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Growth, Yield and Economics of Pigeonpea as Influenced by Biofortification of Zinc and Iron

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ABSTRACT

A field experiment was conducted to study “Growth, yield and economics of pigeonpea as influenced by biofortification of zinc and iron” during *kharif* 2017 at Agriculture Research Station, Kalaburgi on black clay soil. The experiment was laid out in randomized complete block design with ten treatments and three replications comprising of both soil and foliar application of zinc and iron. Among the treatments, RDF + soil application of $ZnSO_4$ @ 15 kg ha^{-1} followed by foliar application 0.5% Zn EDTA recorded significantly higher growth attributes *viz.* plant height (252.5cm), number of primary branches (23.42), secondary branches (25.42), leaf area (17.08), leaf area index (0.95), total dry matter accumulation (210.79 g) at harvest and yield attributes *viz.* number of pods per plant (169.67), seed yield per plant (51.41 g), pod yield per plant (86.27g) and 100 seed weight (12.05g), as compared to rest of the treatments. Among the different biofortification treatments, significantly higher grain yield (1897 kg ha^{-1}), stalk yield (4760 kg ha^{-1}), husk yield (1654 kg ha^{-1}), net returns (Rs. 86933 ha^{-1}) and B: C ratio (3.89) was obtained in RDF+ soil application of $ZnSO_4$ @ 15 kg ha^{-1} followed by foliar application of 0.5% Zn EDTA. Significantly lower growth, yield attributes and economics were recorded with recommended dose of NPK only.

Keywords

$ZnSO_4$, $FeSO_4$, Zn EDTA, Fe EDTA, plant height, leaf area, grain yield, stalk yield

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Introduction

Pulses occupy an area of 76 million hectares and contribute 69 million tonnes to world's food basket (Anon., 2015a). India has the distinction of being world's largest producer of pulses; with the production of 23.95 million tonnes annually from an area of 28.83

million hectares with average productivity of 831 kg ha^{-1} (Anon., 2017). India contributes 25 % to the global pulse production from 32 % area. Pigeonpea is one of the protein rich legumes of the semi-arid tropics grown predominantly under rainfed conditions. In Karnataka, pigeonpea occupies an area of 8.85 lakh hectares, producing 7.29 lakh

tonnes with an average productivity of 824 kg ha⁻¹ (Anon., 2017). Pigeonpea is grown in almost all the states and larger portion of the area lies in the states like Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka and Gujarat.

The productivity of pigeonpea in Karnataka is very low as compared to national level (831 kg ha⁻¹). The low productivity of pigeonpea is mainly attributed to their cultivation in poor soils with inadequate and imbalanced nutrient application without the application of micronutrients (Mukundagowda *et al.*, 2014).

Biofortification is the process of creating micronutrient denser staple food crops with increased bioavailable concentrations through agronomic intervention or genetic selection.

Biofortification works for twin objective of increasing the concentration of the micronutrients in the grains and simultaneously improving the bioavailability of micronutrients in the grains to alleviate the micronutrient deficiency in human beings and also animals.

Hence agronomic biofortification of zinc and iron can be done through soil and foliar applications. The use of micronutrient in pigeonpea is one of the ways to boost up the productivity and to improve the seed quality parameters (Arjun Sharma *et al.*, 2009).

Hence, the present investigation was undertaken to study the effect of soil and foliar application and zinc and iron on growth and yield of pigeonpea.

Materials and Methods

A field experiment was conducted during the *kharif* 2017 at Agriculture Research Station, Kalaburgi, is situated at North Eastern Dry Zone of Karnataka at a latitude of 17° 34'

North, longitude of 76° 79' East and an altitude of 478 meters above mean sea level. The experiment was laid out in Randomized complete block design with 10 treatments replicated thrice.

The treatments were, T₁: Recommended dose of NPK (control), T₂: RDF + 2% urea foliar application at flowering, T₃: RDF + 0.5% Zn EDTA foliar application at flowering, T₄: RDF + 0.1% Fe EDTA foliar application at flowering, T₅: RDF+ Zn EDTA (0.5%) and Fe EDTA (0.1%) through foliar application at flowering, T₆: RDF+ Soil application of ZnSO₄ @ 15 kg ha⁻¹, T₇: RDF+ Soil application of FeSO₄ @ 15 kg ha⁻¹, T₈: RDF+ Soil application of ZnSO₄ @ 15 kg ha⁻¹/fb foliar application of 0.5% Zn EDTA, T₉: RDF+ Soil application of FeSO₄ @ 15 kg ha⁻¹/fb foliar application of 0.1% Fe EDTA, T₁₀: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ + FeSO₄ @ 15 kg ha⁻¹.

Recommended dose of fertilizer for pigeonpea (25:50:0 kg N: P₂O₅: K₂O) were applied at the time of sowing. Nitrogen, phosphorous and potassium were applied in the form of diammonium phosphate (DAP) and Farm yard manure (FYM) @ 6 t ha⁻¹ was incorporated into soil two weeks before sowing. The sowing was done on 18th july, 2017. The total rainfall received during the cropping season 667.70 mm.

The soil of the experimental site was black clay, slightly alkaline (8.30) with an electrical conductivity of 0.2 dS m⁻¹. The soil organic carbon content was low (0.49%).

The soil was low in available nitrogen (232 kg ha⁻¹), medium in available phosphorus (29 kg ha⁻¹) and high in available potassium (430 kg ha⁻¹) and available zinc and Iron (1.76 ppm and 9.72 ppm) respectively. Soil application of fertilizers at 30 DAS and foliar application of fertilizers at 50% flowering stage.

Results and Discussion

Effect of soil and foliar application of zinc and iron on growth parameters

The plant height of pigeonpea differed significantly due to soil and foliar application of micronutrients. In the present study, significantly higher plant height (252.5cm) recorded with RDF + soil application of ZnSO_4 @ 15 kg ha⁻¹ *fb* foliar application of 0.5% Zn EDTA (T₈) over other treatments (Table 1.) may be due to application of micronutrients with RDF responded better in terms of growth and yield attributes due to balanced availability of micronutrients and moisture throughout growing period and application of zinc increased activity of meristematic cells and cell elongation, favorable effect on metabolic process (Price *et al.*, 1972).

Similar kind of results were also found by Sharma *et al.*, (2010) opined that application of ZnSO_4 @ 15 kg ha⁻¹ + RDF recorded significantly higher plant height (196.1cm) compared to the application of RDF alone in pigeonpea, Der *et al.*, (2015) reported that combined application K @ 0.5% + Fe @ 0.5% + Zn @ 0.5% + B @ 0.2% foliar spray at 40 DAS results in significantly higher plant height, over the control in groundnut, Gowthami and Ananda (2015) reported that micronutrient application soil (25 kg ha⁻¹) and foliar (0.5 %) application of ZnSO_4 recorded significantly higher plant height (42.09 cm) in groundnut, Jha *et al.*, (2015) reported that application of 100 % RDF+ Zn+ Fe (N:P:K-20:30:15 kg ha⁻¹ + ZnSO_4 5 kg ha⁻¹ + FeSO_4 5 kg ha⁻¹) recorded significantly highest plant height (34.18 cm) of blackgram respectively over rest of the treatments. Among the treatments tested, significantly higher number of branches was recorded with RDF + soil application of ZnSO_4 @ 15 kg ha⁻¹ *fb* foliar application of 0.5% Zn EDTA (T₈) over other

treatments (Table 1). This might be due to superiority of ZnSO_4 in maintaining higher zinc concentration in the rhizosphere and beneficial role of zinc in synthesis of IAA, metabolism of auxin, biological activity, stimulating effect on photosynthetic pigments and enzyme activity which inturn encourage vegetative growth of plants.

Application of ZnSO_4 @ 15 kg ha⁻¹ + RDF recorded significantly higher number of primary branches per plant (10.1) compared to the application of RDF alone in pigeonpea (Sharma *et al.*, 2010). Application of FeSO_4 + ZnSO_4 @ 25kg ha⁻¹ + borax @ 5 kg ha⁻¹ along with recommended dose of fertilizer recorded the higher number of branches at all growth stages followed by FeSO_4 + ZnSO_4 each @ 10 kg ha⁻¹ + borax @ 2.5 kg ha⁻¹ along with RDF in chickpea (Mahantesh, 2013). Der *et al.*, (2015) reported that combined application K @ 0.5% + Fe @ 0.5% + Zn @ 0.5% + B @ 0.2% foliar spray at 40 DAS results in significantly higher number of branches per plant over the control. Roy *et al.*, (2017) reported that soil application of Zn at 5.5 kg ha⁻¹ increases the number of branches per plant over control in greengram.

Leaf area is an important attribute of plant which determines the active photosynthetic ability, growth, dry matter production and inurn yield of any crop. Leaf area index which depends on leaf area per plant can be widely changed by manipulating cultural practices. Significantly higher leaf area index recorded with RDF + soil application of ZnSO_4 @ 15 kg ha⁻¹ *fb* foliar application of 0.5% Zn EDTA (T₈) over other treatments (Table 1).

Due to increased metabolic activity by increased supply of nutrients, more accumulation of dry matter in leaves helped the photosynthetic area to remain active for longer period and was responsible for overall

growth of plant interms of dry matter production. Almost similar results were found by Gowthami and Ananda (2015) reported that micronutrient application soil (25 kg ha^{-1}) and foliar (0.5 %) application of ZnSO_4 recorded significantly higher leaf area at harvest ($6.30 \text{ dm}^2 \text{ plant}^{-1}$, respectively) and Handiganoor *et al.*, (2016) reported that seed polymer coating (6 ml kg^{-1}) of pigeonpea seeds with the combination of potassium molybdate + ZnSO_4 + boron (each @ 2 g kg^{-1} seed) along with two foliar sprays of potassium molybdate (0.1%) + zinc sulphate (0.5%) in EDTA form + borax (0.2%) at an interval of 10 days during flowering stage (75 and 85 DAS) recorded significantly higher leaf area index (2.48, 3.08 and 2.91) at 45, 90 and 120 DAS respectively compared to control. Jha *et al.*, (2015) reported that application of 100 % RDF+ Zn + Fe (N:P:K-20:30:15 kg ha^{-1} + ZnSO_4 5 kg ha^{-1} + FeSO_4 5 kg ha^{-1}) recorded significantly highest leaf area index (2.216) over rest of the treatments in blackgram, Mukundgouda *et al.*, (2015) revealed that soil application of ZnSO_4 @ 25 kg ha^{-1} along with foliar spray of 19:19:19 @ 0.4% recorded significantly higher leaf area per plant in pigeonpea.

In the present investigation, RDF + soil application of ZnSO_4 @ 15 kg ha^{-1} *fb* foliar application of 0.5% Zn EDTA (T_8) recorded significantly higher dry matter accumulation ($210.79 \text{ g plant}^{-1}$) over other treatments (Table 1). This may be due to soil and foliar application of ZnSO_4 along with RDF which ultimately increased nutrient concentration in root zone followed by spraying of fertilizers through leaves, increased nutrient availability and uptake, increased translocation of photosynthates from source to sink, hence higher dry matter production.

The treatment receiving only recommended dose of NPK (control) recorded significantly lowest dry matter accumulation (154.68 g

plant^{-1}) due to poor availability of nutrients, lower nutrient uptake compared to application of micronutrient application along with RDF. Similar results were also found with application of FeSO_4 + ZnSO_4 @ 25 kg ha^{-1} + borax @ 5 kg ha^{-1} along with recommended dose of fertilizer recorded higher dry matter production at all growth stages followed by FeSO_4 + ZnSO_4 each @ 10 kg ha^{-1} + borax @ 2.5 kg ha^{-1} along with RDF in chickpea (Mahantesh, 2013). Der *et al.*, (2015) reported that combined application K @ 0.5% + Fe @ 0.5% + Zn @ 0.5% + B @ 0.2% foliar spray at 40 DAS results in significantly higher dry matter at 45 and 75 DAS over the control in groundnut. Application of 100 % RDF+ Zn+ Fe (N: P: K- 20:30:15 kg ha^{-1} + ZnSO_4 5 kg ha^{-1} + FeSO_4 5 kg ha^{-1}) recorded significantly highest dry matter ($10.31 \text{ g plant}^{-1}$) of blackgram respectively over rest of the treatments (Jha *et al.*, 2015). Krishna and P. J. George (2017) reported that soil application of phosphorus @ 70 kg ha^{-1} and ZnSO_4 @ 20 kg ha^{-1} recorded significantly higher dry weight (35 g) in kabuli chickpea.

Effect of soil and foliar application of zinc and iron on yield parameters

In the present investigation, significant differences were noticed in yield and yield components of pigeonpea as a consequence of biofortification of micronutrients involving different methods of application. All the biofortified treatments produced significantly higher seed yield ($1475\text{-}1897 \text{ kg ha}^{-1}$) when compared to control (1329 kg ha^{-1}) (Table 2). Control treatment registered 42.7 % reduction in seed yield as compared to the best treatment RDF + soil application of ZnSO_4 @ 15 kg ha^{-1} *fb* foliar application of 0.5% Zn EDTA (T_8). Higher grain yield obtained in this treatment may be due to higher dry matter accumulation, better nutrient uptake (N, P, K, Zn and Fe) and translocation to reproductive parts and

involvement of zinc in various enzymatic processes which helps in catalyzing reaction for growth finally leading to development of more yield attributing characters like number of pods per plant, pod weight, 100 seed weight, and seed yield. Significantly lower seed yield (1329 kg ha⁻¹) obtained with recommended dose of NPK (T₁) may be due to lower availability of major and micronutrient in soil, lower nutrient uptake, reduced photosynthates production which causes lower yield attributing characters and resulted in lower yield.

The improvement in yield was mainly achieved through improvement in yield attributing characters like number of pods plant⁻¹, pod yield plant⁻¹, seed yield plant⁻¹ and 100 seed weight (Table 2). In this study, significantly higher number of pods per plant (169.67), pod weight (86.27 g plant⁻¹), 100 seed weight (12.05 g) and seed yield (51.41 g plant⁻¹) was recorded with RDF + soil application of ZnSO₄ @ 15 kg ha⁻¹ *fb* foliar application of 0.5% Zn EDTA (T₈) when compared to rest of the treatments (Table 2).

Higher seed yield plant⁻¹ may be due to fulfillment of the demand of crop by higher assimilation and translocation of photosynthates from source to sink and better role of zinc during reproductive phase of crop growth. Seed yield plant⁻¹ was governed by number of pods plant⁻¹, number of seeds pod⁻¹ and 100 seed weight.

Significantly higher number of pods plant⁻¹ was recorded with RDF + soil application of ZnSO₄ @ 15 kg ha⁻¹ *fb* foliar application of 0.5% Zn EDTA (T₈) over control. Gowthami and Ananda (2015) reported that micronutrient application soil (25 kg ha⁻¹) and foliar (0.5 %) application of ZnSO₄ recorded significantly higher plant height and leaf area at harvest (42.09 cm and 6.30 dm² plant⁻¹, respectively) and pod yield (2656 kg ha⁻¹).

Srikanth Babu *et al.*, (2012) reported that significantly higher seed yield of pigeonpea (1324 kg ha⁻¹) can be obtained with ZnSO₄ @ 20 kg ha⁻¹ compared to no zinc sulphate (1048 kg ha⁻¹) and ZnSO₄ @ 10 kg ha⁻¹ (1,171 kg ha⁻¹) while it was on par with ZnSO₄ @ 15 kg ha⁻¹ (1296 kg ha⁻¹).

Debroy *et al.*, (2013) revealed that both soil and foliar application of 5.5 kg Zn ha⁻¹ + 0.1% Zn spray through ZnSO₄ resulted in increase in straw yield by 56.4% and seed yield by 57% in greengram. Gowthami and Ananda (2015) reported that micronutrient application soil (25 kg ha⁻¹) and foliar (0.5 %) application of ZnSO₄ recorded significantly higher pod yield (2656 kg ha⁻¹) in groundnut and application of 100 % RDF+ Zn+ Fe (N:P:K- 20:30:15 kg ha⁻¹ + ZnSO₄ 5 kg ha⁻¹ + FeSO₄ 5 kg ha⁻¹) recorded significantly highest number of pods (32.38 plant⁻¹), number of seeds (6.88 pod⁻¹), seed yield (870 kg ha⁻¹), straw yield (1843 kg ha⁻¹), biological yield (2713 kg ha⁻¹) of blackgram respectively over rest of the treatments (Jha *et al.*, 2015).

The data on stalk yield and husk yield of pigeonpea due to biofortification of Zn and Fe indicated that, significantly higher stalk yield (4761 kg ha⁻¹) and husk yield (1655 kg ha⁻¹) were recorded with RDF + soil application of ZnSO₄ @ 15 kg ha⁻¹ *fb* foliar application of 0.5% Zn EDTA (T₈) over other treatments.

The higher stalk yield and husk yield in the above said treatment may be due to improved vegetative growth and growth parameters through adequate availability of major and micronutrient in soil, which in turn, favorably influenced physiological process and buildup of photosynthates.

Almost similar results were found by Ramaprasad *et al.*, (2011) revealed that soil application of 25 kg ZnSO₄ ha⁻¹ along with 0.5% ZnSO₄ foliar spray of twice at 45 and 55

DAS proved significantly superior over the control in seed yield (3046 kg ha⁻¹) and haulm yield (3891 kg ha⁻¹) in *kabuli* chickpea under clay loam soils of Andhra Pradesh., Debroy *et al.*, (2013) studied enrichment of green gram

genotypes with iron through ferti-fortification and concluded that both soil and foliar application of 5.5 kg Zn ha⁻¹ + 0.1% Zn spray through ZnSO₄ resulted in increase in straw yield by 56.4% and seed yield by 57%.

Table.1 Growth attributes of pigeonpea as influenced by soil and foliar application of Zn and Fe

Treatment	Plant height (cm)	No. of 1° branches plant ⁻¹	No. of 2° branches plant ⁻¹	Leaf area (dm ² plant ⁻¹)	Leaf area index	TDMA (g)
T₁: Recommended dose of NPK (control)	185.7	14.07	18.93	10.37	0.58	154.68
T₂: RDF + 2% urea foliar application	201.9	14.95	19.37	12.17	0.67	174.69
T₃: RDF + 0.5% Zn EDTA foliar application	229.7	17.14	21.93	13.19	0.73	191.62
T₄: RDF + 0.1% Fe EDTA foliar application	208.2	15.20	19.54	12.22	0.68	177.26
T₅: RDF+ Zn EDTA (0.5%) and Fe EDTA (0.1%) through foliar application	239.6	18.47	23.36	14.61	0.81	199.32
T₆: RDF+ Soil application of ZnSO₄ @ 15 kg ha⁻¹	235.3	17.47	22.83	14.10	0.78	195.31
T₇: RDF+ Soil application of FeSO₄ @ 15 kg ha⁻¹	214.1	15.47	19.93	12.47	0.69	180.90
T₈: RDF+ Soil application of ZnSO₄ @ 15 kg ha⁻¹ fb foliar application of 0.5% Zn EDTA	252.5	23.42	25.42	17.08	0.95	210.79
T₉: RDF+ Soil application of FeSO₄ @ 15 kg ha⁻¹ fb foliar application of 0.1% Fe EDTA	224.9	16.47	20.53	12.98	0.72	184.87
T₁₀: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ + FeSO₄ @ 15 kg ha⁻¹	247.3	19.00	24.25	14.85	0.83	205.53
S.Em±	9.9	1.72	1.50	1.22	0.067	3.91
CD (p=0.05)	29.4	5.52	4.82	3.91	0.22	12.51
CV (%)	7.66	17.41	12.08	15.79	15.74	3.61

Table.2 Yield and yield attributes of pigeonpea as influenced by soil and foliar application of Zn and Fe

Treatments	No. of pods plant ⁻¹	Pod weight Plant ⁻¹ (g)	Seed yield Plant ⁻¹ (g)	Test weight (g)	Grain yield (kg ha ⁻¹)	Stalk yield (kg ha ⁻¹)	Husk yield (kg ha ⁻¹)
T₁: Recommended dose of NPK (control)	105.67	45.13	32.55	9.79	1329	3088	1185
T₂: RDF + 2% urea foliar application	125.00	62.27	34.68	10.35	1475	3417	1310
T₃: RDF + 0.5% Zn EDTA foliar application	147.33	73.27	45.30	11.24	1639	3876	1451
T₄: RDF + 0.1% Fe EDTA foliar application	132.33	65.33	35.28	10.73	1487	3461	1326
T₅: RDF+ Zn EDTA (0.5%) and Fe EDTA (0.1%) through foliar application	158.33	80.47	48.65	11.46	1656	3971	1483
T₆: RDF+ Soil application of ZnSO₄ @ 15 kg ha⁻¹	151.33	77.93	47.13	11.37	1648	3914	1465
T₇: RDF+ Soil application of FeSO₄ @ 15 kg ha⁻¹	136.67	67.00	36.47	10.74	1530	3550	1359
T₈: RDF+ Soil application of ZnSO₄ @ 15 kg ha⁻¹ fb foliar application of 0.5% Zn EDTA	169.67	86.27	51.41	12.05	1897	4761	1655
T₉: RDF+ Soil application of FeSO₄ @ 15 kg ha⁻¹ fb foliar application of 0.1% Fe EDTA	140.33	68.33	38.10	10.98	1598	3708	1419
T₁₀: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ + FeSO₄ @ 15 kg ha⁻¹	164.33	83.18	49.59	11.56	1738	4337	1532
S.Em±	7.77	5.23	2.22	0.408	87	216	67
CD (p=0.05)	24.88	16.75	7.11	1.307	261	690	215

Table.3 Economic of pigeonpea as influenced by biofortification of zinc and iron

Treatments	Gross returns (₹ ha ⁻¹)	Cost of cultivation (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	BC ratio
T₁: Recommended dose of NPK (control)	81,877	26,570	55,307	3.08
T₂: RDF + 2% urea foliar application	90,863	26,838	59,918	3.23
T₃: RDF + 0.5% Zn EDTA foliar application	1,01,003	29,020	71,983	3.48
T₄: RDF + 0.1% Fe EDTA foliar application	91,613	27,470	64,144	3.34
T₅: RDF+ Zn EDTA (0.5%) and Fe EDTA (0.1%) through foliar application	1,02,087	29,720	72,367	3.44
T₆: RDF+ Soil application of ZnSO₄ @ 15 kg ha⁻¹	1,01,570	27,395	74,175	3.71
T₇: RDF+ Soil application of FeSO₄ @ 15 kg ha⁻¹	94,254	27,020	67,234	3.49
T₈: RDF+ Soil application of ZnSO₄ @ 15 kg ha⁻¹ <i>fb</i> foliar application of 0.5% Zn EDTA	1,17,028	29,845	87,183	3.92
T₉: RDF+ Soil application of FeSO₄ @ 15 kg ha⁻¹ <i>fb</i> foliar application of 0.1% Fe EDTA	98,444	27,920	70,524	3.53
T₁₀: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ + FeSO₄ @ 15 kg ha⁻¹	1,07,214	27,845	79,369	3.85
S.Em±	4870	-	4870	0.10
CD (p=0.05)	15,578	-	15,578	0.31

Economics

Among treatments, significantly higher gross return (₹ 1, 17, 028 ha⁻¹), net return (₹ 87,183 ha⁻¹) and benefit cost ratio (3.92) were recorded with RDF + soil application of ZnSO₄ @ 15 kg ha⁻¹ *fb* foliar application of 0.5% Zn EDTA when compared to rest of the

treatments (Table 3). Significantly higher gross return, net return and BC ratio in the above treatment was due to higher yield levels and higher market price of pigeonpea. The higher yields under this treatment may be due to soil application of fertilizers which might be resulted in higher nutrient concentration in root zone and direct foliar spraying of

fertilizers leads to more absorption of nutrients, better photosynthetic activity and its distribution to various parts, increase in growth and yield attributing characters and finally resulted in higher yields, gross returns, net return and benefit cost ratio. Almost similar result found in Mukundagowda *et al.*, (2014) revealed that soil application of $ZnSO_4$ @ 25 kg ha⁻¹ along with foliar spray of 19:19:19 @ 0.4 % recorded significantly higher gross returns (₹ 55,592 ha⁻¹), net returns (₹ 36,323 ha⁻¹) and benefit cost ratio (2.89). Jha *et al.*, (2015) reported that application of 100 % RDF+ Zn + Fe (N: P: K-20:30:15 kg ha⁻¹ + $ZnSO_4$ 5 kg ha⁻¹ + $FeSO_4$ 5 kg ha⁻¹) recorded significantly highest gross return (₹ 50975 ha⁻¹), net return (₹ 34930 ha⁻¹) and B:C ratio (3.18) respectively over rest of the treatments in blackgram. Rathod *et al.*, (2016) concluded that application of $ZnSO_4$ @ 15 kg ha⁻¹ along with recommended dose of fertilizers recorded significantly higher gross returns (₹ 59,039 ha⁻¹), net returns (₹ 38,209 ha⁻¹) and B: C ratio (2.83).

Among the treatments, RDF + soil application of $ZnSO_4$ @ 15 kg ha⁻¹ *fb* foliar application of 0.5% Zn EDTA (T₈) recorded significantly higher growth parameters like plant height, number of branches, leaf area, leaf area index, total dry matter accumulation and yield parameters like grain yield, stalk yield husk yield, number of pods per plant, seed yield per plant, pod yield per plant and 100 seed weight. Significantly higher net return and BC ratio recorded with treatment, RDF + soil application of $ZnSO_4$ @ 15 kg ha⁻¹ *fb* foliar application of 0.5% Zn EDTA (T₈).

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