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 ZnSO₄ @ 15 kg ha⁻¹ followed by foliar application 0.5% Zn EDTA recorded significantly higher growth attributes viz. plant height (252.5 cm), 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 (86.27 g) and 100 seed weight (12.05 g), 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 ZnSO₄ @ 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: ZnSO₄, FeSO₄, Zn EDTA, Fe EDTA, plant height, leaf area, grain yield, stalk yield

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\(^{\circ}\) 34' North, longitude of 76\(^{\circ}\) 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:
- T\(_1\): Recommended dose of NPK (control),
- T\(_2\): RDF + 2% urea foliar application at flowering,
- T\(_3\): RDF + 0.5% Zn EDTA foliar application at flowering,
- T\(_4\): RDF + 0.1% Fe EDTA foliar application at flowering,
- T\(_5\): RDF+ Zn EDTA (0.5%) and Fe EDTA (0.1%) through foliar application at flowering,
- T\(_6\): RDF+ Soil application of ZnSO\(_4\) @ 15 kg ha\(^{-1}\),
- T\(_7\): RDF+ Soil application of FeSO\(_4\) @ 15 kg ha\(^{-1}\),
- T\(_8\): RDF+ Soil application of ZnSO\(_4\) @ 15 kg ha\(^{-1}\) fb foliar application of 0.5% Zn EDTA ,
- T\(_9\): RDF+ Soil application of FeSO\(_4\) @ 15 kg ha\(^{-1}\) fb foliar application of 0.1% Fe EDTA,
- T\(_{10}\): RDF + Soil application of ZnSO\(_4\) @ 15 kg ha\(^{-1}\) + FeSO\(_4\) @ 15 kg ha\(^{-1}\).

Recommended dose of fertilizer for pigeonpea (25:50:0 kg N: P\(_2\)O\(_5\): K\(_2\)O) 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 18\(^{th}\) 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 (252.5 cm) recorded with RDF + soil application of ZnSO₄ @ 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 ZnSO₄ @ 15 kg ha⁻¹ + RDF recorded significantly higher plant height (196.1 cm) 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 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.

Application of ZnSO₄ @ 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 FeSO₄ + ZnSO₄ @ 25 kg 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 FeSO₄ + ZnSO₄ 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 ZnSO₄ @ 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 internodes 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 ZnSO₄ recorded significantly higher leaf area at harvest (6.30 dm² 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 + ZnSO₄ + 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 + ZnSO₄ 5 kg ha⁻¹ + FeSO₄ 5 kg ha⁻¹) recorded significantly highest dry matter (10.31 g plant⁻¹) of blackgram respectively over rest of the treatments (Jha et al., 2015). 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 + ZnSO₄ 5 kg ha⁻¹ + FeSO₄ 5 kg ha⁻¹) recorded significantly highest dry matter (10.31 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 ZnSO₄ @ 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, RDF + soil application of ZnSO₄ @ 15 kg ha⁻¹ fb foliar application of 0.5% Zn EDTA (T₈) recorded significantly higher dry matter accumulation (210.79 g plant⁻¹) over other treatments (Table 1). This may be due to soil and foliar application of ZnSO₄ 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 FeSO₄ + ZnSO₄ @ 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 FeSO₄+ ZnSO₄ 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 + ZnSO₄ 5 kg ha⁻¹ + FeSO₄ 5 kg ha⁻¹) recorded significantly highest dry matter (10.31 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 ZnSO₄ @ 20 kg ha⁻¹ recorded significantly higher dry weight (35 g) in kabuli chickpea.
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 (T\(_1\)) 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 ZnSO\(_4\) @ 15 kg ha\(^{-1}\) fb foliar application of 0.5% Zn EDTA (T\(_8\)) 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 ZnSO\(_4\) @ 15 kg ha\(^{-1}\) fb foliar application of 0.5% Zn EDTA (T\(_8\)) over control. Gowthami and Ananda (2015) reported that micronutrient application soil (25 kg ha\(^{-1}\)) and foliar (0.5 %) application of ZnSO\(_4\) 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\(^{-1}\) + ZnSO\(_4\) 5 kg ha\(^{-1}\) + FeSO\(_4\) 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 ZnSO\(_4\) @ 15 kg ha\(^{-1}\) fb foliar application of 0.5% Zn EDTA (T\(_8\)) 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 ZnSO\(_4\) ha\(^{-1}\) along with 0.5% ZnSO\(_4\) 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 ZnSO\(_4\) 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)   |
|---------------------------------------------------------------------------|-------------------|-----------------------------------|-----------------------------------|-----------------------------------|----------------|------------|
| **T\(_1\)**: Recommended dose of NPK (control)                            | 185.7             | 14.07                             | 18.93                             | 10.37                             | 0.58           | 154.68     |
| **T\(_2\)**: RDF + 2% urea foliar application                            | 201.9             | 14.95                             | 19.37                             | 12.17                             | 0.67           | 174.69     |
| **T\(_3\)**: RDF + 0.5% Zn EDTA foliar application                       | 229.7             | 17.14                             | 21.93                             | 13.19                             | 0.73           | 191.62     |
| **T\(_4\)**: RDF + 0.1% Fe EDTA foliar application                       | 208.2             | 15.20                             | 19.54                             | 12.22                             | 0.68           | 177.26     |
| **T\(_5\)**: 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     |
| **T\(_6\)**: RDF+ Soil application of ZnSO\(_4\) @ 15 kg ha\(^{-1}\)     | 235.3             | 17.47                             | 22.83                             | 14.10                             | 0.78           | 195.31     |
| **T\(_7\)**: RDF+ Soil application of FeSO\(_4\) @ 15 kg ha\(^{-1}\)    | 214.1             | 15.47                             | 19.93                             | 12.47                             | 0.69           | 180.90     |
| **T\(_8\)**: RDF+ Soil application of ZnSO\(_4\) @ 15 kg ha\(^{-1}\) fb foliar application of 0.5% Zn EDTA | 252.5             | 23.42                             | 25.42                             | 17.08                             | 0.95           | 210.79     |
| **T\(_9\)**: RDF+ Soil application of FeSO\(_4\) @ 15 kg ha\(^{-1}\) fb foliar application of 0.1% Fe EDTA | 224.9             | 16.47                             | 20.53                             | 12.98                             | 0.72           | 184.87     |
| **T\(_{10}\)**: RDF + Soil application of ZnSO\(_4\) @ 15 kg ha\(^{-1}\) + FeSO\(_4\) @ 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       |

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| Treatments                                                                 | No. of pods plant<sup>-1</sup> | Pod weight (g) | Seed yield (g) | Test weight (g) | Grain yield (kg ha<sup>-1</sup>) | Stalk yield (kg ha<sup>-1</sup>) | Husk yield (kg ha<sup>-1</sup>) |
|---------------------------------------------------------------------------|-------------------------------|----------------|----------------|----------------|----------------------------------|--------------------------------|---------------------------------|
| **T<sub>1</sub>: Recommended dose of NPK (control)**                       | 105.67                        | 45.13          | 32.55          | 9.79           | 1329                             | 3088                           | 1185                            |
| **T<sub>2</sub>: RDF + 2% urea foliar application**                        | 125.00                        | 62.27          | 34.68          | 10.35          | 1475                             | 3417                           | 1310                            |
| **T<sub>3</sub>: RDF + 0.5% Zn EDTA foliar application**                  | 147.33                        | 73.27          | 45.30          | 11.24          | 1639                             | 3876                           | 1451                            |
| **T<sub>4</sub>: RDF + 0.1% Fe EDTA foliar application**                  | 132.33                        | 65.33          | 35.28          | 10.73          | 1487                             | 3461                           | 1326                            |
| **T<sub>5</sub>: RDF+ Zn EDTA (0.5%) and Fe EDTA (0.1%) through foliar application** | 158.33                        | 80.47          | 48.65          | 11.46          | 1656                             | 3971                           | 1483                            |
| **T<sub>6</sub>: RDF+ Soil application of ZnSO<sub>4</sub> @ 15 kg ha<sup>-1</sup>** | 151.33                        | 77.93          | 47.13          | 11.37          | 1648                             | 3914                           | 1465                            |
| **T<sub>7</sub>: RDF+ Soil application of FeSO<sub>4</sub> @ 15 kg ha<sup>-1</sup>** | 136.67                        | 67.00          | 36.47          | 10.74          | 1530                             | 3550                           | 1359                            |
| **T<sub>8</sub>: RDF+ Soil application of ZnSO<sub>4</sub> @ 15 kg ha<sup>-1</sup> fb foliar application of 0.5% Zn EDTA** | 169.67                        | 86.27          | 51.41          | 12.05          | 1897                             | 4761                           | 1655                            |
| **T<sub>9</sub>: RDF+ Soil application of FeSO<sub>4</sub> @ 15 kg ha<sup>-1</sup> fb foliar application of 0.1% Fe EDTA** | 140.33                        | 68.33          | 38.10          | 10.98          | 1598                             | 3708                           | 1419                            |
| **T<sub>10</sub>: RDF + Soil application of ZnSO<sub>4</sub> @ 15 kg ha<sup>-1</sup> + FeSO<sub>4</sub> @ 15 kg ha<sup>-1</sup>** | 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 fb 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 fb 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 ZnSO₄ @ 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 + ZnSO₄ 5 kg ha⁻¹ + FeSO₄ 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 ZnSO₄ @ 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 ZnSO₄ @ 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 ZnSO₄ @ 15 kg ha⁻¹ fb foliar application of 0.5% Zn EDTA (T₈).

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