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INFLUENCE OF ZINC AND IRON ON MORPHOPHYSIOLOGICAL PARAMETERS AND YIELD OF LATHYRUS (*Lathyrus sativus* L.)

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ABSTRACT

A triplicate field experiment laid out in randomized block design conducted at farm of Botany section, College of Agriculture, Nagpur, during *rabi* 2018-2019 growth season. Research design comprised of 17 treatments of zinc (0.1%, 0.2%, 0.3%, 0.4% and 0.5%) and iron (0.1%, 0.2%, 0.3%,0.4% and 0.5%) sprayed individually and in their combinations. Combination treatment of zinc and iron application at the rate of 0.5% each at 25 and 40 DAS significantly enhanced plant height, leaf area, total dry matter production, number of branches at harvest, harvest index and seed yield hectare^{-1}. The highest per cent increase in yield (58.82%) over control was observed by same treatment i.e. T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) as foliar spray at 25 and 40 DAS.

(Key words: Lathyrus, Zinc, Iron, $ZnSO_4$, $FeSO_4$, micronutrients, foliar spray, morphophysiological parameters, yield)

INTRODUCTION

The *Lathyrus sativus (* L.*)* (2n = 14) locally called as grass pea lakhori, Blue sweet pea, Indian pea khesari dal, peavine or chanamatra. It belongs to family Leguminosae or Fabaceae, sub family and genus *Lathyrus* with 130 species occurring all over temperate region of Northern hemisphere and the higher altitude of tropical Africa. In India, besides the ornamental *Lathyrus odoratus*, the only other species cultivated is *Lathyrus sativus* which yield the khesari dal. The edible *Lathyrus sativus* originated in the West Central Asia Mediterranean region and North India was its centre of domestication. The states which cultivate grass pea are Maharashtra, Madhya Pradesh, Bihar, West Bengal and Eastern Uttar Pradesh contributing about 4.5 % total pulse production of the country. In Maharashtra it is cultivated in Bhandara, Chandrapur, Gadchiroli, Gondia and Nagpur districts of eastern Vidarbha.

Zinc one of the essential micronutrient and an important constituent of several enzymes and proteins, is only needed by plants in small quantities. However, it is crucial to plant growth and development, as it plays a significant part in a wide range of processes. Zinc activates enzymes that are responsible for the synthesis of certain proteins. It is used in the formation of chlorophyll and some carbohydrates, conversion of starches to sugars. Zinc is essential in the formation of auxins, which help in growth regulation and stem regulation. (Hafeez *et al.*, 2013). Combined application of Zn with organic manures and foliar application with respect to increment in plant growth, yield and productivity of pulse crops (Yashona, 2018)

Iron is a vital element in plant life. Iron has a number of important functions in the overall metabolism of the plant and it is essential for the synthesis of chlorophyll, as it is essential for many enzymes, including cytochrome that is involved in electron transport chain, maintain structure of chloroplast and also in enzyme activity. It plays critical role in metabolic processes such as DNA synthesis, respiration and photosynthesis. (Rout and Sahoo, 2015).

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of year 2018-19 at experimental farm of Agricultural Botany Section, College of Agriculture, Nagpur to asses the effect of foliar sprays of zinc and iron on morphophysiological parameters and yield of lathyrus. This experiment was carried out in RBD with 3 replications. Research design comprised of 17 treatments viz., (T_1), -control, (T_2)- RDF + Control, (T_3)-RDF + $ZnSO_4$ 0.1 %, (T_4) - RDF + $ZnSO_4$ 0.2%, (T_5)- RDF + $FeSO_4$ 0.4%, (T_6)- RDF + $ZnSO_4$ 0.4 % , (T_7)- RDF + $ZnSO_4$ 0.5 %, (T_8)- RDF + $FeSO_4$ 0.1 %, (T_9)- RDF + $FeSO_4$ 0.2 %, (T_{10})- RDF + $FeSO_4$ 0.3%, (T_{11})- RDF + $FeSO_4$ 0.4%, (T_{12})- RDF + $ZnSO_4$ 0.5 %, (T_{13})- RDF + $ZnSO_4$ 0.1% + $FeSO_4$ 0.1%, (T_{14})- RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%, (T_{15})- RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3% , (T_{16})- RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4% and (T_{17})- RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%. The foliar application of zinc

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and iron was given at two stages i.e. at 25 and 40 DAS on lathyrus. Observations on plant height, number of branches plant^{-1}, total dry matter production and leaf area were recorded at 30, 45 and 60 DAS. Whereas, RGR and NAR were calculated at 30-45 and 45-60 DAS. Seed yield hectare^{-1} was also recorded. The observed data were analyzed statistically using analysis of variance at 5% level of significance (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

Plant height

Plant height is a crucial component of plant species. It is the shortest distance between upper boundary of the photosynthetic tissue on a plant and ground level, expressed in centimeters or meter. It is an important measure to determine growth.

Plant height was recorded at 30, 45, and 60 DAS. At 30 DAS foliar application of RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% (T_{17}) registered significantly maximum plant height and also in treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%) and T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%) over control. Where as, at 45 and 60 DAS significantly highest plant height was noticed in plant expose to the treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%), T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%), T_6 (RDF + $ZnSO_4$ 0.4 %), T_{11} (RDF + $FeSO_4$ 0.4%) and T_5 (RDF + $FeSO_4$ 0.4%) over control (T_1).

The increase in plant height may be due to application of zinc and iron through foliar sprays at different growth stages increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately improving the plant height. Saini and Singh (2017) recorded maximum plant height in green gram under treatment T_5 (40 kg S ha^{-1} as gypsum + 0.5% $FeSO_4$ foliar spray at 25 DAS). Uikey *et al.* (2018) observed that plant height in brinjal was significantly influenced by foliar application of RDF + Borax @ 0.2% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%.

Number of branches plant^{-1}

The branches originating from the primary branches are termed as secondary branches. They are sites of leaves, flowers, and thus pods formation. So, it is a desirable character for higher biomass production and yield in plants.

Number of branches plant^{-1} was recorded at 30, 45, and 60 DAS. At 30 DAS significantly highest number of branches plant^{-1} was recorded in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%), T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%), T_6 (RDF + $ZnSO_4$ 0.4 %), T_{11} (RDF + $FeSO_4$ 0.4%), T_5 (RDF + $FeSO_4$ 0.4%), T_{10} (RDF + $FeSO_4$ 0.3%) and T_4 (RDF + $ZnSO_4$ 0.2%) over control. Where as, at 45 and 60 DAS significantly highest number of branches plant^{-1} was observed in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%), T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%) and T_6 (RDF + $ZnSO_4$ 0.4 %) as compared with treatment T_1 (control).

The beneficial effect on branching might be due to interaction effect of zinc and iron with RDF on metabolic activities like synthesis of IAA, metabolism of auxins and synthesis of nitrate reductase enzyme in the leguminous crop. Sale and Nazirkar (2013) carried out a field experiment to study the effect of different micronutrients on growth traits of soybean under rainfed condition in vertisol at the farm of Agricultural Research Station. It was found that foliar application of zinc (0.5%) and iron (0.5%) with seed fortification of molybdenum increased the branching of soybean.

Leaf area plant^{-1}

Leaf area is an important variable affecting light interception, and hence increased photosynthesis and carbohydrate production. Area of leaf depends upon the number and size of leaves. It is an important parameter in determining the plant productivity.

Observations recorded at 30 DAS indicated significant variation. The most pronounced effect observed in plant expose to the treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%) and T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%) and T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%) as compared with treatment T_1 (control). At 45 and 60 DAS significantly highest leaf area over control was observed in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%), T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%), T_6 (RDF + $ZnSO_4$ 0.4 %), T_{11} (RDF + $FeSO_4$ 0.4%), T_5 (RDF + $FeSO_4$ 0.4%) when compared with control.

Leaf area was significantly increased by zinc and iron possibly because it helps in greater assimilation of food material by the plant which resulted in greater meristematic activities of cells and consequently the number of leaves, length and width of leaf of plant.

A field experiment was conducted by Uikey *et al.* (2018) to find out the suitable micronutrient or their combinations for foliar sprays in brinjal. Application of RDF and foliar spray of micronutrients treatment T_8 (RDF+ Borax (0.2%) + $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%) recorded significantly more leaf area and leaf area index. Purushottam *et al*. (2018) found that the leaf area index of chickpea was significantly influenced by spraying of zinc @ 0.5%. At 70 DAS leaf area Index of chickpea plants with foliar spray of 0.5% zinc sulphate was significantly higher than that of other treatments.

Total dry matter production

Total dry matter production, its distribution and partitioning is integral part of growth and development over the entire growth period and is directly related to seed yield.

Dry matter is an important criterion. It determines source sink relationship and depend upon the net gain in processes on anabolism and catabolism of plant.

The data recorded about the total dry matter production were found statistically significant at 30 and 45 DAS. The range of dry matter production recorded was 0.45-0.76 g and 1.07–1.65 respectively. Significantly maximum dry matter production was noticed in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%), T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%) when compared with treatment T_1 (control). Where as, At 60 DAS significantly maximum dry matter production was registered in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7(RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%) and T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%) over control.

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Relative growth rate (RGR)

Relative growth rate RGR represent total dry weight gained over existing dry weight in unit time. This was originally termed as "efficiency index" because it expresses growth in terms of rate of increase in size unit^{-1} of time. As such, it permits more equitable comparisons between organisms than does absolute growth rate. Normally, relative growth rate deals with total dry weight of plant^{-1}, through other measure of size have also been used. Data revealed that RGR was more during the period of 45-60 DAS.

Considering all treatments under study, significantly maximum RGR was observed in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) i.e., 0.0451 g g^{-1} day^{-1} at 30-45 DAS and 0.0737 g g^{-1} day^{-1} at 45-60 DAS. But it was lowest in control 0.0259 g g^{-1} day^{-1} at 30-45 DAS and 0.0659 g g^{-1} day^{-1} at 45-60 DAS.

At 30-45 DAS range of RGR recorded was 0.0259-0.0451 g g^{-1} day^{-1}. Significantly highest RGR was registered in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + ZnSO4 0.4% + $FeSO_4$ 0.4%), T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%) and T_6 (RDF + $ZnSO_4$ 0.4 %) over control and rest of the treatments. Where as, at 45-60 DAS range of RGR recorded was 0.0659-0.0737 g g^{-1} day^{-1}. Significantly maximum RGR was noticed in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + ZnSO4 0.4% + $FeSO_4$ 0.4%) T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%) and T_6 (RDF + $ZnSO_4$ 0.4 %) over control and rest of the treatments.

Net assimilation rate (NAR)

Net assimilation rate (NAR), synonymously called as unit leaf rate expresses the rate of dry matter increase the rate of dry weight increase at any instant on a leaf area basis with leaf representing an estimate of the size of the assimilatory surface area (Gregory, 1926). Increase in NAR during reproductive phases might be due to increase efficiency of leaves for photosynthesis as a response of photosynthetic apparatus to increase demands for assimilates by growing seed fraction and also due to photosynthetic contribution by pod and sink demand on photosynthetic rate of leaves.

At first stage i.e. 30-45 DAS range of NAR recorded was 0.0248-0.0499 g dm^{-2} day^{-1}. Significantly highest NAR was registered in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %) and T_{12} (RDF + $FeSO_4$ 0.5%) over control. Where as, at second stage i.e. 45-60 DAS range of NAR recorded was 0.0783-0.1060 g dm^{-2} day^{-1}. Significantly highest NAR was observed in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%), T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%) and T_6 (RDF + $ZnSO_4$ 0.4 %) over control.

Seed yield hectare^{-1}

Seed yield is the economic yield which is final result of physiological activities of plant. Economic yield is the part of biomass that is converted into economic product. (Nichiporovic, 1960).

Source–sink relation contributes to the seed yield. It includes phloem loading at source (leaf) and unloading at sink (seed and fruit) by which the economic part will be getting the assimilates synthesized by photosynthesis. Partitioning of assimilate in the plant during reproductive development is important for flower, fruit and seeds. Thus, crop yield can be increased either by increasing the total dry matter production or by increasing the proportion of economic yield (harvest index) or both (Gardner *et al*., 1988).

Among all the treatment superior seed yield ha^{-1} manifested in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%),

Table 1. Effect of zinc and iron on plant height (cm), number of branches and leaf area plant^{-1} (dm^2) in lathyrus

Treatments	Plant height (cm)			Number of branches			Leaf area (dm^2)		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1 (Control)	12.53	22.48	42.20	2.93	5.53	5.80	0.46	1.12	2.90
T_2 (RDF + Control)	12.70	22.93	42.80	3.00	5.73	5.80	0.48	1.12	3.00
T_3 (RDF + $ZnSO_4$ 0.1 %)	13.00	23.41	43.83	3.27	5.87	5.93	0.50	1.22	3.09
T_4 (RDF + $ZnSO_4$ 0.2%)	13.53	24.23	46.00	3.60	5.93	6.20	0.55	1.30	3.56
T_5 (RDF + $ZnSO_4$ 0.3 %)	14.07	24.46	47.87	3.67	6.00	6.20	0.58	1.33	3.66
T_6 (RDF + $ZnSO_4$ 0.4 %)	14.60	24.56	48.20	3.73	6.13	6.33	0.60	1.40	3.78
T_7 (RDF + $ZnSO_4$ 0.5 %)	15.57	26.40	49.57	4.13	6.40	6.73	0.68	1.48	4.19
T_8 (RDF + $FeSO_4$ 0.1 %)	12.73	23.35	43.73	3.27	5.80	5.93	0.49	1.20	3.00
T_9 (RDF + $FeSO_4$ 0.2 %)	13.53	24.09	45.80	3.53	5.87	6.20	0.53	1.30	3.35
T_{10} (RDF + $FeSO_4$ 0.3%)	13.87	24.35	47.20	3.67	5.93	6.20	0.56	1.33	3.66
T_{11} (RDF + $FeSO_4$ 0.4%)	14.17	24.47	48.13	3.73	6.00	6.27	0.60	1.37	3.66
T_{12} (RDF + $FeSO_4$ 0.5%)	15.50	25.33	49.30	3.87	6.40	6.67	0.65	1.47	4.00
T_{13} (RDF + $ZnSO_4$ 0.1% + $FeSO_4$ 0.1%)	13.43	23.83	44.87	3.40	5.87	6.13	0.52	1.30	3.20
T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%)	14.73	24.60	48.27	3.73	6.13	6.47	0.62	1.40	3.86
T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%)	15.40	24.86	48.37	3.80	6.27	6.53	0.64	1.40	3.86
T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%)	15.44	25.29	49.17	3.87	6.27	6.53	0.64	1.45	3.97
T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%)	16.03	26.73	50.63	4.20	6.47	6.80	0.71	1.50	4.20
SE(m) ±	0.76	0.66	1.48	0.22	0.14	0.18	0.22	0.14	0.18
CD at 5%	2.19	1.90	4.29	0.64	0.41	0.52	0.64	0.41	0.52

Table 2. Effect of zinc and iron on total dry matter production plant^{-1}, RGR, NAR, seed yield hectare^{-1}, per cent increase in yield and harvest index in lathyrus

Treatment	Total Dry matter production plant^{-1} (g)			RGR		NAR		Seed yield hectare^{-1} (q)	Per cent increase in yield	Harvest index (%)
	30 DAS	45 DAS	60 DAS	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS			
T_1 (Control)	0.45	1.07	4.00	0.0249	0.0659	0.0248	0.0783	8.50	-	28.45
T_2 (RDF + Control)	0.47	1.09	4.10	0.0251	0.0662	0.0258	0.0789	9.50	11.76	28.86
T_3 (RDF + $ZnSO_4$ 0.1 %)	0.51	1.12	4.30	0.0288	0.0673	0.0274	0.0790	10.00	17.65	30.15
T_4 (RDF + $ZnSO_4$ 0.2%)	0.57	1.21	4.80	0.0334	0.0689	0.0321	0.0800	10.30	21.18	31.82
T_5 (RDF + $ZnSO_4$ 0.3 %)	0.61	1.25	5.07	0.0351	0.0700	0.0341	0.0830	11.10	30.59	32.74
T_6 (RDF + $ZnSO_4$ 0.4 %)	0.65	1.35	5.61	0.0397	0.0712	0.0392	0.0889	11.80	38.82	33.37
T_7 (RDF + $ZnSO_4$ 0.5 %)	0.74	1.60	6.95	0.0443	0.0734	0.0482	0.1027	12.90	51.76	34.71
T_8 (RDF + $FeSO_4$ 0.1 %)	0.49	1.10	4.20	0.0255	0.0670	0.0249	0.0789	9.60	12.94	29.88
T_9 (RDF + $FeSO_4$ 0.2 %)	0.55	1.18	4.62	0.0306	0.0682	0.0294	0.0794	10.20	20.00	31.50
T_{10} (RDF + $FeSO_4$ 0.3%)	0.59	1.23	4.95	0.0343	0.0696	0.0330	0.0808	10.60	24.71	32.66
T_{11} (RDF + $FeSO_4$ 0.4%)	0.63	1.30	5.30	0.0362	0.0703	0.0352	0.0858	11.60	36.47	32.86
T_{12} (RDF + $FeSO_4$ 0.5%)	0.72	1.51	6.50	0.0437	0.0730	0.0447	0.0987	12.80	50.59	34.65
T_{13} (RDF + $ZnSO_4$ 0.1% + $FeSO_4$ 0.1%)	0.53	1.15	4.50	0.0301	0.0682	0.0287	0.0794	10.10	18.82	30.96
T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%)	0.66	1.40	5.90	0.0407	0.0719	0.0404	0.0928	12.10	42.35	33.80
T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%)	0.68	1.45	6.15	0.0417	0.0722	0.0428	0.0969	12.70	49.41	34.40
T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%)	0.70	1.50	6.40	0.0426	0.0725	0.0434	0.0979	12.70	49.41	34.50
T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%)	0.76	1.65	7.21	0.0451	0.0737	0.0499	0.1060	13.53	58.82	34.86
SE(m) ±	0.037	0.080	0.327	0.0022	0.0016	0.0022	0.0053	0.69	-	1.49
CD at 5%	0.10	0.231	0.944	0.0063	0.0048	0.0063	0.0155	1.99	-	4.30

T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%), T_6 (RDF + $ZnSO_4$ 0.4 %), T_{11} (RDF + $FeSO_4$ 0.4%) and T_5 (RDF + $FeSO_4$ 0.4%) and T_{10} (RDF + $FeSO_4$ 0.3%) over control and rest of the treatments.

This result might be due to enhancement of enzymatic activity in microelement which effectively increased photosynthesis and ultimately translocation of assimilates to the seed.

Field experiments were conducted by Anitha *et al.* (2005) to elucidate the response of cowpea to zinc and iron fertilization for augmenting the crop productivity. Results of the study indicated that foliar application of micronutrients like iron and zinc has significant Influence on the yield of cowpea. Combined spraying of 0.5% $FeS0_4$ and 0.5% $ZnS0_4$ at 45 DAS proved most effective and increased the seed yield by 43.09 per cent when compared with control foIlowed by combined spraying of 0.5% $FeS0_4$ and 0.5% $ZnSO_4$ at 25 DAS (40.14 %).

In order to study the effect of different micronutrients on yield of soybean a field experiment was carried out by Sale and Nazirkar (2013) and observed that the Zn (0.5 %) and Fe (0.5 %) combined application increased yield in comparison to their seperate application of Zn, Fe and seed fortification of Mo (0.66 g kg^{-1} seed).

Pandey and Gupta in 2012, revealed that foliar application of 0.5% zinc sulfate ($ZnSO_4$) to black gram showed favorable results in yield. Positive effects of foliar Zn (0.5% $ZnSO_4$) application on pigeonpea have also been observed by Sharafi (2015).

Effect of micronutrient on the productivity of cowpea was studied at S. K. Nagar, Jodhpur, under the All India Co-ordinated Research Project on Arid Legumes and showed that 0.5% $FeS0_4$ + 0.5% $ZnS0_4$ spray both at 25 and 45 DAS proved most effective and increased the seed yield by 27.7 per cent when compared with control. (Anonymous, 2002).

Harvest index (HI)

Harvest index is the proportion of biological yield represented by the economic yield. It is a measure of reproductive efficiency representing dry matter partition between seed and vegetative parts. It is measured in per cent.

Harvest index was significantly increased and was highest in treatment T_{17} (RDF + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%) followed by treatments T_7 (RDF + $ZnSO_4$ 0.5 %), T_{12} (RDF + $FeSO_4$ 0.5%), T_{16} (RDF + $ZnSO_4$ 0.4% + $FeSO_4$ 0.4%), T_{15} (RDF + $ZnSO_4$ 0.3% + $FeSO_4$ 0.3%), T_{14} (RDF + $ZnSO_4$ 0.2% + $FeSO_4$ 0.2%), T_6 (RDF + $ZnSO_4$ 0.4 %) and T_{11} (RDF + $FeSO_4$ 0.4%) over control.

Purushottam *et al*. in 2018 concluded that spraying of zinc sulphate at branching and pre flowering @ 0.5% probably helped the crop to produce good growth and development of chickpea and thereby, it recorded maximum seed yield (840 kg ha^{-1}) and stalk yield (1444 kg ha^{-1}). Saini and Singh (2017) observed that maximum grain yield (716.67 kg ha^{-1}) and stover yield (1372.67 kg ha^{-1}) were recorded under treatment T_5 (40 kg S ha^{-1} as gypsum+ 0.5% $FeSO_4$ foliar spray at 25 DAS) in green gram.

The highest per cent increase in yield (58.82%) over control was observed by the application of $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% as foliar spray at 25 and 40 DAS. Next to this treatment foliar spray of $ZnSO_4$ 0.5% also enhanced yield by (51.76%) over control. From overall result it can be stated that foliar application of zinc and iron with different concentrations improved the morpho-physiological parameters and yield of lathyrus.

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