.38	40.63	80.01	15.67	28.02	43.68	33.25	94.76	128.01
T_6	163.35	874.43	1037.78	49.81	180.29	230.10	40.66	42.39	83.05	15.78	27.47	43.25	33.88	98.83	132.72
T_7	167.54	894.06	1061.61	49.48	163.83	213.31	41.06	43.29	84.35	16.33	27.00	43.33	34.71	99.55	134.27
T_8	205.70	1108.33	1314.03	57.95	239.13	297.08	47.21	54.05	101.26	19.08	37.48	56.56	43.28	134.46	177.73
T_9	222.36	1169.83	1392.20	57.44	231.11	288.55	47.64	56.33	103.97	18.93	34.12	53.06	43.25	134.50	177.75
T_{10}	214.14	1128.32	1342.47	59.87	241.05	300.91	48.68	55.26	103.93	19.52	36.18	55.70	44.27	135.32	179.59
T_{11}	231.59	1148.69	1380.28	60.19	239.95	300.14	48.85	55.80	104.65	19.85	38.75	58.60	44.35	137.50	181.85
T_{12}	225.94	1199.41	1425.34	59.34	235.99	295.32	50.16	58.09	108.26	19.45	35.55	55.00	44.40	137.03	181.43
T_{13}	238.05	1179.66	1417.72	59.32	234.79	294.11	49.96	57.16	107.12	19.45	35.67	55.12	44.59	135.22	179.81
S.Em±	12.97	52.25	50.74	3.04	15.30	15.09	2.35	2.93	3.57	1.25	2.07	2.28	2.34	5.60	5.19
CD @5%	37.86	152.50	148.09	8.86	44.67	44.05	6.85	8.56	10.42	3.65	6.04	6.65	6.84	16.35	15.14

Uptake of nutrients

The nitrogen uptake by grain, haulm and total uptake were significant due to treatments effect. Higher nitrogen uptake by grain, haulm and total uptake was observed in T_{12} (71.01, 71.57 and 142.57 kg ha^{-1}, respectively) which was significantly higher than control (41.03, 36.37 and 77.40 kg ha^{-1}, respectively) and T_4 (53.42, 48.51 and 101.93 kg ha^{-1}, respectively). Uptake of phosphorous by grain, haulm and total uptake varied significantly due to treatments. Total P uptake increased from 6.90 kg ha^{-1} in control to 14.58 kg ha^{-1} in T_{13} due to application of STCR based fertilizer dose (50% RDP) with HA 1000 ppm and MM2. However, phosphorous uptake by grain and haulm were also higher in T_{13} (7.29 and 7.29 kg ha^{-1}, respectively). Significantly higher potassium uptake by grain was noticed in T_{13} (40.93 kg ha^{-1}) over control and T_4 (22.73 kg ha^{-1} and 31.58 kg ha^{-1}, respectively). However, potassium uptake by haulm and total uptake were significantly higher in T_{11} (87.33 and 127.62 kg ha^{-1}, respectively). (Table 4)

Calcium uptake by the grains varied from 3.47 to 6.16 kg ha^{-1}. Higher calcium uptake of 6.16 kg ha^{-1} was observed in T_7 (STCR based fertilizer dose with HA 1000 ppm) which was significantly higher than T_1 (3.47 kg ha^{-1}), T_2 (4.97 kg ha^{-1}), T_4 (4.96 kg ha^{-1}), T_5 (4.57 kg ha^{-1}), T_9 (4.55 kg ha^{-1}) and T_{11} (4.99 kg ha^{-1}) but on par with rest of the treatments. Uptake of calcium by haulm and its total uptake were also significant which showed 89.10 and 93.64 kg ha^{-1} of calcium uptake by haulm and total uptake, respectively was observed in T_9 which were significantly higher than T_1, T_4, T_5, T_7 and T_{10}. Magnesium uptake in grain varied significantly. Maximum uptake was observed in T_9 (25.00 kg ha^{-1}) followed by T_6 (24.53 kg ha^{-1}) which were on par with all the treatments except T_1 (13.41 kg ha^{-1}) and T_4 (16.7 kg ha^{-1}). Magnesium uptake in haulm was found to be significantly higher in T_8 (117.73 kg ha^{-1}) than all other treatments except T_7 (113.07 kg ha^{-1}), T_{10} (102.41 kg ha^{-1}) and T_{11} (98.96 kg ha^{-1}). Total uptake of magnesium was found to be higher due to STCR based fertilizer dose (50% RDP) with MM1 (139.0 kg ha^{-1}) which was significantly higher than T_1 (70.15), T_2 (106.08), T_3 (109.72), T_4 (73.41) and T_5 (110.40 kg ha^{-1}). Significantly higher uptake of 3.36 kg ha^{-1} of sulphur by grain was recorded in T_9 (STCR based fertilizer dose with MM2) which was on par with T_{12} and T_{13} (3.01 and 3.03 kg ha^{-1}, respectively) and significant with all other treatments. In haulm, higher uptake was recorded in T_9 (5.52 kg ha^{-1}) which was significantly higher than T_1, T_2, T_4, T_6, T_{11} and T_{12}. Total uptake was also higher in treatment T_9 (8.88 kg ha^{-1}) followed by T_{13} (8.06 kg ha^{-1}). (Table 5)

The iron uptake by grains, haulm and its total uptake differed significantly among the treatments due to application of humic acid and MM with STCR prescribed fertilizers. Significantly higher uptake by grains was observed in T_{13} (238.05 g ha^{-1}) compared to control (89.55 g ha^{-1}) and all other treatments without micronutrient mixture application (T_1 to T_7). Uptake by haulm and total uptake were observed in T_{12} (1199.41 and 1425.34 g ha^{-1}) due to STCR based fertilizer dose (50% RDP) with 500 ppm HA and MM2 which was significantly higher than that recorded in treatmentsT_1 to T_7. Significantly higher manganese uptake by grains was observed in T_{11} (60.19 g ha^{-1}) due to STCR based fertilizer dose (50% RDP) with HA 1000 ppm and MM1 which was on par with T_8 (57.95 g ha^{-1}), T_9 (57.44 g ha^{-1}), T_{10} (59.87 g ha^{-1}), T_{12}, (59.34 g ha^{-1}) and T_{13} (59.32 g ha^{-1}). However, these treatments were significant with control (30.80 g ha^{-1}) and all treatments without MM. Manganese uptake by haulm and total uptake differed significantly due to effect of treatments. Higher uptake by haulm and total was noticed in T_{10} (241.05

and 300.91 g ha^{-1}, respectively) which was on par with T_8 (239.13 and 297.08 g ha^{-1}), T_9 (231.11 and 288.55 g ha^{-1}), T_{11} (239.95 and 300.14 g ha^{-1}), T_{12} (235.99 and 295.32 g ha^{-1}) and T_{13} (234.79 and 294.11 g ha^{-1}). Zinc uptake by the plant varied significantly in grains, haulm and total. Higher uptake of 50.16, 58.09 and 108.26 g ha^{-1} by grain, haulm and its total, respectively was observed in T_{12} with STCR prescribed fertilizer dose (50% RDP) with 500 ppm HA and MM2 followed by T_{13} (49.96, 57.16 and 107.12 g ha^{-1}) which were on par with T_8, T_9, T_{10} and T_{11}, but significant with all other treatments. Copper uptake by grains, haulm and total differed significantly due to treatments. Higher uptake of 19.85, 38.75 and 58.6 g ha^{-1} in grain, haulm and its total was observed in T_{11} with STCR fertilizer dose (50% RDP) with foliar application of HA 1000 ppm and MM1, which was significant with the treatments without MM. Higher uptake of boron by grain was recorded in T_{13} with 44.59 g ha^{-1} followed by 44.40 g ha^{-1} in T_{12} which were significant with T_1 (16.64), T_2 (28.87), T_3 (33.13), T_4 (22.83), T_5 (33.25), T_6 (33.88) and T_7 (34.71). Boron uptake by haulm and total uptake were significantly higher in T_{11} with 137.50 and 181.85 g ha^{-1}, respectively, followed by T_{12} with sssSTCR fertilizer dose (50% RDP) with foliar application of HA 500 ppm and MM2 (137.03 and 181.43 g ha^{-1}, respectively) and these treatments were significantly higher than treatments without MM (T_1 to T_7). (Table 6).

The uptake of nutrients by crop is a product of nutrient content and grain and dry matter yield. Higher total N and K uptake was observed in STCR (50% RDP) + FYM (134.27 and 113.84 kg ha^{-1}, respectively) than RDF+FYM (119.11 and 93.18 kg ha^{-1}, respectively) and control (77.40 and 57.82 kg ha^{-1}, respectively). The increased uptake is due to increased root growth which increased growth parameters, yield parameters and thereby total biomass of the crop in STCR based fertilizer dose which was higher than RDF. Further addition of HA and MM increased the uptake of these macronutrients mainly due to balanced nutrition of the crop and increased efficiency of macronutrients with the application of micronutrients. Total P uptake was higher in RDF (13.37 kg ha^{-1}) than the control. However, application of humic acid and MM increased the P uptake (14.58 kg ha^{-1}) more than that of RDF.

Increased uptake of NPK by HA was in conformity with the findings of Ananthi and Mallika (2014) [1] in green gram, Khaled and Hassan (2011) [8] in corn and Singravel *et al*. (1998) [14] in sesame.

The total uptake of iron and zinc (1425.35 and 108.26 g ha^{-1}, respectively) by grain + haulm was highest in T_{12} and manganese uptake (300.91 g ha^{-1}) in T_{10} and copper and boron (58.60 and 181.85 g ha^{-1}, respectively) in T_{11}. The higher uptake might be attributed to foliar application of micronutrients through MM alone or in combination with humic acid which improved the root growth and thereby overall growth of the plants and absorption of micronutrients applied on foliage.

Elayaraja *et al*. (2011) [4] reported that application of fortified humic acid along with RDF to soil are essential for plant growth, yield and quality of crops. These also help in uptake of major nutrients and also play a vital role in enhancing the growth of plants by acting as catalysts in promoting organic reactions during cell development, respiration, photosynthesis, chlorophyll formation, enzyme activity, hormones synthesis etc. Khaled and Hassan (2011) [8] reported higher uptake of both macro and micronutrients in corn plants treated with humic acid.

Conclusion

Application of STCR (50% RDP) with humic acid and multi micronutrient mixture significantly increased the macro, secondary and micronutrient content in grain and haulm which gave a balanced nutrition to the crop which increased the overall growth and yield of cowpea and thereby increased uptake of all the nutrients.

References

1. Ananthi K, Mallika V. Foliar spray of humic acid with growth regulators in nutrient content and yield of greengram (*Vigna radiata* (L.) Wilczek). Legume Res. 2014; 37(4):359-362.
2. Asad A, Rafique R. Effect of zinc, copper, iron, manganese and boron on the yield and yield components of wheat crop in Tehsil Peshawar. J Pakistan Biol. Sci. 2000; 3:1615-1620.
3. Ehab A, Ibrahima Whaba A, Ramadan. Effect of zinc foliar spray alone and combined with humic acid or/and chitosan on growth, nutrient elements content and yield of dry bean (*Phaseolus vulgaris* L.) plants sown at different dates. Scientia Horti. 2015; 14:101-105.
4. Elayaraja D, Vetriselvan R, Dhanasekaran K. Effect of NPK levels and different humic acid formulations on the growth, yield and nutrients uptake by bhendi. Int. Res. J Pure Appl. Chem. 2011; 19:354-361.
5. El-Azab ME. Effects of foliar NPK spraying with micronutrients on yield and quality of cowpea plants. Asian J Appl. Sci. 2016; 4(2):526-533.
6. Hao HL, Wei YZ, Yang XE, Feng Y, Wu CY. Effects of different nitrogen fertilizer levels on Fe, Mn, Cu and Zn concentrations in shoot and grain quality in rice (*Oryza sativa*). Rice Sci. 2007; 14:289-294.
7. Kaya C, Higgs D, Burton A. Foliar application of iron as a remedy for zinc toxic tomato plants. J Pl. Nutri. 1999; 22:1829-1837.
8. Khaled H, Hassan AF. Effect of different levels of humic acids on the nutrient content, plant growth and soil properties under conditions of salinity. Soil Water Res. 2011; 6(1):21-29.
9. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, manganese and copper. Soil Sci. Soc. American J. 1978; 42:421-428.
10. Mahmoud MM, Hassanein AHA, Mansour SF, Khalefa AM. Effect of soil and foliar application of humic acid on growth and productivity of soybean plants grown on a calcareous soil under different levels of mineral fertilizers. J Soil Sci. Agric. Eng. 2011; 2(8):881-890.
11. Piper CS. Soil and Plant Analysis, Inter-science Publishers, Inc., New York, 1966, 368.
12. Salih HO. Effect of foliar fertilization of Fe, B and Zn on nutrient concentration and seed protein of cowpea (*Vigna ungiculata*). J Agri. Vet. Sci. 2013; 6:42-46.
13. Singh AK, Bhatt BP. Effects of foliar application of zinc on growth and seed yield of late-sown lentil. Indian J Agril. Sci. 2013; 83(6):622-626.
14. Singravel R, Balasubramanian TN, Govindasamy R. Influence of humic acid, nitrogen and azospirillum on yield and nutrient uptake by sesame (*Sesamum indicum*). J Indian Soc. Soil Sci. 1998; 46(1):145-146.
15. Truog E. Fifty Years of Soil Testing. Trans 7th Int. Congr. Soil Sci. Vol. III, Commission IV. 1960; 7:46-53.
16. Zeidan MS, Hozayn M, El-Salam MEE. Yield and quality of lentil as affected by micronutrient deficiencies in sandy soils. J Appl. Sci. Res. 2006; 2(12):1342-1345.