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Deepshikha
Research Scholar, Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Nisha Jangre
Assistant Professor, Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Alka Minz
Ph.D., Scholar, Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Deepshikha
Research Scholar, Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Influence of foliar nutrition of boron, zinc and biofertilizer on vegetative growth and yield parameters of cowpea [*Vigna unguiculata* (L.)Walp] under Agroclimatic conditions of Chhattisgarh plains

Deepshikha, Nisha Jangre and Alka Minz

Abstract
The field experiment was carried out at Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India during *Rabi* season of 2021-22. The experiment was laid out in randomized block design with 8 treatments in three replications. It was observed that the best yield attributes characters in treatment T_8- {Rhizobium +Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} was found highly effective for yield attributing as it showed highest number of pod cluster^{-1} (3.50), number of pod plant^{-1} (14.84), pod length (22.73 cm), girth of pod (2.28 cm), highest pericarp weight (3.12 gm), number of seed pod^{-1} (12.63), pod yield plant^{-1} (168.72 gm), pod yield plot^{-1} (31.21 kg), and highest pod yield was (124.85 q ha^{-1}). At harvest of cowpea maximum number of nodules (19.15) found in T_8 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%}.

Keywords: Biofertilizer, zinc, boron, yield attributes, cowpea

1. Introduction
Cowpea, [*Vigna unguiculata* (L.) Walp], belong to the family Leguminosae (2n= 2x = 22), is an important food crop in less-developed countries of the tropical and subtropical areas, particularly in sub- Saharan Africa, Asia Central and South America (Singh *et al*., 1997) [11]. Amongst legumes, Cowpea is one of the most essential vegetable grown during the rainy, rabi and summer seasons. Tender pods over green shelled seeds are used as vegetable and as a pulse when it dried. Cowpea has stress tolerance property and it has outstanding nutritive qualities.

It supplies high quality, inexpensive protein 3.5 gram, calcium (Ca) 72.0 mg, phosphorous 59.0 mg, iron 2.5 mg, carotene 564.0 mg, thiamine 0.07 mg, riboflavin 0.09 mg and vitamin 'C' 24.0 mg per 100 gm fit for human consumption pods (Gopalan *et al*., 1982) [6]. Amino acid profile reveal that lysine, leucine and phenylalanine content were relatively high in cowpea (Bressani and Elias, 1980) [1].

Micronutrients applied through a foliar application resulted in higher output of yield. It was therefore worthwhile to investigate the reaction of cowpea to foliar zinc and boron application in order to increase production. Among the micronutrients, Zinc and boron are key minerals for the productivity of legumes. Rhizobiums are a unique group of bacterial symbionts of legumes that fix inert elemental atmospheric nitrogen (De Araujo *et al*., 2008) [3]. Among all the N2 fixing micro-organisms, symbiotic relationships between legumes and rhizobium are responsible for the largest contributions of fixed N to farming systems (Unkovich *et al*., 2008) [12].

2. Materials and Methods
The experimental site is located at farm of Krishi Vigyan Kendra, Raipur. Raipur district is located in the central part of Chhattisgarh, agro-climatologically known as Chhattisgarh plains and lies between latitude 21.25º N and longitude 81.62º E with an altitude of 289 meters above mean sea level. The experiment was laid out in randomized block design with 8 treatments in three replications and total number of plots was 24. Cowpea [*Vigna unguiculata* (L.) Walp] var. Kashi Kanchan' were sown in rabi season plots size of 5x5 meter with row spacing 45 cm and Plant to Plant distance 30 cm. The treatment consisted of eight combination of T_1- water spray, T_2- rhizobium, T_3- rhizobium + boron @ 0.2%, T_4- rhizobium + boron @ 0.5%, T_5- rhizobium + zinc @ 0.2%, T_6- rhizobium + zinc @ 0.5%, T_7- rhizobium + boron + zinc @ 0.2% and T_8- rhizobium + boron + zinc @ 0.5%.

3. Results and Discussion

Table 1: Plant yield attributes parameter

Treatment	No of pods cluster^{-1}	No. of pods plant^{-1}	Pod length (cm)	Girth of pod (cm)	Pericarp weight (gm)	No. of seed pod^{-1}	Pod yield plant^{-1} (gm)	Pod yield plot^{-1} (kg)	Pod yield (q/ha)	Nodules number plant^{-1}	
										At 45 days	After harvest
T1	1.82	9.56	17.40	1.75	2.65	9.82	135.50	25.07	100.30	8.72	12.40
T2	2.05	10.30	17.30	1.77	2.68	10.14	140.90	26.06	104.30	9.12	14.25
T3	2.56	12.20	18.50	1.81	3.01	11.09	149.10	27.59	108.10	9.62	15.82
T4	2.13	11.50	18.00	1.78	2.88	10.71	159.20	29.46	114.30	10.58	16.45
T5	2.62	13.80	19.7	1.90	3.04	11.71	155.80	28.82	110.40	10.15	16.05
T6	2.22	11.80	18.1	1.81	2.99	10.91	162.40	30.04	118.20	11.45	17.55
T7	2.85	13.80	21.4	1.98	3.07	11.97	165.30	30.59	122.40	13.05	18.35
T8	3.50	14.80	22.7	2.28	3.12	12.63	168.70	31.21	124.90	14.23	19.15
S.Ed.(+-)	0.46	2.29	2.13	0.2	0.32	1.26	8.59	1.58	6.29	2.51	1.84
C.D. (at 5%)	0.15	0.74	0.69	0.06	0.1	0.41	2.8	0.51	2.05	0.82	0.6

3.1 Influence of foliar nutrition of Boron, Zinc and Biofertilizer on yield attributes

1. No of pods cluster^{-1}

Effect of biofertilizer and different level of foliar application of micronutrients showed that the significant differences, the different treatments of data with respect to the maximum number of pods cluster^{-1} was 3.5 observed under the treatments T_8 {Rhizobium +Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} is 2.85 and T_5 {Rhizobium + Zinc sulphate ($ZnSO_4$) @ 0.2%} is 2.62 and minimum number of pod cluster^{-1} 1.82 was observed under T_1 (Control).

2. Number of pods plant^{-1}

The highest number of pod per plant was 14.84 observed under the treatments T_8 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} is 13.82 and T_5 {Rhizobium + Zinc sulphate ($ZnSO_4$) @ 0.2%} is 13.76 and minimum number of pods plant^{-1} 9.56 was observed under T_1 (Control).

The similar result were obtained by other research findings. Praveena *et al*., (2018) showed that application (0.2% foliar spray) of boron + 5.0Kg ha^{-1} of zinc produced higher number of pods per plant over control.

3. Pod length (cm)

Consequential difference was reported among the treatments with respect to pod length. The highest pod length was 22.73 observed under the treatments T_8 {Rhizobium +Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} is 21.40 and T_5 {Rhizobium + Zinc sulphate ($ZnSO_4$) @ 0.2%} is 19.71 and minimum pod length 17.40 was observed under T_1 (Control).

Experimental result also accordance with results observed by El-Azab (2016) that application of zinc significantly increases pod length. Chatterjee and Bandyopadhyay (2015) [2] also reported that application of biofertilizer (Rhizobium) along with foliar application of boron significantly gives highest pod length.

4. Girth of pod (cm)

The highest girth of pod was 2.28 observed under the treatments T_8 {Rhizobium +Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} is 1.98 and T_5 {Rhizobium + Zinc sulphate ($ZnSO_4$) @ 0.2%} is 1.90 and minimum girth of pod 1.75 was observed under T_1 (Control).

The similar result were obtained by other research findings. Zyada *et al.,* (2020) [14] showed that application of micronutrient @ Zn (6%) and @ B (2%) gives highest girth of pod over the control. Duhan *et al.,* (2018) [4] rported that the application of different level of zinc gives highest girth of pod.

5. Pericarp weight (gm)

The highest pericarp weight was 3.12 observed under the treatments T_8 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} is 3.07 and T_5 {Rhizobium + Zinc sulphate ($ZnSO_4$) @ 0.2%} is 3.04 and minimum pericarp weight 2.65 was observed under T_1 (Control).

6. Number of seed pod^{-1}

The highest number of seed pod^{-1} was 12.63 observed under the treatments T_8 {Rhizobium +Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} is 11.97 and T_5 {Rhizobium + Zinc sulphate ($ZnSO_4$) @ 0.2%} is 11.71 and minimum number of seed pod^{-1} 9.82 was observed under T_1 (Control).

These result corroborate with findings of Patel *et al.,* (2011) [9] reported that the application of zinc sulphate gives highest number of seed per pod. Yadav *et al*., (2019) [13] reported that the application of biofertilizer (Rhizobium) gives higher number of seed per pod. Karimunnisa *et al*., (2021) [8] noted that combined application of Boron 3 kg/ha + Zinc 30 kg/ha increases highest number of seed per pod.

7. Pod yield plant^{-1} (gm)

The highest pod yield plant^{-1} was 168.72 observed under the treatments T_8 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} is 165.34 and T_6 {Rhizobium + Zinc sulphate ($ZnSO_4$) @ 0.5%} is 162.36 and minimum pod yield plant^{-1} 135.51 was observed under T_1 (Control).

The similar result were obtained by other research findings. Chatterjee and Bandyopadhyay (2017) [2] showed that seed treatment with rhizobium and foliar application of boron gives maximum pod yield per plant.

8. Pod yield plot^{-1} (kg)

The highest pod yield plot^{-1} was 31.21 observed under the treatments T_8 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} is 30.59 and T_6 {Rhizobium + Zinc sulphate ($ZnSO_4$) @ 0.5%} is 30.04 and minimum pod yield plot^{-1} 25.07 was observed under T_1 (Control).

These findings were corroborates with result obtained by Hamsa and Puttaiah (2012) [7] reported that Application of Zinc (Zinc sulphate) at 18 Kg ha^{-1} + boron (boric acid) at 4 Kg ha^{-1} brought about significantly the highest impact on yield.

9. Pod yield (q/ha)

The highest pod yield was 124.85 observed under the treatments T_8 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} is 122.35 and T_6 {Rhizobium + Zinc sulphate ($ZnSO_4$) @ 0.5%} is 118.20 and minimum pod yield 100.28 was observed under T_1 (Control).

This result is in concurrence with work of Singh and Singh (2017) who recorded highest crop yield (q/ha) with application of Rhizobium species. Nadeem *et al*., (2017) reported that the Seed inoculation with Rhizobium + PSB significantly increased yield of cowpea (q/ha).

10. Nodules number plant^{-1}

A higher number of nodules (45 days) were found in Treatment T_8 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} 14.23 followed by T_7 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.2%} 13.05 while minimum nodules number plant^{-1} were recorded in T_1 (Control) 8.72. At harvest of cowpea nodules of selected plants were recorded and observed that maximum number of nodules found in T_8 {Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%} with 19.15 while lowest number of nodules seen in T_1 (Control) with 12.04.

Significantly raised in nodulation also recorded by Usman *et al*., (2012) and Parry *et al*., (2016).

4. Conclusion

1. Maximum number of pod per cluster was observed (3.50) in T_8 (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%) followed by 2.85 in T_7 (Rhizobium + Boron + Zinc @ 0.2%) and minimum was recorded (1.82) under T_1- control (water spray).
2. Number of pod plant^{-1} was recorded maximum (14.84) in T_8 (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%). However, minimum number of pod (9.56) was observed under T_1- control (water spray).
3. Maximum length of pod (22.73 cm) was found under T_8 (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%) followed by T_7 (Rhizobium + Boron + Zinc @ 0.2%) 21.40 cm. While, minimum length of pod (17.40 cm) was observed under T_1- control (water spray).
4. Highest girth of pod was recorded (2.28 cm) under T_8 (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%) and lowest girth of pod was recorded (1.75 cm) under T_1- control (water spray).
5. The pericarp weight was recorded maximum in T_8 (3.12 gm) (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%). While, minimum was recorded (2.65 gm) under T_1- control (water spray).
6. Maximum number of seed pod^{-1} was recorded (12.63 gm) in T_8 (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%). While, minimum was recorded (9.82 gm) in T_1- control (water spray).
7. Pod yield plant^{-1} was recorded maximum (168.72 gm) under T_8 (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%) and minimum was recorded (135.51 gm) under T_1. control (water spray).
8. Pod yield plot^{-1} was recorded maximum (31.21 kg) in T_8 (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%) and minimum (25.07 kg) was recorded under T_1- control (water spray).
9. Maximum pod yield was recorded (124.85 q ha^{-1}) under T_8 (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%) followed by T_7 (Rhizobium + Boron + Zinc @ 0.2%) 122.35 q ha^{-1}. And minimum pod yield was recorded (100.28 q ha^{-1}) under T_1- control (water spray).
10. Maximum number of nodules plant^{-1} was noted (14.23 and 19.15) at 45 DAS and at harvest respectively under T_8 (Rhizobium + Zinc sulphate ($ZnSO_4$) + Boric acid (H_3BO_3) @ 0.5%). While, the minimum number of nodules was noted (8.72 and 12.40) at 45 DAS and at harvest respectively under T_1- control (water spray).

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