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Influence of compost and chicken manure applications on vegetative growth, nutrient uptake and yield of Balady mandarin trees

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ABSTRACT

This study was carried out during two successive seasons (2013 and 2014) in a private orchard located at Kata district, Giza Governorate, Egypt to evaluate different sources of fertilizers application on Balady mandarin trees vegetative growth, nutrients uptake and its yield. Seven years old trees (*Citrus reticulate Blom Co*) budded on sour orange (*C. aurantium* L.) rootstock, were planted 5 x 6 meters apart in sandy soil under drip irrigation system were used.The experiment was set in a RCBD with five replications per treatment.The experiment included 5 treatments;T1 (RFD Mineral NPK fertilizers), T2 (25% of the RFD form NPK fertilizer + 75% compost), T3 (100% compost), T4 (25% of the RFD form NPK + 75% chicken manure) and T5 (100% chicken manure). The obtained results showed that; the application of compost and chicken manure and its combinations compared with control led to a significantly increased the branches length and leaf numbers/branch compared with mineral NPK (RFD) only. The highest value was detected, as an average of both seasons, on trees fertilized using 100% chicken manure (25.8 cm and 18.95), which represented 1.62 and 1.46 folds on branches length (cm) and leaf numbers/branch, respectively. Moreover, using 100% chicken manure succeeded to increase leaf contents of nutrients in both seasons. Also, a significantly increased was found in fruit weight and yield, the highest fruit weight (133.5g) and the highest yield (64.8 kg/tree) as an average of both seasons at 100% chicken manure. Greatest values of fruit T.S.S (%) at 100% chicken manure (13.7%) followed by 100% compost (12.5%) as an average in both seasons. Lowest fruit total acidity (5.7%), but all treatments did not show any significant differences during the two seasons.

Keywords: Chicken manure, compost, balady mandarin, macronutrients, micronutrients, vegetative characteristics, fruit characteristics, yield.

Introduction

Egypt has a great potential for citrus production and it is the backbone of fruit grown crop when its ecological and other characteristics were considered. Thus, it is ranked in the first position. Total area of mandarin groves amounted to 124663 feddans producing around 936755 Tons (Ministry of Agriculture and Land Reclamation of Egypt, 2013).

About 30% of citrus orchards in Egypt became located on poor soils and newly reclaimed areas. The continuous reduction in fertility of new reclaimed soil led to multiple nutrient deficiencies that cause low tree productivity (El-Shamma *et al*., 2013).

Organic fertilization enhances the physical, chemical and biological properties of all types of sandy soil, adjusting soil pH, increasing soil solubility and plant productivity. Adding organic fertilizers not only increase the organic matter in the soil, but also increase the available phosphorus and the exchangeable potassium, calcium, and the other micro-elements, through its effect on soil pH, encourages proliferation of soil microorganisms, increases microbial population and activity of microbial enzymes (Abou-Hussein *et al.,* 2002).The advent of synthetic chemical fertilizers decreased organic fertilizer use such that it makes up only about 0.1% of all fertilizers applied to citrus today (Srivastava and Malhotra 2014). However, interest in applying organic amendments to citrus is rising because of increased supplies and reduced cost of non-hazardous organic wastes (Srivastava and Singh 2001b, 2001c). Citrus growers apply these materials for perceived or real improvements in soil physical, chemical, and biological properties, but the main benefits appear to be the increased nutrient availability (Srivastava and Ngullie 2009).Furthermore, chicken manure is preferred amongst other animal wastes because of its high concentration of macro-nutrients (Duncan, 2005). For example, Chescheir *et al*. (1986) found increase in nitrogen levels from 40 - 60% and 17 - 38% with respect to control for Norfolk sandy soils and Cecil sandy loam soils, respectively following application of manure. In addition, application of chicken manure to soil enhances concentration of water soluble nutrients in soil. Abdel Rahman *et al*. (2009) indicated that natural minerals compound increased vegetative growth, fruit set, yield, fruit quality and leaf mineral contents on Navel orange trees. Also, it increased yield,

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improved fruit quality, N, P, K and Fe concentrations in both soil and grapevine leaves of Superior and Thompson seedless berries (Ismail *et al*., 2010).

Therefore, the target of this study was to evaluate the ability of different sources of organic fertilizers as complementary or alternative safe resources on leaf mineral content, yield and fruit quality of balady mandarin trees grown in newly reclaimed soil.

Materials and Methods

Field experiments were carried out during two successive seasons (2013 and 2014) on seven years old Balady mandarin trees (*Citrus reticulate Blom Co.*) budded on sour orange (*C. aurantium* L.) rootstock. Mandarin trees were grown in a private orchard located at Kata district Giza Governorate, Egypt. The trees were planted 5 x 6 meters apart in sandy soil under drip irrigation system. The experiment was set in a randomized complete block design with five replications per treatment, one tree each. All trees were almost uniform in vigor and received the conventional accepted practices.

Soil samples were randomly collected in November from the root tips zone of the under the end of the canopy. Soil samples were collected at the following depth: 0-30, 30-60 and 60-90 cm. The samples were air dried ground to pass 2 mm sieve using a wooden grinding then stored in plastic bottles until analysis. The physical and chemical properties of the soil were determined according to the following methods:

1) Particle size distribution for soil was carried out using the pipette method as described by Dewis and Fertias (1970).
2) Total carbonate was estimated gasometrically using Collins Calcimeter and calculated as calcium carbonate according to Dewis and Fertias (1970).
3) Soil reaction (pH) was measured in saturated soil paste using combined electrode pH meter as mentioned by Richards (1954).
4) Total soluble salts were determined by measuring the electrical conductivity in the saturated soil paste extract and expressed in dS m^{-1} as explained by Jackson (1967).
5) The amounts of water soluble cations and anions were determined in the saturated soil paste extract using the method described by Hesse (1971).
6) Soil available nitrogen N, phosphorus (P) and potassium (K) were extracted and determined according to Olsen *et al*. (1954), Hesse (1971) and Jackson (1967).
7) Available iron, zinc and manganese were extracted using DTPA method (Lindsay and Norvell, 1978), and measured using The Atomic Absorption Spectrophotometer. Some physical and chemical properties of the soil are listed in Table (1).

Table 1: Some physical and chemical properties of the soil at start of the experiment.

Soil properties	**Soil depth (cm)**		
Soil physical properties	0-30	30-60	60-90
Particle size distribution (%)			
C. Sand	82.50	83.40	86.60
F. Sand	9.55	9.08	6.50
Silt	0.67	0.52	0.75
Clay	7.31	7.18	6.50
Soil texture	sandy	sandy	sandy
Soil chemical properties			
$CaCO_3$ (%)	0.65	0.69	0.72
OM (%)	0.38	0.25	0.25
pH	7.65	7.72	7.78
EC (dS m^{-1})	2.52	3.25	4.50
Soluble cations (meq l^{-1})			
Ca^{++}	7.44	9.62	13.29
Mg^{++}	5.16	6.65	9.25
Na^{+}	11.46	14.78	20.46
K^{+}	0.60	0.71	1.04
Soluble anions (meq l^{-1})			
CO_3^{-}	-	-	-
HCO_3^{-}	12.06	15.60	21.45
Cl^{-}	9.18	11.84	16.39
SO_4^{--}	3.78	4.95	6.79

Twenty five healthy trees were chosen to carry out this experiment. The chosen trees were divided into five groups. Each group had five trees. Ammonium nitrate (33.5% N), super phosphate (15.5 % P_2O_5) and potassium sulfate (48% K_2O) were used as mineral fertilizers. Compost and chicken manure was used as the source of organic fertilizers and added at 20 kg/tree/season rate. The analysis of compost and chicken manure is shown in Table (2). Trees received the following fertilization treatments: T1(control) - Applying the recommended mineral fertilizers dose (RFD) for N (1000g N/tree /year), P (500g super phosphate / tree /year) and K (600g potassium sulfate / tree /year). T2- Applying 25% of the RFD form NPK using a mineral fertilizer + 75% compost. T3- Applying 100% compost. T4- Applying 25% of the RFD form NPK using a mineral fertilizer + 75% chicken manure. T5- Applying 100% chicken manure. The organic fertilizers were applied as one patch on the first week of January in holes around the trunk of the tree and were directly irrigated after covering the holes with soil. The chemical fertilizers were applied as one patch on the first week of February. The following parameters were measured during the two growing seasons.

Table 2: Chemical analysis of used chicken manure and compost.

Organic manure	parameters											
	EC (dS/m)	pH (1:2.5)	C (%)	N (%)	C/N ratio	OM (%)	P (%)	K (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
Chicken	0.65	8.50	31.35	1.74	18.01	54.03	0.62	1.65	3550	253	119	19.6
Compost	0.51	8.10	24.97	1.30	19.21	43.06	0.45	1.21	1650	39	115	15.5

Vegetative Growth:

Four main branches, which were nearly uniform in growth, diameter and foliage density and distribution around the periphery of each tree were chosen and labeled in February. In the autumn growth cycle, the branches length (cm) and leaf number/ branches were measured.

Leaves nutrients content:

Fully mature leaf samples were collected randomly around the periphery of the tree, from spring flush, 4 to 7 month old young shoots. Determination of nutrients included: N, P, K, Fe, Zn, Mn and Cu. Samples were washed with tap water, 0.001 N HCl and distilled water, respectively, then dried at 70° C, ground in a stainless steel mill, to passed 40 mesh nylon sieve and stored in plastic bottles. Digestion was performed with a mixture of sulfuric acid and hydrogen peroxide (Wilde *et al*., 1985). Then, nitrogen was measured by micro-kjeldahl methods, phosphorus was determined calorimetrically, potassium was determined using flame photometer and Fe, Mn, Zn, Cu were measured using the Atomic Absorption Spectrophotometer (Perkin-Elemer A Analst 400).

Yield determination:

Ten distributed fruiting shoots around trees were chosen and labeled before beginningthe treatments. At harvest time, in the last week of December, twenty fruits per tree were taken randomly for the determination of fruit weight (g) and then, the yield of fruit per tree was measured and calculated as kg/tree.

Evaluation of fruit quality

Fruit quality was assessed by the analysis of the following chemical parameters. Fresh fruit juice was used in the analysis. Fruits were peeled and flesh was homogenized in a blender. Total acidity, was measured and calculated as percentage citric acid according to the (A.O.A.C., 1995); total soluble solids (TSS), using portable hand refractometer, Germany, according to the (A.O.A.C., 1995).

Statistical analysis

Data were subjected to analysis of variance for each season, according to the procedure described by Snedecor and Cochron (1981). Significance of differences among means was done according to Least Significant Differences test (LSD) at 5% level of probability. Finally, all statistical analysis was carried out using "MSTAT-C" computer software package (Freed *et al*., 1989).

Results and Discussion

The obtained results illustrated the effect of two different sources of organic fertilizer (compost and chicken manure) 100% alone or in a combination with NPK recommended dose as a chemical fertilizer of Balady mandarin on:

Vegetative Growth:

It is clear from data presented in Table (3) that the application of compost and chicken manure significantly increased the branches length (cm) and leaf numbers/branch compared to using the recommended fertilizers dose of mineral NPK (RFD) only. The highest branches length was detected, as an average of both seasons, on trees fertilized using 100% chicken manure (25.8 cm), which represented 1.62 folds increased followed by 25% RFD+75% chicken manure (24.6 cm), which represented 1.55 folds increased comparing with control. However, 100% compost application recorded 23.7 cm as average of both seasons which represented 1.49 folds followed by 22.5 cm (1.42 folds) in 25% RFD + 75% compost treatments. The highest leaf numbers/branch was detected, as average of both seasons, on trees fertilized using 100% compost (18.95), which represented 1.46 folds increased, followed by 100% chicken manure (18.8), which represented 1.44folds increased. However, 25% RFD + 75% chicken manure treatments represented 17.6 (1.35 folds) followed by 25% RFD + 75% compost which recorded 15.8 (1.21 folds) comparing with control. Conclusively, the obtained results may be due to the role of organic fertilizers and/or combined with chemical fertilizers in growth and development of balady mandarin trees; where the use of organic fertilizers was found to have the ability to increase nutrients uptake, which could enhance plant growth through absorption of nutrients and so on enhancing photosynthesis process (Hegde *et al.,*1999).

Table 3: Effect of compost and chicken manure applications on vegetative growth of Balady mandarin trees during 2013 and 2014 seasons.

Treatment	Branch length (cm)		Leaves numbers/branch	
	Season 2013	Season 2014	Season 2013	Season 2014
Control (RFD)	15.3	16.5	10.5	11.0
25% RFD + 75% compost	22.0	23.0	15.0	16.5
100% compost	23.5	23.9	19.9	18.0
25% RFD + 75% chicken manure	24.3	24.9	17.0	18.2
100% chicken manure	25.2	26.4	18.3	19.3
L.S.D. at 0.05	1.05	1.24	0.87	0.95

Leaf nutrient contents:

Data in Table, 4 revealed that 100% chicken manure treatment produced the highest leaf content of macronutrients (N, P, K, Ca and Mg), followed by 100% compost without significant differences between them, while a significant differences was found comparing with control treatment in the two seasons. However, the increments of leaf content of macronutrients were in parallel to the increasing of 25% RFD + 75% compost and 25% RFD+75% chicken manure in the two seasons. Moreover, the compost and chicken manure alone or the combinations between them and chemical fertilizers succeeded to increase the leaf contents of macronutrients as compared with control (which represented a significant difference between them) in the two seasons. Data cleared that, the application of different organic fertilizers sources increased the availability of macronutrient which are sufficient for balady mandarin according to Srivastava and Singh (2008) the sufficient levels in Nagpur Mandarin of macronutrients concentration (%) as: 1.70–2.81 (N), 0.09–0.15 (P), 1.02–2.59 (K), 1.80–3.28 (Ca), and 0.43–0.92 (Mg). Jones *et al*. (1991), Reuter and Robinson (1986, 1997), they reported that the sufficient levels in balady mandarin of macronutrients concentration (%) as: 3.0-3.4 (N), 0.15–0.25 (P), 0.9-1.1 (K), 3-6 (Ca), and 0.3-0.6 (Mg). Also, 100% chicken manure treatment produced the highest leaf content of micronutrients (Fe, Mn and Zn), followed by 100% compost without significant differences between them, while a significant differences was found comparing with control treatment in the two seasons. Moreover, the compost and chicken manure alone or the combinations between them and chemical fertilizers succeeded to increase the leaf contents of macronutrients as compared with control. Data cleared that, the application of different organic fertilizers sources increased the availability of

micronutrient which are sufficient for balady mandarin according to Srivastava and Singh (2008) the sufficient levels in Nagpur Mandarin of micronutrients concentration (ppm) was determined as:74.9–113.4 (Fe), 54.8–84.6 (Mn) and 13.6–29.6 (Zn). Also Jones *et al*. (1991), Reuter and Robinson (1986, 1997 and Khalifa *et al*., 2011), they reported that the sufficient levels in balady mandarin of micronutrients concentration (ppm) as: 60-150 (Fe), 25–200 (Mn) and25-100 (Zn).The recorded results dealing with compost and chicken manure affects as an organic fertilizers on leaf nutrients content of balady mandarin trees are in harmony with those obtained by Abo EI-Komsan and Ebrahiem (2002a) on Valencia orange; Abd EL-Naby *et al.,* (2004) on Washington navel orange.

Table 4: Effect of compost and chicken manure on leaves nutrients contents of Balady mandarin trees during 2013 and 2014 seasons**.**

Treatment	Nutriments leaf content							
	N	P	K	Ca	Mg	Fe	Mn	Zn
			%				ppm	
				Season 2013				
Control (RFD)	2.23	0.12	0.99	4.12	0.35	115.8	28.2	24.5
25% RFD + 75% compost	2.45	0.16	1.17	4.60	0.38	190.0	32.5	43.0
100% compost	2.56	0.17	1.23	4.70	0.41	190.9	34.2	45.0
25% RFD + 75% chicken manure	2.44	0.16	1.26	4.60	0.36	190.0	36.5	42.5
100% chicken manure	2.68	0.18	1.29	4.90	0.38	199.9	35.4	47.0
L.S.D.at 0.05	**0.12**	**0.02**	**0.11**	**0.25**	**0.04**	**11.82**	**2.58**	**2.89**
				Season 2014				
Control (RFD)	2.44	0.14	1.08	4.08	0.33	124.0	27.5	24.2
25% RFD + 75% compost	2.56	017	1.23	4.65	0.37	145.0	31.2	42.5
100% compost	2.55	0.18	1.29	4.80	0.36	147.0	33.4	46.6
25% RFD + 75% chicken manure	2.64	0.17	1.32	4.85	0.34	146.0	34.2	47.7
100% chicken manure	2.79	0.19	1.35	4.90	0.38	148.5	36.5	49.9
L.S.D.at 0.05	**0.09**	**0.02**	**0.08**	**0.23**	**0.06**	**14.56**	**2.05**	**3.12**

Fruit weight and Yield:

To assess the impact of compost and chicken manure applications on balady mandarin fruit weight and yield, we harvested the fruits at maturity and weighed them (Table 5). The results showed under the different treatments and applications rate the fruit weight was significantly increased by addition of compost and chicken manure comparing with control. The highest fruit weight recorded at100% chicken manure (122 and 145g in first and second seasons, respectively). The obtained data also, indicates that the application of compost and chicken manure improved fruit yield of balady mandarin trees. The highest yield scored 64.8kg/tree with 100% chicken manure followed by 100% compost (61.9 kg/tree) as compared with control scored (35.3 kg /tree) as average of both seasons.. The present result goes partially in line with that pointed out by Abdelaal *et al*. (2013), El-Khawaga and Maklad (2013) and El-Khayat and Abdel Rehiem (2013) they cleared that important of organic fertilizers for in increasing vegetative growth, yield and fruit quality of citrus trees.

Table 5: Effect of compost and chicken manure applications on fruit weight and yield of Balady mandarin trees during 2013 and 2014 seasons.

Treatment	Fruit weight (g)		Fruit yield (kg/tree)	
	Season 2013	Season 2014	Season 2013	Season 2014
Control (RFD)	95.0	100.0	35.9	34.6
25% RFD + 75% compost.	115.0	120.0	58.0	59.0
100% compost.	120.0	135.5	60.3	63.5
25% RFD + 75% chicken manure.	117.0	140.0	59.9	62.9
100% chicken manure.	122.0	145.0	63.9	65.6
L.S.D. at 0.05	6.45	4.32	0.44	0.93

Fruit chemical parameters:

Fruit total acidity (%):

Data in Table 5 showed that mineral 100% NPK fertilizers (control) resulted highest fruit total acidity (%) while, compost and chicken manure or its combination with chemical fertilizers reflected the lowest values in this concern during the both seasons of study. All treatments levels did not show any significant differences during the two seasons. In general, the lowest fruit total acidity (%) was scored by chicken manure and it's combined with NPK fertilizers as it gave approximately 5.7% in both seasons.

Fruit T.S.S (%):

Data in Table 6 pointed out that 100% mineral NPK fertilizers (control) resulted lowest fruit T.S.S (11%) while, compost and chicken manure or its combination with chemical fertilizers reflected the highest values in this concern during the both seasons of study. the greatest values of fruit T.S.S (%) at 100% chicken manure (13.7%) followed by 100% compost (12.5%) as an average in both seasons. Some of treatments levels did not show any significant differences during the bothseasons. The present result goes partially in line with that pointed out by Abdel Rahman *et al*. (2009) for improving fruit juice chemical properties.

Table 6: Effect of compost and chicken manure applications on fruit acidity and TSS of Balady mandarin during 2013 and 2014 seasons.

Treatment	Total acidity (%)		TSS (%)	
	Season 2013	Season 2014	Season 2013	Season 2014
Control (RFD)	5.96	5.83	11.0	11.0
25% RFD + 75% compost.	5.79	5.76	11.5	12.0
100% compost.	5.71	5.67	12.5	12.5
25% RFD + 75% chicken manure.	5.67	5.72	13.0	13.0
100% chicken manure.	5.67	5.69	13.5	13.9
L.S.D. at 0.05	N.S	N.S	0.85	0.76

References

Abd El-Naby, S. K. M.; E.A.A. Abd El-Moneim and A. S. E. Abd-Allah, 2004. Effect of source and date of organic manure application on growth, yield, fruit quality and mineral content of Washington navel orange trees grown in sandy soil.Minufiya J. Agric. Res. 29(2): 515-540.

Abdel Rahman, M.; A. El-Metwally and Y. Ibrahim, 2009. Effect of natural minerals compound applications on citrus trees and seedlings production. Egypt. J. Appl. Sci., 24 (10A), 293-307.

Abdelaal, A.H., F.F. Ahmed, S.E. El-Masry and A.A. Abdallah, 2013. Using potassium sulphur aswell as organic and biofertilization for alleviating the adverse effects of salinity on growth andfruiting of Valencia orange trees. Stem Cel, l 4(4):27-32.

Abo El-Komsan, E.A. and T.A. Ebrahiem, 2002a. Integrated nutrient management for Valencia orange trees grown on Troyer citrange and sour orange. 1- Behaviour of growth, flowering, fruit setting and nutritional status of trees. Proc. Minia 1st Conf. for Agric. and Environ. Sci, Minia. Egypt. March, 22: 2177-2198.

Abou-Hussein, S. D.; I. El-Oksha; T. El-Shorbagy and A. M. Gomaa, 2002. Effect of cattle manure, bio fertilizers and reducing mineral fertilizer on nutrient content and yield of potato plant. Egypt. J. Hort., 29 (1): 99-115.

Association of Official Agricultural Chemists (A. O. A. C.), 1995. Official Methods of Analysis. pp. 490-510 14th Ed. Benjamin Franklin Station.Washington, D. C., U.S.A.

Chescheir, P.W.; L.M,Westserman and L.M. Safley, 1986. Laboratory methods for estimating available nitrogen in manures and sludges. Agric. Wastes 18: 175-195.

Dewis, J. and F. Freitas, 1970. Physical and chemical methods of soil & water analysis. Soils Bulletin No. 10, Food and Agriculture Organization of the United Nations, Rome, Italy.

Duncan, J., 2005. Composting chicken manure. WSU Cooperative Extension, King County Master Gardener and Cooperative Extension Livestock Advisor.

El-Khawaga, A.S. and M.F. Maklad, 2013. Effect of combination between bio and chemical fertilization on vegetative growth, yield and quality of Valencia orange fruits. Hort Science Journal of Suez Canal University, 1: 269-279.

El-Khayat, H.M. and M.A. Abdel-Rehiem, 2013. Improving mandarin productivity and quality byusing mineral and bio-fertilization. Alex. J. Agric. Res. 58(2): 141 – 147.

El-Shamma, M.S., Z. ElhamAbd El-Motty, S. Nagwa Zaied, M.A. Maksoud and A.E.M. Mansour, 2013. Efficiency of Some organic fertilizers as safe resources on the performance of Valencia orange trees grown in newly reclaimed soils. World Appl. Sci. J., 25 (9): 1263-1269.

Freed, R.S.P, S. Eisensmith, D. Goetz, V. Reicosky, W. Smail and P. Wolber, 1989. User's Guide to MSTAT-C: A Software Program for the Design, Management and Analysis of Agronomic Research Experiments Michigan State University, East Lansing, ML, USA.

Hegde, D.M., B.S. Dwivedi and S.S. Sudhakara Babu, 1999. Biofertilizers for cereal production in India. A review. Ind. J. Agric. Res., 69(2): 73-83.

Hesse, P.R., 1971. A Text Book of Soil Chemical Analysis. Juan Murry (Publisher) Ltd., London.

Ismail, A.E.; S.S. Soliman; E.M. Abd El- Moniem, M.S. Awaad and A.A. Rashad, 2010. Effect of magnetic iron ore, metal compound fertilizer and bio-NK in controlling Root- Knot Nematode in a newly reclaimed area of Egypt.*Pak. J. Nematol.,* 28(2), 307-328.

Jackson, M.L., 1967. Soil Chemical Analysis. Printice-Hall of India, New Delhi.

Jones, Jr., J. Benton, B. Wolf and H. A. Mills, 1991. Plant Analysis Handbook. Micro-Macro Publishing, Inc., 183 Paradise Blvd, Suite 108, Athens, Georgia 30607 USA, p.162.

Khalifa, R. M., M.M. El-Fouly, S.H.A. Shaaban and H.A. Hamouda, 2011. Diagnosis of Nutrient Status in Balady Mandarin Orchards of a Newly Reclaimed Area in Egypt. J. Am. Sci. 2011;7 (5):219-226.

Lindsay, W.L. and W.A. Norvell, 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Sci. Soc. Am. J. 42, 421–428.

Ministry of Agriculture and Land Reclamation of Egypt, 2013. According to the yearly Bull. Agric. Economic and Statistics.

Olsen, S.R., C. V. Cole, F.S. Watanabe and L.A. Dean, 1954. Estimation of phosphorus in soil by extraction with sodium bicarbonate. US Dept. Agric., Circular No. 939: 1-19.

Reuter, D. J. and J. B. Robinson (ed.), 1986. Plant analysis: An interpretation manual. Inkata Press, Melbourne, Australia.

Reuter, D. J., and J. B. Robinson (ed.). 1997. Plant analysis: An interpretation manual, 2nd ed. CSIRO Publ., Australia.

Richards, L.A., 1954. Diagnosis and Improving of Saline and Alkaline Soils. U.S., Salinity Laboratory Staff. Agric. Handbook, No. 60.

Snedecor G.W. and WG. Cochran, 1981. Statistical Methods 7th ed. Iowa State Univ., Press, Ames, Iowa.

Srivastava, A. K. and E. Ngullie (2009). Integrated nutrient management: Theory and practice. Dynamic Soil, Dynamic Plant 3 (1): 1–30.

Srivastava, A. K. and S. K. Malhotra, 2014. Nutrient management in fruit crops: Issues and strategies. Indian Journal of Fertilisers 10 (12): 72–88.

Srivastava, A. K. and S. Singh, 2001b. Soil fertility limit in relation to optimum yield of Nagpur mandarin (*Citrus reticulata* Blanco). Ind. Soc. of Soil Sci. 49(4): 758–62.

Srivastava, A. K. and S. Singh, 2001c. Development of optimum soil property limits in relation to fruit yield and quality of *Citrus reticulata* Blanco cv. Nagpur mandarin. Tropical Agriculture 78 (3): 174–81.

Srivastava, A. K. and S. Singh, 2008. DRIS Norms and their Field Validation in Nagpur Mandarin, Journal of Plant Nutrition, 31:6, 1091-1107.

Wilde, S.A., B.B. Gorey, J.G. Layer and J.K. Voigt, 1985. Soils and Plant Analysis for tree culture. Published by Mohan primlani, Oxford and IBH publishing Co., New Delhi, p. 1- 142.