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Original Research Article

Validation of STCR Equation with Humic Acid and Multimicronutrient Mixture on Growth and Yield of Cowpea in Southern Dry Zone (Zone 6) of Karnataka

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Keywords

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

A B S T R A C T

A field experiment was conducted to validate the cowpea STCR equation developed for Zone 5 in Zone 6 and to assess its performance with foliar application of humic acid and multi-micronutrient mixture during *Kharif* 2016 on sandy loam soil at college of Agriculture, V.C. Farm, Mandya. The experiment was laid out in RCBD 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. Application of STCR based fertilizer dose (50% RDP) along with foliar application of HA and MM improved all the growth, yield parameters and yield over the control. 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 than that of control and STCR (no P) but it was at par with rest of the treatments. The extent of increase in grain yield was 8.28, 20.04 and 34.50 per cent over RDF+FYM, STCR (no P) and control, respectively. Higher yield obtained might be attributed to improvement in growth and yield attributing parameters with STCR based fertilizer dose with foliar application of HA and MM.

Introduction

Pulses are the important source of proteins, vitamins and minerals and are popularly known as “Poor man’s meat” and “rich man’s vegetable” that contributes significantly to the nutritional security of the country. Currently, India is in the mid-way of achieving self-sustenance in pulse production as India is leading in production, consumption and import as well (Singh and Bhatt, 2013). In India, pulses can be produced with a minimum use of resources and hence, it becomes less costly than animal protein. In comparison to other vegetables, pulses are rich in protein which are less expensive and can be cultivated as an inter-crop and also as mixed crop. Pulses are mostly cultivated under rainfed conditions and do not require intensive irrigation facility and this is the reason why pulses are grown in areas left after satisfying the demand for cereals/cash crops. Even in such conditions, pulses give better returns. Pulses also improves soil fertility and physical structure, fit in mixed or inter-cropping system, crop rotations and dry farming and provide green pods for vegetable and nutritious fodder for cattle as well.

Cowpea is a legume mainly grown in tropical and subtropical regions in the world for vegetable and grains and to lesser extent as a fodder crop. It serves also as cover crop and improves soil fertility by fixing atmospheric nitrogen. Cowpea is one of the important food legume in the hot-dry tropics and subtropics. Cowpea yield remains low (less than 1 t ha^{-1}) in majority of the areas mainly due to lack of high yielding varieties, low soil fertility, inappropriate farming techniques (Justin, 2015).

STCR is unique as it not only indicates soil test based fertilizer dose but also the level of yield that can be obtained if appropriate practices are followed in raising the crop. Targeted yield approach also provides scientific basis for balanced fertilization not only between the nutrients from the external sources but also with soil available nutrients (Ramamoorthy *et al*., 1967).

The yield of any crop is dependent on the major nutrients like N, P and K, but uptake of these macronutrients depends on micronutrients availability. Micro elements are crucial substances for crop growth, however, they are used in lower amounts compared to macronutrients. Green revolution has greatly increased the food crop production in India, but continuous cultivation of high yielding crop varieties have led to depletion of native micronutrient status of soil.

Humic acid is known as black gold of agriculture. In plants, humic acids have positive effects on enzyme activity, plant nutrients and growth stimulant and are considered as a “plant food”. The humic substances in the soil have multiple effects. It plays dual role through direct and indirect effects to improve both soil and plant growth (Sangeetha *et al*., 2006).

Materials and Methods

A field experiment was conducted during *Kharif* 2016 on sandy loam soil at A block, College of Agriculture, V.C. Farm, Mandya, University of agricultural Sciences, Bengaluru, Karnataka to validate the Cowpea STCR equation developed for Zone 5 for its performance in Zone 6. The thirteen treatments combinations including Absolute control, RDF + FYM, STCR only (P maintenance dose i.e. 50% RDP), STCR actual dose (no P), STCR (50% RDP) + FYM and STCR (50% RDP) with different combinations of Micronutrient mixtures and different levels of humic acid. All treatment combinations were replicated thrice in randomized block design.

The soil was sandy loam in texture with bulk density of 1.4 Mg cm^{-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}), available nitrogen (200.7 kg ha^{-1}) and available P_2O_5 (68.32 kg ha^{-1}), while it was medium in K_2O (179.5 kg ha^{-1}). The DTPA extractable micronutrient content *viz.*, iron, zinc, manganese, copper and boron were 11.82, 1.86, 11.80, 0.52 and 0.38 mg kg^{-1}, respectively.

Cowpea variety CO-152 was sown at 45 cm row and 10 cm plant to plant apart. Recommended dose of NPK for cowpea as recommended by UASB package of practice was 25-50-25 kg NPK per hectare. FYM was applied 15 days before sowing at 7.5 t ha^{-1}.

The STCR fertilizer dose was calculated using the equation developed for Zone 5 as mentioned below by substituting the initial soil test values and target yield 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)

Where,

T = Targeted yield (q ha^{-1}) (15 q ha^{-1})
F.N = Nitrogen supplied through fertilizer (kg ha^{-1})
$F.P_2O_5$ = Phosphorous supplied through fertilizer (kg ha^{-1})
$F.K_2O$ = Potassium supplied through fertilizer (kg ha^{-1})
S. N, S. P_2O_5 and S. K_2O are initial soil available N, P_2O_5 and K_2O (kg ha^{-1}), respectively.

Table.1 Calculation of STCR based fertilizer dose

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

*Applied dose of N is less than the actual dose because a upper limit of 200 per cent of the RDF was fixed in low fertile soils. However in case of P fertilizer dose, applied dose is higher than the actual as high fertility soils gives negative value or zero, 50 per cent of RDF is applied as maintenance dose (Prakash *et al*., 2007).

Table.2 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 commercial HA product, Agritone (4% HA) was diluted in water to get 500 and 1000 ppm, respectively. Humic acid and micronutrient mixture were applied as foliar spray at 30 and 45 DAS. After dissolving the micronutrient fertilizers, the pH of the solution was adjusted to 6.5 by adding KOH.

Results and Discussion

Effect of STCR fertilizer dose with HA and MM on growth parameters of cowpea

The plant height differed significantly due to treatment effect with tallest plants in T_{12} (71.60 cm) treatment receiving STCR (50% RDP)+ FYM +HA 500 ppm + MM2 which was significantly higher than that observed with T_4 (55.40 cm) and control (48.13 cm) and on par with rest of the treatments. Significantly higher number of leaves per plant was observed in T13 (10.44) when compared with the absolute control (9.04). Number of branches per plant varied significantly. Higher number of branches were observed in T_{13} (12.97), followed by T_{12} (13.08) which were significantly higher than that recorded in T_1 (8.13), T_2 (11.07), T_3 (11.73) and T_4 (9.77) treatment and it was at par with rest of the treatments (Table 1).

At 60 DAS, significantly higher leaf area of 1209.27 cm^2 $plant^{-1}$ was recorded in T_{12} which was higher than all other treatments except T_1, T_2 and T_4.

At 60 DAS dry matter production per plant differed significantly due to application of STCR based fertilizer dose with HA and MM. Significantly higher dry matter production per plant (14.04 g $plant^{-1}$) was recorded with T_{13} (STCR based fertilizer dose with HA 1000 ppm and MM2) over control (10.17 g $plant^{-1)}$ and T_4 (11.87 g $plant^{-1}$, respectively). However, it was on par with rest of the treatments. (Table 1).

Effect of STCR fertilizer dose with HA and MM on yield parameters of cowpea

Table 2 indicated that the pod length in control was found to be 16.00 cm which increased significantly to 18.00 cm due to application of STCR fertilizer dose (50 % RDP) along with foliar application of HA @ 500 ppm and MM2 at 30 and 45 DAS (T_{12}), followed by 17.9 cm in STCR fertilizer dose (50 % RDP) with foliar application of HA 1000 ppm and MM2 at 30 and 45 DAS (T_{13}) and it was on par with that recorded in T_3 (17.6 cm), T_5 (17.5 cm), T_6 (17.6 cm), T_7 (17.6 cm), T_8 (17.6 cm), T_9 (17.7 cm), T_{10} (17.7 cm) and T_{11} (17.8 cm) but significantly higher than that recorded in T_1 (16.0 cm), T_2 (16.6 cm) and T_4 (16.5 cm) treatments.

Highest number of pods per plant (27.60) was recorded due to application of STCR based fertilizer dose (50% RDP) along with foliar application of HA @ 500 ppm and MM2 at 30 and 45 DAS, followed by 27.43 with the STCR based fertilizer dose (50% RDP) + foliar application of HA 1000 ppm and MM1 mixture and these were significantly higher than control (20.87), T_2 (24.93) and T_4 (25.07). However it was at par with other treatments.

Significantly higher number of seeds per pod was recorded in T_{12} with STCR based fertilizer dose (50% RDP) + foliar application of HA 500 ppm and MM2 (17.43) followed by T_9 (17.33), T_{13} (17.27) and T_{11} (17.23) which were significantly higher than the control (14.23), T_2 (15.57), T_3 (16.00), T_4 (14.93), T_5 (16.00) and T_6 (16.23).

Significantly higher number of seeds per pod was recorded in T_{12} with STCR based fertilizer dose (50% RDP) + foliar application of HA 500 ppm and MM2 (17.43) followed by T_9 (17.33), T_{13} (17.27) and T_{11} (17.23) which were significantly higher than the control (14.23), T_2 (15.57), T_3 (16.00), T_4 (14.93), T_5 (16.00) and T_6 (16.23).

The test weight did not differ significantly due to treatments effect. However, test weight was highest in the treatment having STCR based fertilizer dose + foliar application of 1000 ppm humic acid with MM1 and MM2 i.e. T_{11} and T_{13} (9.44 g). However, the lowest test weight was recorded in control (9.17 g).

The increase in growth parameter and yield attributes with the application of STCR fertilizer dose (50% RDP) with foliar application of HA and MM might be attributed to improvement in cell division, expansion of cell wall, meristematic activity, enzymatic activity, photosynthetic efficiency, increased nutrient absorption and translocation, increase in physiological processes (Harshad Thakur *et al*., 2013) and plant vigour thus resulting in better growth and development of crop and production of more number of flowers which in turn improved all the growth parameters and yield influencing characters of cowpea with the application of HA and MM. The observed increase in growth and yield components recorded in this study are in consonances with previous findings of (Tahir *et al*., 2011).

The increase in growth and yield parameters and yield due to inclusion of HA in the treatment might be attributed to both direct and indirect effects of HA on plant growth and development (Canellas *et al*., 2008). Ebrahim *et al.,* (2011) reported significant increase in plant height, number of branches, fresh weight, leaf area, pod length, number of pods in cowpea with the application of HA along with major nutrients.

Humic substances have positive effects on plant physiology by improving soil structure and fertility and by influencing nutrient uptake and root architecture and they have been shown to contain auxin and an "auxin-like" activity. The studies have shown that humic substances enhance root, leaf and shoot growth but also stimulate the germination of seeds of various crop species. These positive effects are explained as an interaction between humic substances and physiological and metabolic processes. The addition of HA stimulate nutrient uptake, cell permeability and seems to regulate several mechanisms involved in plant growth stimulation. Thus, positive response of cowpea to application of humic acid was recorded in the present investigation also.

The multi-micronutrient mixture facilitate the application of the wide range of plant nutrients in the proportion and to suit the specific requirements of a crop in different stages of growth and are more relevant under specific nutrient management practices (Hegde, 2007). The hidden deficiencies of micronutrients are overcome due to their supplementation during the growth period, which resulted in better crop growth and thereby yield. The beneficial effect with the use of multi micronutrients mixture have been reported in different crops on growth by several workers in Blackgram (Kannan *et al*., 2014) and cowpea (Salih, 2013). The beneficial effects of the multi-micronutrient could be ascribed to the balanced nutrition of the crops and thereby improved crop growth and yield attributes as well as yield. Also, the addition of the micronutrients helps in better utilization of the major nutrients to produce higher yield of the crops.

Significantly lower growth and yield parameters of cowpea were recorded in absolute control which did not receive any fertilizers or manures, where in availability of nutrients were affected by many soil factors and low or deficient content of nutrients in the soil thus it may be attributed to lesser amount of nutrients supplied to crop resulted in reduced growth and development of crop.

Grain and haulm yield

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 to control (1992.22 kg ha^{-1}), RDF + FYM (2513.33 kg ha^{-1}) and T_4 (2337.03 kg ha^{-1}). The lower yields might be attributed to imbalanced application of nutrients. The P is required in the early growth stage of crop establishment as its application stimulates the root initiation and root proliferation, but in the absence of P the root growth is impaired consequently the lower growth and yield was noticed. (Table 3)

The increase in grain and haulm yield due to nutrients application as compared to control might be attributed to increase in yield parameters like pod length, number of pods per plant and number of seeds per pod due to higher plant height and more number of green leaves per plant. The improvement in growth and yield attributing parameter was mainly due to supply of nutrients which resulted in higher uptake and consequently higher yields. The increase in growth parameter and yield attributes with the application of STCR fertilizer dose (50% RDP) with foliar application of HA and MM might be attributed to improvement in cell division, expansion of cell wall, meristematic activity, enzymatic activity, photosynthetic efficiency, increased nutrient absorption and translocation, increase in physiological processes (Harshad Thakur *et al.*, 2013) and plant vigour thus resulting in better growth and development of crop and production of more number of flowers which in turn improved all the growth parameters and yield influencing characters of cowpea with the application of HA and MM.

Table.1 Effect of STCR based fertilizer recommendation along with foliar application of humic acid and multi-micronutrient mixture on growth parameters of cowpea

Treatment	**Plant height (cm)**	**Number of leaves per plant**	**Number of branches per plant**	**Leaf area (cm^2 $plant^{-1}$) 60 DAS**	**Dry matter production (g per plant) 60 DAS**
$\mathbf{T_1}$ - Absolute control	48.13	9.04	8.13	900.83	10.17
$\mathbf{T_2}$ - RDF + FYM	61.10	10.32	11.07	1071.17	13.61
$\mathbf{T_3}$ – STCR	65.93	10.39	11.73	1161.70	13.82
$\mathbf{T_4}$ - STCR (no P)	55.40	10.27	9.77	1044.03	11.87
$\mathbf{T_5}$ - STCR (50% RDP) + FYM	66.03	10.37	12.40	1140.57	13.92
$\mathbf{T_6}$ - T_5 + HA 500 ppm	70.50	10.39	12.60	1163.27	13.89
$\mathbf{T_7}$ - T_5 + HA 1000 ppm	70.13	10.41	12.50	1172.23	13.94
$\mathbf{T_8}$ - T_5 + MM1	68.30	10.41	12.80	1169.07	13.86
$\mathbf{T_9}$ - T_5 + MM2	68.37	10.41	12.87	1186.37	13.96
$\mathbf{T_{10}}$ - T_5 + HA 500 ppm + MM1	70.23	10.41	12.60	1184.90	13.95
$\mathbf{T_{11}}$ - T_5 + HA 1000 ppm + MM1	70.30	10.35	12.87	1106.00	13.97
$\mathbf{T_{12}}$ - T_5 + HA 500 ppm + MM2	71.60	10.42	13.08	1209.27	14.02
$\mathbf{T_{13}}$ - T_5 + HA 1000 ppm + MM2	71.13	10.44	12.97	1135.10	14.04
S.Em±	**4.24**	**0.12**	**0.38**	**44.99**	**0.30**
CD (P=0.05)	**12.39**	**0.35**	**1.11**	**131.32**	**0.87**

Table.2 Yield attributes of cowpea as influenced by STCR based fertilizer dose with foliar HA and MM application

Treatment	Pod length(cm)	No. of pods per plant	No. of seeds per pod	Test weight (g)
T_1 - Absolute control	16.0	20.87	14.23	9.17
T_2 - RDF + FYM	16.6	24.93	15.57	9.32
T_3 - STCR	17.6	26.70	16.00	9.39
T_4 - STCR (no P)	16.5	25.07	14.93	9.31
T_5 - STCR (50% RDP) + FYM	17.5	26.60	16.00	9.37
T_6 - T_5 + HA 500 ppm	17.6	26.43	16.23	9.39
T_7 - T_5 + HA 1000 ppm	17.6	26.73	16.37	9.41
T_8 - T_5 + MM1	17.6	27.30	17.20	9.42
T_9 - T_5 + MM2	17.7	27.37	17.33	9.41
T_{10} - T_5 + HA 500 ppm + MM1	17.7	27.40	17.22	9.41
T_{11} - T_5 + HA 1000 ppm + MM1	17.8	27.43	17.23	9.44
T_{12} - T_5 + HA 500 ppm + MM2	18.0	27.60	17.43	9.42
T_{13} - T_5 + HA 1000 ppm + MM2	17.9	27.40	17.27	9.44
S.Em±	**0.4**	**0.74**	**0.31**	**0.08**
CD (P=0.05)	**1.1**	**2.16**	**0.91**	**NS**

Table.3 Effect of STCR based fertilizer recommendation along with foliar application of humic acid and multi-micronutrient mixture on yield and BC ratio of cowpea

Treatment	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	B:C ratio
T_1 - Absolute control	1015.66	1992.22	3.09
T_2 - RDF + FYM	1422.22	2513.33	2.96
T_3 - STCR	1522.09	2875.92	3.99
T_4 - STCR (no P)	1239.90	2337.03	3.44
T_5 - STCR (50% RDP) + FYM	1522.22	2907.40	3.22
T_6 - T_5 + HA 500 ppm	1526.67	3007.40	3.03
T_7 - T_5 + HA 1000 ppm	1529.90	3016.29	2.92
T_8 - T_5 + MM1	1532.93	3029.26	3.16
T_9 - T_5 + MM2	1537.32	3036.29	3.16
T_{10} - T_5 + HA 500 ppm + MM1	1541.92	3061.11	3.05
T_{11} - T_5 + HA 1000 ppm + MM1	1545.25	3081.85	2.93
T_{12} - T_5 + HA 500 ppm + MM2	1550.61	3096.29	3.06
T_{13} - T_5 + HA 1000 ppm + MM2	1547.80	3060.74	2.94
S.Em±	**66.21**	**141.95**	
CD (P=0.05)	**193.24**	**414.32**	

The economic analysis revealed that, the highest B:C ratio of 3.99 was obtained in STCR (50% RDP, no FYM) followed by 3.44 in STCR (no P) treatment. The lowest B:C ratio of 2.92 was recorded in T_7 (STCR + FYM + HA 1000 ppm). Highest ratio in T_3 is due to higher net returns, as cost of FYM is not incurred. Lowest ratio in T_7 is due to higher cost of humic acid and cost of foliar spraying.

In conclusion, application of STCR based fertilizer dose (50% RDP) along with foliar application of HA and MM improved all the growth, yield parameters and yield over the control. The yield target of 1500 kg ha^{-1} fixed for using STCR fertilizer dose calculation was achieved with all the STCR treatments (T_3 to T_{13}) except T_4. Hence the STCR equation developed for Zone 5 can be used successfully for Zone 6 to achieve a yield target of 15 q ha^{-1} with 50 per cent recommended dose of phosphorous as maintenance dose.

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