International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 5, No. 2, p. 175-182, 2014

RESEARCH PAPER OPEN ACCESS

Study of the effects of compost and nitrogen on concentrations of nutrients in citrange seedlings

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Key words: Compost, nitrogen, nutrients, citrange.

http://dx.doi.org/10.12692/ijb/5.2.175-182 Article published on July 28, 2014

Abstract

A one-year factorial experiment using the randomized complete block design with three replications was carried out to study the effects of compost and nitrogen on the concentrations of nutrients in citrange seedlings. The treatments included various levels of the organic matter compost (zero, 2.5, 5, and 7.5%) and different levels of pure nitrogen from ammonium sulfate (zero, 20, 40, and 80 mg/kg soil). In all, 48 treatments were applied on citrange stocks. Comparison of mean squares for the effects of compost and nitrogen fertilizer on micronutrients showed that these effects were significant on potassium and manganese at the five percent probability level (and on iron, zinc, and copper at the one percent probability level), but were not significant on elements such as nitrogen, phosphorous, or magnesium, in citrange rootstocks. The maximum nitrogen and potassium concentrations in citrange leaves (2.90 and 1.83%, respectively) were achieved in the treatment of applying 7.5% compost with no nitrogen fertilizer. The highest phosphorous concentration in citrange leaves (0.80%) was observed in the treatment of applying 2.5% compost with no nitrogen fertilizer. The maximum potassium concentration in citrange leaves in the treatment of applying 7.5% compost and 40 mg/kg nitrogen was 0.74%. The highest iron and zinc concentrations in citrange leaves (201.4 mg/kg and 16.32 mg/kg, respectively) were achieved by the application of 2.5% compost and 40 mg/kg of the nitrogen fertilizer. The maximum potassium concentration in citrange leaves by applying 7.5% compost and 80 mg/kg of the nitrogen fertilizer was 32.35 mg/kg.The highest copper concentration in citrange leaves by the application of 5% compost with no nitrogen fertilizer was 15.24 mg/kg.

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Introduction

Citrus is commercially grown in about 49 countries in tropical and subtropical regions. Iran is also one of the countries suitable for citrus production. It has made great progress in growing and producing citrus in the past four decades, and is ranked seventh in acreage under citrus production and the sixth in citrus fruit production in the world (Singh and Naqvi, 2002). Chemical fertilizers are considered as one of the main factors in maintaining soil fertility, but their excessive use, together with unsuitable management practices including burning stubble, has severely reduced soil organic matter content. This has influenced soil physical, chemical, and biological characteristics and increased the danger of erosion (Davari and Haghnia, 2004). Fertility of agricultural and horticultural soils is regularly enhanced by applying chemical fertilizers, large quantities of lime, and (animal or plant) organic fertilizers too. Organic fertilizers generally have positive effects on agricultural crops used by man (Jordan *et al.*, 2002). The process of making compost by utilizing and fixating waste through employing composting earthworms is a simple and nature-friendly technology for producing organic fertilizer (Jeabel, 2001). Plants need nitrogen most during flowering and fruit set; therefore, spraying nitrogen has more effects on plant nutrition than its application to the soil. In most cases, nutritional sprays are carried out during spring and, in some cases, during summer (Chang and RonWall, 2004; Morgan *et al.*, 2006). In the short run, application of higher rates of nitrogen and zinc can play an important part in reducing toxicity (Malakooti and Rastegari, 1998; Swietlik, 1995). In recent years, conducting studies with the purpose of finding combinations of stock and scion resistant to iron chlorosis has been one of the important research strategies in preventing this nutritional problem (Moreno *et al.*, 1996). Although macrophylla stock absorbs more iron compared to sour orange stock, stocks in citrus usually have less effect on iron absorption compared to scions. For example, it was observed that of the two lemon varieties Primofiori and Verna that were both grafted on macrophylla stock, the Primofiori variety contained more iron (Carpena-Artes *et al.*, 1995). Among orange varieties grafted on the same stock, the Washington Navel variety is the most resistant with regard to iron chlorosis. On the other hand, orange varieties on the same stock showed fewer visible symptoms of iron chlorosis compared to lemons, although leaf iron contents were the same and (even lower in orange varieties compared to lemon varieties). Pointing to extensive chlorosis resulting from iron deficiency in calcareous soils and the pronounced resultant reduction in yield, Jolley *et al.* said applying chemical fertilizers was not cost effective and a more logical solution was to introduce varieties that were more resistant to iron deficiency-caused chlorosis (Jolley *et al.*, 1996). The macrophylla stock is the most resistant stock to iron chlorosis for lemon varieties while, based on visual indices of iron chlorosis, the volkameriana stock is the superior stock for orange varieties with regard to iron deficiency, and is more resistant to this deficiency than Cleopatra mandarin stock (Moreno *et al.*, 1996). Compost increases leaf potassium content. Organic fertilizers contain elements including potassium and, since they have a negative surface charge, release potassium fixated in the soil, increase its retention capability and, hence, increase potassium absorption by plant roots (Alipoor and Hosseinifard, 2003). Considering that citrus ranks second in fruit production in Iran, attention to its nutrition, and to nutrients it contains, is of special importance. This experiment was conducted with the purpose of studying the effects of compost and nitrogen on micronutrients (Fe, Zn, Cu, and Mn) and on macronutrients (N, P, K, and Mg) in citrange seedlings.

Materials and methods

Design of Experiments

A factorial experiment using the randomized complete block design with three replications was conducted in the Horticultural Research Center of Ghaemshahr in 2011-2012 to study the effects of compost on sour orange, citrange, and citromello stocks. The treatments included various levels of compost (zero, 2.5, 5, and 7.5%) made from waste materials at the Wood and Paper Industry Factory of

Mazandaran Province and different levels of pure nitrogen obtained from ammonium sulfate (zero, 20, 40, and 80 mg/kg of soil).

Soil Sampling

Soil samples were taken from several places in the Research Center and their organic carbon contents were measured. The sample containing the least organic carbon was selected for soil analysis, was gently ground in the laboratory, passed through a 2-millimeter mesh sieve, and its physical and chemical properties such as texture, pH, EC, C.E.C., percentage saturation, and total nitrogen were measured. Seven kilograms of the sieved soil sample were added to each pot. To apply the treatments, the calculated quantities of the compost were added to the soils in the pots, and one-year-old sour orange, citrange, and citromello seedlings, grown under identical conditions and of similar heights, were planted in the pots. Basin irrigation was used to equally irrigate all the pots until they reached field capacity. Nutrients required by the plants (except for nitrogen) were applied based on results of soil analysis.

Methods of measuring nutrient

At the end of the experiment, concentrations of the macroelements N (Rayan *et al.*, 2001), P (Emam, 1996), K (Qupta, 2000; Tandom, 1995), and Mg (Gimenez *et al.*, 1996), and of the micronutrients Fe and Zn (Rod Joyce, and Boskin, 1999), and Mn and Cu (Karunaichamy *et al.*, 1999) in citrange leaves were measured.

Statistical Analysis

MSTATC and EXCEL were used to analyze the collected data and Duncan's multiple test was employed to compare the means.

Results and discussion

Leaf nitrogen concentration

The table of comparison of the means shows that the mutual effects of compost and nitrogen on nitrogen concentration in citrange leaves were not statistically significant. The maximum nitrogen concentration in citrange leaves (2.90%, which was 51.99% more than the control treatment) was achieved in the treatment of applying 7.5% compost without nitrogen fertilizer, and the minimum (1.91%) in the control treatment (in which no compost or nitrogen fertilizer was applied). Results indicated the type of stock influenced concentrations of mineral elements. Other researchers have also proved this point (Bassal, 2009; Giorgio, 2001; Jr *et al.*, 2003). Application of nitrogen fertilizers increases nitrogen concentration in plant leaves, with ammonium sulfate increasing it more than nitrate fertilizers (Roosta *et al.*, 2009). Results of our experiment also revealed that leaf nitrogen concentration rose with the application of ammonium sulfate.

Table 1. Mean squares of micronutrient concentrations as influenced by compost and nitrogen application in scions grafted on citrange stock.

sov	df	Zn	Mn	Cu	Fe	Mg	K	P	N
Compost	3	**209/25	**133/95	*11/5	**19824/01	0/041 ^{ns}	**0/32	*0/006	*0/95
Nitrogen	3	**44/13	4/2 ^{ns}	*17/99	**8668/99	0/033 ^{ns}	**1/81	0/003 ^{ns}	0/38 ^{ns}
Compost×Nitrogen	9	**84/06	*196/5	**94/18	**33689/16	0/061 ^{ns}	*0/93	0/11 ^{ns}	1/5 ^{ns}
Error	32	38/62	289/19	51/09	912/69	0/241	0/14	0/25	2/93
% Cv		10/12	10/91	9/86	5/67	13/93	5/78	14/01	12/32

Ns,*,** :non significant, significant at $p<0.05$ and $p<0.01$, respectivel.

Leaf phosphorous concentration

As the data in Table 1 shows, the mutual effects of compost and nitrogen on phosphorous concentration in citrange leaves were not statistically significant. Comparison of the means indicates that the maximum phosphorous concentration in citrange leaves (0.80%, which was 14.28% more than the control treatment) was observed in the treatment of applying 2.5 percent compost without any nitrogen fertilizer. The minimum phosphorous concentration in citrange leaves (0.17%, which was 75.28% less than the control) belonged to the treatment of applying 80 mg/kg of the nitrogen fertilizer with no compost. In experiments Serna *et al.* (1992) carried out on citrus, it was found that application of ammonium sulfate increased leaf nitrogen concentration more than application of nitrate nitrogen fertilizers. Roosta and Schjoerring J. K. (2007) found similar results in responses of cucumbers to ammonium sulfate.

Leaf potassium concentration

Table 1 shows that the mutual effects of compost and nitrogen on potassium concentration in citrange leaves were statistically significant at the five percent probability level. Comparison of the means indicated that the maximum potassium concentration in citrange leaves (1.83%, which was 40.76% more than the control treatment) was achieved in the treatment of applying 7.5%t compost without any nitrogen fertilizer. The minimum leaf potassium concentration (0.83%, which was 35.7% less than the control treatment) belonged to the treatment of applying 80 mg/kg of the nitrogen fertilizer without any compost. Potassium improves ammonium utilization and reduces its toxic effects, while ammonium prevents potassium absorption (although, contradicting this, there are reports that there are interactions between potassium and ammonium in plants) (Morgan and Jackson, 1989; Wang and Below, 1996). Roosta (1996) reported that ammonium might use the potassium transport system by attaching itself to the potassium transporter (thus changing its structure). There are also reports that suggest there is no competition in the absorption of ammonium and potassium. Serna *et al.* (1992) also, in their experiments on citrus nutrition with ammonium, found that ammonium reduced absorptions of cations like potassium.

Table 2. Comparison of the means of the mutual effects of compost and nitrogen fertilizer on concentrations of micronutrients in citrus grafted on citrange stock.

Levels	Cu	Zn	Mn	Fe	Mg	K	P	N
Compost×Nitrogen	Mg/g				%			
0 × 0	11/54^{e}	8/07^{f}	21/07^{d}	123/6^{bc}	0/61^{abc}	1/3^{cd}	0/7^{c}	1/91^{d}
0×20	14/63^{ab}	10/79^{bcd}	29/04^{abc}	94/05^{e}	0/6^{abc}	1/39^{c}	0/8^{a}	2/25^{bcd}
0 ×40	12/23^{cde}	8/073^{f}	27/69^{abc}	71/01^{fg}	0/56^{bc}	1/04^{fg}	0/19^{bc}	2/63^{abc}
0 × 80	14/61^{ab}	7/87^{f}	25/28^{cd}	65/04^{gh}	0/51^{c}	0/83^{i}	0/17^{bc}	2/35^{abcd}
2/5 × 0	12/67^{bcde}	11/08^{bcd}	31/2^{ab}	89/06^{e}	0/61^{abc}	1/4b^{c}	0/2^{abc}	2/11^{cd}
2/5 ×20	12/56^{bcde}	12/58^{b}	25/04^{cd}	131/5^{b}	0/67^{ab}	0/98^{gh}	0/22^{abc}	2/38^{abcd}
2/5 ×40	14/33^{abc}	16/32^{a}	26/57^{bc}	201/4^{a}	0/63^{abc}	0/89^{hi}	0/21^{abc}	2/62^{abc}
2/5×80	11/34^{e}	9/607^{def}	26/96^{bc}	62/08^{h}	0/62^{abc}	1/21de	0/2^{abc}	2/53^{abc}
5× 0	15/24^{a}	8/17^{f}	27/54^{abc}	62/2^{gh}	0/63^{abc}	1/51^{b}	0/25^{ab}	2/49^{abcd}
5×20	11/74^{e}	10/48^{cde}	26/68^{bc}	64/13^{gh}	0/59^{abc}	0/91^{hi}	0/19^{bc}	2/39^{abcd}
5×40	11/76^{e}	8/93^{ef}	26/26^{bc}	68/29^{gh}	0/72^{ab}	1/12^{df}	0/18^{bc}	2/33^{bcd}
5×80	14/19^{abc}	7/97^{f}	26/66^{bc}	66/64^{gh}	0/64^{abc}	0/98^{gh}	0/2^{abc}	2/37^{ab}
7/5 × 0	13/40^{abcde}	11/59^{bc}	29/23^{abc}	118/9^{c}	0/6^{abc}	1/83^{a}	0/2^{abc}	2/9^{a}
7/5 ×20	14/05^{abcd}	12/49^{b}	30/88^{ab}	77/79^{e}	0/59^{abc}	1/12de	0/22^{ab}	2/35^{abc}
7/5 ×40	8/84^{f}	14/65^{ab}	28/62^{abc}	107/6^{d}	0/74^{a}	1/15^{df}	0/18^{bc}	2/75^{abc}
7/5 ×80	12/02de	14/93^{ab}	32/35^{a}	105/1^{d}	0/59^{abc}	0/09^{fg}	0/18^{bc}	2/7^{abc}

N: Nitrogen, P: Phosphorous, K: Potassium, Mg: Mangnesium, Fe: Iron, Mn: Manganese, Zn: Zinc , Cu: Copper.

Leaf Magnesium Concentration

The data in Table 1 indicates that the mutual effects of compost and nitrogen on magnesium concentration in citrange leaves were not statistically significant. The table of comparison of the means shows that the maximum magnesium concentration in citrange leaves (0.74%, which was 20.71% more than the control treatment) was observed in the treatment of applying 7.5%t compost and 40mg/kg of the nitrogen fertilizer. The minimum magnesium_concentration in citrange leaves (0.51%, which was 15.8 percent less than the control treatment) belonged to the treatment of applying 80mg/kg of the nitrogen fertilizer with no compost. Based on results of previous research (that agree with those of ours), evaluation of Valencia orange trees grafted on sour orange and volkameriana stocks in calcareous soil showed that phosphorous and iron concentrations of leaves of Valencia on these two stocks were significantly higher compared to other stocks. However, it was also observed that the use of sour orange stock in calcareous soils increases magnesium, manganese, and boron contents (Carpena-Artes *et al.*, 1995; Moreno *et al.*, 1996).

Leaf iron content

The data in Table 1 shows that the mutual effects of compost and nitrogen on iron concentration in citrange leaves were statistically significant at the 1% probability level. The table of comparison of the means reveals that the maximum iron concentration in citrange leaves (201.4 mg/kg, which was 62.94% more than the control treatment) was achieved in the treatment of applying 2.5% compost and 40 mg/kg of the nitrogen fertilizer. The minimum iron concentration in citrange leaves (62.08 mg/kg, which was 49.77% less than the control treatment) was observed in the treatment of applying 2.5% compost and 80 mg/kg of the nitrogen fertilizer._Carpena-Artes *et al.* (1995) showed that although, for example, macrophylla stock absorbs more iron compared to sour orange stock, stocks in citrus generally have less effect on absorbing iron compared to scions. Dong *et al.* (2005) found that spraying Washington Navel orange trees with nitrogen during spring caused physiological changes, improved total yield, and increased the number and size of fruit. As for micronutrients also, the concentrations of iron, zinc, and boron in scion leaves on all stocks were at desirable levels, with manganese lower than the desired concentration on lemon stock and copper and chlorine more than the desirable levels on all stocks (Obreza *et al.*, 2002).

Leaf manganese concentration

The data in Table 1 indicates that the mutual effects of compost and nitrogen on manganese concentration in citrange leaves were statistically significant at the 5% probability level. The table of comparison of the means shows that the maximum manganese concentration in citrange leaves (32.34 mg/kg, which was 53.53% more than the control treatment) was observed in the treatment of applying 7.5% compost and 80 mg/kg of the nitrogen fertilizer. The minimum manganese concentration in citrange leaves (21.07 mg/kg) belonged to the control treatment in which compost and the nitrogen fertilizer were not applied. Soils with high levels of organic matter retain only a small portion of manganese by adsorption, and these soils offer little help to plants in absorbing manganese (Salehi, 2006).

Leaf zinc concentration

The data in Table 1 shows that the mutual effects of compost and nitrogen on zinc concentration in citrange leaves were statistically significant at the 1% probability level. The table of comparison of the means indicates that the maximum zinc concentration in citrange leaves (16.32 mg/kg, which was 100% more than the control) was obtained in the treatment of applying 2.5% compost and 40 mg/kg of the nitrogen fertilizer. The minimum zinc concentration in citrange leaves (7.78 mg/kg, which was 3.55% less than the control treatment) belonged to the treatment of applying 80 mg/kg of the nitrogen fertilizer without any compost. In their preliminary studies, Embleton *et al.* (1965) showed that the maximum citrus fruit yield was achieved when the concentrations of zinc and manganese in leaves increased.

Leaf copper concentration

The data in Table 1 shows the mutual effects of compost and nitrogen on copper concentration in citrange leaves were statistically significant at the 1% probability level. The table of comparison of the means indicates the maximum copper concentration in citrange leaves (15.24 mg/kg, which was 32.06% more than the control treatment) was achieved in treatment of applying 5% compost without any nitrogen fertilizer. The minimum copper concentration in citrange leaves (8.84 mg/kg, which was 23.30% less than the control treatment) belonged to the treatment of applying 7.5% compost and 40 mg/kg of the fertilizer. In fertilizers that contain both nitrate and ammoniacal nitrogen fertilizers, the quantity of nitrate nitrogen consumption decreases because of the inhibitory effect of ammonium ions on the nitrate reductase enzyme. Normally, sprayed NH $^{4+}$ is rapidly absorbed; and, when trees are exposed to ammonium ions, they produce more flowers so long as they are continually exposed to nitrates (Marschener, 1995).

Conclusions

In general, comparison of the means showed that the type of stock affected concentrations of macro-and micronutrients in citrange leaves and that, in some cases, these effects were significant. The maximum nitrogen concentration in citrange leaves (2.90%, which was 51.99% more than the control treatment) was achieved in the treatment of applying 7.5 percent compost without any nitrogen fertilizer. The highest phosphorous concentration in citrange leaves (0.80%, which was 14.28% more than the control treatment) was observed in the treatment in which 2.5% compost was applied without any nitrogen fertilizer. The maximum potassium concentration in citrange leaves (1.83%, which was 40.76% more than the control treatment) was obtained with the application of 7.5% compost without any nitrogen fertilizer. Potassium concentration in citrange leaves with the application of 7.5% compost and 40 mg/kg of the nitrogen fertilizer reached 0.74% (which was 20.71% more than the control) and 32.35 mg/kg (53.53% more than the control) when 7.5% compost and 80 mg/kg of the nitrogen fertilizer were applied. The maximum iron concentration in citrange leaves (201.4 mg/kg mg/kg , which was 62.94% more than the control) was observed in the treatment of applying 2.5% compost and 40 mg/kg of the nitrogen fertilizer. The highest zinc concentration in citrange leaves (16.32 mg/kg, which was 100% more than the control) was obtained with the application of 2.5% compost and 40 mg/kg of the nitrogen fertilizer. The maximum copper concentration in citrange leaves (15.24 mg/kg, which was 32.06% more than the control treatment) belonged to the treatment in which 5% compost was applied with no nitrogen fertilizer. The general conclusion was that, despite the effects of stock on absorption of macro- and micronutrients in citrange stock leaves, application of the organic fertilizer and ammonium sulfate, in general, considerably increased citrange yield; and, therefore, it is recommended that these fertilizers be used in citrus orchards.

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