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Fate of micronutrients in post-harvest soil of grated tomato

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Abstract
Micronutrients are required in small quantity but their role is very crucial in crop production. Their deficiency or toxicity results with loss of yield and quality. A pot culture experiment was conducted in Central Horticultural Experiment Station (Aiginia), Bhubaneswar. To study the micronutrients status in post-harvest soil of grafted tomato by using organic and inorganic nutrients in incremental and decremental proportions. The experimental results revealed that micronutrient status of the post-harvest soil was decreased in the organic treatments and showed more availability in incremental proportion of inorganic treatments. Over all the micronutrient status of the soil was decreased after the crop harvest.

Keywords: Grafted tomato, organic and inorganic nutrients, micronutrients, post-harvest soil.

Introduction
Tomato (*Solanum lycopersicon*) is one of the widely grown vegetable and most important food crops in India. It is rich in minerals, essential amino acids, sugars and dietary fibres. It also contains more vitamin B and C, iron, lycopene and phosphorus (Bagal *et al*., 1989). It is a rich source of minerals, vitamins and organic acids. It provides 3-4 per cent total sugar, 4-7 per cent total solids, 15-30 mg/100g ascorbic acid, 7.5-10 mg/100ml titratable acidity and 20-50 mg of lycopene per 100 g fruit. Tomato is a heavy feeder of nutrients.
Micronutrients play vital role in plant growth, production and quality of produce through their participation in metabolic process, biochemical reactions and increase in the utility o major and secondary nutrient in plants. Micronutrient availability in the rhizosphere is controlled by soil and plant properties, and interactions of roots with microorganisms and the surrounding soil. Plants exude a variety of organic compounds (carboxylate anions, phenolics, carbohydrates, amino acids, enzymes, etc.) and inorganic ions (protons, phosphate, etc.) to change chemistry and biology of the rhizosphere and increase micronutrient availability. Increased availability may result from solubilization and mobilization by short-chain organic acid anions, amino acids and other low-molecular-weight organic compounds. Acidification of the rhizosphere soil increases mobilization of micronutrients and at a same time increase in soil pH results in reduce in micronutrient status of soil.

Material Method
The experiment was conducted in Central Horticultural Experiment Station (Aiginia), Bhubaneswar with Grafted Tomato (BT-10 grafted on brinjal var. Utkal Anushree), Non-Grafted Tomato and Self-Grafted Tomato (BT-10 grafted on BT-10), during 2017-18 in a Completely Randomized Design with six treatments with Grafting interaction and each treatment was replicated thrice. Each ploy bag was filled with 15 kg soil. Initial physico-chemical properties of soil were analyzed before transplanting of tomato crop. The experimental soil was sandy loam texture (77.5 % sand + 11.0 % silt + 11.5 % clay), pHw (1:2.5)- 4.33, EC (dS m^{-1})- 0.04, Organic Carbon (g kg^{-1})- 3.4, Lime requirement ($CaCO_3$t ha^{-1})- 6.72, Cation exchange capacity -17.12 (c mol (p+) kg^{-1}), Available N (kg ha^{-1})-296 (medium), Available P (kg ha^{-1})-3.92 (low), Available k (kg ha^{-1})-157 (medium), Available S (kg ha^{-1})-2.9 (low), Calcium (c mol (p+) kg^{-1} soil)-2.3 (Adequate), Magnesium (c mol (p+) kg^{-1} soil)-1.8, Fe (mg kg^{-1} soil)- 18.2 (Adequate), Mn (mg kg^{-1} soil)- 4.4 (Adequate), Cu (mg kg^{-1} soil)- 1.25 (Adequate), Zn (mg kg^{-1} soil)- 1.61 (Adequate). Micronutrient analysis was done by DTPA method (Lindsay and Norvell1978) as described by Page *et al*, 1982. The vermicompost was analyzed before the application to tomato crop. The Moisture content (%) - 14.6, Organic carbon (%)- 9.3, C:N- 9.5:1, N (%)- 0.97, P_2O_5 (%)- 0.26, K_2O (%)- 0.26, Ca (%)- 0.64, Mg (%)-0.60, S (%)- 0.13, B (%)- 0.0016, Fe (%)- 1.13, Mn (%)- 1.33, Cu (%)- 0.014, Zn- (%)- 0.009.

Treatment details

T_1 (Absolute Control), T_2 (100 % inorganic nitrogen), T_3 (75 % inorganic nitrogen + 25 % organic nitrogen), T_4 (50 % inorganic nitrogen + 50 % organic nitrogen), T_5 (25 % inorganic nitrogen + 75 % organic nitrogen), T_6 (100 % organic nitrogen). Sources of Nutrients applied are Urea, SSP, MOP & Vermicompost.

Nursery raising and grafting

Before grafting, scion and rootstock were exposed to sunshine for three days. Two crop varieties *viz*. Tomato- Utkal Kumari (BT-10) and Brinjal-Utkal Anushree were sown in the protrys. In Grafted Tomato Utkal Kumari (BT-10) scion were grafted onto the Utkal Anushree (brinjal var.) rootstock using "side grafting" and in Self Grafted Tomato Utkal Kumari (BT-10) scion were grafted onto the Utkal Kumari (BT-10) rootstock using "side grafting". Non-grafted seedlings were used directly. Grafting was carried out at 2-3 leaf stage (20-25 days) of scion seedlings and 3-4 leaf stage (55-60 days) of root stock. Grafting was made with similar thickness of scion and root stock which was cut at 45^0 and joined by using plastic clips and carried out in a moist chamber. The grafted plants were transplanted after thirty-five days after sowing.

Statistical analysis

The experimental data pertaining to chemical properties of soil were recorded, compiled in appropriate tables and analyzed statistically as per the procedure appropriate to the design (Panse and Sukhatme, 1978) and Gomez and Gomez (1976). All the data were statistically analyzed by two-factorial CRD ANOVA.

Results and Discussion

Available Fe in soil (mg kg^{-1} soil)

The available Fe status at the beginning of crop was 18.2 mg kg^{-1} soil. It was adequate in soil. T_2 showed highest Fe availability in post-harvest soil (8.4 mg kg^{-1} soil) and lowest in control (Table-1). The Fe availability was decreased in incremental proportion of organic in the treatments. Increase in soil pH favour conversion of plant-available Fe^{2+}ions into non-available (non-toxic) Fe^{3+} (Genon *et al*., 1994) (Rengel, 2002b; Khabaz-Saberi and Rengel, 2010).

Available Mn in soil (mg kg^{-1} soil)

The available Mn status at the beginning of crop was 4.4 mg kg^{-1}soil. It was adequate in soil. T_2 showed highest Mn availability in post-harvest soil (4.03 mg kg^{-1} soil) and lowest in control (Table-1). The Mn availability was decreased in incremental proportion of organic in the treatments. At higher pH in soils where reducing conditions of Mn prevail (Rengel, 2000; Porter *et al*., 2004; Khabaz-Saberi and Rengel, 2010). Where as in case of Mn toxicity, redox potential is more important than just pH (Rengel, 2000).

Available Cu in soil (mg kg^{-1} soil)

The available Cu status at the beginning of crop was 1.25 mg kg^{-1}soil. It was adequate in soil. T_2 showed highest Fe availability in post-harvest soil (0.67 mg kg^{-1} soil) and lowest in control (Table-2). The Cu availability was decreased in incremental proportion of organic in the treatments. Each unit change in pH in soil decrease the Cu availability 100 folds in soil.

Table-1: Influence of INM practices on Availability of Fe and Mn in post-harvest soil

Treatment	Available Fe (mg kg^{-1} soil)				Available Mn (mg kg^{-1} soil)			
	BGT	NGT	SGT	Mean T	BGT	NGT	SGT	Mean T
T_1 (control)	10.1	8.2	4.1	7.4	2.36	2.85	2.7	2.64
T_2 (100 % I.N)	9.2	10.6	5.6	8.4	4.42	3.70	3.98	4.03
T_3 (75 % I.N + 25 % O.N)	8.1	11.6	5.1	8.2	4.25	3.47	3.75	3.82
T_4(50 % I.N + 50 % O.N)	9.8	7.2	7.6	8.2	3.20	4.09	3.66	3.65
T_5 (25 % I.N + 75 % O.N)	8.8	7.9	7.6	8.1	2.64	3.16	4.84	3.54
T_6 (100 % O.N)	9.0	8.7	6.1	8.0	3.34	2.86	4.29	3.50
Mean B	9.1	9.1	5.8		3.37	3.36	3.87	
	T	B	TXB		T	B	TXB	
SE(m) (±)	0.06	0.04	0.10		0.01	0.01	0.02	
C. D. (0.05)	0.16	0.11	0.28		0.04	0.03	0.07	

Available Zn in soil (mg kg^{-1} soil)

The available Zn status at the beginning of crop was 1.61 mg kg^{-1}soil. It was adequate in soil. The DTPA zinc in post-harvest soil decreased and in many cases gone below the deficiency rang. T_2 showed highest Zn availability in post-harvest soil (8.4 mg kg^{-1} soil) and lowest in control (Table-2). The Zn availability was decreased in incremental proportion of organic in the treatments. Increasing soil pH, especially above 6.5, results in decreased extractability and plant availability of soil Zn. Soil Zn is usually more available in soils with greater organic matter content (Iratkar *et al*., 2014) and a relatively higher proportion of clay (Rengel, 2002a; Alloway, 2009) but the present experimental soil is not enough of organic and clay content. In contrast, Zn extractability from soil is negatively related to phosphate (Yang *et al*., 2011) and calcium carbonate content in soil (Iratkar *et al*., 2014). Therefore, low plant availability of Zn can be expected in calcareous soils (high pH).

Table-2: Influence of INM practices on Availability of Cu and Zn in post-harvest soil

Treatment	Available Cu (mg kg^{-1} soil)				Available Zn (mg kg^{-1} soil)			
	BGT	NGT	SGT	Mean T	BGT	NGT	SGT	Mean T
T_1 (control)	0.51	0.54	0.16	0.40	0.48	0.49	0.44	0.47
T_2 (100 % I.N)	0.83	0.52	0.67	0.67	0.52	0.51	0.65	0.56
T_3 (75 % I.N + 25 % O.N)	0.61	0.80	0.56	0.65	0.62	0.47	0.47	0.52
T_4(50 % I.N + 50 % O.N)	0.58	0.71	0.62	0.63	0.46	0.58	0.50	0.52
T_5 (25 % I.N + 75 % O.N)	0.70	0.69	0.39	0.60	0.49	0.45	0.60	0.51

T_6 (100 % O.N)	0.64	0.68	0.17	0.50	0.38	0.60	0.47	0.48
Mean B	0.64	0.65	0.43		0.49	0.52	0.52	
	T	B	TXB		T	B	TXB	
SE(m) (±)	0.003	0.002	0.005		0.004	0.003	0.007	
C. D. (0.05)	0.01	0.01	0.02		0.01	0.01	0.02	

Soil pH has a dominant effect on solubility and therefore availability and potential phytotoxicity of ions (nutrients as well as toxic elements) (Clark and Baligar, 2000). Whereas low pH shifts the equilibrium toward free metal cations and protonated anions, higher pH favours carbonate or hydroxyl complexes. Therefore, availability of the micronutrient and toxic ions present in soil solution as cations (e.g. Al^{3+}, $Mn^{2+}$and Fe^{2+}) increases with increasing soil acidity (Porter *et al*., 2004; Khabaz-Saberi and Rengel, 2010), whereas availability of those present as anions [MoO_4^{2-}, CrO_4^{2-}, SeO_4-, SeO_3- and $B(OH)_4$-] increases with increasing pH (Rengel, 2002b; 2011). Organic matter is a reservoir for essential plant nutrients, continuously supplying these nutrients to the crop as it decomposes over time. Soils that receive regular additions of organic residues such as manures rarely show micronutrient deficiencies. An exception is deficiencies caused by nutrient imbalances, such as a deficiency of manganese caused by an excess of phosphorus in overly manured soils. Another exception is soils of extremely high organic matter such as muck or peat soils. In these soils, strong, natural chelation (the combination of a micronutrient with an organic molecule) can make some micronutrients unavailable, particularly copper, manganese and zinc (E. Truog. 1946).

Conclusions

Micronutrient availability in the rhizosphere soil is influenced by the complex microbe-plant-micronutrient interactions. The studies of these interactions will improve our understanding of the rhizosphere effects influencing growth and nutrition of plants in the environments with availability of micronutrients (Fe, Mn, Cu and Zn). This knowledge will allow integration of abiotic (soil chemistry pH, EC etc.) and biotic factors (plants, microorganisms, etc.) into dynamic agricultural ecosystems that will underpin production of crops with improved micronutrient nutrition as a cornerstone of sustainable agriculture.

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