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Research Article

Uptake of Micronutrients and Heavy Metals by Tomato Plants Treated with Gray Water

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Abstract

Water scarcity can be regard as a major thread in near future, which rises along with increasing population that makes bad impact in the field of agriculture, that force to search for alternative options. Taking care of this view a field experiment was taken on "Uptake of micronutrients and heavy metals by tomato plants treated with gray water" during the Rabi season of 2017 at RPCAU, Pusa, Bihar. Total of 7 treatments taken where gray water and fresh water applied in different proportions. The uptake of micronutrients like zinc, iron, manganese and copper were recorded highest viz. 249.3 g ha^{-1}, 2896.7 g ha^{-1}, 144.3 g ha^{-1} and 308.0 g kg^{-1} respectively in 50% grey water along with 50% fresh water treated plants. Whereas, 100% grey water applied plants shows higher heavy metal (lead and chromium) concentrations i.e. 26.5 mg kg^{-1} and 4.13 mg kg^{-1} respectively, though nickel and cadmium were not detectable in plant. Use of gray water along with fresh water can help to conserve freshwater sources as well as provide micronutrients to crop.

Keywords: Gray water, Micronutrient, Heavy metal, Tomato Plant

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Introduction

Water available per person is decreasing rapidly along with the population growth. The use of water for irrigation in the agricultural proposes accounts to 80% of the global water intake and is considered as limiting factor in crop production in several countries [1]. In this situation agricultural countries like India needs to focus more urgently for alternative options to solve water scarcity. Among the various methods for use of water sources, recycling of grey water for crop husbandry can be considered as one of the innovative method. It can be taken as social upliftment as well as reduce impacts on environment by saving waste water in that region. Grey water includes all waste water produced in household by various actions. Grey water is rich source of nutrients and can be a good option for irrigation. Ground water is depleting in very faster rate, moreover many Indian states are dry.

Gray water not only a good source of major nutrients like phosphorous, potassium and nitrogen but also contains micro nutrients like zinc (Zn), iron (Fe), manganese (Mn), copper (Cu) which also essential for a better crop production. Gray water contains heavy metals like lead (Pb), chromium 9Cr), nickel (Ni) etc. These heavy metals are hazardous to human health. Another environment risks causing due to reuse of grey water is that of ground water pollution. So the soil, water and produce crop must be analyze to get the nutrients and heavy metal contents on it. Keeping in all these view plant uptake of micronutrients and heavy metals are studied.

Material and Methods

In this experiment conducted during Rabi season of 2017 under AICRP on Integrated Water Management at Crop Research Center, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, situated at 25°31' N latitude, 85°-39' E longitude and 52.2 meter above sea level, in tropical sub-humid climate. The soil is under order entisol and texture is sandy loam with alkaline pH. The experimental soil was low in organic carbon but medium in available NPK while very high in $CaCO_3$ content (**Table 1**). Available micronutrients (Fe, Mn, Cu and Zn) were extracted from the plant sample using Diethylene Triamine Penta Acetic Acid (DTPA) solution (0.005 M DTPA + 0.1 M TEA + 0.01 M $CaCl_2$; pH 7.3) in ratio of 1:2 and shaken for two hours [2]. The available micronutrients were determined in the clear aliquot with the help of Atomic Absorption Spectrophotometer. Dried 0.5 g plant samples were digested in diacid mixture prepared by mixing concentrated HNO_3 and $HClO_4$ in the ratio of 9:4 for analysis of the micronutrients and heavy metals. The nutrient uptake by plants was calculated by using the following formula:

Uptake of nutrients (gha^{-1}) = Concentration (mg/kg) x Yield (ton/ha)

The experiment was laid out in a Randomized Block Design (RBD) in three replications by taking different proportion of fresh water and grey water for irrigation, seven different treatments were: T_1= 100% fresh water, T_2= 75% fresh water + 25% grey water, T_3= 50% fresh water + 50% grey water, T_4= 25% fresh water +75% grey water, T_5= 100% grey water, T_6= Alternate irrigation by fresh and grey water, T_7 = Two irrigation by fresh water followed by one grey water. Seed rate was 350 g/ha and N, P, K applied 120, 80, 80 respectively. For control of late blight in tomato Mancozeb @ 2g/liter was applied and Imidachlorpid @ 1ml/liter was applied for control of curling of leaf in tomato.

Table 1 General physio-chemical properties of soil before growing crop

Properties	Value
Sand (%)	59.12
Silt (%)	27.71
Clay (%)	13.86
Textural class	Sandy loam
Bulk density (g/cc)	1.29-1.59
pH (1:2)	8.4
EC (dS m^{-1})	0.16
Organic carbon (g kg^{-1})	3.61
Available N (kg ha^{-1})	316.7
Available P (kg ha^{-1})	121.2
Available K (kg ha^{-1})	133.4
Free $CaCO_3$ (%)	44.07
Available S (ppm)	6.71
Available B (ppm)	0.31
Available Fe (mg kg^{-1})	36.9
Available Mn (mg kg^{-1})	9.58
Available Cu (mg kg^{-1})	2.79
Available Zn (mg kg^{-1})	0.26

Result and Discussion

Uptake of micronutrients by tomato plants

Uptake of Zinc

The uptake of Zn by tomato crop under different irrigation treatment ranged 24 to 249.3 g ha^{-1} is presented in **Table 2**. The highest Zn uptake 249.3 g ha^{-1} was recorded in tomato plants receiving 50 % grey water along with 50 % fresh water (T_3) followed by 150 g ha^{-1} (T_4) which were also significantly higher over control. This might be due to the fact the favorable pH of the soil at which uptake by the plants will made to the greater extent. Long-term use of reclaimed water can lead to salt and metal accumulation in the soil and subsequent uptake of micronutrients by the plants [3]. Some crops have the potential to maintain the same levels of nutritious elements, such as Zn, when they were irrigated with either grey water or potable water. Similarly, it has been observed that barley and vegetable crops produced better response to Zn grown in grey water applied soil as reported by Rusan et al [4] and Eriksson et al [5].

Table 2 Uptake of micro nutrient by tomato crop

Treatments	Iron (g ha^{-1})	Manganese (g ha^{-1})	Cupper(g ha^{-1})	Zinc(g ha^{-1})
T_1	1510.0	85.0	170	103.7
T_2	1516.7	90	186	127.3
T_3	2896.7	144.3	308	249.3
T_4	2213.3	126.3	235	150.0
T_5	801.3	58.7	36	67.0
T_6	673.7	38.6	86	36.0
T_7	514.0	29.6	38	24.0
SE(m) ±	67.1	5.64	0.010	8.9
CD (P = 0.05)	208.9	17.57	0.030	27.9
CV	8.031	11.95	10.756	14.323

Uptake of Iron

The uptake of iron by tomato crop ranged between 514.0 to 2896.7 g ha^{-1} in grey water treated soils (Table 2). The data revealed that T_3 showed significantly higher Fe uptake 2896.7 (g ha^{-1}) followed by T_4 as compare to the other treatments. T_5 and T_6 has recorded higher iron uptake of plant compare to T_7 but, not significantly higher. Lowest value of Fe uptake was recorded in T_7 .The findings obtained by Hamaiedeh and Bino prove that long-term use of reclaimed water can lead to salt and metal accumulation in the soil and subsequent uptake of micro-nutrients by the plants [3].

Uptake of Manganese

The uptake of manganese by tomato crop in grey water treated soils varied from 29.6 and 144.3 g ha^{-1} are presented Table 2. The perusal of the data indicated that T_3 and T_4 have significantly higher manganese uptake over control. T_3 recorded highest uptake of Mn (144.3 g $ha^{-1)}$ followed by T_4 (126 g ha^{-1}) and lowest by T_7 (29.6 g ha^{-1}). The lowest uptake of Mn in two irrigations by fresh water followed by one grey water. Grey water treated soils might be due to metal accumulation in the soil and subsequent uptake of Mn by the plants.

Uptake of Copper

The uptake of copper by tomato crop ranged from 36 to 308 g ha^{-1} (Table 2). The uptake of Cu was found to be significantly higher in T_3 (308 g ha^{-1}) followed by T_4 (0.235 g ha^{-1}) over control. However, perusal of the data indicated that tomato crop irrigated with 50 % grey water + 50 % ground water and 75 % grey water +25 % ground water were found superior to all other treatments. This might be due to the fact that such combination of irrigation with grey and fresh water may provide the optimum translocation of these micronutrients to tomato plants due to higher solubility of these cations.

Concentration of heavy metal cations in tomato plants

The concentration of heavy metal cations in plants were analysed and found that only two heavy metals like Pb and Cr were recorded where Cd and Ni were found traces are presented in (**Table 3**).

Table 3 Heavy metals concentration in plants

Treatments	**P b (mg kg^{-1})**	**Cr (mg kg^{-1})**	**Ni**	**Cd**
T_1	12.1	1.30	Trace	Trace
T_2	13.9	1.70	Trace	Trace
T_3	18.5	2.06	Trace	Trace
T_4	20.7	2.93	Trace	Trace
T_5	26.5	4.13	Trace	Trace
T_6	18.4	2.73	Trace	Trace
T_7	17.0	2.33	Trace	Trace
SE(m) ±	1.01	0.24		
CD (P = 0.05)	3.16	0.76		
CV	9.67	17.17		

Concentration of Lead

The concentration of Lead in tomato crop under different treatment ranged 17.03 and 26.50 mgl^{-1} T_5, T_4, T_3, T_7 has significantly higher lead compare to T_1. T_5 recorded highest lead among all the treatments followed by $T_{4,}$ $T_{3,}$ T_7, $T_{5,}$ T_6 and $T_{7.}$ This suggests that the area has been constantly exposed to certain health hazardous metals. More attention is recommended, even though at this time a wastewater treatment plant has been built and partly treated water is used to irrigate the crops [6]. Heavy metals such as lead are commonly found in contaminated soils [7]. Considering heavy metals such as lead (Pb) measurements show little increase in the uptake by plants, since their concentration was low in treated grey water and soil [3]. Lead concentration is more common in grey water applied vegetables [5].

Concentration of Chromium

The chromium of plant concentration of tomato crop under different treatment ranged from 1.30 and 4.13(mgl^{-1}). T_5, T_4, T_6, T_3 has significantly higher lead compare to T_1. T_5 recorded highest cr among all the treatments followed by $T_{4,}$

$T_{6,}$ T_3, $T_{7,}$ T_3 and $T_{2.}$ It suggests that is an important variable and that it can influence the mobility of metals in those areas where high concentrations, coincide with constant irrigation. Considering heavy metals such as chromium (Cr), measurements show little increase in the uptake by plants, since their concentration was low in treated grey water and soil [3].

Nickel and Cadmium (Plant concentration of tomato crop)

The Plant concentration of nickel and Cadmium was not detectable. Considering heavy metals such as Nickel (Ni) measurements show little increase in the uptake by plants, since their concentration was low in treated grey water and soil [3].

Uptake of Lead

The uptake of lead of tomato crop in grey water treated soils under varied from 30.7 to 122.7 g ha^{-1} is presented (**Table 4**). The perusal of the data indicated that T_4, T_3 and T_5 have significantly higher lead uptake over control. T_4 recorded highest uptake of lead 122.7 g ha^{-1} followed by T_3 (122.7 g ha^{-1} and lowest by $T_{7.}$ (30.7g ha^{-1}). This might be the fact that such combination of irrigation with grey and fresh water may provide the optimum translocation of these Pb to tomato plants due to higher solubility of these cations [3].

Table 4 Uptake of heavy metal by tomato crop (g ha^{-1})

Treatments	P b	Cr	Ni	Cd
T_1	58.3	6.1	Trace	Trace
T_2	65.0	8.6	Trace	Trace
T_3	111.0	13.2	Trace	Trace
T_4	122.7	19.1	Trace	Trace
T_5	104.3	16.5	Trace	Trace
T_6	39.7	25.6	Trace	Trace
T_7	30.7	4.0	Trace	Trace
SE(m) ±	4.3	7.3		
CD (P = 0.05)	13.5	N/A		
CV	9.881	95.202		

Uptake of Chromium

The uptake of chromium by tomato crop ranged from 90 to 13 g ha^{-1} (Table 4). Perusal of the data indicated that tomato crop irrigated with alternatively grey water and ground water were found superior to all other treatments. This might be due to metal accumulation in the soil and subsequent uptake of chromium by the plants [6].

Conclusion

Tomato plant uptakes significantly higher micronutrients in gray water treated soil than fresh water irrigated soil. These shows grey water is efficient source of these micro nutrients and can be applied to meet micronutrient demands in areas where water scarcity is a major problem. Among the treatments soil irrigated with 50% fresh water with 50% grey water shows significantly higher micronutrients uptake, however heavy metal concentrations as well as heavy metal uptake was found higher in plants irrigated with gray water than plants irrigated with fresh water. From this experiment it’s easy to conclude that application of gray water with fresh water can be taken as a good alternative to reuse water which helps to reduce depend on freshwater resources, on other hand it supplies micronutrients.

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