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The Effects of Inorganic and Organic Fertilizers on An Olive Orchard Grown on A Sandy Soil

M.A. Abdel-Salam and H.M. Salem
Department of Soil, Faculty of Agriculture (Moshtohor), Benha University, Egypt.

A FIELD experiment was conducted for two successive years in an olive orchard on sandy soil in the El-Tor area of South Sinai, Egypt. The goal was to investigate the effects of fertilization (inorganic or organic) and fertilizer application methods (surface application or mixing within the soil) on the soil physicochemical characteristics and the nutrient status of soils and plants. Two factors relating to the fertilizer source (F) and method of application (M) were as follows: (i) the fertilizer source (F) included two treatments, *i.e.*, inorganic fertilizer (F_1) (with each tree receiving 412 g N in the form of ammonium sulfate + 264 g P as calcium superphosphate) and olive compost (F_2) (with each tree receiving 25 kg of compost containing 512 g N + 152 g P), and ii) the application method (M) included two treatments, *i.e.*, surface application (in which fertilizers were added to the soil surface without subsequent plowing) (M_1), and application by mixing the fertilizer and plowing it into the 15-cm soil surface layer (M_2). The results showed that F_1 surpassed F_2 in increasing the N, P, K and Ca contents for olive plant parts relative to the non-fertilized treatment, with average increases of 26.8, 34.2, 32.8, 42.6 and 21.5% in leaf-N (N content in leaf), fruit-N, fruit-P, leaf-K and fruit-Ca, respectively. Additionally, the F_1 treatment resulted in average increases of 27.3 and 28.6% in available N and P, respectively, at the soil surface (0-20 cm); in the soil subsurface (20-40 cm) the respective increases were 12.3% and 13.6%. The F_2 treatment positively affected soil physical properties. It increased the total porosity by an average of 13.5% and decreased hydraulic conductivity by an average of 32.6% and bulk density by an average of 6.5%. The M_2 treatment was more effective than M_1. M_2 caused greater increases in the nutrient status than the non-fertilized treatment, producing average increases of 21.5, 31.0, 32.8, 38.0 and 19.5% in leaf-N, fruit-N, fruit-P, leaf-K and leaf-Ca, respectively. With respect to available nutrients in soil, M_1 surpassed M_2 in its effects on soil surface nutrient status; it led to an average increase of 33.1 and 37.9% in available N and P, respectively, but had no effect on available K. In the soil subsurface, M_2 surpassed M_1, giving average increases of 36.4, 33.8 and 4.5% in available N, P and K, respectively.

Keywords: Olive, Compost, Inorganic fertilizer, Nutrient content of soils and plants, Physical properties.

Olive is one of the most important crops in the Mediterranean region, where it occupies an area of 8.2 million ha (Boussadia *et al.*, 2010). Olive orchards are

Corresponding Author: salemh2000eg@yahoo.com

invariably subjected to a loss of fertility and soil erosion related to the Mediterranean climate, long periods of drought followed by torrential storms, and a lack of soil cover (Gomez *et al.,* 2003, 2004). Olive farming requires efficient fertilizer management, which minimizes the hazards of excessive mineral fertilizers due to their negative environmental impact and maximizes the economic feasibility and cost efficiency of fertilization (Gastal and Lemaire, 2002). Soil organic matter is very low in the Mediterranean region, thus organic waste recycling for agricultural purposes is very important for maintaining soil productivity (Lasaridi *et al.,* 2006 and Martinez-Blanco *et al.,* 2011). Most residues of olive orchards and olive oil factories are usually burned, which is not a favorable practice for many reasons including the risk of the unintended burning of olive trees and CO_2 emissions from the fire, which contribute to global warming (Gogebakan and Selcuk, 2009 and Qingren *et al.,* 2010). Composting olive oil residues as a low cost organic fertilizer has proven to be a suitable commercial organic amendment (Tortosa *et al.,* 2012). Under organic management, biological activity and hydrolytic activity is greater than under conventional or integrated systems (Benitez *et al.,* 2006). Application of olive residues as organic amendments increases the contents of macronutrients in soil (Madejon *et al.,* 2003 and Convertini *et al.,* 2008). Available nutrients are released as a result of organic matter decomposition, which depends on the residue characteristics, method of application, management system and soil type (Cabrera *et al.,* 2005, Alvararado, 2006, Castro *et al.,* 2008, Aranda *et al.,* 2011 and Repullo *et al.,* 2012). Christensen (1996) stated that soil texture plays an important role in influencing organic matter status in soil, since after 100 years of constant animal manure addition, clay soils accumulated more organic matter than sandy soils.

The aim of the current study was to investigate both the interaction between different fertilizer sources (inorganic N and P and organic olive pomace compost) and different methods of application (surface applications and mixing within the soil) and their effects on nutrient status in soil and plant as well as on the physicochemical characteristics of the soil.

Material and Methods

A field experiment was conducted for two successive years in an olive orchard at the El-Tor area in South Sinai, Egypt to investigate the effects of fertilizer source (inorganic or organic) and method of application (*i.e.,* application to the surface or mixing within the top 15 cm of soil) on soil nutrient status and physicochemical characteristics. Soil characteristics from the experimental field are presented in Table 1.

TABLE 1. Properties of the experimental soil.

Property	Value
pH (1:2.5 soil: water suspension.)	8.13
EC (dSm^{-1}) in paste extract	1.10
Organic matter ($g\ kg^{-1}$)	3.0
Calcium carbonate ($g\ kg^{-1}$)	19.2
Bulk density ($Mg\ m^{-3}$)	1.72
Hydraulic conductivity ($m\ day^{-1}$)	2.76
Total porosity (TP)	35.1
ESP (exchangeable sodium percentage)	10.8
Available macro-nutrients (mg kg^{-1}):	
Nitrogen (N), ammonium bicarbonate extractable	15.4
Phosphorus (P), sodium bicarbonate extractable	7.0
Potassium (K), ammonium acetate extractable	39.0
Particle size-distribution (%):	
Coarse sand	50.0
Fine sand	40.4
Silt	5.9
Clay	3.7
Texture class	Sand

With regard to the fertilizer source (F), two treatments were tested as follows: (i) inorganic fertilizer (F_1), in which each tree received 412 g of N in the form of ammonium sulfate with 20.6% N + 264 g P as calcium superphosphate with 6.6% P, and (ii) olive pomace compost (F_2), in which each tree received 25 kg of olive pomace compost containing 512 g N + 152 g P. These rates are typical of what the growers use in this area. Two methods of application (M) were tested as follows: (i) surface application of the fertilizer to the soil without plowing (M_1), and (ii) a mixing application, in which the fertilizer was added to the 15-cm soil surface layer and then plowed (M_2). The experimental design was a randomized complete block with three replicates. The area of the experimental plot was 100 m^2, which included 4 trees. Olive pomace residues were composted by mixing the pressed olive residues with wheat straw, chicken manure, and urea at ratios (by weight) of 90.6:3.6:5.3:0.5, respectively. The composting process lasted 80 days, and moisture and temperature levels were regularly monitored. Table 2 details the compost characteristics. Fertilizer and compost applications were carried out on the 15th of January during each year. The orchard was managed by using the proper husbandry operations of the local growers. Samples of olive leaves and fruits, in addition to soil samples, were collected in December of each year for analysis. Soil samples were taken from the soil located below the rim of the tree crown, which is where the fertilization was carried out.

TABLE 2. Properties of olive compost used in the experiment.

EC dSm^{-1}	pH	Total nutrients (g kg^{-1})			C/N ratio	OM (g kg^{-1})	BD (Mg m^{-3})
(1:5 w:v extract)		N	P	K			
2.6	8.97	20.5	6.1	4.0	18.9	666.8	0.284

Note: OM=organic matter, BD = Bulk density.

Soil and plant analyses

Soil analyses included particle size distribution determination by pipette method. Other soil analyses included bulk density, total porosity, aggregate size distribution by wet sieving, and hydraulic conductivity (all of which were performed on undisturbed soil cores) as well as soil pH, electrical conductivity (EC), available N, P and K, calcium carbonate and organic matter and these analyses were done as described by Page *et al.* (1982). Plant samples were analyzed for N, P, K, Ca and Mg .

Analysis of variance for the obtained data was performed according to the methods described by Gomez and Gomez (1984).

Results and Discussion

Macronutrient contents in leaves and fruits

N content

As shown in Table 3, both of the inorganic fertilizer (F_1) and the compost (F_2) generally led to greater N concentrations in leaves (leaf-N) and fruits (fruit-N) than were found in the non-fertilized treatment. F_1 treatments showed an average increase of 26.8% in leaf-N in comparison with an average increase of only 1.1% in response to F_2 treatment. The increase in fruit-N was more pronounced, being 34.2% due to F_1 treatment compared with 9.5% due to F_2. The mixing application method (M_2) was superior to the surface application method (M_1) in terms of both leaf-N and fruit-N. Average increases in leaf-N due to M_2 and M_1 were 21.5 and 6.4%, respectively; the corresponding increases in fruit-N were 31.0% and 12.6%, respectively. Superiority of M_2 over M_1 was particularly evident in leaf-N and fruit-N under inorganic fertilization and not the compost treatment. Applying compost by either the M_2 or the M_1 method yielded similar responses in terms of leaf-N; however, for fruit-N, the M_2 method was again superior to M_1. Despite the higher total N in the soil from the compost compared with that from the inorganic fertilizer, this result was not reflected in the N content of olive fruits or leaves. These data are an indication of the slow release of N from the compost (Aranda *et al.*, 2011). N loss from sandy soils fertilized with ammonium sulfate could be a result of ammonia volatilization (Mroczkowski and Stuczynski, 2006), thus the mixing application method may have decreased possible N loss.

P content

Both inorganic fertilizer (F_1) and compost (F_2) treatments generally led to greater P content than the non-fertilized treatment in the leaves (leaf-P) and fruits (fruit-P). Regarding leaf-P, the difference between the two fertilizers (F_1 and F_2) or between the two methods of application (M_1 and M_2) were not significant. Both forms of fertilizer surpassed the non-fertilized treatments with respect to fruit-P content, with F_1 being superior to F_2.

TABLE 3. Effect of fertilizer source and method of application on macronutrient content (g kg^{-1}) in leaves and fruits of olive trees.

Fertilizer source (F)	Method of application (M)														
	M_1	**M_2**	**mean**	**M_1**	**M_2**	**mean**	**M_1**	**M_2**	**mean**	**M_1**	**M_2**	**mean**	**M_1**	**M_2**	**mean**
	N g kg^{-1} (leaf)			N g kg^{-1} (fruit)			P g kg^{-1} (leaf)			P g kg^{-1} (fruit)			K g kg^{-1} (leaf)		
F_1	12.40	15.50	13.95	9.70	11.50	10.60	2.00	2.30	2.15	4.00	4.50	4.25	6.70	8.70	7.70
F_2	11.00	11.23	11.12	8.10	9.20	8.65	1.80	2.00	1.90	3.60	4.00	3.80	5.90	6.20	6.05
mean	11.70	13.37		8.90	10.35		1.90	2.15		3.80	4.25		6.30	7.45	
	Non-treated : 11.00			Non-treated : 7.90			Non-treated : 1.80			Non-treated : 3.20			Non-treated : 5.40		
LSD 5%:	M: 0.915 F: 0.915 MF: 1.293			M: 0.543 F: 0.543 MF: ns			M: n.s F: n.s MF: ns			M: 0.446 F: 0.446 MF: ns			M: 0.760 F: 0.760 MF: 1.074		
Fertilizer Source (F)	Method of application (M)														
	M_1	M_2	mean	M_1	M_2	mean	M_1	M_2	mean	M_1	M_2	mean	M_1	M_2	mean
	K g kg^{-1} (fruit)			Ca g kg^{-1} (leaf)			Ca g kg^{-1} (fruit)			Mg g kg^{-1} (leaf)			Mg g kg^{-1} (fruit)		
F_1	32.20	33.50	32.85	15.10	16.20	15.65	11.80	12.50	12.15	0.90	1.00	0.95	3.90	3.90	3.90
F_2	30.00	31.00	30.50	14.20	15.20	14.70	10.80	11.40	11.10	1.00	1.00	1.00	3.70	4.00	3.85
mean	31.10	32.25		14.65	15.70		11.30	11.95		0.95	1.00		3.80	3.95	
	Non-treated : 29.90			Non-treated : 13.20			Non-treated : 10.00			Non-treated : 0.60			Non-treated : 3.50		
LSD 5%:	M: ns F: ns MF: ns			M: n.s F: ns MF: ns			M: 0.452 F: 0.452 MF: ns			M: ns F: ns MF: ns			M: ns F: ns MF : ns		

Fertilizer source: F_1, inorganic fertilizer (ammonium sulfate + calcium super phosphate); F_2, olive pomace compost. Method of application : M_1, surface application; M_2, adding fertilizer within the 15-cm soil surface by plowing. ns, not significant.

The F_1 treatment caused an average increase of 32.8% in fruit-P, while F_2 caused an average increase of 18.8%. The mixing application, M_2, gave greater fruit-P as compared with the surface application M_1, with average increases of 32.8% and 18.8%, respectively. Increases identical to those between M_1 and M_2 occurred between F_1 and F_2. Soils containing $CaCO_3$ would cause P fixation (Shedeed *et al.*, 2009) therefore , mixing P fertilizer into the soil may increase fertilizer (nutrient) contact with olive roots, which would absorb more soil available P because the M_2 treatments were performed in a place where the $CaCO_3$% of the soil was low. Thus, there was no difference between the F_1 and F_2 treatments at the soil surface (Table 3).

K content

Both inorganic fertilizer (F_1) and compost (F_2) resulted in greater K contents than the non-fertilized treatment in olive leaves (leaf-K) and fruits (fruit-K). Both forms of fertilizer caused greater leaf-K, with F_1 being superior to F_2. The F_1 treatment caused an average increase of 42.6% in leaf-K, and the F_2 gave an average increase of 12.0%. A comparison between the two fertilizers in relation to fruit-K shows no significant difference; also, there was no significant difference between the two application methods. M_1 gave lower leaf-K in comparison with M_2. The M_1 treatment caused an average increase of 16.7% in leaf-K and M_2 led to an average increase of 38.0%. Using compost with the M_1 or M_2 methods was of similar response in relation to leaf-K.

The inorganic fertilizer showed nearly the same effects on leaf-K as the compost when added by M_1 method, despite not containing K fertilizer. The positive effect of the inorganic fertilizer on increasing leaf-K despite not containing K, could be attributed to the enhancement of plant growth by N and P fertilizers and the consequent increase in K uptake from the soil. This finding is confirmed when soils treated with the inorganic fertilizer showed less available K at their surface and their subsurface (Table 4).

Ca content

Both F_1 and F_2 resulted in greater Ca contents than the non-fertilized treatment in leaves (leaf-Ca) as well as fruits (fruit-Ca). In the leaf-Ca, there was no significant difference between the two fertilizers or between the two methods of application. The F_1 caused an average increase of 21.5% in the fruit-Ca, and the F_2 caused an average increase of 11.0%. The M_1 treatment caused an average increase of 13.0% in fruit-Ca, and M_2 led to an average increase of 19.5%. The resemblance of the Ca and P response patterns in plants reflects the fact that Ca constitutes approximately 20% of the P-inorganic fertilizer (Ca-superphosphate) used in the experiment.

Mg content

Both F_1 and F_2 were associated with greater Mg contents than the non-fertilized treatment. There was no significant difference between the two fertilizers or the two methods of application on olive leaves or fruits.

TABLE 4. Effect of fertilizer source and method of application on soil EC and available N, P and K.

Fertilizer source(F)	Method of application(M)											
	M_1	**M_2**	**mean**	**M_1**	**M_2**	**mean**	**M_1**	**M_2**	**mean**	**M_1**	**M_2**	**mean**
	EC dSm^{-1} (0-20 cm soil)			Available N mg kg^{-1} (0-20 cm soil)			Available P mg kg^{-1} (0-20 cm soil)			Available K mg kg^{-1} (0-20 cm soil)		
F_1	1.20	1.11	1.15	22.40	16.80	19.60	10.00	8.00	9.00	30.00	28.00	29.00
F_2	1.18	1.10	1.14	18.6	16.00	17.30	9.30	8.00	8.65	48.00	45.00	46.50
mean	1.19	1.10		20.50	16.40		9.65	8.00		39.00	36.50	
	Non-treated: 1.10			Non-treated: 15.40			Non-treated: 7.00			Non-treated: 39.00		
LSD 5%:	M: 0.034 F: ns MF: ns			M: 0.616 F: 0.616 MF: 0.871			M: 0.107 F: 0.107 MF: 0.152			M: 0.676 F: 0.676 MF: ns		
Fertilizer source (F)	Method of application(M)											
	M_1	M_2	mean	M_1	M_2	mean	M_1	M_2	mean	M_1	M_2	mean
	EC dSm^{-1} (20-40 cm soil)			Available N mg kg^{-1} (20-40 cm soil)			Available P mg kg^{-1} (20-40 cm soil)			Available K mg kg^{-1} (20-40 cm soil)		
F_1	1.18	1.22	1.20	20.60	24.00	22.30	8.20	11.20	9.70	33.00	35.00	34.00
F_2	1.16	1.20	1.18	17.00	21.10	19.05	7.30	10.30	8.80	42.00	49.00	45.50
mean	1.17	1.21		18.80	22.55		7.75	10.75		37.50	42.00	
	Non-treated : 1.15			Non-treated : 16.60			Non-treated : 7.80			Non-treated : 40.20		
LSD 5%:	M: 0.028 F: ns MF: ns			M: 0.533 F: 0.533 MF: ns			M: 0.282 F: 0.282 MF: ns			M: 0.227 F: 0.227 MF: 0.321		

Fertilizer source: F_1, inorganic fertilizer (ammonium sulfate + calcium super phosphate); F_2, olive pomace compost. Method of application : M_1, surface application; M_2, adding fertilizer within the 15-cm soil surface by plowing. ns, not significant.

Soil EC and available N, P and K

Data in Table 4 show no significant difference between the two fertilizers in relation to the soil EC for both the soil surface (0-20 cm) and the soil subsurface (20-40 cm) and a significant difference between the two methods of fertilizer application. In the soil surface, the M_2 treatment had a lower EC than the M_1. The M_2 had no effect on EC while M_1 increased EC by 8.2% in comparison with the non-fertilized treatment. In the soil subsurface, M_2 was associated with a greater EC than the M_1, since M_1 increased the EC by 1.7% while M_2 increased it by 5.2%. Mixing the fertilizer into the soil (M_2) contributed to a greater EC in the subsurface of the soil.

This effect of fertilizer was of a similar trend either in soil surface or subsurface with respect to available N and P, but not with respect to available K. In the soil surface and subsurface, the F_1 treatment led to greater available N and P than F_2, since F_1 showed an average increase of 27.3 and 28.6% in available N and P, respectively; and F_2 showed respective average increases of 12.3 and 23.6%. In the soil subsurface, F_1 showed an average increase of 34.4 and 24.4% in available N and P, respectively, and F_2 showed average respective increases of

14.8 and 12.8%. Regarding available K, F_2 was superior to F_1 in the soil surface and subsurface. In the soil surface, F_1 caused an average decrease of 25.6% and F_2 caused an average increase of 19.2%. In the soil subsurface, F_1 caused an average decrease of 15.4% and F_2 caused an average increase of 13.2%. Thus, both F_1 and F_2 had the same effect on available N and P when mixed within the 15-cm soil surface.

The application method effect on available N, P, and K in soil showed the same trend within the soil surface and the subsurface. In the soil surface, M_1 was superior to M_2 in relation to available N, P and K. The M_1 treatment caused average increases of 33.1 and 37.9% in available N and P, respectively; while it had no effect on available K (there was no increase). The M_2 treatment caused average increases of 6.5 and 14.3% in available N and P, respectively, and it caused an average decrease in available K of 6.4%. In the soil subsurface, the M_2 treatment was superior to the M_1 in terms of available N, P and K, in which M_2 caused average increases of 36.4, 37.8 and 4.5% in available N, P and K, respectively. M_1 caused average increases of 13.2% in available N, while it caused an average decrease of 0.6 and 6.7% in available P and K, respectively.

These results indicate that the mixing method increased the N, P and K in the soil, which is reflected by higher N, P and K contents in the olive plant (Table 3). Increases were also shown in soil EC.

Soil bulk density, total porosity and hydraulic conductivity

As shown in Table 5, there was a significant difference between the inorganic fertilizer (F_1) and compost (F_2) treatments. The F_2 treatment decreased soil bulk density (BD), increased total porosity (TP) and decreased hydraulic conductivity (HC), and it decreased BD and HC relative to the non-fertilized treatment by an average of 6.5 and 32.6%, respectively, while increased TP more than the non-fertilized treatment by an average of 13.5%. In general, the F_1 treatment showed no effect on the BD, TP, and HC. It had no effect on BD; it slightly increased TP by 1.2% and slightly decreased HD by 0.7%. There was a significant difference between the surface application method (M_1) and the mixing application method (M_2) on BD and TP, and no significant difference occurred in HC. The M_2 effect was more favorable than that of M_1. The M_2 decreased BD by an average of 4.1% and increased TP by an average of 8.7% while the M_1 average respective effects involved a decrease of 2.4% and an increase of 6.0%. The greater favorable effect of M_2 over M_1 was particularly noticeable where compost fertilizer was used. In locations where inorganic fertilizer was used, the effects of M_1 and M_2 were similar in relation to BD, TP and HC. Adding compost had a positive effect on soil physical properties (BD, TP and HC), especially when mixed with the soil surface.

TABLE 5. Effect of fertilizer source and method of application on soil bulk density, total porosity and hydraulic conductivity.

Fertilizer source (F)	Method of application (M)								
	M_1	**M_2**	**mean**	**M_1**	**M_2**	**mean**	**M_1**	**M_2**	**mean**
	Bulk density (Mg m^{-3})			Total porosity (%)			Hydraulic conductivity (m day^{-1})		
F_1	1.70	1.70	1.70	35.50	35.50	35.50	2.74	2.74	2.74
F_2	1.62	1.56	1.59	38.87	40.80	39.83	2.04	1.68	1.86
mean	1.66	1.63		37.18	38.15		2.39	2.21	
	Non-treated: 1.70			Non-treated: 35.09			Non-treated: 2.76		
LSD 5%:	M: 0.008 F: 0.008 MF: 0.012			M: 0.536 F: 0.536 MF: 0.759			M: ns F: 0.119 MF: ns		

Fertilizer source: F_1, inorganic fertilizer (ammonium sulfate + calcium super phosphate); F_2, olive pomace compost. Method of application : M_1, surface application; M_2, adding fertilizer within the 15-cm soil surface by plowing. ns, not significant.

Soil aggregation

Figures 1 and 2 show that compost increased soil aggregates of the very large (>2 mm), large (2-1 mm) and sub-medium (0.5-0.25 mm) size by an average of 715.8% (more than 7 folds), 115.2% (nearly one fold) and 8.0% over the non-fertilized treatment, respectively, and decreased the medium (1-0.5 mm) aggregates by an average of 22.6%. On the other hand, the inorganic fertilizer increased the very large, large and sub-medium aggregates by averages of 25.7, 33.8 and 2.0%, respectively, and decreased the medium ones by an average of 6.0%. The surface application method (M_1) increased the very large, large and sub-medium aggregates by averages of 476.2% (nearly 5 folds), 65.0 and 6.4%, respectively, and decreased the medium ones by an average of 16.5%. The mixing application method (M_2) increased the very large, large and sub-medium aggregates by averages of 265.3% (nearly 3 folds), 84.1 and 3.6%, respectively, and decreased the medium ones by an average of 12.0%. The results indicate that compost caused more positive changes in soil aggregation than resulted from use of the inorganic fertilizer. The effect of inorganic fertilizer could be attributed mainly to its enhancement of root growth.

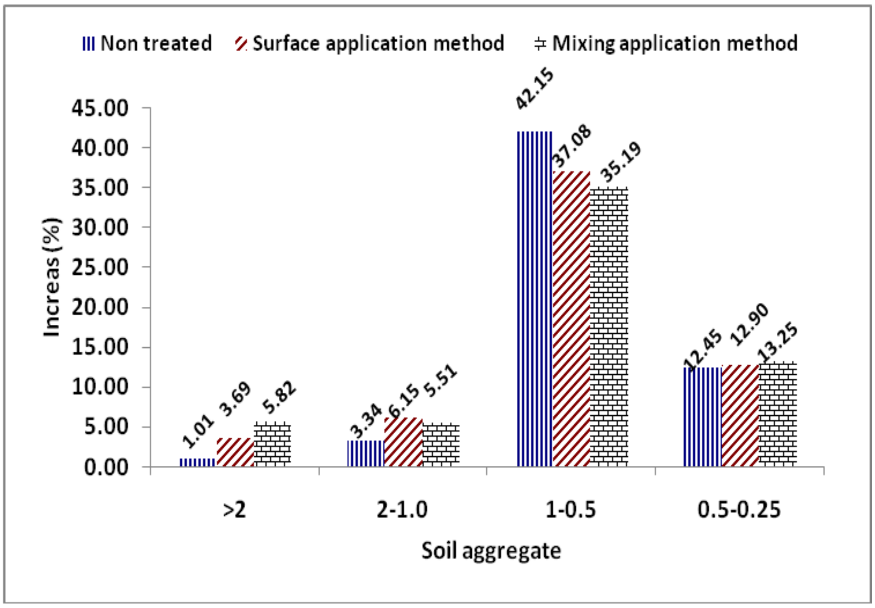

Fig. 1. Effect of method of application on soil aggregation.

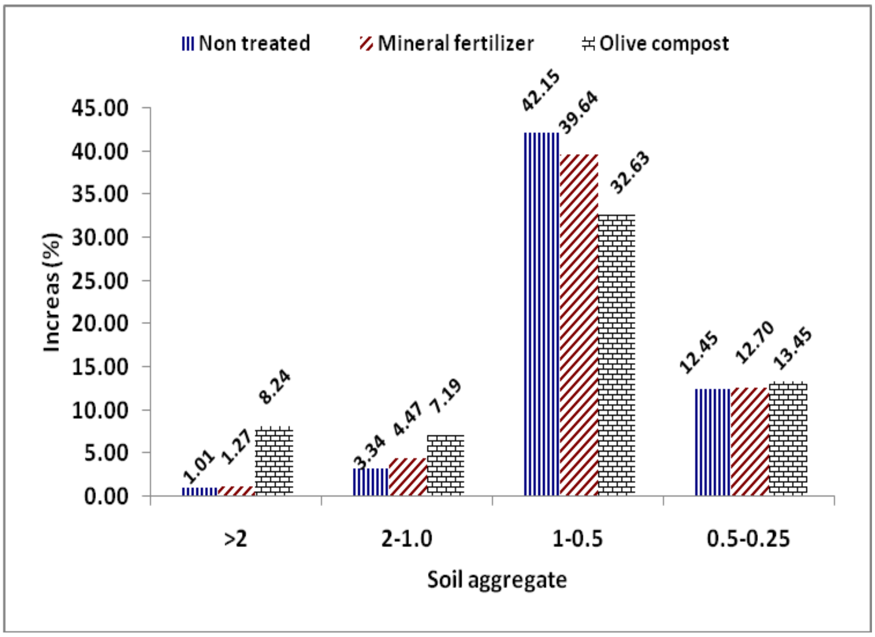

Fig. 2. Effect of fertilizer source on soil aggregation.

Conclusion

In sandy soils, mixing fertilizer within the 15-cm soil surface increases nutrient availability, resulting in more nutrient content in olive plants and nutrient content in the soil surface and subsurface. Compost application positively affects soil physical properties such as total porosity, hydraulic conductivity and bulk density. Fertilization with P and N fertilizers in inorganic forms increases the N, P, K and Ca contents in olives, in addition to increasing the available N and P in the soil surface (0-20 cm) and subsurface (20-40 cm).

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تأثيرات الأسمدة الغير عضوية و العضوية على بستان زيتون منزرع فى أرض رملية

محمد على أحمد عبد السلام و هيثم محمد شحاته سالم
قسم الأراضى – كلية الزراعة (مشتهر) – جامعة بنها – مصر .

تم تنفيذ تجربة حقلية لعامين متتاليين في بستان زيتون منزرع فى تربة رملية في منطقة الطور جنوب سيناء ، مصر . وكان الهدف من التجربة هو دراسة تأثير إستخدام الأسمدة (العضوية و غير العضوية) وطرق إضافة الأسمدة (إضافة سطحية و خلط داخل التربة) على الخصائص الفيزيائية والكيميائية للتربة و حالة المغذيـــات فى التربة والنباتات .وكانت عوامـــل التجربة المتعلقة بمصدر الأسمــدة (F) و طريقة الإضافـة (M) على النحو التالــي : (أ) مصدر الأسمدة (F) إشتملت على اثنين من المصادر ، الأسمدة غير العضوية (F_1) (حيث تم إضافة 412 جم N في صورة سلفات الأمونيوم + 264 جم P فى صورة السوبر فوسفات الكالسيوم لكل شجرة) و كمبوست الزيتون (F_2) (حيث أضيف لكل شجرة 25 كجم من السماد تحتــوي على 512 جم N + 152 جم P) ، (ب) طريقة الإضافة (M) و إشتملت أيضا على إثنين من طرق الإضافة ، الإضافة السطحية (حيث أضيفت الأسمدة لسطح التربة دون حرث) (M_1) والإضافة عن طريق خلط الأسمدة وحرثها فى طبقة التربة السطحية (M_2). وأظهرت النتائج أن F_1 تفوقت على F_2 فى زيادة محتوى أجزاء نبات الزيتون من عناصر N, P, K, Ca مقارنة بالنباتات الغير معاملة بمتوسط زيادة قـــدره 26.8 ، 34.2 ، 32.8 ، 42.6، 21.5 ٪ فى محتوى النيتروجين بالأوراق و محتوى النيتروجين بالثمار و محتوى الفوسفور بالثمار و محتوى البوتاسيوم بالأوراق و محتوى الكالسيوم بالثمار على التوالى.

بالإضافة إلى ذلك، أدت F_1 إلى متوسط زيادة بمقدار 27.3٪ و 28.6 ٪ في النتروجين الميسر و الفوسفور الميسر ، على التوالي ، فى طبقة سطح التربة (0-20 سم) ، بينما في التربة تحت السطحية (20- 40 سم) كانت الزيـــادات 12.3 ٪ و 13.6 ٪ على التوالى . كان F_2 أثرا إيجابيا على الخواص الفيزيائية للتربة . فقد ارتفعت المسامية الكلية بمعدل 13.5 ٪ و انخفض كل من التوصيل الهيدروليكي بمعدل 32.6 ٪ و الكثافة الظاهرية بمعدل 6.5 ٪ و كانت طريقة الإضافة M_2 أكثر تأثيرا من M_1 . نتج عن المعاملة M_2 زيادات أكبر في محتوى المغذيات مقارنة بالنباتات الغير معاملة ، و كان متوسط الـزيادات 21.5 ، 31.0 ، 32.8 ، 38.0 و 19.5 ٪ في محتوى النيتروجين بالأوراق ، محتوى النيتروجين بالثمار ، محتوى الفوسفور بالثمار ، محتوى البوتاسيوم بالأوراق و محتوى الكالسيوم بالثمار على التوالى. فيما يتعلق بتيسر المغذيات في التربة ، تفوقت M_1 على M_2 في أثرها على تيسر المغذيات فى طبقة سطح التربة ، حيث أدت إلى متوسط زيادة 33.1 و 37.9 ٪ في النيتروجين الميسر و الفوسفور الميسر على التوالي ، ولكن لم يكن لها تأثير على البوتاسيوم الميسر. في التربة تحت السطحية ، تفوقت M_2 على M_1 ، معطية متوسط زيادات 36.4 ، 33.8 ، 4.5 ٪ في النيتروجين الميسر ، الفوسفور الميسر ، البوتاسيوم الميسر، على التوالي.