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HR Galande
M.Sc. Student, Department of Horticulture, VNMKV, Parbhani, Maharashtra, India

AM Bhosale
Assistant Professor, Department of Horticulture, VNMKV, Parbhani, Maharashtra, India

SJ Syed
Agriculture Assistant, Department of Horticulture, COA Latur, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
AM Bhosale
Assistant Professor, Department of Horticulture, VNMKV, Parbhani, Maharashtra, India

Effects of graded levels of zinc and zinc solubilizing microbial cultures on flowering, fruiting and harvest duration in tomato (*Lycopersicon esculentum* L.) cv. Shivam

HR Galande, AM Bhosale and SJ Syed

Abstract
The present investigation on "Effects of graded levels of zinc and zinc solubilizing microbial cultures on Flowering, Fruiting parameters and Harvest Duration in Tomato (*Lycopersicon esculentum* L.) cv. Shivam". The experiment was laid out in Factorial RBD with two factor i.e. factor first is zinc solubilizers and factor second is levels of zinc, it has twelve treatments replicated three times. *Trichoderma viride* and *Pseudomonas strita* are used as source zinc solubilizers along with different levels of zinc. The effect of zinc solubilizers indicated that the zinc solubilizer B_2 (*Trichoderma viride*) recorded maximum no. of flowers per plant (43.96), maximum no. of flower clusters per plant (14.46), minimum days to 50% flowering (35.00 day), maximum no. of fruits/plant (31.30), no. of marketable fruits /plant (30.02), no. of locules/fruit (4.83), length of fruit (6.85 cm), diameter of fruit (8.00 cm), minimum days to first picking (70.40 day), harvest duration (79.60 day). The effect of different levels of zinc indicated that the levels of zinc Zn_3 (30 kg $ZnSO_4$/ha) recorded maximum no. of flowers per plant (41.00), maximum no. of flower clusters per plant (13.65), minimum days to 50% flowering (35.55 day), maximum no. of fruits /plant (28.75), no. of marketable fruits/plant (27.44), no. of locules per fruit (4.45), length of fruit (6.51 cm), diameter of fruit (7.63 cm), minimum days to first picking (70.80 day), harvest duration (74.76 days). The interaction effect of different zinc solubilizers and levels of zinc indicated that the B_2Zn_3 (*Trichoderma viride* + 30 kg $ZnSO_4$/ha) recorded maximum no. of flowers per plant (46.84), maximum no. of flower clusters/plant (15.69), minimum days to 50% flowering (34.00 days), maximum no. of fruits/plant (36.50), no. of marketable fruits/plant (35.33), no. of locules/fruit (5.10), length of fruit (7.12 cm), diameter of fruit (8.38 cm), minimum days to first picking (69.33 days), harvest duration (82.05 days).

Keywords: Flowering, fruiting, *Pseudomonas striata*, Shivam, tomato, *Trichoderma viride*, Zinc

Introduction
Tomato (*Lycopersicon esculentum* L.) belongs to solanaceae family. Its chromosome number is 24. South America (Peru) is native origin of tomato. It is herbaceous plant with alternate leaves, flowers are present in cluster on the stem between the nodes fruits are berry type, it has fleshy placenta and small kidney shaped seeds which are covered with short hairs. It is a self-pollinated crop. It is susceptible to high temperature, most favorable temperature for fruit set is 25-30 °C. It is neither tolerate to frost nor to water logged condition. It will not perform well if the temperature goes above 35 °C and below 15 °C. Lycopene is highest at 21-24 °C while production of this pigment drops off rapidly above 27 °C. A well-drained loamy soil is ideal for its growth. The best soil pH is 6.00-7.00. Zinc is an essential Micronutrient required for plants, for their normal healthy growth and reproduction. In plants, zinc plays a key role as a structural constituent or regulatory co-factor which contents a wide range of different enzymes and protein in many important biochemical pathways are these are mainly concerned with carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch and protein metabolism. (Samreen, *et al*., 2017) [8]. Zinc is one of the most important essential micronutrients required in the range of 5 to 100 mg kg^{-1} concentrations in tissues for the management of nutrients, growth and reproduction of plants (Samreen, *et al*., 2017; Sharma, *et al*., 2013; Goteti *et al*., 2013) [8, 1]. Zinc deficiency is the major constraints in obtaining high yield, growth and quality of tomato. Zinc reported to play a vital role in modifying the growth and development of many horticultural crops (Sathiyamurthy, 2017) [9]. Few zinc solubiizing bacterial genera *viz. Bacillus spp., Pseudomonas spp., Thiobacillus spp.*, etc and facultative

thermophilic iron oxidizers were reported as zinc solubilizers. *Pseudomonas* sp. is omnipresent bacteria in agricultural soils and has many traits that make them well suited as zinc solubilisation. *Pseudomonas* strain used to suppress soil borne diseases and promot plant growth. *Pseudomonas* has been used for their beneficial effects on plant growth. *Pseudomonas* whose beneficial effects on the plant result from different mechanism *i.e.* direct mechanism (Solubilization of phosphorus, potassium, zinc, nitrogen fixation, sequestration of iron by siderophores, production of growth regulators etc.) or indirect mechanisms such as antibiotic production. *Trichoderma* spp. are free living in nature. They are filamentous fungi and some of them are the most potent agents for the biocontrol of soil borne plant pathogens. *A Trichoderma strain improves* the vegetative growth and development of tomato.

Material and Methods

The field experiment entitled "Effects of graded levels of zinc and zinc solubilizing microbial cultures on Flowering, Fruiting parameters and Harvest Duration in Tomato (*Lycopersicon esculentum* L.) cv. Shivam" was carried out during summer season, 2021 at Department of Horticulture, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The field trial was laid out in Factorial randomized block design (FRBD) with 12 treatments and three replications Distance between two treatments and replications (50 cm and 1.6 m respectively). The size of plot was 4.5 m × 0.8 m. spacing adopted was 60 cm × 60 cm. Experimental field was laid out as per the plan after preparation of land. The layout consisted of 36 experimental units.

Treatment details

Sr. No.	Treatment	Treatment Details
Factor		
A	Zinc Solubilizer	
	B_0	Control
	B_1	*Pseudomonas strita* (liquid)
	B_2	*Trichoderma viride* (liquid)
B	Levels of zinc (kg/ha)	
	Zn_0	00 kg/ha
	Zn_1	10 kg/ha
	Zn_2	20 kg/ha
	Zn_3	30 kg/ha

Treatment No.	Treatment combination
T_1	Control: Control
T_2	Control: 10 kg $ZnSO_4$/ha.
T_3	Control: 20 kg $ZnSO_4$/ha.
T_4	Control: 30 kg $ZnSO_4$/ha.
T_5	*Pseudomonas strita*: Control
T_6	*Pseudomonas strita*: 10 kg $ZnSO_4$/ha.
T_7	*Pseudomonas strita*: 20 kg $ZnSO_4$/ha.
T_8	*Pseudomonas strita*: 30 kg $ZnSO_4$/ha.
T_9	*Trichoderma viride*: Control
T_{10}	*Trichoderma viride*: 10 kg $ZnSO_4$/ha.
T_{11}	*Trichoderma viride*: 20 kg $ZnSO_4$/ha.
T_{12}	*Trichoderma viride*: 30 kg $ZnSO_4$/ha.

Treatments and fertilizer application: Recommended dose Nitrogen, phosphorus and potash were applied through urea, single superphosphate and muriate of potash, at 250 kg N/ha, 250 kg P_2O_5/ha and 250 kg K_2O/ha. respectively. Chemical fertilizers, full dose of P_2O_5 and K_2O were applied respectively through single super phosphate and muriate of potash at the 8 DAT in the rows while application of nitrogen was made through urea was in two equal split doses i.e. 50% at the 8 DAT and remaining 50% at the time of flowering. Quantity of fertilizers applied per plot was common and uniform. Fertilizers were applied at the depth of 5 cm and were properly mixed with soil. Plots were irrigated immediately after application of fertilizers. *Pseudomonas strita* (1 lit/ha) and *Trichoderma viride* (1 liter/ha) was applied as per treatments (Drenching at 15 DAT) zinc sulphate was applied as per treatments (soil application at 15 DAT).

Raising the nursery: The seeds of tomato were sown in pro tray filled with coco peat. After germination, 21-25 days old seedlings with well root development and uniform growth were selected and used transplanting.

Seedling treatment: Tomato seedlings were treated with mixture of *Pseudomonas strita* + *Trichoderma viride*. The seedlings were treated with mixture of *Pseudomonas strita* + *Trichoderma viride* by dipping 20 min. and after that remove seedlings from solution and then immediately after that transplanting is done.

Observations recorded: Five plants were randomly selected from each of 36 plots and were labeled. The following observations were recorded on the different characters which are given as follows.

Flowering parameters

Number of flowers per plant

The number of flowers per plant was recorded after first flowering to final harvest at 8-10 days interval from selected plants and mean was worked out.

Number of flower clusters per plant

The number of flower clusters per plant was counted at 8-10 days interval from selected plants and mean was worked out.

Days to 50 percent flowering

Number of days required from the date of transplanting to the date on which 50 percent of the plants in the net plot showed flowering was observed as days to 50 percent flowering.

Fruiting parameters: For recording physical parameters of fruit, ten fruits were selected randomly from each plot.

Number of fruits per plant

The number of fruits per plant was counted from selected plants in a each harvesting and mean was taken.

Number of Marketable fruits per plant

Total number of good quality and marketable fruits harvested on five randomly observational plants in each treatment were counted from different pickings and average was calculated and expressed as total number of marketable fruits per plant.

Number of locules per fruit

The fruits were horizontally cut and locules were counted. Ten fruits from each plots were selected and mean was taken.

Length of fruit (cm)

The length of each selected fruit was measured from the base

to tip of the fruit and average of ten fruits was computed and expressed in centimeters.

Diameter of fruit (cm)
The diameter of the selected fruits was measured at the centre of fruits by using Vernier caliper and average of ten fruits was recorded.

Days to first picking
Days to first picking was recorded in each plot from a day between transplanting to first picking. It is expressed in a days.

Harvest duration
Harvest Duration was recorded in each plot from a day between first harvesting to last harvesting. Harvest Duration was expressed in a days.

Results and Discussion

Flowering parameters

Number of flowers per plant
The data pertaining to number of flowers per plant influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 1.

Effect of zinc solubilizers
The different zinc solubilizers resulted in significant differences in number of flowers per plant of tomato. Maximum number of flowers per plant (43.96) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, minimum number of flowers per plant (35.12) was observed in B_0 (Control) in tomato.
The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded maximum number of flowers per plant as compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the physiological characters of tomato. It increases number of flowers per plant as compare to *Pseudomonas strita* and Control. These results were in conformity with the results obtained by Molla, *et al.*, (2012) [6] in tomato where soil application of 50% Trichoderma-enriched biofertilizer and 50% NPK significantly increased number of flowers as compared to other treatments.

Effect of levels of zinc
The different levels of zinc resulted in significant differences in number of flowers per plant of tomato. Maximum number of flowers per plant (41.00) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, minimum number of flowers per plant (36.62) was observed in Zn_0 (Control) in tomato.
The above result indicated that there was a increase in number of flowers due to increase in the levels of zinc *i.e.* Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for maximizes flower set. Similar results were reported by Rahman, *et al.*, (2019) [7] in tomato where significantly increased number of flowers with increasing concentration of zinc at 0.5 kg/ha as compared to other treatments.

Interaction effect of zinc solubilizers and levels of zinc
It is evident from the data presented in a Table 1 that interaction effect of zinc solubilizers and levels of zinc was revealed to be significant on number of flowers per plant in tomato. Maximum number of flowers per plant (46.84) was observed in B_2Zn_3 which was at par with B_2Zn_2 and minimum number of flowers per plant (34.35) was observed in B_0Zn_0 (Control) in tomato.

Table 1: Effect of different zinc solubilizers and levels of zinc on flowering characters of tomato.

Treatment	Number of flowers per plant	Number of flower cluster per plant	Days for 50% flowering
Zinc Solubilizers (B)			
B_0	35.12	11.69	37.91
B_1	43.94	14.44	35.35
B_2	43.96	14.46	35.00
S.E m +	0.009	0.005	0.10
CD at 5% Level	0.02	0.014	0.31
Levels of zinc (Zn)			
Zn_0	36.62	12.18	37.66
Zn_1	37.80	12.57	36.44
Zn_2	40.98	13.63	35.91
Zn_3	41.00	13.65	35.55
S.E m +	0.011	0.006	0.12
CD at 5% Level	0.03	0.016	0.36
Interaction (B×Zn)			
B_0Zn_0	34.35	11.43	39.00
B_0Zn_1	34.89	11.62	38.66
B_0Zn_2	35.24	11.72	37.00
B_0Zn_3	35.99	11.99	37.00
B_1Zn_0	35.47	11.81	37.33
B_1Zn_1	36.39	12.11	36.00
B_1Zn_2	38.24	12.72	35.66
B_1Zn_3	40.18	13.37	35.66
B_2Zn_0	40.05	13.32	36.66
B_2Zn_1	42.12	14.00	34.66
B_2Zn_2	46.82	15.57	34.62
B_2Zn_3	46.84	15.59	34.00
S.E m +	0.018	0.01	0.21
CD at 5% Level	0.05	0.029	0.62

Number of flower cluster per plant
The data pertaining to number of flower cluster per plant influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 1.

Effect of zinc solubilizers
The different zinc solubilizers resulted in significant differences in number of flower cluster per plant of tomato. Maximum number of flower cluter per plant (14.46) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, minimum number of flower cluster per plant (11.69) was observed in B_0 (Control) in tomato.
The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded maximum number of flower cluster per plant as compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the physiological characters of tomato. It increases number of flower cluster per plant as compare to *Pseudomonas strita* and Control. These results were in conformity with the results obtained by Molla, *et al.*, (2012) [6] in tomato where soil application of 50% Trichoderma-enriched biofertilizer and 50% NPK significantly increased number of flower cluster as compared to other treatments.

Effect of levels of zinc
The different levels of zinc resulted in significant differences

in number of flower cluster per plant of tomato. Maximum number of flower cluster per plant (13.65) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, minimum number of flower cluster per plant (12.18) was observed in Zn_0 (Control) in tomato.

The above result indicated that there was a increase in number of flower cluster due to increase in the levels of zinc i.e. Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for maximizes flower set. Similar results were reported by Rahman, *et al.*, (2019) [7] in tomato where significantly increased number of flower cluster with increasing concentration of zinc at 0.5 kg/ha as compared to other treatments, Ullah, *et al.*, (2015) [11] in tomato where significantly increased number of flower cluster (5.66) with increasing concentration of zinc at 0.4% as compared to other treatments.

Interaction effect of zinc solubilizers and levels of zinc

It is evident from the data presented in a Table 1 that interaction effect of zinc solubilizers and levels of zinc was revealed to be significant on number of flower cluster per plant in tomato. Maximum number of flower cluster per plant (15.69) was observed in B_2Zn_3 which was at par with B_2Zn_2 and minimum number of flower cluster per plant (11.43) was observed in B_0Zn_0 (Control) in tomato.

Days for 50% flowering

The data pertaining to days for 50% flowering influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 1.

Effect of zinc solubilizers

The different zinc solubilizers resulted in significant differences in days for 50% flowering. Minimum days for 50% flowering (35.00 days) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, maximum days for 50% flowering (37.91 days) was observed in B_0 (Control) in tomato.

The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded minimum days for 50% flowering as compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the physiological characters of tomato. It minimizes the days for 50% flowering as compared to *Pseudomonas strita* and Control. These results were in conformity with the results obtained by Sujata Kumari, *et al.*, (2019) [10] in bell paper where soil application of *Trichoderma harzianum* significantly minimized the days for 50% flowering (51) as compared to other treatments.

Effect of levels of zinc

The different levels of zinc resulted in significant differences in days for 50% flowering. Minimum days for 50% flowering (35.55 days) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, maximum days for 50% flowering (37.66 days) was observed in Zn_0 (Control) in tomato.

The above result indicated that there was a minimize day for 50% flowering due to increase in the levels of zinc i.e. Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for minimizes days for 50% flowering. Similar results were reported by Rahman, *et al.*, (2019) [7] in tomato where significantly minimized days for 50% flowering with increasing concentration of zinc at 0.5 kg/ha as compared to other treatments.

Interaction effect of zinc solubilizers and levels of zinc

It is evident from the data presented in a 1 that interaction effect of zinc solubilizers and levels of zinc was revealed to be significant on days for 50% flowering. Minimum days for 50% flowering (34.00 days) was observed in B_2Zn_3 which was at par with B_2Zn_2 and maximum days for 50% flowering (39.00) was observed in B_0Zn_0 (Control) in tomato

Fruiting parameters

Number of fruits per plant

The data pertaining to number of fruits per plant influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 2.

Effect of zinc solubilizers

The different zinc solubilizers resulted in significant differences in number of fruits per plant of tomato. Maximum number of fruits per plant (31.30) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, minimum number of fruits per plant (22.78) was observed in B_0 (Control) in tomato.

The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded maximum number of fruits per plant as compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the hormonal characters of tomato. It enhance the chlorophyll synthesis and uptake of essential ions including N,P & K which helps to setting of fruits as compare to *Pseudomonas strita* and Control. These results were in conformity with the results obtained by Haque, *et al.*, (2012) [3] in tomato where 50% N + 50% *Trichoderma harzianum* coated wheat grains increases number of fruits per plant (41.03) as compared to other treatments..

Effect of levels of zinc

The different levels of zinc resulted in significant differences in number of fruits per plant of tomato. Maximum number of fruits per plant (28.75) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, minimum number of fruits per plant (22.71) was observed in Zn_0 (Control) in tomato.

The above result indicated that there was a increase in number of fruits due to increase in the levels of zinc i.e. Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for maximizes fruit set. Similar results were reported by Meena, *et al.*, (2015) [5] in tomato where significantly increased number of fruits (45.64) with increasing concentration of zinc at 100 ppm as compared to other treatments.

Interaction effect of zinc solubilizers and levels of zinc:

It is evident from the data presented in a Table 2 that interaction effect of zinc solubilizers and levels of zinc was revealed to be significant on number of fruits per plant in tomato. Maximum number of fruits per plant (36.50) was observed in B_2Zn_3 which was at par with B_2Zn_2 and minimum number of fruits per plant (20.83) was observed in B_0Zn_0 (Control) in tomato.

Table 2: Effect of different zinc solubilizers and levels of zinc on fruiting characters of tomato.

Treatment	Number of fruits per plant	Number of marketable fruits per plant	Number of locules per fruit
Zinc Solubilizers (B)			
B_0	22.78	21.25	3.24
B_1	31.02	29.62	4.75
B_2	31.30	30.02	4.83
S.E m +	0.10	0.14	0.02
CD at 5% Level	0.30	0.43	0.08
Levels of zinc (Zn)			
Zn_0	22.71	21.16	3.50
Zn_1	25.05	23.66	3.97
Zn_2	28.43	26.96	4.37
Zn_3	28.75	27.44	4.45
S.E m +	0.12	0.17	0.03
CD at 5% Level	0.35	0.49	0.09
Interaction (B×Zn)			
B_0Zn_0	20.83	19.33	2.60
B_0Zn_1	22.83	21.33	2.86
B_0Zn_2	23.50	22.00	3.70
B_0Zn_3	23.93	22.33	3.80
B_1Zn_0	22.83	21.33	3.56
B_1Zn_1	24.50	24.50	4.16
B_1Zn_2	24.97	23.67	4.33
B_1Zn_3	25.83	24.67	4.46
B_2Zn_0	24.47	22.83	4.33
B_2Zn_1	27.83	26.67	4.90
B_2Zn_2	36.40	35.23	5.00
B_2Zn_3	36.50	35.33	5.10
S.E m +	0.21	0.29	0.05
CD at 5% Level	0.62	0.88	0.16

Number of marketable fruits per plant

The data pertaining to number of marketable fruits per plant influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 2.

Effect of zinc solubilizers

The different zinc solubilizers resulted in significant differences in number of marketable fruits per plant of tomato. Maximum number of marketable fruits per plant (30.02) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, minimum number of marketable fruits per plant (21.25) was observed in B_0 (Control) in tomato.

The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded maximum number of flowers per plant as compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the hormonal characters of tomato. It enhance the chlorophyll synthesis and uptake of essential ions including N,P & K which helps to setting of fruits as compare to *Pseudomonas strita* and Control. These results were in conformity with the results obtained by Haque, *et al.*,(2012) [3] in tomato where 50% N + 50% *Trichoderma harzianum* coated wheat grains increases number of marketable fruits per plant as compared to other treatments..

Effect of levels of zinc

The different levels of zinc resulted in significant differences in number of marketable fruits per plant of tomato. Maximum number of marketable fruits per plant (27.44) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, minimum number of marketable fruits per plant (21.16) was observed in Zn_0 (Control) in tomato.

The above result indicated that there was a increase in number of fruits due to increase in the levels of zinc i.e. Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for maximizes fruit set. Similar results were reported by Meena, *et al.*, (2015) [5] in tomato where significantly increased number of fruits with increasing concentration of zinc at 100 ppm as compared to other treatments.

Interaction effect of zinc solubilizers and levels of zinc

It is evident from the data presented in a Table 2 that interaction effect of zinc solubilizers and levels of zinc was revealed to be significant on number of marketable fruits per plant in tomato. Maximum number of marketable fruits per plant (35.33) was observed in B_2Zn_3 which was at par with B_2Zn_2 and minimum number of marketable fruits per plant (19.33) was observed in B_0Zn_0 (Control) in tomato.

Number of locules per fruit

The data pertaining to number of locules per fruit influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 2.

Effect of zinc solubilizers

The different zinc solubilizers resulted in significant differences in number of locules per fruit of tomato. Maximum number of locules per fruit (4.83) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, minimum number of locules per fruit (3.24) was observed in B_0 (Control) in tomato.

The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded maximum number of locules per fruit as compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the hormonal characters of tomato. It enhance the chlorophyll synthesis and uptake of essential ions including N,P & K which helps to setting of fruits and maximizes number of locules as compare to *Pseudomonas strita* and Control. These results were in conformity with the results obtained by Sujata Kumari, *et al.*, (2019) [10] in bell pepper where soil application *Trichoderma harzianum* increases number of locules per fruits as compared to other treatments..

Effect of levels of zinc

The different levels of zinc resulted in significant differences in number of locules per fruit of tomato. Maximum number of locules per fruits (4.45) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, minimum number of locules per fruits (3.50) was observed in Zn_0 (Control) in tomato.

The above result indicated that there was a increase in number of fruits due to increase in the levels of zinc i.e. Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for maximizes fruit set and number of locules. Similar results were reported by Meena, *et al.*, (2015) [5] in tomato where significantly increased number of locules per fruit (6.27) with increasing concentration of zinc at 100 ppm as compared to other treatments.

Interaction effect of zinc solubilizers and levels of zinc

It is evident from the data presented in a Table 2 that interaction effect of zinc solubilizers and levels of zinc was

revealed to be significant on number of locules per fruit in tomato. Maximum number of locules per fruits (5.10) was observed in B_2Zn_3 which was at par with B_2Zn_2 and minimum number of locules per fruit (2.60) was observed in B_0Zn_0 (Control) in tomato.

Length of fruit (Cm)

The data recorded to length of fruit influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 3.

Effect of zinc solubilizers

The different zinc solubilizers resulted in significant differences in length of fruit of tomato. Maximum length of fruit (6.85 cm) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, minimum length of fruit (5.27 cm) was observed in B_0 (Control) in tomato.

The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded maximum length of fruit as compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the hormonal and physiological characters of tomato as compare to *Pseudomonas strita* and Control. These similar results were found in Sujata Kumari, *et al.*, (2019) [10] in bell pepper where soil application *Trichoderma harzianum* increases length of fruit (6.68 cm) as compared to other treatments.

Effect of levels of zinc

The different levels of zinc resulted in significant differences in length of fruit of tomato. Maximum length of fruit (6.51 cm) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, minimum length of fruit (5.61cm) was observed in Zn_0 (Control) in tomato.

The above result indicated that there was a increase in length of fruit due to increase in the levels of zinc i.e. Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for maximizes fruit set and length of fruit. Similar results were reported by Meena, *et al.*, (2015) [5] in tomato where significantly increased length of fruit (4.22 cm) with increasing concentration of zinc at 100 ppm as compared to other treatments.

Interaction effect of zinc solubilizers and levels of zinc

It is evident from the data presented in a Table 3 that interaction effect of zinc solubilizers and levels of zinc was revealed to be significant on length of fruit in tomato. Maximum length of fruit (7.12 cm) was observed in B_2Zn_3 which was at par with B_2Zn_2 and minimum length of fruit (4.85 cm) was observed in B_0Zn_0 (Control) in tomato.

Table 3: Effect of different zinc solubilizers and levels of zinc on fruiting characters of tomato

Treatment	Fruit Length (cm)	Fruit Diameter (cm)	Days to First picking	Harvest Duration (Days)
Zinc Solubilizers (B)				
B_0	5.27	6.73	74.00	54.57
B_1	6.83	7.98	70.83	78.90
B_2	6.85	8.00	70.40	79.60
S.E m +	0.01	0.01	0.14	0.23
CD at 5% Level	0.03	0.04	0.42	0.70
Levels of zinc (Zn)				
Zn_0	5.61	6.91	73.44	61.38
Zn_1	6.04	7.21	72.00	65.71
Zn_2	6.49	7.60	71.37	73.98
Zn_3	6.51	7.63	70.88	74.76
S.E m +	0.01	0.01	0.16	0.27
CD at 5% Level	0.03	0.04	0.48	0.80
Interaction (B×Zn)				
B_0Zn_0	4.85	6.41	76.67	47.04
B_0Zn_1	5.12	6.62	73.67	52.03
B_0Zn_2	5.25	6.86	73.00	57.08
B_0Zn_3	5.86	7.03	72.67	62.14
B_1Zn_0	5.66	6.95	72.00	60.07
B_1Zn_1	6.12	7.11	72.00	66.82
B_1Zn_2	6.34	7.28	71.00	74.07
B_1Zn_3	6.56	7.48	70.67	80.10
B_2Zn_0	6.33	7.38	71.67	77.05
B_2Zn_1	6.89	7.92	70.33	78.29
B_2Zn_2	7.07	8.30	70.27	80.99
B_2Zn_3	7.12	8.38	69.33	82.05
S.E m +	0.02	0.03	0.28	0.47
CD at 5% Level	0.06	0.08	0.86	1.43

Diameter of fruit (cm)

The data recorded to diameter of fruit influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 3.

Effect of zinc solubilizers

The different zinc solubilizers resulted in significant differences in diameter of fruit of tomato. Maximum diameter of fruit (8.00 cm) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, minimum diameter of fruit (6.73 cm) was observed in B_0 (Control) in tomato.

The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded maximum diameter of fruit as

compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the hormonal and physiological characters of tomato as compare to *Pseudomonas strita* and Control. These similar results were found in Sujata Kumari, *et al.,* (2019) [10] in bell pepper where soil application *Trichoderma harzianum* increases diameter of fruit as compared to other treatments..

Effect of levels of zinc

The different levels of zinc resulted in significant differences in diameter of fruit of tomato. Maximum diameter of fruit (7.63 cm) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, minimum diameter of fruit (6.91cm) was observed in Zn_0 (Control) in tomato.

The above result indicated that there was a increase in diameter of fruit due to increase in the levels of zinc i.e. Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for maximizes the diameter of fruit. Similar results were reported by Meena, *et al.,* (2015) [5] in tomato where significantly increased diameter of fruit (3.89 cm) with increasing concentration of zinc at 100 ppm as compared to other treatments.

Interaction effect of zinc solubilizers and levels of zinc:

It is evident from the data presented in a Table 3 that interaction effect of zinc solubilizers and levels of zinc was revealed to be significant on diameter of fruit in tomato. Maximum diameter of fruit (8.38 cm) was observed in B_2Zn_3 which was at par with B_2Zn_2 and minimum diameter of fruit (6.41 cm) was observed in B_0Zn_0 (Control) in tomato.

Days to first picking (days)

The data recorded to days to first picking influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 3.

Effect of zinc solubilizers

The different zinc solubilizers resulted in significant differences in days to first picking of tomato. Minimum days to first picking (70.40) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, maximum days to first picking (74.00) was observed in B_0 (Control) in tomato.

The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded minimum days to first picking as compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the hormonal and physiological characters of tomato as compare to *Pseudomonas strita* and Control. These similar results were found in Sujata Kumari, *et al.,* (2019) [10] in bell pepper where soil application *Trichoderma harzianum* minimizes days to first picking (82.27) as compared to other treatments..

Effect of levels of zinc

The different levels of zinc resulted in significant differences in days to first picking of tomato. Minimum days to first picking (70.80) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, maximum days to first picking (73.44) was observed in Zn_0 (Control) in tomato.

The above result indicated that there was a minimizes days to first picking due to increase in the levels of zinc i.e. Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for minimize days to first picking. Similar results were reported by Yadav, *et al.,* (2001) in tomato where significantly minimized the day to first picking with increasing concentration of zinc at 7.5 ppm as compared to other treatments.

Interaction effect of zinc solubilizers and levels of zinc

It is evident from the data presented in a Table 3 that interaction effect of zinc solubilizers and levels of zinc was revealed to be significant on days to first picking in tomato. Minimum day to first picking (69.33) was observed in B_2Zn_3 which was at par with B_2Zn_2 and maximum days to first picking (76.67) was observed in B_0Zn_0 (Control) in tomato.

Harvest duration (days)

The data recorded to harvest duration influenced by different zinc solubilizing bacteria, different levels of zinc and their interaction effect is given in Table 3.

Effect of zinc solubilizers

The different zinc solubilizers resulted in significant differences in harvest duration of tomato. Maximum harvest duration (79.60) was observed in B_2 (*Trichoderma viride*) which was at par with B_1 (*Pseudomonas strita*) whereas, minimum harvest duration (54.57) was observed in B_0 (Control) in tomato.

The above result indicated that zinc solubilizers i.e. B_2 (*Trichoderma viride*) recorded maximum harvest duration as compared to B_1 (*Pseudomonas strita*) and B_0 (Control). The *Trichoderma viride* improve the hormonal and physiological characters of tomato which helps to increase harvest duration as compare to *Pseudomonas strita* and Control. These similar results were found in Jasim, *et al.,*(2019) [4] in sweet pepper where soil application *Trichoderma spp.* increases harvest duration as compared to other treatments.

Effect of levels of zinc

The different levels of zinc resulted in significant differences in harvest duration of tomato. Maximum harvest duration (74.76) was observed in Zn_3 (30 kg $ZnSO_4$/ha) which was at par with Zn_2 (20 kg $ZnSO_4$/ha) in tomato whereas, minimum harvest duration (61.38) was observed in Zn_0 (Control) in tomato.

The above result indicated that there was a maximum harvest duration due to increase in the levels of zinc i.e. Zn_3 (30 kg $ZnSO_4$/ha.). Zinc is a essential micronutrient which responsible for maximizes harvest duration. Similar results were reported by Haleema, *et al.,* (2017) in tomato where significantly increased harvest duration with increasing the Zn concentration to 0.5%.

Interaction effect of zinc solubilizers and levels of zinc:

It is evident from the data presented in a Table 3 that interaction effect of zinc solubilizers and levels of zinc was revealed to be significant on harvest duration of tomato. Maximum harvest duration (82.05) was observed in B_2Zn_3 which was at par with B_2Zn_2 and minimum harvest duration (47.04) was observed in B_0Zn_0 (Control) in tomato.

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