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Effect of Zinc as Foliar Application on Seed Yield in Radish

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***Abstract*:** A field experiment was conducted to study the effect of zinc as foliar application on seed yield and quality in radish which was carried out in Pandah farm of Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry Nauni, Solan during 2018-19. Treatments involved four zinc levels (0g l^{-1}, 1g l^{-1}, 2g l^{-1}, 3g l^{-1}) and three stages of application (Bolting, Bolting +14 days after first application, Bolting +14 days + 28 days after first application) resulting in 12 treatment combinations. Zn_3S_1(2g/L zinc at the time of bolting) was found superior over all the treatment combinations for growth and seed yield parameters viz: plant height (118.92 cm), number of siliquae plant^{-1} (146.40), siliqua length (7.09 cm), number of seeds siliqua^{-1} (6.34), days to maturity (104.67), average seed weight siliqua^{-1}(0.185 g), seed yield plant^{-1}(27.03 kg) and seed yield ha^{-1}(9.90 q ha^{-1}).

***Keywords*:** Radish, Micronutrient, Zinc, Foliar application, Seed yield

Radish is an important root crop of cruciferae family and is cultivated in tropical as well as temperate regions of the world and is native of Europe and Asia. The production of seed per unit area in radish is low which might be increased by improved management practices conventionally by foliar application of micronutrients. The micronutrients play an important role in germination and seedling formation from cell wall development to respiration, photosynthesis, chlorophyll formation etc. The uptake of all the plant nutrients is hastened by the application of micronutrients and they also generate the mechanism against insect-pests and diseases, therefore improving growth and yield (Anuprita et al 2005). The requirement of the micronutrients is very diminutive but its deficiency can limit the growth and production. Foliar spray is latest method for nourishment of crops, usually of micronutrients applied to leaves in liquid form. Efficacy of foliar spray is 6 to 20 times more in comparison to soil application (Arif et al 2006). Micronutrients like zinc play an important role in growth and plant development and production of biomass as it is vital for the formation of Indole Acetic Acid (IAA). It also helps in energy production, protein and growth regulator synthesis (Kumar et al 2016) and is necessary in pollen development, sexual fertilization and germination (Cakmak 2008), higher seed yield and number of seeds fruit^{-1}. It also enhances growth hormone biosynthesis, formation of starch, production and maturation of seeds (Brady and Weil, 2002). Zinc also increases the viability as well as vigour of seed. It is an essential part of ribosome and is important for their structural integrity (Trivedi, 2013). Zinc has many insignificant roles in the growth of plant and a regular and continuous supply is required for better growth and maximum yield (Acquaah, 2002). The form of zinc available to plants is the Zn^{2+} ion. Zinc applied through foliar spray is more effective than soil application due to its adsorption with soil particles and lesser contact with roots of crop (Wissuwa et al 2008).

MATERIAL AND METHODS

The investigation was carried out at Panda Farm of the Department of Seed Science and Technology, Nauni, Solan during 2018-19. Research Farm is situated at an altitude of 1250 meters above mean sea level in the mid-hill zone of Himachal Pradesh. The climate of the area is sub-tropical to sub-temperate and semi-humid characterized by cold winters. The Research Farm had loam to clay loam type of soil with pH from 6.85-7.05.The seeds were sown in September on the raised beds. All the measures were taken during the production of the roots as per Package of Practices recommended by Dr Yashwant Singh Parmar, University of Horticulture and Forestry, Nauni (Anonymous, 2014). Fully matured roots were uprooted carefully in the month of January in year 2019. True to type roots were selected according to the characteristics of the variety (Japanese White). The roots which were diseased, deformed, forked, split and over matured were discarded for preparation of the stecklings. Stecklings were prepared by keeping 10 cm portion at the top and 10 cm root portion. The prepared stecklings were transplanted in the month of

January on the flat beds of size 3.0 × 1.8 m at spacing of 60 × 30 cm. Four different levels of zinc were used viz. 0g l^{-1}, 1g l^{-1}, 2g l^{-1}, 3g l^{-1} and stages of application were Bolting, Bolting + 14 days after first application, Bolting + 14 days and 28 days after first application.

Plant height of the ten randomly selected plants was recorded from the soil level to the tip of the plant at the end of the crop season with the help of a scale and mean height was expressed in centimetres. Days to seed maturity were counted from the date of sowing to fully develop mature pods for getting seeds. The number of siliqua from each harvest of ten randomly selected plants were counted and averaged to work out mean number of pods $plant^{-1}$. Length of ten randomly selected healthy siliqua was measured from the point of attachment to the tip of pod with the help of a scale. The siliqua used for measuring siliqua length were shelled for counting the seeds and the mean value of seeds pod^{-1} was determined. In each replication, 100 seeds were counted with the help of an electronic counter from the total seed produced in each plot and were weighed on electronic balance to record the weight. For seed yield per plant, ten plants randomly selected from each replication per treatment for pod characters were harvested at complete physiological maturity stage, and thus obtained seeds properly dried in shade. The seeds were cleaned properly and weighed with the help of an electronic balance and average was worked out. Seed yield per hectare was worked out on the basis of seed obtained per m^2 as per the formula:

$$\text{Seed yield ha}^{-1}\text{ (q)} = \frac{\text{Seed yield/m}^2\text{ (kg)} \times 8000}{100}$$

While calculating the seed yield per hectare, twenty per cent area was considered as depreciation for construction of channels in the field.

RESULTS AND DISCUSSION

Plant height: The zinc levels, stages of application and their interaction significantly influenced the plant height (Table 1). The maximum plant height (110.90 cm) was observed in Zn_3 and thereafter there was a decrease in plant height at Zn_4. Minimum plant height was recorded in Zn_1 (Water spray). Zinc increases the height of plant due to its involvement in chlorophyll formation which might help in cell division, expansion of cell and formation of cell wall. It is also engaged in synthesis of tryptophan a major precursor of IAA (indole acetic acid) responsible for synthesis of amino acid favouring plant growth. The decrease in plant height might be due to high inflation of zinc which retarded the growth of the plant and development of roots (Wang et al 2009) through a reduction in mitotic index as a result of restraint of DNA synthesis. Among stages of application, maximum plant height (105.70cm) was in S_1 (Bolting) and with every subsequent spray, there was a decrease in plant height and minimum plant height (99.44 cm) was in S_3. In case of interaction, maximum plant height was observed in Zn_3S_1 and minimum (89.33 cm) in Zn_1S_3. Similar result was obtained by Pariari et al (2009) in fenugreek

Number of siliquae $plant^{-1}$: Number of siliques $plant^{-1}$ was significantly influenced by zinc levels, stages of application and their interaction (Table 1). Maximum number of siliques $plant^{-1}$ (118.11) was in Zn_3 (2g l^{-1}) and after that there was a significant decrease in number of siliques $plant^{-1}$ in Zn_4. Increased number of siliques $plant^{-1}$ may be due to the reason that zinc is responsible for more number of new filling sinks which affects the mitochondrial activities of the plant and increases photosynthetic rate which ensure higher translocation and assimilation of metabolites in the sink (Singh et al 2015). In stages of application, S_1 (Bolting) revealed maximum number of siliques $plant^{-1}$ (124.08) and there was a decrease in number of siliques $plant^{-1}$ with every stage of application and minimum (99.26) was recorded in S_3. Zinc applied at bolting stage might have increased silique number attributably to high rate of protein synthesis and metabolism of carbohydrates during bolting stage which is directly involved in increasing number of siliques $plant^{-1}$. Among the interactions, maximum number of siliques $plant^{-1}$ (146.40) was observed in Zn_3S_1 and minimum (77.73) was in Zn_1S_3.

Siliqua length (cm): Zinc levels, stages of application and their interaction significantly affected the siliqua length (Table 1). Linear increase in siliqua length (6.48 cm) was noticed in up to Zn_3 and after that a decrease in siliqua length was observed in Zn_4. The increase in siliqua length might be due to the reason that zinc is convoluted in synthesis of tryptophan which is a precursor of growth promoting hormone (auxins) and leads to growth and development of cells and finally resulted in increased silique length (Krishna, 2000). In stages of application, S_1 revealed maximum siliqua length (6.43 cm) and minimum (6.13 cm) was observed in S_3. Maximum siliqua length during bolting stage might be due to more tryptophan synthesis which enhances the auxin production and resulted in increased siliqua length. The Zn_3S_1 recorded maximum siliqua length (7.09 cm) and minimum (5.86 cm) was observed in Zn_1S_1. The above findings are in line with Pariari et al (2009) in fenugreek.

Number of seeds $siliqua^{-1}$: Zinc levels and stages of application significantly affected zinc levels, maximum number of seeds $silique^{-1}$ (5.58) was observed in Zn_3 which was at par with Zn_4 and minimum (4.47) was in Zn_1. Among stages of application, maximum number of seeds $silique^{-1}$ (5.36) was recorded in S_1 which was at par with S_2 and minimum (4.92) was obtained in S_3.

Average seed weight siliqua^{-1}(g): Among zinc levels, maximum average seed weight silique^{-1} (0.171 g) was in Zn_3 (2g l^{-1}) which was at par with Zn_2 and minimum (0.158 g) was in Zn) (Table 2). Zinc is known to upgrade the biosynthesis of growth hormones, formation and maturation of starch which eventually increased average seed weight (Tariq et al 2014). Among stages of application, maximum average seed weight siliqua^{-1} (0.171 g) was in S_1 and minimum (0.162 g) was in S_3, which was at par with S_2. Zinc at bolting might have increased the starch content in the seed because of its increased synthesis that resulted in development of seeds and led to maximum average seed weight silique^{-1}. Among treatment combinations, maximum weight of seed silique^{-1} (0.185 g) was in Zn_3S_1 and minimum (0.156 g) was in Zn_1S_1 being statistically at par with Zn_1S_1 and Zn_1S_2.

Days to seed maturity: Minimum days to seed maturity (109.78) was when zinc was applied @ 2g l^{-1} (Zn_3) being significantly different from other levels of zinc while maximum days to seed maturity (119.67) were observed in Zn_1 (Water spray) (Table 2). In case of stages of application, significantly minimum days to seed maturity (110.00) were in S_1 and maximum (116.58) in 3rd stage. In case of treatment combinations, minimum days to seed maturity (104.67) were in Zn_3S_1 being significantly lower than other treatment combinations, whereas, maximum days to seed maturity (120.00) were observed in Zn_1S_3 (which had statistical similarity with Zn_1S_1 and Zn_1S_2.

Seed yield plant^{-1} (g): The increase in seed yield (20.08 g plant^{-1}) was noticed up to Zn_3 level of zinc (2g l^{-1}) and a significant reduction was then observed in Zn_4 with a minimum seed yield of 13.65 g plant^{-1} in Zn_1 (Table 2). Foliar application of zinc also played a significant role in enhancing seed yield potential as zinc applied through foliar sprays brings vast changes in different metabolic processes within the plant system. In case of stages of application, maximum seed yield (21.35 g plant^{-1}) was in S_1 and thereafter there was a sharp reduction in seed yield at successive stages, being

Table 1. Effect of foliar application of zinc, stages of application and their interaction on growth parameters in radish

Factors	Plant height (cm)	Number of siliquae plant^{-1}	Siliqua length (cm)	Number of seeds siliqua^{-1}
Zinc levels				
Zn_1	91.76	86.93	5.99	4.47
Zn_2	106.90	113.40	6.28	5.20
Zn_3	110.90	118.11	6.48	5.58
Zn_4	102.60	113.70	6.19	5.23
CD (p=0.05)	0.92	1.39	0.06	0.36
Stages of application (S)				
S_1	105.70	124.08	6.43	5.36
S_2	103.99	100.77	6.15	5.08
S_3	99.44	99.26	6.13	4.92
CD (p=0.05)	0.80	1.21	0.05	0.31
Interaction Zn× S				
Zn_1S_1	90.82	93.53	5.86	4.50
Zn_1S_2	95.15	89.53	6.04	4.50
Zn_1S_3	89.33	77.73	6.06	4.40
Zn_2S_1	106.27	132.83	6.44	5.20
Zn_2S_2	107.33	104.13	6.26	5.30
Zn_2S_3	107.10	103.23	6.13	5.10
Zn_3S_1	118.92	146.40	7.09	6.34
Zn_3S_2	113.34	108.33	6.13	5.23
Zn_3S_3	100.44	99.60	6.23	5.17
Zn_4S_1	106.77	123.57	6.33	5.40
Zn_4S_2	100.13	101.07	6.16	5.30
Zn_4S_3	100.89	116.47	6.09	5.00
CD (p=0.05)	1.59	2.41	0.11	NS

Table 2. Effect of foliar application of zinc, stages of application and their interaction on seed parameters in radish

Factors	Average seed weight siliqua^{-1} (g)	Days to seed maturity	Seed yield plant^{-1} (g)	Seed yield ha^{-1} (q)
Zinc levels (Zn)				
Zn_1	0.158	119.67	13.65	6.76
Zn_2	0.169	110.00	19.23	8.30
Zn3	0.171	109.78	20.08	8.76
Zn_4	0.164	112.22	18.61	8.18
CD (p=0.05)	0.003	1.15	0.58	0.37
Stages of application (S)				
S_1	0.171	110.00	21.35	8.63
S_2	0.164	112.16	16.25	7.85
S_3	0.162	116.58	16.09	7.52
CD (p=0.05)	0.003	1.00	0.50	0.32
Interaction Zn× S				
Zn_1S_1	0.159	119.67	14.86	6.97
Zn_1S_2	0.157	119.33	13.98	7.10
Zn_1S_3	0.156	120.00	12.12	6.22
Zn_2S_1	0.177	108.00	23.57	8.73
Zn_2S_2	0.167	108.00	17.28	8.01
Zn_2S_3	0.164	114.00	16.92	8.17
Zn_3S_1	0.185	104.67	27.03	9.90
Zn_3S_2	0.1643	110.33	16.93	8.21
Zn_3S_3	0.164	114.33	16.29	8.17
Zn_4S_1	0.162	107.67	20.01	8.93
Zn_4S_2	0.167	110.00	16.80	8.07
Zn_4S_3	0.163	118.00	19.01	7.53
CD (p=0.05)	0.005	2.00	1.00	0.64

minimum (16.25 g plant^{-1}) in S_3 which was at par with S_2. However, among interactions, maximum seed yield (27.03 g plant^{-1}) was recorded in Zn_3S_1 and minimum (12.12 g plant^{-1}) in Zn_1S_3. These findings are in line with Kiran (2006) in brinjal, Pariari et al (2009) in fenugreek and Lakshami et al (2017) in black gram.

Seed yield ha^{-1} (q): There were significant differences in seed yield hectare^{-1} for zinc levels, different stages of application and their combinations (Table 2). There was a linear increase in the seed yield (8.76 q ha^{-1}) up to 2g l^{-1} (Zn_3) and thereafter there was a significant decrease in the seed yield hectare^{-1} at the highest level, however, minimum value of seed yield (6.88 q ha^{-1}) was in Zn_1 whereas among stages of application, maximum seed yield (8.63 q ha^{-1}) was in first stage of application, S_1 with a significant reduction at later stages and minimum yield (6.83 q ha^{-1}) was obtained in stage S_3. In case of interaction, maximum seed yield (9.90 q ha^{-1}) was in Zn_3S_1 while minimum (6.57 q ha^{-1}) was with Zn_1S_3.

CONCLUSION

Among different zinc levels, Zn_3 (2g l^{-1}) was significantly superior over other zinc levels for most of the growth as well as seed yield parameters. In case of stages of application, S_1 (Bolting stage) proved its superiority over other stages of application for most of the growth parameters related to seed yield. Resultantly, treatment combinations, Zn_3S_1(2g l^{-1} at the time of bolting) was superior over other treatment combinations for most of the growth and seed yield and quality parameters namely plant height, number of siliquae plant^{-1}, siliqua length, number of seeds siliqua^{-1}, average seed weight siliqua^{-1}, minimum days to seed maturity, seed yield (plant^{-1} and ha^{-1}).

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