Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP2: 514-518

N Senthilkumar
Department of Soil Science and Agricultural Chemistry, Annamalai University, Annamalai nagar, Tamil Nadu, India

P Poonkodi
Department of Soil Science and Agricultural Chemistry, Annamalai University, Annamalai nagar, Tamil Nadu, India

P Shanmugaraja
Department of Agricultural Extension, Faculty of Agriculture, Annamalai University, Annamalai nagar, Tamil Nadu, India

Correspondence
N Senthilkumar
Department of Soil Science and Agricultural Chemistry, Annamalai University, Annamalai nagar, Tamil Nadu, India

Response of tomato to iron nutrition in saline soil

N Senthilkumar, P Poonkodi and P Shanmugaraja

Abstract

A field experiment was conducted at Theerthampalayam village, Cuddalore distict on saline soil to study the Response of tomato to iron nutrition in saline soil. The experiment was laid out in Randomized Block Design and replicated three times. The treatments were T_1- RDF + Water spray (Control), T_2- RDF + Soil application $FeSO_4$ 10 kg ha^{-1},T_3- RDF+ Soil application $FeSO_4$ 20 kg ha^{-1}, T_4- RDF + Soil application $FeSO_4$ 30 kg ha^{-1}, T_5- RDF +Foliar spray 0.25 % ($FeSO_4$ 45 & 60 DAT),T_6- RDF + Foliar pray 0.50 % ($FeSO_4$ 45 & 60 DAT), T_7- RDF +Foliar spray 1.0 % ($FeSO_4$ 45 & 60 DAT),T_8- T_2 + Foliar spray 0.25% ($FeSO_4$ 45 & 60 DAT), T_9- T_3+ Foliar spray 0.25% ($FeSO_4$ 45 & 60 DAT) T_{10}- T_4 + Foliar spray 0.25% ($FeSO_4$ 45 & 60 DAT) T_{11}- T_2 + Foliar spray 0.50 % ($FeSO_4$ 45 & 60 DAT), T_{12}- T_3 + Foliar spray 0.50% ($FeSO_4$ 45 & 60 DAT), T_{13}-T_4 + Foliar spray 0.50 % ($FeSO_4$ 45 & 60 DAT) T_{14}- T_2 + Foliar spray 1.0% ($FeSO_4$ 45 & 60 DAT), T_{15} – T_3 + Foliar spray 1.0% ($FeSO_4$ 45 & 60 DAT) and T_{16}- T_4 + Foliar spray 1.0% ($FeSO_4$ 45 & 60 DAT).The results revealed that application of either soil or foliar or combined application of iron significantly influenced the tomato yield, iron uptake and iron use efficiency over control. The tomato yield was higher in combined application of soil and foliar iron compared to their individual applications. The highest tomato yield (365.50 q ha^{-1}) and iron uptake (fruit 1112.65 and stover 897.15 g ha^{-1}) was noticed T_{12} Combined application of soil and foliar iron recorded higher agronomic efficiency and apparent iron recovery compared to their individual applications which explained the highest yield in the best treatment.

Keywords: Micronutrient, growth, yield and saline soil

Introduction

In India 11.7 million ha^{-1} is likely to be affected by salinity and alkalinity problem by 2025. 25 % of ground water used for irrigation is either saline or brackish. 10 million ha^{-1} of land are lost because of salinity caused by irrigation each year. Most salt-affected soils are deficient in N and Zn and are medium to high in K. In order to provide micronutrient to plant in a sustained manner, it is advocated to apply micronutrients in enriched form with organic manures. Soil salinity is considered as one of the major environmental stress which adversely affects plant growth and metabolism resulting in considerable losses in crop productivity. Salinity has affected more than 800 million hectares of land throughout the world which is almost 6% of the world's total land area (Anonymous, 2008) [3]. In arid and semiarid regions, use of low quality water for irrigation, limited rainfall, high evapotranspiration, high temperature and faulty soil management have further contributed to the salinity problem. Apart from naturally existing saline lands, a significant proportion of recently cultivated agricultural land has become saline due to secondary salinity as a result of the human activity. Soil salinity affects plants in two ways viz., high concentrations of salts in the soil make it harder for roots to extract water while high concentrations of salts within the plant become toxic for growth (Munns & Tester, 2008) [12].

To cope with toxic effect of salts, plants develop biochemical and molecular mechanisms which include compartmentalization of ions at cellular and whole-plant level, synthesis of compatible solutes, change in photosynthetic pathway, alteration in membrane structure, induction of antioxidative enzymes and plant hormones (Flowers *et al*., 2010) [7].

Tomato (*Lycopersicom esculentum* L.) is one of the important crop in the world. It occupies an important place in view of its nutritive value, multivarious use and tops the list of processed vegetables. Tomato is an important mineral, protein and vitamin rich vegetable crop which plays a vital role in Indian economy by virtue of its various modes of consumption in human diet. India is the world second largest producer of vegetables next to china. The present production of vegetable has to be raised to 250 million tonnes by 2025. Although production is almost doubled during the last three decades, the technology used and practices adopted are predominantly traditional. This results in low productivity and poor quality of vegetables are considered as productive supplementary of food as they contain large quantities of minerals, vitamins and essential amino acids, which are required for normal functioning of the human metabolic process. Though we have attained food security through enhancement of cereal production the much needed nutrition security can be achieved only through fruits and vegetables and hence, there is an imperative need to double the production from its present levels so as to meet the per capita supply of 210 g per day.

In India, it is grown in an area of 6.1 lakh hectares with an annual production of about 8.0 million tonnes (FAO, 2013) [5] and in Tamilnadu, it is grown in an area of 0.46 lakh hectare with an annual production of 0.36 million tonnes (Namasivayam, 2014) [13]. The average productivity of tomato in India is only 17.5 t ha^{-1} which is very low as compared to the world average production of tomato (25 t ha^{-1}). For increasing the high quality and quantity it needs to apply high amount of fertilizers, it leads to affect the soil parameters and affect the soil health. In recent years, adoption of high yielding varieties and use of high analysis NPK fertilizers led to decline in the micronutrient status in soil to below normal at which productivity of crops cannot be sustained (Kumar and Babel, 2011) [9]. Velu *et al*. (2008) [16] reported that 67 per cent of the soils of Cuddalore district were deficient in available Zinc (Zn) which needed attention towards Zn management in crops. Copper (Cu) and Iron (Fe) were deficient to the extent of 4 and 26 per cent respectively. Hence, it is an imperative need to develop a technology which improves the yield of crop without affecting the quality of produces as well as soil health. In Tamil Nadu about 57 and 44 per cent of total area is deficient in Zn and B respectively. Growing of tomato in such nutrient deficient soil is also one of the reasons for low productivity.

In India Salt affected soils are found in 2.95 million hectare. In Tamil Nadu it is 13,231 ha. Saline soil defined as soil having a conductivity of the saturation extract greater than 4 dS m^{-1} and exchangeable sodium percentage less than 15. pH is usually less than 8.5, Formerly these soils were called white alkali soil because of surface crust of white salts. Osmotic pressure is high enough to prevent absorption of moisture and plant nutrients from such soils. (Mioli Mandal *et al.*, 2009) [10]. The results are quite encouraging, present investigation was carried out to achieve the yield and quality of tomato in salt affected soil.

Materials and Methods

A field experiment was conducted during 2011 at Theerthampalayam village, Cuddalore District, Tamil Nadu with tomato cv., PKM-1. The experimental soil was sandy loam with a pH of 8.41, EC of 4.02 dS m^{-1} and CEC of 15.20 cmol (p^+) kg^{-1}. The available nitrogen, phosphorus and potassium content were 216, 9 and 150.7 kg ha^{-1} respectively. The available zinc and boron contents were 0.67 and 0.29 mg kg^{-1}. The exchangeable calcium, magnesium, potassium and sodium contents were 5.3, 2.9, 3.2 and 3.8 cmol (p^+) kg^{-1} respectively. The treatments consisted of application of different levels and foliar spray with micronutrients. The treatments were T_1- RDF + Water spray (Control), T_2- RDF +Soil application $FeSO_4$ 10 kg ha^{-1},T_3- RDF+ Soil application $FeSO_4$ 20 kg ha^{-1}, T_4- RDF + Soil application $FeSO_4$ 30 kg ha^{-1}, T_5- RDF +Foliar spray 0.25 % ($FeSO_4$ 45 & 60 DAT),T_6- RDF + Foliar pray 0.50 % ($FeSO_4$ 45 & 60 DAT), T_7- RDF +Foliar spray 1.0 % ($FeSO_4$ 45 & 60 DAT),T_8- T_2 +Foliar spray 0.25% ($FeSO_4$ 45 & 60 DAT),T_9- T_3+ Foliar spray 0.25% ($FeSO_4$ 45 & 60 DAT) T_{10}- T_4 + Foliar spray 0.25% ($FeSO_4$ 45 & 60 DAT) T_{11}- T_2 + Foliar spray 0.50 % ($FeSO_4$ 45 & 60 DAT), T_{12}- T_3 + Foliar spray 0.50% ($FeSO_4$ 45 & 60 DAT), T_{13}-T_4 + Foliar spray 0.50 % ($FeSO_4$ 45 & 60 DAT) T_{14}- T_2 + Foliar spray 1.0% ($FeSO_4$ 45 & 60 DAT) T_{15} – T_3 + Foliar spray 1.0% ($FeSO_4$ 45 & 60 DAT) and T_{16}- T_4 + Foliar spray 1.0% ($FeSO_4$ 45 & 60 DAT).The experiment was laid out in Randomized Block Design (RBD) and replicated three times. The recommended dose of fertilizers *viz.*, 150:100:50 kg N: P_2O_5: K_2O ha^{-1} was applied uniformly to all plots. The growth attributes *viz.*, plant height was recorded on 45 and 60 days after transplanting. The number of branches was recorded 45 days after transplanting, number of flowers was recorded 65 days after transplanting and number of fruits was recorded 65 days after transplanting. The stover and fruit yield were recorded at harvest. Ascorbic acid and total soluble solid content were also estimated in the fruits at harvest stage. The nutrient uptake *viz.*, N, P, K, and Fe by plant, stover and fruit at harvest were computed from the dry matter production recorded and the stover and fruit yield and their nutrient contents (N, P, K and Fe). The available nutrient status of the post-harvest soil was also analyzed. As every kind of economic activity - by definition - should be concerned with efficiency, it is small wonder that nutrient efficiency is one of the key issues in farming and fertilization. Efficiency is defined as the amount of product produced per unit of resource used. Two types of efficiency are classified by Craswell and Godwin (1984) [8]:

Agronomic Efficiency = the Enomic Production Obtained Per Unit of Nutrient Applied

Calculation: Expressed in kg kg-1, g g-1

$$\text{Agronomic Efficiency} = \frac{\text{Yield of fertilized crop - Yield of unfert. crop}}{\text{Quantity of fertilizer applied}}$$

Apparent recovery efficiency = Quantity of nutrient taken up per unit of nutrient applied

$$\text{APPARENT RECOVERY EFFICIENCY} = \frac{\text{NUTRIENT UPTAKE OF FERT. CROP - NUTRIENT UPTAKE UNFERT. CROP}}{\text{QUANTITY OF FERTILIZER APPLIED}} \times 100 = \%$$

The above soil and plant sample was collected periodically and analysis for standard procedures and experimental data were processed statistical analysis followed.

Results and Discussion

The present investigation was under taken to find out the studies on methods of application of iron on tomato yield, iron uptake and iron use efficiency in a saline soil on growth components, yield attributes, yield and quality (Table-2).

Physico – chemical properties of initial soil

The initial soil collected from the experimental field was analysed for the physico – chemical properties and the results are furnished in Table 1.

The soil of Theerthampalayam Village was found to contain 48.9, 22.4 and 27.9 per cent sand, silt and clay respectively and come under the textural class sandy loam. The bulk density, Particle density, pore space, pH, electrical conductivity and contain exchange capacity of the soil were 1.20, 2.03 Mg m^{-3}, 45.0 per cent and 8.41, 4.02 dS m^{-1} and 15.20 cmol (p^+) kg^{-1} respectively. The organic carbon content of soil was 6.8 g kg^{-1}. The available N, P and K content of soil was 216.0, 9.0 and 150.7 kg ha^{-1} respectively. The available sulphur content was 12.5 mg kg^{-1}. The exchangeable Calcium, Magnesium, Potassium and Sodium content were 5.3, 2.9, 3.2 and 3.8 cmol (p^+) kg^{-1} respectively. The available Micronutrients Zn, Fe, Mn, Cu and B content of Soil was 0.67, 1.45, 1.67, 0.24 and 0.29 mg kg^{-1} respectively.

Table 1: Physico – Chemical Properties of initial soil

I	Physical Properties	Contents
	Mechanical analysis	
a)	Sand (%)	48.90
	Silt (%)	22.40
	Clay (%)	27.90
	Textural Class	Sandy Loan
	Bulk density(Mg m^{-3})	1.20
	Particle density(Mg m^{-3})	2.03
	Pore Space (%)	45.0
II	**Physico-Chemical properties**	
1)	pH	8.41
2)	EC (dS m^{-1})	4.02
3)	Organic Carbon(g kg^{-1})	6.80
4)	CEC cmol (p^+) kg^{-1}	15.20
5)	**Available Macronutrients**	
I	Alkaline $KMnO_4$ (kg ha^{-1})	216.0
Ii	Olsen's-p (kg ha^{-1})	9.0
Iii	NH_40AC- K (kg ha^{-1})	150.70
Iv	Available Sulphur (mg kg^{-1})	12.50
6)	**Available micro nutrients**	
A	DTPA – Zn (mg kg $^{-1}$)	0.67
B	DTPA – Fe (mg kg^{-1})	1.45
C	DTPA – Mn (mg kg^{-1})	1.67
D	DTPA – Cu (mg kg^{-1})	0.24
E	Hot Water – B (mg kg^{-1})	0.29
7)	**Exchangeable Cations**	
A	Ca cmol (p^+) kg^{-1}	5.30
B	Mg cmol (p^+) kg^{-1}	2.90
C	Na cmol (p^+) kg^{-1}	3.80
D	K cmol (p^+) kg^{-1}	3.20

Growth Characters

Among the different treatments tried, The recommended dose of fertilizers with $FeSO_4$ micronutrient fertilizer for different methods, levels of soil application, foliar spray and combination of soil and foliar spray. From the experiments was find out optimized dose.

Among the traitements, The soil application of RDF+ $FeSo_4$ 20 kg ha^{-1} + 0.50% $FeSO_4$ F.S on 45 and 60 DAT (T_{12}) significantly increased the growth components *viz.*, Plant height (45 and 60 DAT), number of branches (45 DAT) and number of flowers $plant^{-1}$ (60 DAT) respectively. Regarding the growth attributes, the best treatment was T_{12} (RDF+Soil application of $FeSO_4$ 20 kg ha^{-1} + 0.50% $FeSO_4$ as F.S on 45 and 60 DAT). The highest plant height 68.20 and 76.70 cm on 45 and 60 DAT, Number of branches $plant^{-1}$ of 10.2 was recorded at 45 DAT and number of flowers $plant^{-1}$ of 41.63 was recorded at 60 DAT respectively in the same treatment.

Yield and quality

Among the different treatments tried, soil application of $FeSO_4$ 20 kg ha^{-1} + 0.50% $FeSO_4$ as F.S on 45 and 60 DAT (T_{12}) significantly increased the yield attributes *viz.*, number of fruits $plant^{-1}$, single fruit weight, TSS (%), ascorbic acid content (mg 100 g^{-1}), fruit yield and Stover yield. Soil application of 20 kg ha^{-1} + 0.50% $FeSO_4$ as F.S on 45 and 60 DAT (T_{12}) registered maximum number of fruits $plant^{-1}$ 30.89, single fruit weight of 48.11gm on 60 DAT, 5.18 per cent and 26.92 mg 100 g^{-1} fruit respectively. The maximum fruit yield of 365.50 q ha^{-1} and Stover yield of 2335.00 kg ha^{-1} was recorded in the treatment $T_{12.}$ This was followed by T_{13} soil application of $FeSO_4$ 30 kg ha^{-1} + 0.50% Fe_2So_4 as F.S on 45 and 60 DAT.

Nutrient use efficiency

Among the different treatments tried, soil application of $FeSO_4$ 20 kg ha^{-1} + 0.50% $FeSO_4$ as F.S on 45 and 60 DAT (T_{12}) significantly increased nutrient uptake and nutrient use efficiency *viz.*, fruit and Stover iron uptake g ha^{-1}, agronomic efficiency % and apparent iron recovery %. Soil application of 20 kg ha^{-1} + 0.50% $FeSO_4$ as F.S on 45 and 60 DAT (T_{12}) registered highest iron uptake (fruit 1112.65 and stover 897.15 g ha-^{1}) was noticed $T_{12.}$ Combined application of soil and foliar iron recorded higher agronomic efficiency 51.28 % and apparent iron recovery (fruit 12.63 and stover 10.97 %) compared to their individual applications which explained the highest yield in the best treatment.

One approach is the use of foliar spraying for increasing plant tolerance to salinity by alleviating Na and Cl injury to plants (Alpaslan *et al.*, 1999; El-Fouly *et al.*, 2010) [2, 4]. The effect of micronutrient elements on yield and crop performance has been reported by many investigators. Rehm and Albert (2006) [14] reported that, yields were higher for the treatments with micronutrients. In this respect, they reported that, foliar sprays of ferrous sulphate or chelates are found to be more effective and efficient than soil application in correcting Fe-chlorosis in wheat. Micronutrients spraying led to increasing macro and micronutrients uptake as a result of improving root growth which consequently led to greater absorbing surface (Abdalla *et al*., 1992) [1]. The most important use of foliar sprays has been in the application of micronutrients. In foliar sprays, macronutrient concentrations of generally less than 2% are used to avoid leaf burning. Macronutrient solution concentrations vary from 0.1 to 1.2% depending on the nutrient. Plant age should also be considered in selecting nutrient concentration. Older plants are more tolerant to higher concentrations of salts compared to younger plants. In foliar fertilization, droplet size and fertilizer solubility should be carefully controlled since it will affect crop response. Foliar fertilization in food crops may not increase yield but may increase protein content of grains, if applied during anthesis or flowering. Foliar fertilization cannot substitute for soil application. It is simply a nutrient corrective technique in crops during growth cycle when soil application is ineffective due to immobilization of soil applied nutrients or cost or methods of application are prohibitive (Fageria *et al.*, 2009) [6].

Thiruppathi *et al.* (2001) [15] announced that the foliar application and fertilization. In these ways the absorption of nitrogen, phosphorus, potassium, harvest index, yield components and seed yield in sesame increased. This experiment was conducted to study the effect of salinity and foliar application of iron and zinc on yield and some traits of Ajowan. The foliar applications of iron and zinc could lead to some positive effect on yield and yield components (Mohammadreza Ramezani *et al*., 2012) [11].

Table 2: Effect of different levels and method of soil application $FeSO_4$ and foliar spray on growth, yield and quality in tomato crop.

Treatments	Plant height (cm)		Number of branches plant^{-1}	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Single fruit weight (g)	Fruit yield (q ha^{-1})	Dry matter production (kg ha^{-1})	TSS (%)	Ascorbic acid (mg 100 g^{-1})	% over control
	45 DAT	60 DAT									
T_1	35.7	40.5	5.5	29.52	13.35	33.30	150.10	1992.0	2.05	19.25	
T_2	42.2	50.3	5.7	31.25	15.91	36.59	182.70	1175.0	2.20	20.46	21.73
T_3	48.7	55.7	6.3	33.96	17.68	38.12	213.40	1296.0	2.40	21.65	42.17
T_4	46.5	54.4	5.9	32.82	15.55	37.47	196.50	1180.0	2.35	21.48	30.91
T_5	52.6	58.6	7.0	34.10	20.71	41.22	230.50	1356.0	2.67	22.89	53.61
T_6	55.9	62.3	7.5	35.65	22.68	42.75	252.60	1585.0	3.20	23.75	68.28
T_7	53.4	61.5	7.2	35.25	21.82	42.50	246.70	1420.0	2.95	23.50	64.33
T_8	61.7	64.6	8.2	36.51	23.47	43.30	269.50	1645.0	3.57	24.22	79.56
T_9	63.4	67.9	8.5	37.30	25.67	45.62	282.32	1779.0	4.12	24.86	88.08
T_{10}	62.8	67.2	8.4	36.86	24.56	44.24	275.50	1710.0	3.98	24.40	83.58
T_{11}	66.7	73.2	10.1	40.12	27.75	47.20	325.40	2150.0	4.98	26.30	116.80
T_{12}	**68.2**	**76.7**	**10.2**	**41.63**	**30.89**	**48.11**	**365.50**	**2335.0**	**5.18**	**26.92**	**143.50**
T_{13}	67.5	75.5	10.1	40.92	28.84	47.60	334.20	2222.0	5.10	26.35	122.65
T_{14}	65.6	67.4	9.1	38.20	24.75	46.12	290.40	1810.0	4.50	25.67	93.47
T_{15}	66.1	70.8	9.4	39.29	26.47	46.97	315.60	1940.0	4.75	26.14	110.26
T_{16}	65.8	70.3	9.3	38.54	25.89	46.30	305.70	1862.0	4.60	25.98	103.66
SEd	1.69	1.90	0.25	1.03	0.77	1.18	9.10	52.2	0.11	0.66	
CD (p = 0.05)	3.40	3.81	0.50	2.06	1.54	2.36	18.20	104.4	0.22	1.33	

Table 3: Effect of different levels and method of soil application $FeSO_4$ and foliar spray on nutrient uptake, agronomic efficiency and apparent Fe recovery efficiency on tomato crop.

Treatments	Fruit yield (q ha^{-1})	Agronomic Efficiency (%)	Iron Uptake by Fruit (g ha^{-1})	Apparent iron Recovery efficiency (%)	Iron Uptake by Stover (g ha^{-1})	Apparent iron Recovery efficiency (%)
T_1	150.10		582.01		436.27	
T_2	182.70	16.35	653.16	3.55	524.10	4.39
T_3	213.40	15.82	819.29	5.93	575.25	3.47
T_4	196.50	7.73	784.42	3.37	563.19	2.11
T_5	230.50	-	841.40	-	610.43	-
T_6	252.60	-	896.12	-	638.16	-
T_7	246.70	-	867.56	-	626.58	-
T_8	269.50	56.85	911.14	15.67	651.12	10.23
T_9	282.32	32.24	962.43	9.27	705.32	6.56
T_{10}	275.50	20.55	937.22	5.82	683.28	4.04
T_{11}	325.40	79.68	1085.30	22.87	812.32	17.09
T_{12}	**365.50**	**51.28**	**1112.65**	**12.63**	**897.15**	**10.97**
T_{13}	334.20	29.69	1100.25	8.35	854.27	6.74
T_{14}	290.40	58.45	984.15	16.75	725.14	12.03
T_{15}	315.60	37.61	1024.24	10.05	786.25	7.95
T_{16}	305.70	24.31	996.46	6.47	742.13	4.77
SEd	9.10	-	17.81	-	12.42	-
CD (p = 0.05)	18.20	-	35.62	-	24.85	-

Conclusion

The finally concluded field experiment was conducted with tomato crop to optimize the dose and method of application of iron, it was concluded that the optimum dose and method of application of iron to tomato crop was application of RDF +20 kg of $FeSO_4$ per hectare as soil application along with application of 0.50% $FeSO_4$ as foliar spray on 45 and 60 DAT (T_{12}) significantly increased growth, yield, nutrient uptake, and agronomic efficiency, apparent iron recovery of tomato crop in saline soil.

Referances

1. Abdalla FE, Zeinab MM, El-Sayed AA. Effect of micronutrients foliar application on uptake of macronutrients by wheat and faba bean. Afr. J Agric. Sci. 1992; 19(1):181-192.
2. Alpaslan M, Inal A, Gunes A, Cikili V, Ozcan H. Effect of zinc treatment on the alleviation of sodium and chloride injury in tomato (*Lycopersicum esculentum* (L.) Mill. cv. Lale) grown under salinity. Turk. J Bot. 1999; 23(1):1-6.
3. Anonymous. FAO land and plant nutrition management service, 2008. http://www.fao.org/ag/agl/agll/spush.
4. El-Fouly MM, Mobarak ZM, Salama ZA. Improving tolerance of faba bean during early growth stages to salinity through micronutrients foliar spray. Not. Sci. Biol. 2010; 2:98-102.
5. FAO. Quarterly bulletin of statistics. Food and organization of United Nations, 2013.
6. Fageria NK, Barbosa MP, Filho Moreira A, Guimaraes CM. Foliar Fertilization of Crop Plants. Journal of Plant Nutrition. 2009; 32:1044-1064.

7. Flowers TJ, Gaur PM, Laxmipathi Gowda CL, Krishnamurthy L, Samineni S, Siddique KHM *et al.* Salt sensitivity in chickpea. Plant, Cell & Environ. 2010; 33:490-509.
8. Craswell ET, Godwin DC. The efficiency of nitrogen fertilizers applied to cereals in different climates. Adv. Plant Nutr. 1984; 1:1-55.
9. Kumar M, Babel AL. Available micronutrient status and their relationship with soil properties of Jhunjhunu tehsil, Jhunjhunu, Rajasthan. Indian. J Agric. Sci. 2011; 3:97-106.
10. Mioli Mandal, Niwar Ranjan Roy, Dabarihis Mazumdar, Dilip kumar Das. Effect of different sources of boron on its maintenance in soil in relation to rape, *Arch. of Agron. and Soil Sci.* 2009; 4:247-253.
11. Mohammadreza Ramezani, Mohammadjavad Seghatoleslami, Gholamreza Mousavi, Mohammad Hassan Sayyari-Zahan. Effect of salinity and foliar application of iron and zinc on yield and water use efficiency of Ajowan (*Carum copticum*). International Journal of Agriculture and Crop Sciences. 2012; 4(7):421-426.
12. Munns R, Tester M. Mechanism of salinity tolerance. *Annl. Rev. Plant Biol.* 2008; 59:651-681.
13. Namasivayam N. Production of tomato. Kissanworld, 2014, 56-60.
14. Rehm G, Albert S. Micronutrients and Production of Hard Red Spring Wheat. Minnesota Crop News, 2006, 1-3.
15. Thiruppathi MK, Thanunathan K, Prakashand M, Imayavaramban V. Use of biofertilizer, phytohormone and zinc as a cost effective agro technique for increasing sesame productivity. Sesame and Safflower Newsletter. 2001; 16:46-50
16. Velu V, Mathew Usha, Baskar A. Scenario of micro and secondary nutrient deficiencies in the states of Tamil Nadu, Kerala and Pondicherry and amelioration practices for increasing crop production and ensuring food security. Paper presented in the National seminar on Micro and Secondary Nutrients for Balanced Fertilization and Food Security. March 11-12, AAU, Anand, Gujarat, 2008.