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Effect of Multi-Micronutrients Fertilizers on Yield and Micronutrients Uptake by Okra *(Abelmoschus esculentus* L.) Grown on 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 2012-2015 (Three Years) to study the efficacy of multi-micronutrients formulation mixture fertilizers in improving crop production of okra. The results revealed that the mean green pod(12363 kg ha^{-1}),stalk (5056 kg ha^{-1})and drypod (1114 kg ha^{-1})yields increased significantly due to soil application of $FeSO_4$ @ 15 kg ha^{-1} and $ZnSO_4$ @ 8 kg ha^{-1} as per soil test value (STV),follow by foliar multi-micronutrients supplementation through 1.0% spray of multi-micronutrients mixture having Fe-4.0%, Mn-0.1%, Zn-5.0%, Cu-0.5% and B-0.5 % grade-IV(T_5-For Zn and Fe deficiency) at 45,60 and 75 days after sowing (DAS).Significantly higher value of internode length (8.2 cm), fruit length (13.6 cm), No of fruits per plant (19.9), plant height (129 cm), fruit girth (6.1 cm) and fruit weight (15.9 g) were also recorded with soil application of $FeSO_4$ @ 15 kg/ha^{-1} and $ZnSO_4$ @ 8 kg/ha^{-1} as per soil test value (STV).These both the treatment was statistically at par with each other but significantly superior over control. The soil application of multi-micronutrients mixture as per STV or foliar spray 1.0% grade -IV were found beneficial and economical in increasing okra yield.

Key words: *Okra, Fiber, Micronutrients, Vegetable, Fruit*

INTRODUCTION

Okra [*Abelmoschus esculents* (L.) Moench] is one of the most important vegetable crop grown in tropical and sub-tropical region and is said to be native of South Africa and Asia. In India, it is cultivated almost in all states throughout the year and consumed by bulk of the people. Major okra growing states in India are Andhra Pradesh, West Bengal, Uttar Pradesh, Gujarat, Bihar and Orissa. The total area under okra crop in India is about 5, 33,000 ha with production of 63, 46,000 metric tons with productivity 11.90 metric tons per hectare.

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In Gujarat it is grown on an area about 65,990 ha with production of 7, 59,000 metric tons with productivity 11.50 metric tonsper hectare in year 2013-14[1].Okra is considered by many as a super vegetable with a lot of nutrition and medicinal benefits. It is rich in nutrients, soluble fiber, vitamin B_6 and folic acid. Soluble fiber helps to reduce serum cholesterol, thus reducing the risk of heart disease. Fiber also helps in stabilizing blood sugar[2]. Wide spread deficiencies of micronutrients are frequently reported in soils of India[12] and in Gujarat[7]. 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. Zinc, Fe and B deficiency is one of the most frequently encountered micronutrient deficiencies in vegetables. Reports indicated that Zn and Fe deficiency causes remarkable losses in yields of vegetables and these deficiencies warrants the need for research on Zn and Fe especially on their usage individually and in mixtures as foliar/soil application. Hence, the present investigation was undertaken to study the effect of different multi-micronutrient mixtures on yield and micronutrients content and uptake by okra.

MATERIALS AND METHODS

A field experiment was conducted consecutive three years (2013-2015)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 efficacy of multi-micronutrient mixture in improving crop production of okra (cv. GJO-3)). 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 @ 20kgha^{-1}), T_7 - mixture Grade-V (Soil application @ 40kgha^{-1}) and T_8 - soil application of micronutrients as per Soil Test Value (STV- FeSO4@ 15 kgha-1 and ZnSO4). The multi-micronutrient mixture grades having composition shown as under were prepared in the laboratory.

Chemical composition of local formulation grade approved by Govt. of Gujarat

Sr. 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 % and Soil application T_6 - @ 20 kgha^{-1},and T_7-@ 40 kg ha^{-1}and T_8-soil application of micronutrients as per soil test values ($FeSO_4$ @ 15 kg ha^{-1} and Zn SO_4 @ 8 kg ha^{-1}).The treatments were repeated four in randomized block design. The soil of the experimental field was clayey in texture(*Typic Hplustepts*) and had $pH_{2.5}$- 8.1, $EC_{2.5}$ - 0.36dS m^{-1}, Organic Carbon - 6.56 g kg^{-1}, available P_2O_5 - 41.0 kg ha^{-1}, available K_2O - 386 kgha^{-1}, available S-17.5 kg ha^{-1} ,Fe - 9.6 mg kg^{-1}, Mn - 16.4 mg kg^{-1}, Zn - 0.58 mg kg^{-1} and Cu - 2.84

mg kg^{-1}. The recommendation dose of 150 kg Nha^{-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. Okra 'GJO-3 was sown in rows, 60 x 30 cm. apart using 10 kg seeds ha^{-1} in fourth week of June during all the three years. Total rainfall received during crop season was 1520.3, 1271.5 and 765.4 mm.in 62, 40 and 28 rainy days during 2013, 2014 and 2015, respectively.All the standard recommended cultural practices and plant protection measures were followed throughout the experimental periods.The crop was harvested at first and second week of October during all the three years and green fruit, stalk yields, growth and yields attributes were recorded. The green fruits and stalk samples were oven dry at 60^{o}C for 48 hour in oven. The oven dried fruits and stalk samples were finely ground in a S. S. Wiley mill and were digested with di-acid mixture of HNO3 : $HClO_4$ (3:1) as per the procedure outline by Jackson[5]. Sulphurin digest determined by turbidimetric method[3]. The micronutrients in digest was determined by Atomic Absorption spectrophotometer[13]. 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 and sulphur removal by crop was calculated by multiplying the concentration values. Data were statistically analyzed using following standard method.

RESULTS AND DISCUSSION

Yield

The application of micronutrients soil or foliar spray significantly influenced yield and yield attributing characters of okra. The green pod and stalk yields of okra improved dueto foliar and soil application of micronutrients mixture in all three years as well as in pooled basis. The significantly higher green fruit (11678, 14554, 10856 and 12363 kg ha^{-1}), stalk (4600, 5733, 4836 and 5056 kg ha^{-1}) and dry pod (993, 1237, 1113 and 1114 kg ha^{-1}) yields were recorded with application of micro nutrients as per soil test value (T_8) in all three years as well as in pooled basis, respectively. (Table 1 and 2) and which was statistically at par with treatment T_5 (foliar spray of 1.0 % of multi-micronutrient formulation Grade IV at 45,60 and 75 days after sowing -DAS) in all three years and in pooled basis. The magnitude of increased in green fruit yield and stalk yields were 23.4 and 27.0 % and 18.5 and 21.7 % owing to soil application of FeSO4 @15$kgha^{-1}$ + ZnSO4 @ 8 $kgha^{-1}$ (STV-T_8) and Micronutrients mixture grade -IV(T_5) spray @ 1.0 % at 45,60 and 75 days after sowing (DAS),respectively, over control.The results clearly indicated that application of micronutrients either through soil or foliar spray wasfound beneficial for increase in the yield of okra. Increased yield of okra due to micronutrients application may be attributed to enhanced photosynthesis activity and increased in production and accumulation of carbohydrates and favorable effect on vegetative growth, and retention of flowers and fruits. Satpute*et al*.[8] revealed that the increased dry matter production may be attributed to greater accumulation of photosynthates by vegetative parts and fruits in okra. The finding are in agreement with those reported by Singh *et al.*[10] in okra crop.

Growth and yields attributes

The three year mean data in table 3 revealed that the significantly higher growth and yields attributes Viz., plant height (129 cm), internode length (8.2 cm), fruit length (13.6 cm), No of fruits per plant (19.9), fruit girth (6.1 cm) and fruit weight (15.9 g) were recorded with treatment T_8 (Application of micronutrients as per soil test values of $FeSO_4$ @ 15 $kgha^{-1}$ and ZnSO4 @ 8 $kgha^{-1}$) and this treatment was at par with treatment T_5 (Foliar spray of micronutrients mixture Grade IV @1.0 % at 45, 60 and 75 days after sowing - DAS)and treatment T_7 (soil applicationof multi micronutrient mixture @ 40$kgha^{-1}$)in

respect to growth and yields attributes (Table 3). 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 okra. 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. Boron exhibits pronounce effect in improving the yield attribute and yield. It takes part in active photosynthesis, which ultimately helps towards increase in number and weight of fruits. These findings confirms the results reported by Singh and Maurya[11] and Satpute*et al*.

Micronutrients uptake

The perusal of three year mean data on uptake of micronutrients (Fe,Mn,Zn and Cu) by pod and stalk revealed that application of micronutrients either soil or spray was found significantly superior in respect of Fe,Mn,Zn and cu uptake (Table 4).Significantly, the highestuptake of Fe (422 and 5145 g ha^{-1}) and Zn (163 and 735 g ha^{-1}) by pod and stalk were registered with treatment T_8 (micronutrients application as per STV), respectively, followedby Fe (199 and 4859g ha^{-1}) and Zn(146 and 636 g ha^{-1}) with T_5 treatment (foliar spray of micronutrients mixture Grade IV @1.0 % at 45, 60 and 75 days after sowing -DAS) as compared to control. While application of multi micronutrient formulation grade IV resulted in significantly the highest uptake of Cu (25.8 and 101 g ha^{-1}) and Mn (68.4 and 953 g ha^{-1}) by pod and stalk, respectively, followed by Mn (61.7 and 607 g ha^{-1}) and Cu (21.1 and 88 g ha^{-1}) by pod and stalk 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).The lowest uptake of Fe, Mn, Zn and Cu (282,45.9,86 and 16.1 g ha^{-1}) by pod and (3279,454,321 and 70 g ha^{-1}) by stalk 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 okra crop due to use of multi-micronutrients fertilizers have also been reported by several workers[4,6,8,11].

Soil available nutrients

The data given in table 5 revealed that the soil application of micronutrients significantly enhanced the DTPA extractable Fe, Zn, Mn and Cuin soil after harvest of crop. The application of micronutrients as per soil test value(T_8) significantly increased the availability of Fe and Zn (11.3 and 0.828 mg kg^{-1} and application of multi micronutrient formulation grade V @ 40 kg ha^{-1} significantly increased the availability of Mn and Cu (19.3 and 2.46 ppm) in soil after harvest of okra crop, respectively. 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. Similar results was also reported by Patel *et al*[6].

Economic

The mean data of three years given in table 6 revealed that the application micronutrients as per soil test value (T8) gave highest yield (13366 kg ha-1), net income of Rs. 142595/- and cost benefit ratioof 4.33 followed by application multi-micronutrient formulation Grade IV. Application multi-micronutrient formulation Grade IV gave net income Rs. 135101/- and cost benefit ratio of 4.14.Therefore, use of foliar spray of grade-IV and soil application as per STV of micronutrients were found almost equally

beneficial in obtaining higher okra yield and net realization. The increased in okra green pod yield was by 1862 and 2346 kgha-1 due to grade – IV and STV,respectively, over control (10017 kgha-1).The samecan be recommended to the farmers for getting higher okra yield.

Table 1: Effect of multi-micronutrient formulations mixture on okra yield

Treatments	Green pod Yield (kgha^{-1})				Stalk yield (kgha^{-1})			
	2013	**2014**	**2015**	**Pooled**	**2013**	**2014**	**2015**	**Pooled**
T_1. Control	9786	11642	8622	10017	3648	4415	3879	3981
T_2. Grade I	10297	12205	9163	10555	3045	3610	4260	3638
T_3. Grade II	10501	12827	9465	10931	3892	4754	4284	4310
T_4. Grade III	10451	12650	9519	10873	3825	4629	4307	4254
T_5. Grade IV	11460	13908	10268	11879	4467	5324	4746	4846
T_6. Grade V @ 20 kg ha^{-1}	10303	12228	9014	10515	3713	4407	3963	4028
T_7. Grade V @ 40 kg ha^{-1}	10991	13083	9739	11271	3949	4700	4232	4294
T_8. As per STV	11678	14554	10856	12363	4600	5733	4836	5056
SEm ±	398	582	403	271	155	222	143	102
C.D. at 5%	**1170**	**1713**	**1184**	**765**	**456**	**652**	**422**	**288**

Table 2: Effect of multi-micronutrient formulations on dry pod yield of okra

Treatments	Dry pod yield (kgha^{-1})			
	2013	**2014**	**2015**	**Pooled**
T_1. Control	832	990	879	900
T_2. Grade I	875	1037	927	947
T_3. Grade II	893	1090	984	989
T_4. Grade III	888	1075	980	981
T_5. Grade IV	974	1182	1061	1072
T_6. Grade V @ 20 kg ha^{-1}	876	1039	920	945
T_7. Grade V @ 40 kg ha^{-1}	934	1112	994	1013
T_8. As per STV	993	1237	1113	1114
SEm ±	34	49	41	24
C.D. at 5%	**99**	**146**	**121**	**69**

Table 3: Effect of multi-micronutrient formulations on yield attributes of okra (mean data of three years)

Treatments	Plant height (cm)	Internode length (cm)	Fruit length (cm)	No Fruits plant^{-1}	Fruit Girth (cm)	Fruit weight (gm)
T_1. Control	101	7.0	11.8	12.9	5.4	11.7
T_2. Grade I	107	7.9	11.8	13.6	5.2	11.9
T_3. Grade II	121	8.0	12.7	15.3	5.7	14.3
T_4. Grade III	118	8.1	12.0	14.9	5.4	13.8
T_5. Grade IV	123	8.1	13.2	18.6	6.0	15.0
T_6. Grade V @ 20 kg ha^{-1}	110	7.8	12.3	14.6	5.6	13.3
T_7. Grade V @ 40 kg ha^{-1}	118	7.9	13.1	18.1	6.0	14.6
T_8. As per STV	129	8.2	13.6	19.9	6.1	15.9
SEm ±	3	0.2	0.3	0.4	0.1	0.3
C.D. at 5%	**8**	**0.6**	**0.7**	**1.1**	**0.4**	**0.9**

Table 4: Effect of multi micronutrient formulations on nutrients uptake by okra pod (mean data of three years)

Treatments	uptake by pod (gha^{-1})				Uptake by stalk(gha^{-1})			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
T_1. Control	282	45.9	86	16.1	3279	454	321	70
T_2. Grade I	314	54.3	105	19.8	3490	588	394	72
T_3. Grade II	323	57.9	145	22.7	3989	754	618	93
T_4. Grade III	356	61.6	114	21.3	4339	799	474	83
T_5. Grade IV	399	68.4	146	25.8	4857	953	636	101
T_6. Grade V @ 20 kg ha^{-1}	324	54.1	113	19.0	3687	668	479	79
T_7. Grade V @ 40 kg ha^{-1}	378	59.9	143	19.8	4131	740	580	88
T_8. As per STV	422	61.7	163	21.1	5145	607	735	88
SEm ±	13	1.8	4	0.9	121	22	24	3
C.D. at 5%	35.5	5.0	12	2.4	343	61	73	7

Table 5: Effect of multi-micronutrient formulations on micronutrients availability in soil after harvest of okra

Treatments	Soil Available micronutrients (mgka^{-1})			
	Fe	Mn	Zn	Cu
T_1. Control	8.9	14.8	0.584	2.00
T_2. Grade I	9.8	16.4	0.620	2.09
T_3. Grade II	9.7	16.4	0.627	2.10
T_4. Grade III	9.8	16.3	0.637	2.08
T_5. Grade IV	9.7	16.4	0.625	2.10
T_6. Grade V @ 20 kg ha^{-1}	10.1	17.9	0.722	2.32
T_7. Grade V @ 40 kg ha^{-1}	10.3	**19.3**	0.782	**2.46**
T_8. As per STV	**11.3**	15.9	**0.828**	2.07
SEm ±	0.3	0.5	0.018	0.06
C.D. at 5%	**0.8**	**1.5**	**0.050**	**0.16**

Table 6: Economics of different treatments on okra yield

	Treatment	Okra fruit yield (kgha^{-1})	Income from Fruit (Rsha^{-1})	Cost of cultivation (Rsha^{-1})	Net realization (Rsha^{-1})	B:C ratio
1	T_1. Control	10017	150255	42000	108255	3.58
2	T_2. Grade I	10555	158325	42964	115361	3.69
3	T_3. Grade II	10931	163965	43059	120906	3.81
4	T_4. Grade III	10873	163095	43052	120043	3.79
5	T_5. Grade IV	11879	178185	43084	135101	4.14
6	T_6. Grade V @ 20 kg ha-1	10515	157725	42418	115307	3.72
7	T_7. Grade V @ 40 kg ha-1	11271	169065	42836	126229	3.95
8	T_8. As per STV	12363	185445	42850	142595	4.33

CONCLUSION

The results of the study suggested thatthe okra yields increased due to soil application of FeSO4 @ 15 kg ha^{-1} and ZnSO4 @ 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 toovercome the ever-increasing multi-micronutrientdeficiencies in the areas where intensive cropping is practiced. However, other micronutrients need to be supplied in an appropriate proportion in order to providebalanced nutrition to the crop.

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