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Response of garlic to micronutrients application in medium black calcareous soils of Saurashtra Region of Gujarat

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Abstract
A field experiment was conducted on *Typic Heplustptes* soils of Vegetable Research Farm, Junagadh Agricultural University, Junagadh, Gujarat, during 2014-15 and 2015-16 to study the response of garlic to multi-micronutrients formulation mixture fertilizers in medium black calcareous soils. The results revealed that higher bulb(6712, 5762 and 6237 kg ha^{-1}) and dry leaves (1370, 1181 and 1275 kg ha^{-1}) yields in year 2014-15, 2015-16 and pooled results, respectively,as well as Fe, Mn, Zn and Cu uptake by bulb and dry leaves of garlic were registered with soil application of $FeSO_4$ @ 15 kg ha^{-1} and $ZnSO_4$ @ 8 kg ha^{-1} as per soil test value (STV),follow by soil application of multi-micronutrients Grade-V @ 40 kg ha^{-1}(T_7) and foliar multi-micronutrients supplementation through 1.0 % spray having Fe-4.0%,Mn-0.1%,Zn-5.0%, Cu-0.5% and B-0.5 % grade-IV (T_5) at 60, 75 and 90 days after sowing (DAS).These all the treatment were statistically at par with each other but significantly superior over control.The magnitude of increased in fruit yield were 22.8 and 14.8 and 14.2 % owing to soil application of $FeSO_4$ @15kg ha^{-1} + $ZnSO_4$ @ 8 kg ha^{-1} (STV-T_8) and soil application of micronutrients mixture grade- V @ 40 kg ha^{-1}(T_7) and micronutrients mixture grade-IV spray @ 1.0 % (T_5) at 60,75 and 90 days after sowing (DAS), respectively, over control. Significantly higher value of bulb height (2.3 cm), plant height (26.5 cm), No of cloves per bulb (10.9) and bulb girth (1.9 cm) were also recorded with soil application of $FeSO_4$ @ 15 $kgha^{-1}$ and $ZnSO_4$ @ 8 $kgha^{-1}$ as per soil test value (STV), follow by foliar multi-micronutrients mixture Grade IV (T_5). These both the treatments were statistically at par with each other but significantly superior over control. The soil application of multi-micronutrients mixture as per STV, soil application of multi-micronutrients @ 40 kg ha^{-1} and foliar spray 1.0% grade -IV were found beneficial and economical in increasing garlic yield.

Keywords: Micronutrients mixture grade, micronutrients uptake, garlic yields

Introduction
Garlic (*Allium sativum* L.) is one of the most important bulb vegetable crops and is next to onion in importance. It is commonly used as a spice or in the medicinal purposes. In India, it has been generally cultivated for both local consumption and export. India ranks second in area and production in the world. The area and production of garlic in India are about 2.47 Lakh hectares and 1.25 million tons of bulbs, respectively, with an average yield of 4.95 t/ha. In Gujarat the garlic area, production and productivity are about 39.2 thousand hectares, 277.46 thousand metric tons and 7.08 tons/ha, respectively (NHB, 2014). The garlic yield is very low as compared to other countries. Reasons for the low yield of garlic are mainly due to depletion of macro and micro- nutrients from the soil, use of low yielding varieties with low or no inputs and poor management practices. Rattan and Sharma (2004) [9] reported an increase in deficiencies of micronutrients across the country in various field crops. Micronutrients mixtures provide all the essential micronutrient in proportionate doses, thereby ensuring the crop yields though balance plant nutrition. Patel *et al*., (2008) [7] reported that the okra yields significantly increased due to soil application of multi-micronutrients mixture Grade V @ 20 kg ha^{-1} at the time of sowing along with recommended NPK dose to get higher yield and net returns. Although, the requirement of micronutrients like Zn, Cu, Mn, Fe, B and Mo are relatively less but their role in normal crop production is indispensable because of their active role in plant metabolic processes involving cell wall development, respiration, photosynthesis, chlorophyll formation, enzyme activity and nitrogen fixation. Direct spray of micronutrients to foliage of the crop is very beneficial.

Hence, the present investigation was taken to study the response of garlic to multi-micronutrients formulation mixture fertilizers on the growth and yield of garlic.

Materials and Methods

A field experiment was conducted consecutive two years (2014-15 and 2015-16) at Vegetable Research farm, (Latitide 21^{O} 30' N, longitude 70^{0}26' E and altitude 61m) Junagadh Agricultural University, Junagadh, Gujarat for studying the response of garlic (cv. Guj. Garlic-4) to multi-micronutrient mixture fertilizer in medium black calcareous soils. There were eight treatments viz., T_1 - Control (only NPK); water spray treatments: T_2 - mixture Grade-I (General); T_3 - Grade-II (For Zn deficiency); T_4 -Grade-III (For Fe deficiency); T_5 - Grade- IV (For Zn and Fe deficiency) and soil application treatments: T_6 - mixture Grade-V(Soil application @ 20 kg ha^{-1}), T_7 - mixture Grade-V (Soil application @ 40 kg ha^{-1}) and T_8 - soil application of micronutrients as per Soil Test Value (STV- $FeSO_4$@ 15 $kgha^{-1}$ and $ZnSO_4$). The multi-micronutrient mixture grades having composition shown as under were prepared in the laboratory.

Chemical composition of local formulation grade approved by Government of Gujarat

S. No	Multi -micronutrients mixture grades	Content (%)				
		Fe	Mn	Zn	Cu	B
	For foliar spray					
1.	Mixture grade I (General) LF- I	2.0	0.5	4.0	0.3	0.5
2.	Mixture Grade II (for Zn deficiency) LF-II	2.0	0.5	8.0	0.5	0.5
3.	Mixture Grade III (for Fe deficiency) LF-III	6.0	1.0	4.0	0.3	0.5
4.	Mixture Grade IV (for Fe & Zn deficiency) LF-IV	4.0	1.0	6.0	0.5	0.5
	For soil application					
5.	LF Mixture Grade V (Soil application) LF-V	2.0	0.5	5.0	0.2	0.5

The mixture grade I and V were prepared on the basis of average removal of micronutrients by different crops and rest of grades II to IV on the basis of wide occurrence of Zn or Fe or Zn and Fe deficiencies in soils of Gujarat. Rate of application of T_2, T_3, T_4 and T_5 - Foliar spray @ 1 % at 60, 75 and 90 days after sowing (DAS) and Soil application T_6 - @ 20 kg ha^{-1}, and T_7 -@ 40 kg $ha^{-1}$and T_8-soil application of micronutrients as per soil test values (FeSO4 @ 15 kg ha^{-1} and Zn SO_4 @ 8 kg ha^{-1}). The treatments were repeated fourtime in randomized block design. The soil of the experimental field was clayey in texture (*Typic Hplustepts*) and had $pH_{2.5}$- 7.8, $EC_{2.5}$ - 0.63 dS m^{-1}, available N 213 kg kg^{-1}, available P_2O_5 - 26.0 kg ha^{-1}, available K_2O - 318 $kgha^{-1}$, available S-13.6 kg ha^{-1}, Fe - 11.3 mg kg^{-1}, Mn -20.4 mg kg^{-1}, Zn - 0.76 mg kg^{-1} and Cu - 2.04 mg kg^{-1}. The recommendation dose of 50 kg N ha^{-1}, 50 kg P_2O_5 ha^{-1} and 50 kg K_2Oha^{-1} was applied through urea, diammonium phosphate and muriate of potash, respectively, to all treatments plots at time of sowing. Half of the N and full of P_2O_5 and K_2O were applied as basal dressing at sowing and while remaining half N was top dressed at the time of 45 day after sowing. The cloves of garlic cv. Guj. Garlic-4 were planted on third week of November for both years in 6 m x 1.2 m plot at 15 cm x 10 cm spacing. The first irrigation was given immediately after planting. All the standard recommended cultural practices and plant protection measures were followed throughout the experimental periods.

The crop was harvested at last week of March during both the years and bulb, dry leaves yields, growth and yields attributes were recorded. The bulb and dry leaves samples were oven dry at 60 ^{o}C for 48 hour in oven. The oven dried bulb and dry leaves samples were finely ground in a S. Wiley mill and were digested with di-acid mixture of HNO_3: $HClO_4$ (3:1) as per the procedure outline given by Jackson (1973). The micronutrients in digest was determined by Atomic Absorption spectrophotometer (Lindsayand Novell, 1978). The soil samples drawn from the experimental field at harvest were analyzed for available micronutrients by extracting with 0.005 M DTPA and the contents were determined by atomic absorption spectrophotometer. The micronutrients removal by crop was calculated by multiplying the concentration values. Data were statistically analyzed using following standard method.

Results and Discussion

Garlic Yields

The application of micronutrients soil or foliar spray significantly influenced yield and yield attributing characters of garlic. The bulb and dry leaves yields of garlic improved due to foliar and soil application of micronutrients mixture during both the years, as well as in pooled basis (Table 1). The significantly higher bulb (6712, 5762 and 6237 kg ha^{-1}) and dry leaves (1370, 1181 and 1275 kg ha^{-1}) yields were registered with application of micro nutrients as per soil test value (T_8) respectively, in individual years and in pooled, and this treatment were statistically at par with treatment T_5 (multi-micronutrient formulation Grade IV foliar spray of 1.0 % at 60, 75 and 90 days after sowing (DAS) and soil application of multi-micronutrients Grade-V @ 40 kg ha^{-1}(T_7). The magnitude of increased in fruit yield yields were 22.8 and 14.8 and 14.2 % owing to soil application of FeSO4 @15kg ha^{-1} + ZnSO4 @ 8 kg ha^{-1} (STV-T_8), soil application of micronutrients mixture grade- V @ 40 kg ha^{-1}(T_7) and micronutrients mixture grade-IVspray @ 1.0 % (T_5) at 60, 75 and 90 days after sowing (DAS), respectively, over control. The results clearly indicated that application of micronutrients either through soil or foliar spray was found beneficial for increase in the yield of garlic. Increased yield of garlic due to micronutrients application may be attributed to enhance photosynthesis activity and increased in production and accumulation of carbohydrates and favorable effect on vegetative growth, and their allocation to the bulbs. Micronutrients also plays role in physiological activities and as a cofactor in number of plant enzymes and in protein metabolism. The results are in conformity with the findings of Srivastava *et al.* (2005) [12], Rahohida *et al*. (2010), Yousuf *et al.* (2015) [13] and Choudhary *et al*. (2014) [1] in garlic crop.The application of micronutrients soil or foliar spray significantly influenced bulb yield of onion crop (Pramanik and Tripathy, 2017 and Singh *et al.*, 2015) [8, 11].

Table 1: Effect of multi-micronutrient formulations on bulb and dry leaves of yield of garlic

Treatments	Garlic yields (kg ha^{-1})					
	Bulb yield			Dry leaves yield		
	2014-15	2015-16	Mean	2014-15	2015-16	Mean
T_1. Control	5464	4698	5081	1108	955	1031
T_2. Grade I	5684	4894	5289	1156	996	1076
T_3. Grade II	5931	5109	5520	1207	1041	1124
T_4. Grade III	5973	5144	5558	1218	1050	1134
T_5. Grade IV	6071	5535	5803	1232	1124	1178
T_6. Grade V @ 20 kg ha^{-1}	5714	4916	5315	1158	998	1078
T_7. Grade V @ 40 kg ha^{-1}	6430	5231	5831	1304	1062	1183
T_8. As per STV	6712	5762	6237	1370	1181	1275
SEm ±	258	215	168	54	43	34
C.D. at 5%	758	631	479	162	126	98
C.V. %	10.5	11.0.3	10.5	11.9	10.1	10.6

Growth and yields attributes

The two year mean data in table 2 revealed that the significantly higher growth and yields attributes viz., bulb height (2.3 cm), plant height (26.5 cm), No of cloves per bulb (10.9) and bulb girth (1.9 cm) were recorded with treatment T_8 (application of micronutrients as per soil test values of $FeSO_4$ @ 15 kg ha^{-1} and $ZnSO_4$ @ 8 kg ha^{-1}) and this treatment was at statistically par with treatment T_5 (Foliar spray of micronutrients mixture Grade IV @1.0 % at 60,750 and 90 days after sowing -DAS) and treatment T_7 (soil application of multi micronutrient mixture @ 40 kg ha^{-1}) in respect to growth and yields attributes. The results clearly indicated that the application of micronutrients either through soil or foliar spray found beneficial for increase in growth and yields attributes of garlic. The increase growth and yields attributes due to effective role of micronutrients. These micronutrients play a vital role in the physiology of plants. The increase in growth and yield attributes due to micronutrients might be due to their role in fundamental processes involved in the cellular mechanism and respiration. This effect positively for improvement in fruits size and fruit weight. Micronutrients takes active part in photosynthesis, which ultimately helps towards increase in number and weight of bulbs. Similarly, significant influence of micronutrients mixture on growth and yield parameters of garlic as reported by Srivastava *et al*. (2005) [12], Rahohidas *et al*. (2010), Yousuf *et al*., (2015) [13] and Choudhary *et al*. (2014) [1] in garlic crop. Pramanik and Tripathy (2017) [8] reported that application of micronutrients mixture have marked influence on growth and yield attributing characters of onion like plant height, number of roots per plant, diameter of bulb and bulb weight as well as bulb height.

Table 2: Effect of multi-micronutrient formulations on yield attributes of garlic (pooled)

Treatments	Bulb height (cm)	Plant Height (cm)	No. of cloves/bulb	Bulb Girth (cm)
T_1. Control	2.0	23.1	9.4	1.6
T_2. Grade I	2.0	23.5	9.9	1.7
T_3. Grade II	2.1	24.1	10.1	1.7
T_4. Grade III	2.0	24.4	10.5	1.5
T_5. Grade IV	2.2	25.5	10.5	1.8
T_6. Grade V @ 20 kg ha^{-1}	2.1	24.0	9.7	1.6
T_7. Grade V @ 40 kg ha^{-1}	2.2	25.8	10.5	1.8
T_8. As per STV	2.3	26.5	10.9	1.9
SEm ±	0.1	0.8	0.2	0.1
C.D. at 5%	0.2	2.2	0.6	0.2
C.V. %	9.4	8.7	5.6	9.5

Micronutrients Uptake

The perusal of two year mean data on uptake of micronutrients (Fe, Mn, Zn and Cu) by bulb and dry leaves revealed that application of micronutrients either soil or spray was found significantly superior in respect of Fe, Mn, Zn and Cu uptake by bulb and dry leaves of garlic (Table 3). Significantly, higher uptake of Fe (640 and 1023 g ha^{-1}) and Zn (53 and 48 g ha^{-1}) by bulb and dry leaves were registered with treatment T_8 (micronutrients application as per STV), respectively, followed by Fe (591 and 873g ha^{-1}) and Zn (49 and 42 g ha^{-1}) with T_5 treatment (foliar spray of micronutrients mixture Grade IV @ 1.0 % at 60, 75 and 90 days after sowing as compared to control. While application of multi-micronutrient formulation grade IV resulted in significantly higher uptake of Mn (30.4and 84 g ha^{-1}) and Cu (34.2 and 85 g ha^{-1}) by bulb and dry leaves, respectively, followed by Mn (27.5 and 69 g ha^{-1}) and Cu (31.4 and 83 g ha^{-1}) by bulb and dry leaves with treatment T_8 (application of micronutrients as per soil test value $FeSO_4$ @ 15kg ha^{-1} and $ZnSO_4$ 8 kg ha^{-1}), as compared to control (T_1). These both the treatment were at par with each other but significantly superior over control. The lowest uptake of Fe, Mn, Zn and Cu (424, 19.7, 31, and 22 g ha^{-1}) by bulb and (630, 55, 28 and 61 g ha^{-1}) by dry leaves were registered with control treatment (T_1), respectively. The improvement in the nutrients use efficiency could be attributed to an enhancement in absorption and assimilation of the micronutrients which provided balanced nutrition to the crops for higher growth and thereby nutrients uptake which ultimately resulted into higher yield of the crops. The increase in content of micronutrients and their uptake by garlic crop due to use of multi-micronutrients fertilizers have also been reported by El Sayed *et al*., (2015) [3] and El-Tohamy *et al*. (2009) [2] in garlic and Hamid and Mohsen (2013) [4] in tomato crop.

Table 3: Effect of multi-micronutrient formulations on micronutrients uptake by garlic bulb and dry leaves (pooled)

Treatments	Micronutrients uptake (g ha^{-1})							
	Bulb				Dry leaves			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
T_1. Control	424	19.7	31	22.0	630	55	28	61
T_2. Grade I	472	22.9	40	27.7	693	65	36	74
T_3. Grade II	499	25.7	43	31.6	777	68	41	79
T_4. Grade III	537	27.1	41	30.1	838	74	38	76
T_5. Grade IV	591	30.4	49	34.2	873	84	42	85
T_6. Grade V @ 20 kg ha^{-1}	492	24.5	38	27.8	725	71	37	73
T_7. Grade V @ 40 kg ha^{-1}	586	26.6	42	27.5	865	76	41	77
T_8. As per STV	640	27.5	53	31.4	1023	69	48	83
SEm ±	26	1.2	2	1.2	31	3	2	3
C.D. at 5%	73.6	3.3	6	3.5	87	8	5	7
C.V. %	13.7	12.9	13.4	11.8	10.8	11.3	12.0	9.5

Soil available micronutrients nutrients

The results revealed that the soil application of micronutrients significantly enhanced the DTPA extractable Fe, Zn, Mn and Cu in soil after harvest of crop (Table 4). The application of micronutrients as per soil test value(T_8) significantly increased the availability of Fe and Zn (14.7 and 0.922 mg kg^{-1}) and application of multi micronutrient formulation grade V @ 40 kg ha^{-1} significantly increased the availability of Mn and Cu (24.9 and 2.93mg kg^{-1}) in soil after harvest of garlic crop, respectively over control. The foliar application of multi-micronutrients treatments did not produced significant effect of soil available micronutrients in soils after harvest of crop. In general, the average contents of DTPA-extractable micronutrients of the soil improved due to application of multi-micronutrients through soil application at the end of the experiment. However, the improvement in DTPA-micronutrients was not that alarming to adversely affect the soil health. The results are in conformity with the findings of Patel *et al.*, (2008) [7].

Table 4: Effect of multi-micronutrient formulations on micronutrients availability in soil after harvest of garlic (pooled)

Treatments	Soil available micronutrients (mg kg^{-1})			
	Fe	Mn	Zn	Cu
T_1. Control	10.5	19.1	0.735	1.96
T_2. Grade I	11.1	18.9	0.786	2.17
T_3. Grade II	11.2	20.1	0.767	2.15
T_4. Grade III	10.1	20.7	0.757	2.19
T_5. Grade IV	10.1	19.4	0.765	2.22
T_6. Grade V @ 20 kg ha^{-1}	12.6	22.6	0.862	2.73
T_7. Grade V @ 40 kg ha^{-1}	13.6	24.9	0.896	2.93
T_8. As per STV	14.7	19.6	0.922	1.97
SEm ±	0.4	0.7	0.027	0.12
C.D. at 5%	1.1	2.1	0.078	0.40
C.V. %	9.5	10.0	9.6	9.5

Economic

The results showed (Table 5) that the application micronutrients as per soil test value (T_8) gave highest yield (6237 kg ha^{-1}), net income of Rs. 3,48,073/- and cost benefit ratio of 3.31 followed bysoil application of multi-micronutrients Grade-V @ 40 kg ha^{-1} (T_7) and multi-micronutrient formulation Grade IV foliar spray of 1.0% (T_5). Therefore, use of foliar spray of grade-IV, soil application of multi-micronutrients grade V, and soil application as per STV of micronutrients were found almost equally beneficial in obtaining higher garlic yield and net realization. The increased in garlic bulb yield was by 1156, 750 and722 kg ha^{-1} due to STV, grade -V and grade-IV, respectively, over control (5081 kg ha^{-1}). The same can be recommended to the farmers for getting higher garlic yield.

Table 5: Economics of different treatments on garlic yield

	Treatment	Garlic bulb yield (kg/ha)	Income from bulb (Rs/ha)	Cost of cultivation (Rs/ha)	Net realization (Rs/ha)	B:C ratio
1	T_1. Control	5081	406471	150000	256471	2.71
2	T_2. Grade I	5289	423101	150964	272137	2.80
3	T_3. Grade II	5520	441599	151059	290540	2.92
4	T_4. Grade III	5558	444670	151052	293617	2.94
5	T_5. Grade IV	5803	464243	151084	313159	3.07
6	T_6. Grade V @ 20 kg ha-1	5315	425214	150467	274747	2.83
7	T_7. Grade V @ 40 kg ha-1	5831	466445	150934	315511	3.09
8	T_8. As per STV	6237	498923	150850	348073	3.31

Price Considered

Garlic bulb Rs. 8000/q $FeSO_4$ Rs. 30/kg $MnSO_4$ Rs. 70/kg $ZnSO_4$ Rs.50/kg
$CuSO_4$ Rs. 75/kg Boric acid Rs. 100/kg Gypsum Rs. 4/kg

Conclusion

The results of the study suggested that the garlic yields increased due to soil application of $FeSO_4$ @ 15 kg ha^{-1} and $ZnSO_4$ @ 8 kg ha^{-1} as per soil test value (STV), and also foliar treatment *i.e.* micronutrient mixture grade-IV (for Fe and Zn deficiency).There is a scope for the use of the mixture of multi-micronutrients to overcome the ever-increasing multi-micronutrient deficiencies in the areas where intensive cropping is practiced. However, other micronutrients need to be supplied in an appropriate proportion in order to provide balanced nutrition to the crop.

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