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EFFECT OF ZINC SULPHATE, ZINC SOLUBILIZING BACTERIA AND VESICULAR ARBUSCULAR MYCORRHIZAE ON GROWTH ATTRIBUTES OF OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH.)

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Abstract

The experiment was laid out on a farmer's field at Keela Thanneerpalli village, Kulithalai block, Karur district, Tamil Nadu during the year 2018. The treatments comprises of different combinations of farm yard manure (FYM), recommended dose of fertilizers (RDF), zinc sulphate ($ZnSO_4$), zinc solubilising bacteria (ZSB) and vesicular arbuscular mycorrhizae (VAM). The results revealed that the maximum values for the growth attributes *viz.*, plant height (87.95 and 87.12 cm), number of branches (4.63 and 4.53), number of leaves (24.02 and 24.60), leaf area (220.36 and 190.51 cm^2) and dry matter production (140.10 and 138.41 g $plant^{-1}$) and minimum intermodal length (4.33 and 4.37 cm) were recorded in the plots which received the application of FYM + RDF + ZSB + VAM + 40 kg $ZnSO_4$ ha^{-1} during the first and second season respectively. This treatment was closely followed by the treatment combination FYM + RDF + ZSB + VAM + 30 kg $ZnSO_4$, ha^{-1} and found to be on par with the best treatment.

Key words: okra, zinc sulphate, ZSB, VAM, bhendi. growth.

Introduction

Among the various ways to improve productivity nutrient management is a important concept. Vegetable crops need both major and micronutrients to express its yield potential. The Indian farmers are supplying all the major nutrients to the vegetable crops but not the micronutrients since the green revolution. Due to non-judicious use of inorganic fertilizers, now a days the crops are showing micronutrient deficiency. Vegetable crops are responding to micronutrients and their use in vegetable growing would be of great significant. The micronutrients namely Zn, B, Mn, Fe, Mo, Cl and Cu play an important role in vegetable production. Micronutrients play a catalytic role in nutrient absorption and balancing other nutrients (Singh and kallo, 2000). Among the various micronutrients, zinc plays an important role in synthesis of protein, cell division and synthesis of indole acetic acid. Low zinc solubility in soil is the main cause of zinc deficiency in okra rather than low total zinc content. Its low availability decreases the yield and lead to inferior quality of okra and is responsible for its deficiency in human (Rehman *et al.,* 2018). Okra (*Abelmoschus esculentus* L. Moench.) is the only vegetable crop of significance in the Malvaceae family. Okra is a good source of vitamins A, B, and C and minerals like iron, calcium, magnesium, phosphorus and zinc. Similarly, okra fruit is an excellent source of iodine, which is necessary for the resistance against throat disease like goitre. In view of the above facts, the present investigation was carried out to study the effect of zinc sulphate, Zinc solubilizing bacteria and vesicular arbuscular mycorrhizae on growth attributes of okra.

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Materials and Methods

The experiment was conducted in a farmer's field at Keela Thanneerpalli village, Kulithalai block, Karur district, Tamil Nadu during the year 2018. The experiment was laid out by following the principles of randomized block design with eight treatments replicated thrice. The treatment schedule is as follows: T_1 - FYM + RDF, T_2 - FYM + RDF + $ZnSO_4$ @ 20 kg/ha as soil application, T_3 - FYM + RDF + $ZnSO_4$ @ 30 kg/ha as soil application, T_4 - FYM + RDF + $ZnSO_4$ @ 40 kg/ha as soil application, T_5 - FYM + RDF + ZSB +VAM, T_6 - FYM + RDF +

ZSB +VAM + $ZnSO_4$ 20 kg/ha as soil application, T_7 - FYM + RDF + ZSB +VAM + $ZnSO_4$ 30 kg/ha as soil application, T_8 - FYM + RDF + ZSB +VAM + $ZnSO_4$ 40 kg/ha as soil application, The plot size is 4.5 m × 3 m (13.5 m^2) accommodating 100 plants with a spacing of 45 cm × 30 cm. The trial was conducted in two seasons starting in the month of January and June for first and second season respectively. Seeds of bhendi variety 'Arka Anamika' were used for this study.

The field was brought to a fine tilth by ploughing thrice with a help of tractor. During last ploughing FYM @ 25 t/ha and basal dose of fertilizers, 20 kg ha^{-1} of nitrogen, 50 kg ha^{-1} of phosphorus and 30 kg ha^{-1} of potash were applied. Then the field was divided into plots of 13.5 m^2 each. The micronutrient zinc was applied in the form of zinc sulphate to various plots as per the treatment schedule. The biofertilizers ZSB was applied @ 5 kg ha^{-1} and VAM was applied @ 10 kg ha^{-1} after mixing them with FYM as per treatment schedule. Ridges and furrows were formed at a spacing of 45 cm and seeds were sown at a spacing of 30 cm along one side of the ridge at the rate of two seeds per hill. Another 20 kg of nitrogen was given as top dressing on 30 days after sowing. The nutrients were applied in the form of urea, super phosphate and muriate of potash. Other cultural practices like irrigation, weeding and plant protection were adopted as per recommendation. Five plants were randomly tagged in each treatment/replication for recording the observations on growth attributes. The data recorded were statistically analysed and wherever the results were found significant, the critical differences were worked out at 5 percent level and statistical conclusions were drawn.

Results and Discussions

Growth is one of the essential parameters for the attribution of yield. Various growth attributes like plant height, number of branches, number of leaves, leaf area, and dry matter production have a significant influence on the yield; hence, these parameters are to be considered for the study.

The results of the present investigation revealed that there was a significant difference between the treatments on the growth parameters *viz.*, plant height, number of branches, internodal length, number of leaves, leaf area and dry matter production. The maximum values for the above said growth attributes were recorded in the plots which received the application of FYM + RDF + ZSB + VAM + 40 kg $ZnSO_4$. This treatment was closely followed by the treatment combination FYM + RDF + ZSB + VAM + 30 kg $ZnSO_4$, and found to be on par with the best treatment.

This increase in plant height and number of branches might due to synthesis of tryptophan in the presence of zinc, the precursor of IAA, which simulated the growth of the plant tissue (Naruka *et al.,* 2000). The physiological parameters pertaining to photosynthesis, stomatal conductance and transpiration also exhibited significant increment with zinc supplied through zinc sulphate in soil. It also influenced cell division, meristematic activity of tissues and expansion of cell and formation of cell wall (Sharma *et al.,* 2018).

The increase in the growth parameters in the present investigation was also due to the inoculation of zinc solubilising bacteria which produces organic acids which in turn increase the availability of nutrients through solubilisation and mobilisation. ZSB also produces plant growth hormones like IAA and GA_3 which might have contributed to the positive response in growth characters. The present findings are similar to the results of Fatima *et al.,* (2018) who reported that inoculation of ZSB strains significantly improved the growth of okra. According to Vidyashree *et al.,* (2018), the improved growth parameters observed in *B. aryabhattai* and *Bacillus* sp. (PAN-TM1) treatment was due to zinc solubilisation

Table 1: Effect of zinc on plant height and number of branches at 90 DAS in okra

S. No	Treatments	Plant height (cm)		Number of branches	
		1st Season	2nd Season	1st Season	2nd Season
T_1	FYM + RDF	75.77	78.12	1.90	2.12
T_2	FYM + RDF + $ZnSO_4$ @ 20 kg/ha	81.25	81.95	2.96	2.99
T_3	FYM + RDF + $ZnSO_4$ @ 30 kg/ha	85.40	84.25	3.82	3.76
T_4	FYM + RDF + $ZnSO_4$ @ 40 kg/ha	86.15	85.41	4.01	4.11
T_5	FYM + RDF + ZSB + VAM	80.12	80.24	2.79	2.33
T_6	FYM + RDF + ZSB + VAM + $ZnSO_4$ 20 kg/ha	82.14	83.65	3.37	3.38
T_7	FYM + RDF + ZSB + VAM + $ZnSO_4$ 30 kg/ha	87.15	86.34	4.57	4.49
T_8	FYM + RDF + ZSB + VAM + $ZnSO_4$ 40 kg/ha	87.95	87.12	4.63	4.53
	S.Ed	1.56	1.53	0.08	0.08
	CD(p=0.05)	3.38	3.33	0.17	0.17

FYM= 25 t ha^{-1}, Recommended fertilizer= 40:50:30 Kg NPK ha^{-1}.

Table 2: Effect of zinc on intermodal length and number of leaves in okra

S. No	Treatments	Internodal length at harvest (cm)		Number of leaves at 90 days	
		1st Season	2nd Season	1st Season	2nd Season
T_1	FYM + RDF	5.13	5.24	17.87	18.35
T_2	FYM + RDF + $ZnSO_4$ @ 20 kg/ha	4.93	4.85	19.52	19.98
T_3	FYM + RDF + $ZnSO_4$ @ 30 kg/ha	4.53	4.60	22.03	22.35
T_4	FYM + RDF + $ZnSO_4$ @ 40 kg/ha	4.44	4.54	22.93	23.00
T_5	FYM + RDF + ZSB + VAM	4.99	5.01	18.54	19.56
T_6	FYM + RDF + ZSB + VAM + $ZnSO_4$ 20 kg/ha	4.72	4.68	20.13	20.28
T_7	FYM + RDF + ZSB + VAM + $ZnSO_4$ 30 kg/ha	4.36	4.41	23.65	24.12
T_8	FYM + RDF + ZSB + VAM + $ZnSO_4$ 40 kg/ha	4.33	4.37	24.02	24.60
	S.Ed	0.07	0.09	0.44	0.46
	CD(p=0.05)	0.17	0.17	0.90	0.92

FYM= 25 t ha^{-1}, Recommended fertilizer= 40:50:30 Kg NPK ha^{-1}.

Table 3: Effect of zinc on leaf area and dry matter content in okra

S. No	Treatments	Leaf area at 90 DAS (cm^2)		Dry matter content(g $plant^{-1}$)	
		1st Season	2nd Season	1st Season	2nd Season
T_1	FYM + RDF	180.73	160.67	107.33	105.60
T_2	FYM + RDF + $ZnSO_4$ @ 20 kg/ha	185.12	172.45	120.10	115.35
T_3	FYM + RDF + $ZnSO_4$ @ 30 kg/ha	190.64	178.94	128.52	122.85
T_4	FYM + RDF + $ZnSO_4$ @ 40 kg/ha	193.18	180.50	135.00	128.67
T_5	FYM + RDF + ZSB + VAM	183.44	169.72	111.67	109.20
T_6	FYM + RDF + ZSB + VAM + $ZnSO_4$ 20 kg/ha	186.95	175.23	122.86	118.30
T_7	FYM + RDF + ZSB + VAM + $ZnSO_4$ 30 kg/ha	219.12	189.00	138.33	136.00
T_8	FYM + RDF + ZSB + VAM + $ZnSO_4$ 40 kg/ha	220.36	190.51	140.10	138.41
	S.Ed	3.71	3.32	2.50	2.40
	CD(p=0.05)	8.03	7.19	5.20	5.10

FYM= 25 t ha^{-1}, Recommended fertilizer= 40:50:30 Kg NPK ha^{-1}.

potential by the production of various organic acids and these isolates were also found to be positive for the production of plant growth promoting substances like IAA, GA3 and siderophore production. As a result of this better uptake of nutrients takes place which resulted in an increased growth of tomato plant.

The significant response to the growth characters was also due to the inoculation of VAM fungi which increases the phosphorus and zinc uptake and translocation in okra. The transfer of nutrients mainly phosphorus from the soil to the cells of the root cortex is mediated by intracellular obligate fungal endosymbiont of the genera *Glomus, Gigaspora, Acaulospora, Scleroscystis* and *Endogone* which possess vesicles for storage of nutrients and arbuscules for funneling these nutrients into the root system. The mycorrhizal fungi mobilize phosphates and other micronutrients like zinc, boron and molybdenum from adjacent soil to the root system through hyphal network which in turn increased the plant growth (Rao *et al.,* 2014). AMF hyphae exclusively colonize the root cortex and form highly branched structures inside the cells, *i.e.*, arbuscules, which are considered the functional site of nutrient exchange (Balestrini *et al.,* 2015). The increase in plant height and number of branches might also be due to more balance C: N ratio, abundant supply of available nutrients from soil with comparatively lesser retention in roots and more translocation to aerial parts for protoplasmic proteins and synthesis of other compounds (Dhawale *et al.,* 2011).

Dry matter production is an important prerequisite for higher yield as it signifies photosynthetic ability of the crop and also indicates other synthetic process during developmental sequences. The results of present investigation revealed that various treatments resulted in an increase in dry matter production. This was probably due to the uptake of nutrients which increased vegetative growth and hence provided greater translocation from leaf to shoot and thereby enhanced shoot growth and weight. This was also due to the effect of K and Zn nutrition on cell elongation, turgourr potential in leaves. Inoculation of ZSB (*B. aryabhattai*) strains significantly increased shoot weight, Zn uptake/assimilation as compared to un-inoculated control in soybean and wheat crops cultivated under vertisols of central India (Khande

et al., 2017). Similar increases in dry matter accumulation, zinc acquisition through the inoculation of plant growth promoting rhizobacteria have been reported (Mader *et al.,* 2010; Rana *et al.,* 2012).

From the results of this experiment it is concluded that application of FYM plus recommended dose of fertilizers plus 30 kg of zinc sulphate plus zinc solubilising bacteria plus vesicular arbuscular mycorrhizae was beneficial in increasing the growth attributes of okra.

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