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Effect of varied of fertility, zinc and zinc biofertilizer on growth attributes of Indian mustard {*Brassica juncea* (L.) Czern & Coss} under Inceptisols of Southern Rajasthan

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Abstract
A field study entitled "Effect of Varied Levels of Fertility, Zinc and Zinc Biofertilizer on growth attributes of Indian mustard {*Brassica juncea* (L.) Czern & Coss} Under Inceptisols of Southern" was conducted with 18 treatments at Rajasthan College of Agriculture, Udaipur during *rabi* 2020-21. All the growth attributes improve significantly with the application of 100% RDF, zinc fertilizer as well as zinc biofertilizer. Among fertility levels, the highest plant height of mustard recorded under application 100% RDF at 30 (40.21 cm), 60 DAS (195.30 cm) and at harvest (210.75 cm), significantly maximum dry matter accumulation at 30 (5.89 g plant^{-1}), 60 (26.01 g plant^{-1}), 90 DAS (34.53 g plant^{-1}) and at harvest (38.74 g plant^{-1}) and crop growth rate (0.670 g m^{-2} day^{-1}) between 30-60 DAS. Whereas, among zinc levels application of 5.0 kg Zn ha^{-1} recorded significantly higher plant height at 30 (38.84 cm), 60 DAS(186.10 cm) and at harvest (202.28 cm), maximum dry matter accumulation at 30 (5.17 g plant^{-1}), 60 (24.52 g plant^{-1}), 90 DAS (33.71 g plant^{-1}) and at harvest (37.28 g plant^{-1}) and crop growth rate (0.645 g m^{-2} day^{-1}) between 30-60 DAS. Application of zinc solubilizer recorded significantly higher plant height and dry matter accumulation at all stages.

Keywords: Varied, fertility, zinc, biofertilizer, *Brassica juncea* L.

1. Introduction

Mustard {*Brassica juncea* (L.) Czern & Coss} belongs to the family cruciferae popularly known as rai, raya or lahi and it is important *Rabi* season oilseed crop of north India. It possesses a higher potential of production per unit area than other members of the family cruciferae. India is one of the largest rapeseed and mustard growing country in the world, occupying the first rank in area and second in production next to China. Total area under rapeseed and mustard in India is 6.23 million hectares with a production of 9.34 million tonnes and productivity of 1499 kg ha^{-1} (GOI, 2018) [8].

Indian mustard is nutritionally very rich having 35-40 per cent oil content and the protein range from 25-30 per cent. It is second most important edible oilseed crop, contributes 28.6 per cent in the total oilseed production among the seven edible oilseeds cultivated in India and ranks second after groundnut sharing 27.8 per cent in the India's oilseed economy (Singh *et al*., 2017) [15].

Soil fertility is a complex quality of soils that is closest to plant nutrient management. It is the component of overall soil productivity that deals with its available nutrient status and its ability to provide nutrients out of its own reserves and through external applications for crop production. Imbalanced use of chemical fertilizers especially NPK without of S, Zn, B and organic manure not only lowers productivity but also adversely affect soil health by continuous mining of nutrients (Singh *et al*., 2012) [14]. Zinc is an essential micronutrient, plays an important role in plant system for the proper growth, development and production of biomass (Cakmak, 2008) [4]. Plants can uptake zinc as divalent cation (Alloway, 2008) [1]. Plant requires zinc in the range of 5-100 mg kg^{-1} but is critical for membrane function, photosynthesis, protein synthesis, carbohydrate, auxin metabolism, influences the development of roots, grain yield and uptake of water etc. Zinc is required for chlorophyll production, pollen function and fertilization. Zinc involved in diverse metabolic activities, influences the activities of hydrogenase and carbonic anhydrase, synthesis of cytochrome, the stabilization of ribosomal fractions and nitrogen metabolism which leads to high yield and yield components

(Tisdale *et al.*, 1984) [16]. Indian soils are deficient in zinc, resulting low crop production to overcome such problems, the use of efficient bio-fertilizers can play a significant role than application of chemical fertilizers alone (Bakhshandeh *et al*., 2017) [2]. The levels of zinc nutrient for potential crop production especially when it is used with zinc solubilizing microbial inoculants that meet out the zinc requirement with the fertility status of soil. Zinc solubilizing microbial inoculants possess plant growth promoting traits, influencing towards increment of crop yield. To enrich soil profile by enhancing its texture, supplementation of organic residues such as cow dung in being introduces, along with the use of microorganism inoculants also encourages accomplishment of required plant growth and soil health (Kloepper *et al*., 2004) [9]. The use of beneficial microorganisms as bio-inoculants to increase availability of native zinc to crop assimilation and achieve the objectives of low-input and sustainable agriculture and to overcome zinc malnutrition in human populations could be a viable option. Among the bacterial species, strains belonging to the genera *Acinetobacter*, *Bacillus*, *Gluconacetobacter* and *Pseudomonas* have been reported (Fasim *et al*., 2002) [7] as zinc solubilizers, fertilizers and manures to enhance soil fertility and crop productivity. Since adequate information is lacking on the choice of fertility levels specially zinc fertilization along with related biofertilizers in Indian mustard, this investigation will be undertaken to find out the suitability of various levels of fertility, zinc and biofertilizers for mustard grown in inceptisols of southern Rajasthan. Keeping these points in view, the present investigation **"**Effect of Varied Levels of Fertility, Zinc and Biofertilizer on growth of Indian mustard [*Brassica juncea* (L.)] Under Inceptisols of Southern Rajasthan" has been carried out.

2. Results and Discussion

2.1 Effect of various levels of fertility, zinc and zinc solubilizers on growth attributes

The data related to growth attributes are presented in table 1, 2 & 3 and figure 1.

3. Effect of fertility levels

In the present study, it was observed that, application of primary nutrients at 100% RDF recorded significantly higher plant height at 30 (40.21 cm) and 60 DAS (195.30 cm) over 75% RDF and no nutrients. While at harvest stage, significantly maximum plant height (210.7 cm) registered under 100% RDF in comparison to no nutrients which was found statistically at par with 75% RDF. Dry matter significantly accumulated under application of primary nutrients at 100% RDF at 30 (5.89 g plant^{-1}), 60 (26.01 g plant^{-1}) and at harvest (38.74 g plant^{-1}) in comparison to 75% RDF and no nutrients. While at 90 DAS, enhancement in dry matter accumulation under application of nutrients at 100% RDF observed statistically superior over no nutrients which was proved at par with 75% RDF (Table 1 and 2). Significantly enhanced crop growth rate recorded under application of nutrients at 100% RDF over 75% RDF and no nutrients by the magnitude of 12.04 and 19.0 per cent between 30-60 DAS. However, fertility levels did not bring any significant effect on CGR between 60-90 DAS, RGR between 30-60 and 60-90 DAS (Table 3). It might be due to plant height and dry matter accumulation increased by soil nutrients over no nutrients. Thus under proper soil fertility, adequate availability of nitrogen and phosphorus which increased photosynthesis rate, metabolites synthesized, meristematic activity, assimilates transport that can be reasoned for significant crop growth thereby more increase in volume of the crop and accumulation of dry matter. The soil fertility also resulted in significant maximum CGR and RGR which might be due to greater the ability of plant to produce photosynthates which converted into greater dry matter there by better partitioning of photosynthesis to reproductive parts. Similar contentions were given by Shorna *et al.* (2020) [13], Upadhyay *et al.* (2018) [17], Kumar *et al.* (2017) [10] and Bindhani *et al.* (2020) [3].

4. Effect of Zinc Levels

Results revealed that application of 5.0 kg zinc ha^{-1} recorded statistically maximum plant height at 60 DAS (186.10 cm) over 2.5 kg zinc ha^{-1} and no zinc. However, enhancement in plant height observed with application of 5.0 kg zinc ha^{-1} and registered significantly exclusive at 30 DAS (38.84 cm) and at harvest (202.28 cm) over no zinc which was found statistically at par with 2.5 kg zinc ha^{-1} in this regard (Table 1). Application of 5.0 kg zinc ha^{-1} significantly higher accumulation of dry matter 5.17, 24.52 and 33.71 and 37.28 g plant^{-1} at 30, 60 and 90 DAS, and at harvest, respectively over no zinc which was found statistically at par with 2.5 kg Zn ha^{-1} in this regard (Table 2). Application of 5.0 kg zinc ha^{-1} significantly enhanced CGR over no zinc by the magnitude of 14.76 per cent between 30-60 DAS. However, application of zinc did not bringing any significant effect on CGR between 60-90 DAS and RGR (Table 3). It was observed that different zinc levels found significant relevant to plant height and dry matter accumulation. It may be due auxin biosynthesis, initial metabolic reactions in plant body, oxidation in plant cells and transformation of carbohydrates significantly increased with zinc nutrient. Also the zinc fertilization has significant importance on CGR by encouraging the plant height, improving soil physical properties and release of growth promoting hormone ultimately increased dry biomass of the crop which contributed in crop growth rate. These results are in close conformity with Singh and Pandey, (2017) [15] and Quddus *et al*., (2014) [12] and Upadhyay *et al.* (2018) [17]

5. Effect of zinc biofertilizer

Application of zinc solubilizing bacteria was found significant in regard to plant height at 30 DAS (37.98 cm), 60 DAS (177.89 cm) and at harvest (197.21 cm) over without zinc solubilizing bacteria (Table 1). Application of zinc solubilizing bacteria accumulated significantly higher dry matter (5.03, 23.54, 33.08 and 36.07 g plant^{-1}) at 30, 60, 90 DAS and at harvest, respectively (Table 2). Whereas, application of zinc solubilizing bacteria did not bring any significant effect on CGR and RGR (Table 3).

Zinc solubilizing bacteria had a remarkable influence on the growth characters of mustard. Zinc solubilizing bacteria improved plant growth by increasing the availability of plant nutrients and improving soil biological condition which indirectly contributed in maximum dry matter accumulation of mustard. The increased endogenous nitrogen content due to inoculation might have promoted crop growth. Zinc solubilizing bacteria are known to colonize rhizosphere of crop and increasing plant growth through production indole-3-acetic acid. This hormone can also improve the root growth and increasing plant hormone. Similar results were reported by Deshmukh *et al.* (2019) [5] and Nazir *et al.* (2021) [11]

Table 1: Effect of fertility, zinc and zinc biofertilizer on plant population and plant height

Treatment	Plant population (in Lacs)		Plant height (cm)		
	30 DAS	Harvest	30 DAS	60 DAS	At harvest
Fertility levels					
Control	3.39	3.15	33.33	144.89	163.61
75% RDF	3.55	3.15	38.09	181.06	200.46
100% RDF	3.58	3.18	40.21	195.30	210.75
S.Em ±	0.07	0.03	0.66	3.24	3.59
CD (P=0.05)	NS	NS	1.89	9.32	10.32
Zinc levels					
Control	3.52	3.16	34.86	158.87	177.02
2.5 kg ha^{-1}	3.46	3.17	37.92	176.28	195.52
5 kg ha^{-1}	3.55	3.15	38.84	186.10	202.28
S.Em ±	0.07	0.03	0.66	3.24	3.59
CD (P=0.05)	NS	NS	1.89	9.32	10.32
Zn Solubilizers					
Control	3.51	3.15	36.43	169.61	186.01
Zinc solubilizers	3.51	3.17	37.98	177.89	197.21
S.Em ±	0.06	0.03	0.54	2.65	2.93
CD (P=0.05)	NS	NS	1.55	7.61	8.43

Table 2: Effect of fertility, zinc and zinc biofertilizer on dry matter accumulation

Treatment	Dry matter accumulation (g $plant^{-1}$)			
	30 DAS	60 DAS	90 DAS	At harvest
Fertility levels				
Control	3.27	20.66	29.04	31.89
75% RDF	4.80	22.74	33.34	34.16
100% RDF	5.89	26.01	34.53	38.74
S.Em ±	0.18	0.33	0.61	0.57
CD (P=0.05)	0.51	0.96	1.76	1.64
Zinc levels				
Control	3.66	20.51	30.30	33.64
2.5 kg ha^{-1}	5.13	24.38	32.89	35.98
5 kg ha^{-1}	5.17	24.52	33.71	37.28
S.Em ±	0.18	0.33	0.61	0.57
CD (P=0.05)	0.51	0.96	1.76	1.64
Zn Solubilizers				
Control	4.27	22.73	31.52	33.80
Zinc solubilizers	5.03	23.54	33.08	36.07
S.Em ±	0.15	0.27	0.50	0.46
CD (P=0.05)	0.42	0.79	1.44	1.34

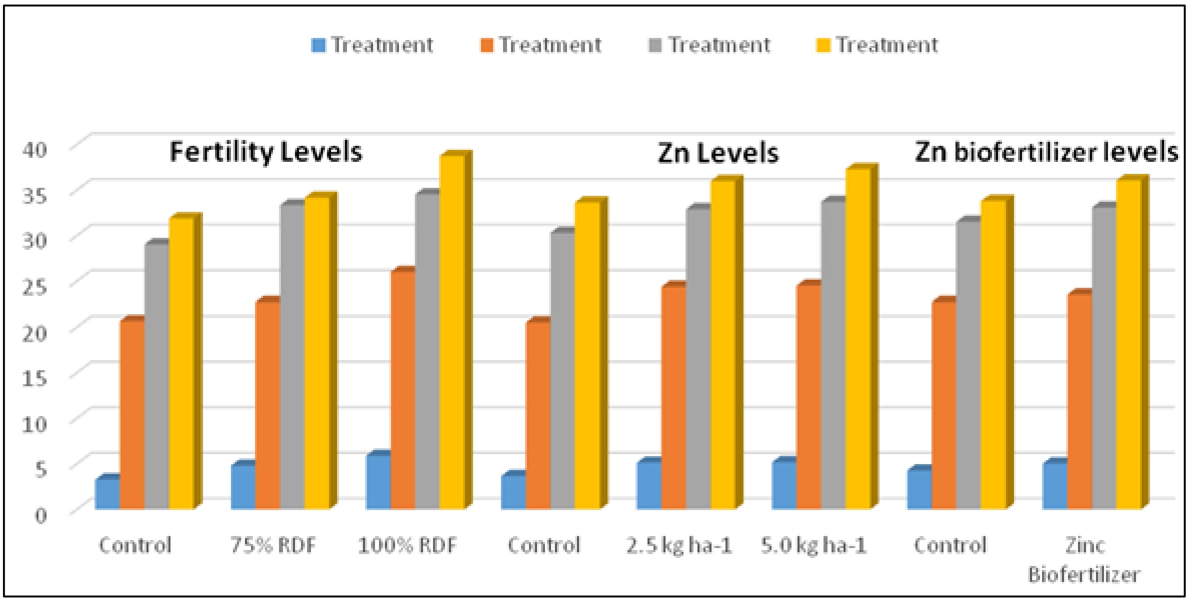

Fig 1: Effect of fertility, zinc and zinc biofertilizer on Dry matter accumulation (g $plant^{-1}$)

Table 3: Effect of fertility, zinc and zinc biofertilizer on crop growth rate and relative growth rate

Treatment	Crop growth rate (g m^{-2} day^{-1})		Relative growth rate (g g^{-1} day^{-1})	
	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS
Fertility levels				
Control	0.563	0.279	0.058	0.011
75% RDF	0.598	0.353	0.053	0.012
100% RDF	0.670	0.284	0.050	0.009
S.Em ±	0.012	0.023	0.003	0.001
CD (P=0.05)	0.035	NS	NS	NS
Zinc levels				
Control	0.562	0.326	0.055	0.012
2.5 kg ha^{-1}	0.642	0.284	0.053	0.010
5 kg ha^{-1}	0.645	0.306	0.053	0.011
S.Em ±	0.012	0.023	0.003	0.001
CD (P=0.05)	0.035	NS	NS	NS
Zn Solubilizers				
Control	0.615	0.291	0.055	
Zinc solubilizers	0.617	0.318	0.052	0.011
S.Em ±	0.010	0.019	0.002	0.001
CD (P=0.05)	NS	NS	NS	NS

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