EVALUATION OF DATE PALM (*Phoenix dactylifera* L.) PRODUCTION UNDER ORGANIC MANURE APPLICATION WITH *arbascular mycorrhizal fungi* ADDS ON SANDY SOILS IN STATE OF KUWAIT

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Abstract: An experiment was conducted at Amghara Station of the State of Kuwait on date palm *Barhee* cv with ten treatment combinations involving different sources and levels of organic manure application in conjunction with *arbascular mycorrhizal* fungi (AMF) on sandy soils during 3 seasons (2013-2016). The experimental design adopted was RCBD with five replications.

The results showed that the Date palm Tamar fruit yield increased with increasing rates of sewage sludge and compost manure as compared to control. The influence of sewage sludge in conjunction with AMF on the Tamar yield of crop was more pronounced than that of compost manure. Such an increase in the yield may be attributed to the improvement in the fruit yield parameters such as number of fruiting spikelet's and fruits per bunch; weight, length and girth of fruit.

On an average over 3 years, application of 10 t/ha of sewage sludge (71.97 t/ha or 22.57% increase) or compost manure (70.00 t/ha or 19.31% increase) along with AMF over control (58.43 t/ha) could be recommended to date palm to increase the yield levels and fertility status especially the organic matter content of the soil.

Keywords: Organic manure, AMF, sewage sludge, compost manure, date palm, date yield.

INTRODUCTION

Date palm is one of the most important dry fruit crops grown under the hot arid conditions in Kuwait. Since the soils are sandy in nature, the growth of date palm (*Phoenix*

dactylifera L.) is highly affected by organic matter content, water and nutrient availability in the soil.

Sewage sludge can substitute for commercial fertilizers and organic matter, if applied in the right amounts to soil. By using sludge, it is a possibility for farmers to supply their lands with organic fertilizer at low costs. Therefore, recycling of sludge for agricultural purpose seems to be an appealing solution for sustainable management of sludge. Sewage sludge (bio-solids), which is enriched in nitrogen, phosphorus, organic matter and other trace elements, represents a good source of nutrients for plant growth and a good soil conditioner to improve soil physical properties. Due to its high organic matter content, sewage sludge can improve physical, chemical, and biological properties of soil (Alcantara et *al*., 2009). Thus, sludge application helps to reduce soil erosion and improves the soil quality as a plant growth medium. The fertilizer effect enables a reduction in cost for nitrogen and phosphorus mineral fertilizers and may improve crops yield on sludge treated fields (Wild and Jones, 1991; Petersen et *al*., 2003).

According to the study by Veysel et *al*. (2010), sewage sludge when applied to the soil with increasing amounts raised the mineral matter content of plant and resulted in the increase of growth and herbage yield of bird's foot trefoil. Heavy metal contents were below the critical levels in the soil and plant. Delgado Arroyo et *al*. (2002) reported that the application of sewage sludge compost @ 12 t/ha plus 350 kg urea/ha resulted in 20% greatest growth of maize than the mineral fertilization. No toxic effects arising from the heavy metals in the plant were observed. Moreover, the concentration of heavy metals in the soil was below Spanish and European legal limits.

Considerable research has been accomplished worldwide on the use of sewage sludge on soil and crop. In many investigations with different climatic and soil conditions have reported a substantial increase in plant growth, crop yield and biomass production upon sewage sludge application (Samaras et *al*., 2008 ; Togay et al., 2008). Using organic wastes such as sewage sludge, compost and cow manure is a proper practice for returning organic matter and some nutrients into the soil, particularly in arid and semi-arid regions. Application of sewage sludge, compost and cow manure at 25 Mg/ha significantly increased available Fe and Zn of the soil. The application of organic wastes increased the dry matter yield of the corn, alfalfa and targets flower plants (Sharifi et *al*., 2011).
Application of FYM with higher fertilizer level has given maximum tuber yield of potato in sandy clay loam soil (Krishnamurthy *et al*., 1999). Poultry waste compost under VAT method is agronomically efficient in sunflower production (Jayabharat *et al*., 2000). Application of organic manure 25 t/ha resulted in significantly higher tuber yield of potato (27.9%) as compared to 12.5 t/ha (Al Khalak *et al*., 2007).

This study was conducted in order to evaluate date palm production and soil properties in relation to the sources and levels of organic manure application in conjunction with AMF on sandy soils in Amghara area of The State of Kuwait.

MATERIAL AND METHODS

An experiment was conducted at Amghara Station of The State of Kuwait on *Barhee* cv of date palm with ten treatment combinations involving different sources and levels of organic manure application in conjunction with AMF on sandy soils during October, 2013 to September, 2016. The experimental design adopted was randomized complete block with five replications. The treatment combinations included in the experiment were as detailed below.

F1 – Control
F2 – AMF
F3 – Sewage sludge @ 5 t/ha
F4 – Sewage sludge @ 5 t/ha + AMF
F5 – Sewage sludge @ 10 t/ha
F6 – Sewage sludge @ 10 t/ha + AMF
F7 – Compost manure @ 5 t/ha
F8 – Compost manure @ 5 t/ha + AMF
F9 – Compost manure @ 10 t/ha
F10 – Compost manure @ 10 t/ha + AMF

The sandy loam soil at Amghara initially had a pH of 7.52, EC 9.48 dSm^{-1} , OM 0.29%, PO_4 4.24 ppm, K 1.91 meq/l, Ca 24.76 meq/l, Mg 13.22, Na 77.73 meq/l, Cl 78.07 meq/l, HCO_3 3.66 meq/l, SO_4 36.19 meq/l, and B 1.08 ppm(Table 1).

Soil sampling was done from 2 depths (0-25cm & 25-50cm) for initial physical, chemical and microbial analysis. Sewage sludge and organic manure with and without *Mycorrhiza* were incorporated as per the treatments @ 5 or 10 t/ha/year in October by opening a furrow to a depth of 15-20cm around each tree in the basin. The organic manure with or without mycorrhiza were mixed well and covered. Mycorrhizal inoculum (*Glomus intraradices* L.) procured from Germany was used in the experiment.

Compost manure had a pH of 7.2, O.M. 45%, N 2.3%, P_2O_5 1.01% & K 0.63 meq/l (Table 2). Sewage sludge manure had a pH of 8.88, O.M. 14.3%, N 1.002%, P_2O_5 1.63% & K 16 meq/l with a moisture content of 34.86% (Table 3).

First and second split dose of N, P_2O_5 and K_2O complex fertilizer (18-18-18 + TE) @ 1 kg//tree was applied in to the small furrows opened 5-10 cm deep around each date palm tree in the basin during the months of December and February. Micro nutrient mixture in the form of micromel combi @ 100g/tree was also applied during February. Later the fertilizers were mixed well in the soil and covered. Whereas, the third split dose of complex fertilizer (20-20-20 + TE) @ 1 kg//tree along with potassium sulphate @ 200 g/tree was applied during the month of April. After each application, irrigation was given to dissolve the fertilizer which helps in further uptake of nutrients by date palm crop.

Fourth stage treated sewage water was used for irrigation and it had a pH of 7.5, EC 0.25 dSm^{-1}, TDS 160 ppm, K 0.3 meq/l, Na 1.1 meq/l, Mg 0.2 meq/l, Ca 1.6 meq/l, HCO_3 1.2 meq/l, Cl 1.6 meq/l and SO_4 0.4 meq/l. Total Coliforms count was 140 MPN/100 ml (Table 5).

Bubbler irrigation was scheduled to the crop as per the requirement of the trees depending upon the climatic conditions and growth stages (Table 2).
All the crop management practices were adopted as per the recommendation. The necessary data on soil properties, soil moisture, irrigation water and biometrics were recorded. The Tamar fruit yield data was subjected to statistical analyses as per standard procedure and presented.

RESULTS AND DISCUSSION

The results of the average of 3 seasons (2013-2014, 2014-2015, 2015-2016) obtained and the discussion on the evaluation of date palm (Phoenix dactylifera L.) production and soil properties in relation to the sources and levels of organic manure application in conjunction with AMF on sandy soils in Amghara area of the State of Kuwait is presented in tables 5, 6 & 7 and graphically represented also in Figures 2 &3.

Use of sewage sludge manure is economically advantageous to compost manure as the sewage sludge manure is locally available from the waste water treatment plants in Kuwait & hence the cost involved will be reduced. Hence, either compost or sewage sludge manure could be used favorably in the sandy soils of Kuwait.

The results showed that the dates yield increased with increasing rates of sewage sludge and compost manure as compared to control. The influence of sewage sludge in conjunction with AMF on the Tamar yield of crop was more pronounced than that of compost manure (Table 6 & Fig. 2). Such an increase in the yield of Tamar may be attributed to the improvement in the fruit yield parameters such as number of fruiting branches and fruits per bunch; weight, length and girth of fruit (Table **7** & **8**). This may further be related to the maintenance of higher moisture and availability of nutrients in the soil (Table **9** & Fig. 3). Similar results were also reported by other workers in different crops (Khalak and Kumaraswamy, 1993; Veeranna *et al*., 2001; Khalak et *al.* 2007).

On an average over 3 years, 10 t/ha of sewage sludge (71.97 t/ha or 22.57% increase) or compost manure (70.00 t/ha or 19.31% increase) along with AM fungi over control (58.43 t/ha) could be recommended to date palm crop to increase the yield levels and fertility status especially the organic matter content of the soil.

Treatment wise soil nutrient status at 0-25 cm and 25-50 cm depths after the harvest of dates from the date palm trees in the ICARDA experimental site during 2015-2016 at Amghara Station, Kuwait has been presented in Tables 10 & 11.

Similarly, according to the study by Veysel Saruhan et al. (2010), sewage sludge when applied to the soil with increasing amounts raised the mineral matter content of plant and resulted in the increase of growth and herbage yield of bird's foot trefoil. Heavy metal contents were below the critical levels in the soil and plant. Delgado Arroyo et *al*. (2002)

reported that the application of sewage sludge compost @ 12 t/ha plus 350 kg urea/ha resulted in 20% greatest growth of maize than the mineral fertilization. No toxic effects arising from the heavy metals in the plant were observed. Moreover, the concentration of heavy metals in the soil was below Spanish and European legal limits.

The motivation for recycling of sewage sludge to agricultural soil is the low cost of this disposal method, the soil organic matter preservation effect and the fertilization effect. Sewage sludge (biosolids), which is enriched in nitrogen, phosphorus, organic matter and other trace elements, represents a good source of nutrients for plant growth and a good soil conditioner to improve soil physical properties. Due to its high organic matter content, sewage sludge can improve physical, chemical, and biological properties of soil (Alcantara et *al*., 2009).

Thus, sludge application helps to reduce soil erosion and improves the soil quality as a plant growth medium. The fertilizer effect enables a reduction in cost for nitrogen and phosphorus mineral fertilizers and may improve crops yield on sludge treated fields (Wild and Jones, 1991; Petersen et al. 2003). Application of sewage sludge, compost and cow manure at 25 Mg/ha significantly increased available Fe and Zn of the soil (Sharifi et *al*., 2011). Sewage sludge can substitute for commercial fertilizers and organic matter, if applied in the right amounts to soil. By using sludge, it is a possibility for farmers to supply their lands with organic fertilizer at low costs. Therefore, recycling of sludge for agricultural purpose seems to be an appealing solution for sustainable management of sludge.

In the present study, the date palm crop has responded well to the application of both the sources of organic manure at with the increasing rates of their application in sandy soils of Kuwait. However, the influence of especially the sewage sludge manure addition at 10 t/ha was more pronounced than compost manure. Likewise, considerable research has been accomplished worldwide on the use of sewage sludge on soil and crop. In many investigations with different climatic and soil conditions have reported a substantial increase in plant growth, crop yield and biomass production upon sewage sludge application (Samaras et *al*., 2008; Togay et *al*., 2008). Using organic wastes such as sewage sludge, compost and cow manure is a proper practice for returning organic matter and some nutrients into the soil, particularly in arid and semi-arid regions. The application of organic wastes increased the dry matter yield of the corn, alfalfa and targets flower plants (Sharifi et *al*., 2011).

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Several earlier workers (Krishnamurthy *et al*., 1999 and Jayabharat *et al*., 2000 and Abd Al Khalak et *al*., 2007) also reported that the application of higher quantities of organic manure is responsible for the improvement in the growth and yield of potato and sunflower crops. Since the soils are sandy and poor in organic matter content, incorporation of sunflower plants after harvesting organic manure @ 25t/ha and enriches soil fertility and addition of organic manures sustains sunflower production for long time in Kuwait. Veeranna *et al*. (2001) have also revealed similar results and quoted that potato production can be sustained over a long time by maintaining the soil moisture and nutrient status.

CONCLUSION AND RECOMMENDATIONS

The results of adding sewage sludge in conjunction with AMF in Al Amghara research station in Kuwait increased the Tamar yield. This increase of yield may be attributed to the improvement in the fruit yield parameters such as number of fruiting spikelet's and fruits per bunch; weight, length and girth of fruit.

Below some recommendations of this research experimentation are presented:

- It is possible to grow successful crop of Date palm on sandy loam soils of Kuwait in the open field under bubbler irrigation by adopting proper management practices.

- The influence of addition of sewage sludge manure to the Date palm crop was more pronounced than compost manure, as it was largely responsible for the improvement in the physical, chemical and biological properties of the soil.

- Since the soils are sandy, poor in organic matter and nutrient content, it is advisable to apply organic manure in the form of sewage sludge (71.97 t/ha or 22.57% increase in yield) or compost manure (70.00 t/ha or 19.31% increase in yield) when applied @ 10 t/ha along with Mycorrhiza and the recommended dose of fertilizers gives higher Date palm Tamar fruit yield.

- Addition of organic manure in the form of sewage sludge/ compost manure enriches soil fertility which in turn also helps in sustaining the production for long time in Kuwait.

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Tables

Table 1. Initial soil nutrient status of ICARDA Date palm organic manures and AMF at Amghara Station, Kuwait during October, 2013.

Parameter	Unit	Soil depth(cm)		
		0-25	**25-50**	**Mean**
1. pH	-	7.52	7.52	7.52
2. ECe	dSm^{-1}	12.28	6.68	9.48
3. K	meq/l	3.04	0.78	1.91
4. O.M.	%	0.37	0.22	0.29
5. Ca	meq/l	28.32	21.80	24.76
6. Mg	meq/l	16.44	10.00	13.22
7. Na	meq/l	106.32	49.14	77.73
8. Cl	meq/l	105.32	50.82	78.07
9. HCO_3	meq/l	4.00	3.32	3.66
10. SO_4	meq/l	44.80	27.58	36.19
11. PO_4	ppm	7.20	1.28	4.24
12. B	ppm	1.00	1.15	1.08

Table 2. Annual irrigation schedule applied to date palm experimentation plot

Month	Water Requirement (Imperial Gallons/day)	Irrigation Interval (days)
January	10	8
February	12	8
March	18	4
April	24	4
May	32	3
June	40	2

July	40	2
August	36	2
September	28	3
October	20	4
November	14	8
December	10	8

Table 3. Chemical analysis of the compost manure used in Amghara Station, Kuwait.

Parameter	Unit	Value
1. pH	-	7.20
2. O.M.	%	45.0
3. N	%	2.30
4. P2O5	%	1.01
5. K	meq/l	0.63
6. Cu	ppm	0.15
7. Mn	ppm	0.50
8. Mg	ppm	2.70
9. Fe	ppm	1.10
10. Zn	ppm	0.71

Table 4. Chemical analysis of the sewage sludge used in Amghara Station, Kuwait.

Parameter	Unit	Value
1. pH	-	8.88
2. EC 1:5	dSm^{-1}	1.79
3. MC	%	34.86
4. OM	%	14.30
5. N	%	1.002
6. P2O5	%	1.63

7. Na	meq/l	2.93
8. K	meq/l	16.00
9. Cu	ppm	0
10. Mn	ppm	0.554
11. Cd	ppm	0.10
12. Zn	ppm	0.78
13. Fe	ppm	7.50
14. Ni	ppm	0.57
15. Pb	ppm	3.00
16. E. coli	MPN/ g	240
17. TotalColiforms	MPN/ g	135

Table 5: Chemical and microbial analyses of irrigation water (fourth stage treated sewage water) used in the experimentation

Parameter	**Unit**	**Value**
1. pH	-	7.5
2. EC	dSm^{-1}	0.25
3. TDS	ppm	160
4. Na	meq/l	1.1
5. K	meq/l	0.3
6. Ca	meq/l	1.6
7. Mg	meq/l	0.2
8. CO3	meq/l	-
9. HCO3	meq/l	1.2
10. Cl	meq/l	1.6
11. SO4	meq/l	0.4
12. Total Coliforms	MPN/100 ml	140

Table 6. Dates yield as influenced by the sources and levels of organic manure application in conjunction with AMF in Amghara (average of 3 years).

Treatment	Tamar yield (kg/tree)	Tamar yield (tons/ha)	Increase over control (%)
F1 – Control	58.43	11.92	-
F2 – AMF	61.20	12.49	4.30
F3 – Sewage sludge @ 5 t/ha	64.70	13.20	10.07
F4 – Sewage sludge @ 5 t/ha + AMF	67.00	13.76	14.34
F5 – Sewage sludge @ 10 t/ha	66.30	13.53	12.82
F6– Sewage sludge @ 10 t/ha + AMF	71.97	14.69	22.27
F7 – Compost manure @ 5 t/ha	63.73	13.00	8.70
F8 – Compost manure @ 5 t/ha + AMF	65.53	13.37	12.03
F9 – Compost manure @ 10 t/ha	64.67	13.20	10.55
F10 – Compost manure @ 10 t/ha + AMF	70.00	14.29	19.31
S.Em.+_	3.242	0.662	-
C.D. at 5%	9.102	1.857	-
Mean	**65.40**	**13.55**	**-**

Table 7. Moisture content and yield parameters of date palm fruits as influenced by the sources and levels of organic manure application in conjunction with AMF in Amghara (average of 3 years).

Treatment	Moisture content of fruits at Khalal stage(%)	Fruit bunch wt(kg)	Fruit stalk wt(kg/ bunch)	Fruit wt(kg/ bunch)	No. of fruits/ bunch
F1 – Control	23.0	7.60	0.50	7.10	738
F2 – AMF	24.4	8.15	0.75	7.40	780
F3 – Sewage sludge @ 5 t/ha	35.0	9.60	0.65	8.95	1087
F4 – Sewage sludge @ 5 t/ha + AMF	43.9	10.50	0.80	9.70	1189
F5 – Sewage sludge @ 10	40.1	10.25	0.63	9.62	1130

t/ha					
F6– Sewage sludge @ 10 t/ha + AMF	47.3	11.20	0.70	10.50	1423
F7 – Compost manure @ 5 t/ha	25.6	9.10	0.45	8.65	930
F8 – Compost manure @ 5 t/ha + AMF	36.9	9.95	0.56	9.39	1094
F9 – Compost manure @ 10 t/ha	29.6	9.25	0.55	8.70	1045
F10 – Compost manure @ 10 t/ha + AMF	46.2	11.00	0.65	10.35	1320
Mean	**35.2**	**9.50**	**0.63**	**8.87**	**1074**

Table 8. Fruit yield parameters of date palm fruits as influenced by the sources and levels of organic manure application in conjunction with AMF in Amghara (average of 3 years).

Treatment	No. of fruit branches/ bunch	Weight/ fruit (g)	Fruit length (cm)	Fruit girth (cm)
F1 – Control	64	7.72	2.42	1.90
F2 – AMF	67	8.68	2.57	1.92
F3 – Sewage sludge @ 5 t/ha	68	9.15	2.68	1.97
F4 – Sewage sludge @ 5 t/ha + AMF	80	9.95	2.77	2.07
F5 – Sewage sludge @ 10 t/ha	71	9.85	2.77	2.03
F6– Sewage sludge @ 10 t/ha + AMF	88	11.10	2.93	2.18
F7 – Compost manure @ 5 t/ha	67	8.86	2.58	1.93
F8 – Compost manure @ 5 t/ha + AMF	71	9.32	2.73	2.02
F9 – Compost manure @ 10 t/ha	68	8.98	2.68	1.95
F10 – Compost manure @ 10 t/ha + AMF	86	10.00	2.78	2.17
Mean	**73**	**9.36**	**2.69**	**2.02**

Table 9. Soil moisture content (%) before irrigation at 30cm depth during flowering of date palm crop as influenced by the sources and levels of organic manure application in conjunction with AMF in Amghara**.**

Treatments	Actual soil moisture content (%)			
	2013-14	2014-15	2015-16	Mean
F1 – Control	7.54	8.04	7.69	7.76
F2 – AMF	7.98	9.48	9.91	9.12
F3 – Sewage sludge @ 5 t/ha	8.94	10.44	10.46	9.95
F4 – Sewage sludge @ 5 t/ha + AMF	11.42	12.92	13.03	12.46
F5 – Sewage sludge @ 10 t/ha	9.49	10.99	11.10	10.53
F6– Sewage sludge @ 10 t/ha + AMF	12.97	14.47	14.60	14.01
F7 – Compost manure @ 5 t/ha	8.49	9.99	9.96	9.48
F8 – Compost manure @ 5 t/ha + AMF	11.12	12.62	12.74	12.16
F9 – Compost manure @ 10 t/ha	9.17	10.67	11.98	10.61
F10 – Compost manure @ 10 t/ha + AMF	12.36	13.86	13.96	13.39
Mean	**9.95**	**11.35**	**11.54**	**10.95**

Table 10. Treatment wise soil nutrient status at 0-25 cm depth after the harvest of Tamar fruits from the date palm trees during September 2016 at Amghara.

Parameter	Unit	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
1. pH	-	8.00	7.41	8.04	7.81	8.03	7.91	7.62	7.35	7.61	7.93
2. ECe	dS^{-m}	1.15	3.40	0.60	2.13	0.77	1.31	3.59	5.62	3.43	0.95
3. Ca	Meq/L	2.6	11.8	1.4	3.6	8.1	3.0	8.4	14.0	5.8	2.2
4. Mg	Meq/L	0.4	4.0	1.4	1.8	1.2	0.8	1.4	5.8	2.0	0.8
5. HCO_3	Meq/L	3.4	6.6	5.0	3.0	4.4	3.4	6.0	7.6	2.4	4.0
6. Cl^-	Meq/L	8	17	5	17	7	8	25	3.4	35	7
7. O.M	%	0.71	1.48	0.67	1.82	0.98	1.45	0.07	0.17	1.88	0.84
8. B	ppm	0.681	0.404	0.046	0.271	0.359	0.306	0.989	0.791	0.433	0.143
9. N	%	0.008	0.006	0.009	0.008	0.005	0.007	0.008	0.005	0.006	0.009
10. P_2O_5	ppm	25.4	59.2	37.4	80.4	41.8	27.8	31.2	45.2	64.487.56	36.6
11. Sand	%	82.64	81.28	83.28	78.56	82.28	81.6	82.64	83.28	87.56	87.92
12. Silt	%	14.36	13.72	12.72	15.44	13.72	12.44	13.36	12.72	12.44	11.08
13. Clay	%	3	5	4	6	4	6	4	4	0	1

Table 11. Treatment wise soil nutrient status at 25-50 cm depth after the harvest of Tamar fruits from the date palm trees during September 2016 at Amghara.

Parameter	Unit	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
1. pH	-	7.91	7.65	8.00	7.83	7.93	7.84	7.82	8.08	7.41	7.91
2. ECe	dS^{-m}	5.17	5.44	0.84	1.18	1.16	1.48	5.84	1.07	7.36	4.99

3. Ca	Meq/ L	1.4	10.8	2.2	2.4	3.2	3.0	10.8	2.1	13.0	12.0
4. Mg	Meq/ L	0.7	2.6	2.4	0.8	3.0	2.6	4.0	1.8	3.0	4.4
5. HCO_3	Meq/ L	3.6	6.0	4.0	3.8	3.8	2.6	4.0	3.0	5.6	5.2
6. Cl^-	Meq/ L	28	39	6	8	10	10	34	7	6	35
7. O.M	%	0.47	0.94	0.30	0.57	0.81	1.31	0.57	0.07	1.72	0.81
8. B	ppm	0.514	0.662	0.737	0.206	0.163	0.454	0.269	0.244	0.712	0.469
9. N	%	0.038	0.008	0.005	0.007	0.008	0.005	0.011	0.010	0.007	0.005
10. P_2O_5	ppm	19.16	31.2	29.8	45.2	46.0	12.6	21.4	8.2	49.4	15.2
11. Sand	%	82.28	81.28	80.92	75.56	83.28	77.56	87.28	83.92	74.56	81.28
12. Silt	%	13.72	13.72	14.08	17.44	11.72	14.44	10.72	14.08	17.44	13.72
13. Clay	%	4	5	5	7	5	8	2	2	8	5

Figures

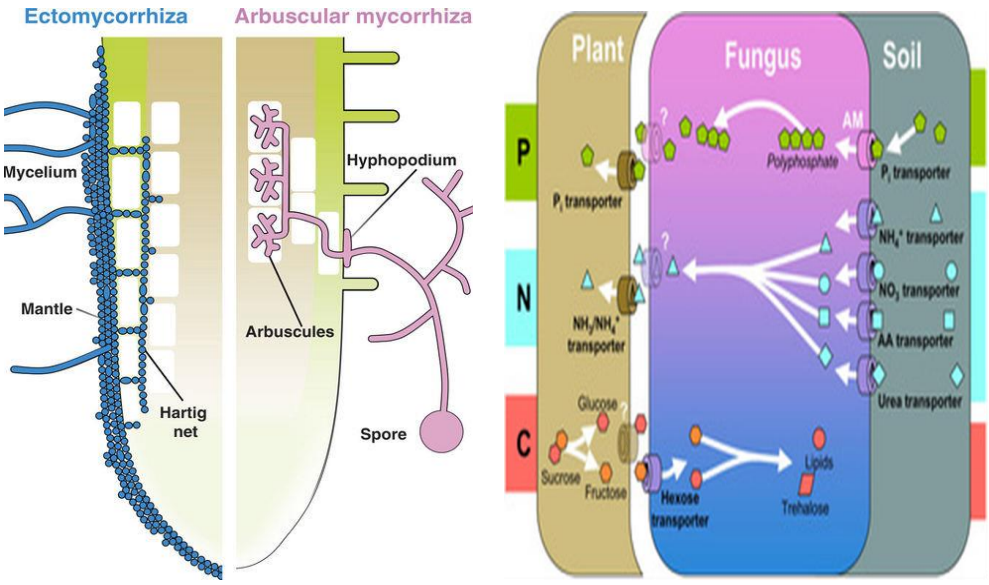

Fig. 1. Mycorrhiza & its association with plant & soil system

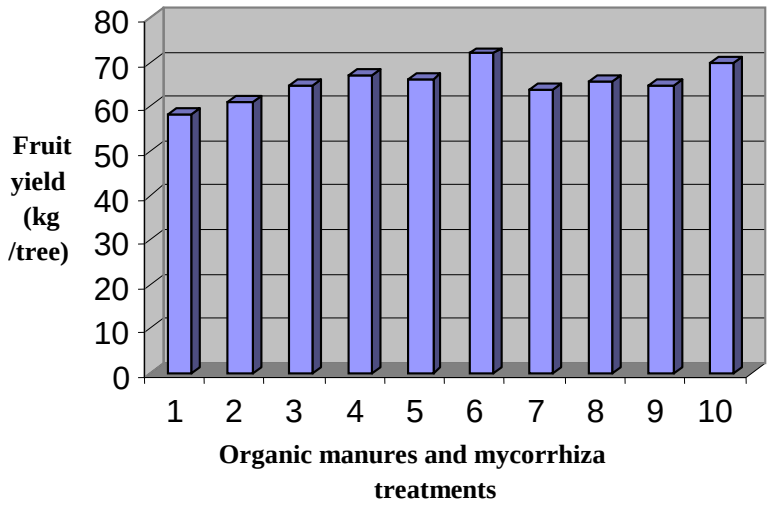

Fig. 2. Fruit yield of date palm as influenced by organic manures and AMF (average of 3 years).

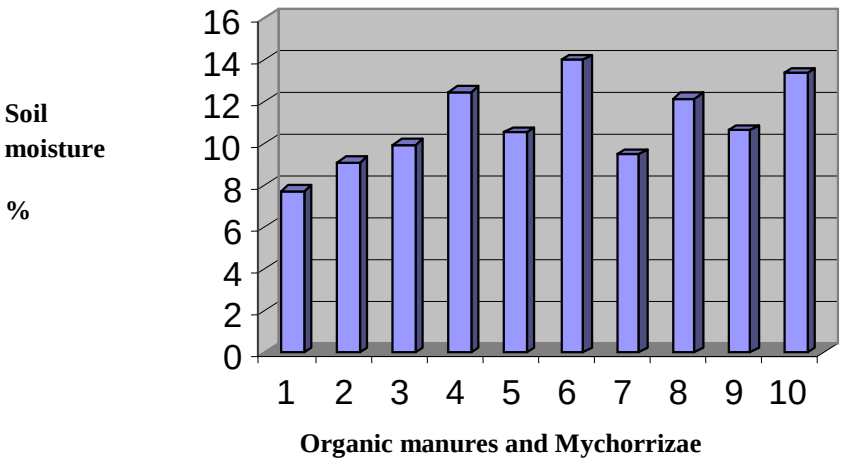

Fig. 3. Actual soil moisture content before irrigation as influenced by organic manures and AMF in date palm crop (average of 3 years)