Efficacy of Intercropping Mango, Mandarin or Egyptian Clover Plants with Date Palm on Soil Properties, Rhizospere Microflora and Quality and Quantity of Date Fruits

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Abstract: Intercropping is claimed to be one of the most significant cropping techniques in sustainable agriculture; to its utilization a number of environmental benefits, from promoting land biodiversity to diversifying agricultural outcome. This model integrates low, medium, and tall plants, as well as plants of short, medium, and long life cycles, including trees. Therefore, a study was carried out to evaluate the impact of intercropping mango (*Mangifera indica* L.), Balady mandarin (*Citrus reticulate* Blanco) and Egyptian clover (*Trifolium alexandrinum* L) crops with date palm on soil chemical properties and quality and quantity of date fruits, in comparison with date palm sole. Rhisosphere of palm (pure stand) had a high concentration of N compared to palms intercropped with mango or mandarin. Intercropped mandarin with palms caused a depletion of N from soil by 14.3%, relative to date palm pure stand. High levels of Zn and Mn in soil were recorded in rhisosphere of clover and palms intercropped with mandarin. The effect of intercropping on occurrence and enumeration of microorganisms in the rhizosphere of trees was also studied. The results indicated that the colony count of fungi and bacteria in date palm rhizosphere were fluctuated according to plantation method. Intercropping date palm with mandarin decreased the total fungal count from 21.17 cfu x 10^3g^{-1} in the non-intercropped roots to 16.00 cfu x 10^3g^{-1} (24.4% decrease) in date palm root intercropped with mandarin. While, intercropping date palm with mango and clover increased the total fungal count to 118.32 cfu x 10^3g^{-1} and 52.00 x10^3g^{-1} in date palm root intercropped with mango and clover, respectively. Growing mango or mandarin under date palm resulted in the highest fruit yield/palm. However, intercropping Egyptian clover with date palm caused a significant reduction in fruit diameter. Intercropping mango gave the highest net profit ($8213/ha/yr), followed by the same area intercropped with mandarin ($3992/ha/yr). Evaluation of growing mango, mandarin or Egyptian clover with date palm indicated that growing mango with date palm could be used for combating desertification in sandy soil in arid lands regions and gave the highest net return per unit area. [Journal of American Science. 2010;6(12):230-238]. (ISSN: 1545-1003).

Key words: intercropping, date palm, Egyptian clover, mango, mandarin, fruit

1. Introduction:

In Egypt, date palm ranked the third crop after orange and grape (Agricultural Economic Bulletin, 2005). Date palm trees provide enough space for intercropping even if they are fully grown as they do not cover much area being a very tall tree (Akyurt *et al*. 2002). They reviewed the literature and reported that, it is possible to grow a mixed fruit orchard, such as date intercropped with citrus (Morton 1987 and Anon- 1 2008). Field crops, such as fodders and vegetables may also be grown together with date palms (Anon- 1, 2008; Mahmoudi *et al*. 2008; Shirazi *et al.*, 2008). Intercropping in date palm with suitable crops bring good income and improves the fertility of the soil. During the first few years, intercropping can be practiced with no shortage of irrigation. Intercrops such as gram, peas, mash, moong, moth, senji and lentil can be sown during summer. Intercropping of some vegetables in plantation located near the cities can be practiced if sufficient irrigation and manuring facilities are available. On the other hand, Morton (1987) reported that in mechanized plantations, intercropping is not possible as much as space must be left for the mobile equipment.

In addition, desertification is a worldwide problem that directly affects over 250 million people and a third of the earth's land surface. It is especially concentrated in developing countries. Effectively dealing with desertification will lead to a reduction in global poverty (Millennium Ecosystem Assessment 2005).

The recent report of Egypt indicated that 67.4% of the first class area of the agricultural land was reduced from 1.260 million hectares (in the 2000) to 0.411 million hectares (in 2005). Combating desertification requires an integrated approach. Polyculture is claimed to be one of the most significant cropping techniques in sustainable agriculture, to its utilization a number of environmental benefits, from promoting land biodiversity to diversifying agricultural outcome. This model integrates low, medium, and tall plants, as well as plants of short, medium, and long life cycles, including trees.

Therefore, the tendency for exploitation the land under date palms whether for annual or perennial crops is increasing day by day to better utilization the microclimate and soils under date palm. Little research papers about the impact of intercropping on the date palm were found in the literature, except some reports and fact sheets. Ali *et al*. (1998) reported that the intercropping of legumes, which was found to improve quality and yield, was practiced up to 50%. They add that the inter-cropping of legumes (cowpea and pigeon pea) which was proved to have a positive effect on the soil and consequently dates quality is practiced up to 35%. While 15% of the studied cases practiced the intercropping adversely affects the soil. They also indicated that several crops can be intercropped with date palm utilizing canal irrigation such as alfalfa, okra and tomato that increase the profitability of date palm cultivation when intercropped. While intercropping date palm with other crops is difficult in drip irrigation (Ali *et al*.1998). In the Northern part of the delta and river Nile state date palm is intercropped with wheat, broad beans and fodder. Reyad *et al*. (1997) reported that 70 % of farmers in Umjawasir intercrop alfalfa with date palm. They found that intercropping alfalfa with date palm increases the income of one hectare up to US$ 3085/yr. At the same time, as tomato gained the second most profitable crop that increase the date palm hectare net income to US$ 2740/year. Okra is the third profitable crops when it is intercrop with dates in canal irrigation, which increases the income of one ha up to US$ 1621/yr (ELmakki, 2006). Some farmers growing oil palm intercropping with Cavendish banana (Ong *et al*. 2000).

Date palm is still grown in Egypt at a conventional method and stile cultivated with intercropped crops such as mango, citrus, legume etc. The rhizosphere is the habitat of both bacteria and fungi, which have a negative or positive effect on the growth and development of plants (Kurek and Kobus 1990). Root exudates, which are the main source of amino acids, sugars, vitamins, phenols, organic acids and metal ions, affect the composition of microorganism in the soil, especially in the rhizosphere (Darcy, 1982). Obied (2000) determined mycoflora of date palm associated with some pathological symptoms as *Fusarium moniliforme*, *Mauginiella sp*., *Thiolaviopsis paradoxa*, *Aspergillus sp*. and *Helminthosporium sp.* The distribution and pathogenesis of date palm fungi in Egypt was studied by El-Deeb *et al*. (2008) and in Bahrain by Qaher *et al*. (2005). The fungus *Fusarium oxysporum sp. albedinis* is soilborne; caused Bayoud of date palm (*Phoenix dactylifera* L.), however, the henna bush, when intercropped with date palm, may serve as a symptomless carrier of the fungus (Carpenter and Klotz 1966).

Therefore, a study was carried out to investigate the impact of intercropping mango (*Mangifera indica* L.), Balady mandarin (*Citrus reticulate* Blanco) and Egyptian clover (*Trifolium alexandrinum* L) crops with date palm on the quantity and quality of date fruits. The effect of intercropping on occurrence and enumeration of microorganisms in the rhizosphere of trees was also studied.

2. Material and Methods:

A study was carried out in a 15-yr-old date palm intercropped with mango and mandarin trees (10-yr-old) at a private orchard at Salheia Destricat, Sharkia Governorate, Egypt. The experiments were conducted to evaluate the impact of intercropping mango (*Mangifera indica* L.), Balady mandarin (*Citrus reticulate* Blanco) and Egyptian clover (*Trifolium alexandrinum* L) crops in comparison with date palm sole.

The Intercropping Treatments Were:

1- Date palm (pure stand)
2- Intercropping mango trees with date palm
3- Intercropping mandarin trees with date palm
4- Intercropping Egyptian clover under date palm

Three trees in each treatment were used as a replicate in split-plot Design. Where the date palms occurred in main plot, and the intercropping crops maintained in sub plot. Data recorded: Number of bunches per palm, mean weight of bunch and average yield per palm were recorded.

Physico-chemical characteristics of fruits (length and diameter of fruit, diameter: length ratio, size, percentage of flush weight, average fruit weight and stone criteria (diameter, length, and weight) were studied. Total soluble solids (TSS), total acidity, reducing, non-reducing and total sugars were determined in pulp juice as outlined by A.O.A.C (1995). Tannins content was determined using Indigo carmine indicator after Winton and Winton (1958). For comparison between treatments, approximately net profit ($/ha./yr) was calculated.

Collection of Rhizosphere Samples:

Rhizosphere samples were collected from depth of 15-30 cm adhering very closely to date palm roots. Seven rhizosphere samples from soil of date palm intercropped were obtained from the following treatments:

1. Rhizosphere of non-intercropped date palm (control; pure stand).
2. Rhizosphere of mango (monoculture)
3. Rhizosphere of date palm intercropped with mango
4. Rhizosphere of mango intercropped with date palm
5. Rhizosphere of mandarin (monoculture)
6. Rhizosphere date palm intercropped with mandarin.

7. Rhizosphere date palm intercropped with Egyptian clover

Enumeration of Microorganisms:

To estimate the number of soil microflora, counts were calculated on the basis of serial 10-fold dilutions, in duplicate, using the pour plate method using triplicate samples of 1g soil, and an appropriate dilution (Johnson and Curl, 1972); each value presented here is therefore an average of three individual counts. All petri dishes contained 15ml medium and the plates were incubated at 28-30°C in the dark. Colony-forming unites (CFU) were recorded after 1 week; the average number per gram oven-dry weight of soil was calculated.

For total bacterial flora, soil extract agar medium modified by Mahmoud *et al*.(1964) and Martin's medium (Allen, 1961) for fungi were used.

Microscopic Examination and Identification of Fungal Isolates:

Microscopic examination of mould growth was done by observing the colonial morphology- colour of colony, texture, shape and surface appearance and cultural characteristic- a sexual and sexual reproductive structures like sporangia, conidial head, arthrospores, the vegetative mycelia, septate or non-septate (Gilman, 1957; Nilson et al., 1983 and Barnett and Hunter, 1986). Microscopic examination of the moulds was done by using needle mount method.

A small portion of each colony was picked with sterile needle and teased out in a drop of clean microscopic slide. Slides were prepared likewise, using methylene blue in place of water.

Soil Chemical properties

Electrical conductivity (EC) and pH were measured in a soil 1:10 (w/v) by using a pH meter (WTW Germany, pH 330) and an EC meter (WTW Germany, LF 330), respectively.

To analyze macro and micronutrients in soil (rhisosphere zone), samples were taken from each treatment, and then dried at 70°C. From each sample 0.2 g was digested using 5 cm^3 of the mixture of sulfuric (H_2SO_4) and perchloric ($HCLO_4$) acids (1:1) as described by Peterburgski (1968). Total nitrogen was determined by micro-Kjeldahl method and phosphorus was determined calorimetrically at wavelength 680 nm using spectrophotometer (Spekol) as well as potassium was determined by using Gallen Kamp flame photometer. Micronutrients, i.e., Zn, Fe, Zn and Mn were measured using atomic absorption spectrophotometer Perkin Elmer model 5000 (Cottenie *et al*. 1982).

Statistical Analysis

The obtained data from each season were exposed to the proper statistical analysis of variance according to Gomez and Gomez (1984). The combined analysis of variance for the data of the two seasons was performed after testing the error homogeneity and LSD at 0.05 level of significance was used for the comparison between means.

3. Results and Discussion:

Soil Chemical Properties

Data in Fig.1 indicated that EC, pH and macro and micronutrients were affected by the plant species as well as by the methods of planting i.e. in pure stand or intercropping. Intercropping date palm with mango caused a reduction of EC by 17% (from 0.18 to 0.15 dS/cm), while sowing clover crops and mandarin resulted in increasing the EC value by 61 and 44%, respectively, compared to date palm sole.

Concerning pH value, Data in Fig. (1) indicated that the lowest values of pH were noticed under intercropping date palm with clover or mandarin. Rhisosphere of palm (pure stand) had a high concentration of N compared to palms intercropped with mango or mandarin. This result may be due to that the N not uptake by the palm is uptake by the mandarin or mango trees. Intercropped mandarin with palms caused a depletion of N from soil by 14.3 relative to date palm pure stand (Fig 1). By placing deep-rooted crops intercropping with shallow rooted crops where available N is present in deeper soil layers, nitrogen losses can be reduced (Thorup-Kristensen and Sørensen, 1999). On the other hand sowing clover with palms increased the N availability in soil by 3.6%. The atmospherically-fixed N in mixed swards containing 30-50% clover was estimated as 157kg^{-1}ha yr^{-1} (Kristensen *et al*. 1995).

Phosphorus status in soil was increase under the three intercropping patterns, and the highest level of P in soil was occurred under palm intercropped with clover where it increased by 136.7% than in rhisosphere of palms (sole).Tthis may be that the date palm trees have a high requirement from P nutrient. All intercropping pattern increase the K levels in soil and the highest value was recorded with palm intercropped with mandarin (90% increment). Similar trend was noticed with Fe element (Fig.1). High levels of Zn and Mn in soil were recorded in rhisosphere of clover and palms intercropped with mandarin. We could concluded that the status of nutrients in the soil not affected by the pH value but depends mainly on plant species and intercropping plants (root density, soil microbial activity, root exudates, etc.)

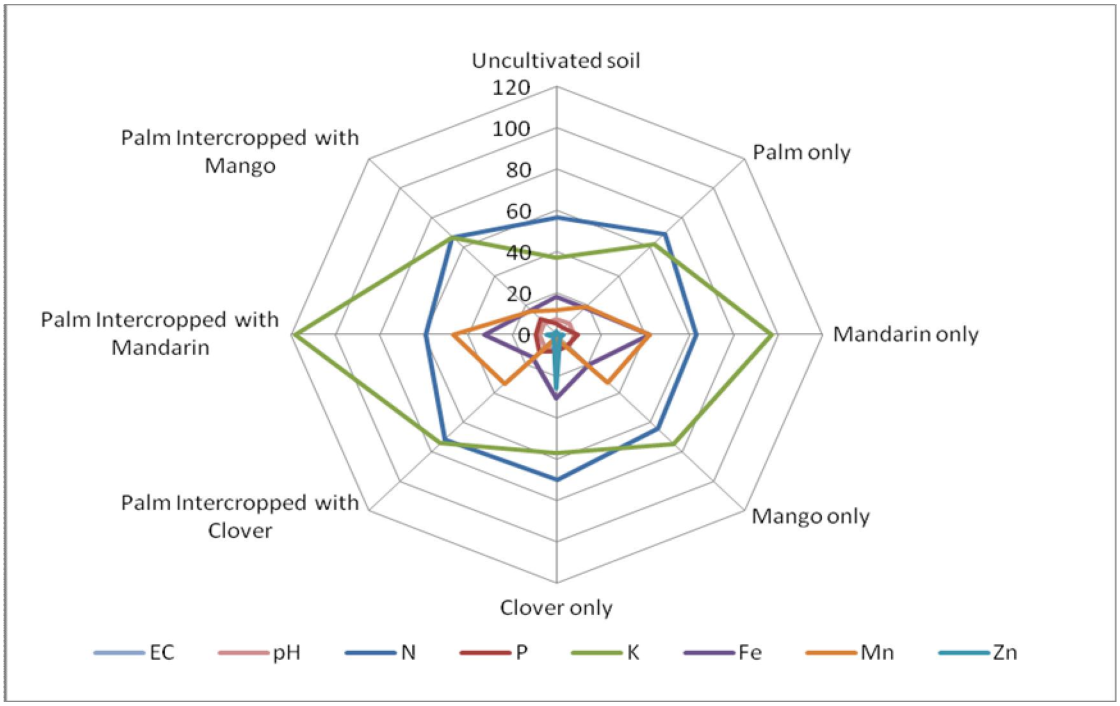

Fig 1: Soil chemical properties as affected by intercropping date palm with clover, mandarin or mango trees.

Rhizosphere Microflora

1-Fungi and Bacteria Occurrence:

Results of a laboratory microbiological analysis of particular rhizosphere samples of date palm showed different numbers of bacteria and fungi (Table, 1). The total number of bacteria in the rhizosphere samples (d.w.) ranged from 56.54 cfu X 10^5 g $^{-1}$to 375.52 cfu x 10^5 g^{-1}. Tyner (1940) reported that the decomposable root debris and root exudates had supplied the microorganisms with available sources of nutrients to grow and proliferate. Similar results were also obtained on date palm rhizosphere by Kurek & Kobus, 1990 and Obied, 2000.

The greatest number of bacteria was observed in the rhizosphere taken from the root of mandarin followed by root of date palm intercropped with mango. One the other hand, the number of bacteria increased from 65.19 cfu x 10^5g^{-1} in the control (non-intercropped palm) to 92.22, 190.82 and 268.15 cfu x 10^5 g^{-1} (41.5%, 192.7 and 311.3% increase) in the roots of date palm intercropped with clover, mandarin and mango, respectively.

The total number of fungi in the rhizosphere of date palm ranged between 16.00 and 128.07 cfu x 10^3g^{-1}. Intercropping date palm with mandarin decreased the total fungal count from 21.17 cfu x 10^3g^{-1} in the non- intercropped roots to 16.00 cfu x 10^3g^{-1} (24.4% decrease) in date palm root intercropped with mandarin. While, intercropping date palm with mango and clover increased the total fungal count to 118.32 cfu x 10^3g^{-1} and 52.00 x10^3 g^{-1}, respectively, compared to date palm sole. On the contrary, Shirazi *et al*., 2008 found that intercropping of date plantations with alfalfa (*Medicago sativa*) and sorghum (*Sorghum vulgaris*) cultivations increased relative humidity in the garden and decreased the disease. They added that alfalfa was more effective than sorghum.

On the other hand, growing clover plants and mango trees under date palms caused increase in the total fungal count by 145.6% and 458.9% respectively. The dynamic increase of the microorganisms in the rhizosphere of date palm intercropped with other cultivations can be explained by the favorable quantitative and qualitative composition of organic compounds provided in the form of root exudates and crop residues. This fact is confirmed by earlier information from the previous investigators (Rovira, 1969 and Funck & Hockenhull, 1984).

2- Frequency and identification of rhizospheric fungi:

The genera and species from the rhizosphere of date palm intercropped with other crops or non- intercropped were isolated and identified (Table, 2). Depending upon their frequency of occurrence genera were grouped as major components and minor components. Major components include most frequently encountered such as *Fusarium sp., Aspergillus niger*, and *Gliocladium sp*. While, minor components include less frequent and sporadic types such as *Alternaria tenuis, Aspergillus sulphoreus, Trichoderma harzianum, harzianum, Rhizoctonia solani* and *Penicillium funiculosum* in descending order.

Fungal species in the rhizosphere of non-intercropped date palm recorded eight fungal species belonging to four genera namely *Aspergillus niger* (30%), *Fusarium sp* (50%), *Mucor mucedo* (10 %) and *Rhizopus nigricans* (10%). On the other hand, some fungi were appeared or disappeared in the rhizosphere of date palm according to the type of intercropped plants. Genearly, the quantitative and qualitative differences in frequent occurrence of fungal genera or species between different treatments were recorded. For example, root of mango intercropped with date palm stimulated the growth *of Phycomycetes* grouping fungi, *Penicillium sp.* and *Rhizoctonia solani* from 0.0 to 7.14%, *Gliocladium sp.* from 0.0 to 4.67% and *T. viride* from 0.0 to 9.52%. While, intercropped mandarin with date palm stimulated the growth of *Fusarium sp* from 50% to 71.43% and *Penicillium sp.* from 0.0 to 21.43 %, but *Mucor mucedo* and *Rhizopus nigricans* disappeared on the roots of date palm (Table.2).

Growing Egyptian clover under date palms led to increased *Gliocladium sp., Penicillium sp.* and *Phycomycetes fungi* from 0.0 to 17.14, 5.72 and 11.43%, respectively. On the other hand, some intercropping mango, mandarin and clover with date palm resulted in reduced or disappearing *A. niger*, *Fusarium sp.*, *R. nigricans* and *Mucor mucedo* that recorded with date palm (non intercropped).

Cultivation of date palm trees intercropped with other crops grow in close proximity to each other and the root exudates may accumulate in the rhizosphere from all sides causing a marked inhibitory or stimulatory effect to microflora in the rhizosphere of date palm. Root exudates are known to either stimulate or inhibit the growth of different species of microorganisms. For example, root exudates of *Crotalaria medicaginea* stimulated the growth of *Penicillium herquei, Aspergillus niger* and *Alternaria humicola* but significantly reduced the growth of *Trichoderma lignorum* (Sulia, 1973). In addition, Hakkou and Bouakka (2004) reported that the spread of the disease is promoted by intercropping, especially by the more water-demanding intercrops.

Table 1: Total bacteria and fungal counts in the rhizosphere of date palm intercropped with some crops.

Intercropped plant	**Bacteria (cfu x $10^5 g^{-1}$)**	**Fungi (cfu x $10^3 g^{-1}$)**
Rhizosphere of palm only (pure stand)	65.19	21.17
Rhizosphere of mango (pure stand)	56.54	31.55
Rhizosphere of palm intercropped with mango	268.15	118.32
Rhizosphere of mango intercropped with palm	136.30	128.07
Rhizosphere of mandarin (pure stand)	375.52	30.16
Rhizosphere of palm intercropped with mandarin	190.82	16.00
Rhizosphere of Palm intercropped with clover	92.22	52.00

Table 2: Fungal genera and species (%) in the rhizosphere of date palm sole or intercropped with (+) other crops

Isolated fungi	Rhizosphere of							Mean
	Palm (Sole)	Mango (Sole)	Mandarin (Sole)	Palm + mango	palm + Mango	Palm + mandarin	Palm + clover	
Alternaria tenuis	-	-	2.38	-	-	-	-	0.34
Aspergillus humicola	-	15.63	-	4.67	7.41	-	-	3.96
A. niger	30.00	6.25	4.77	23.81	24.07	7.14	34.28	18.62
A. sulphoreus	-	6.25	-	-	-	-	-	0.89
Fusarium sp.	50.00	15.63	59.52	19.04	14.81	71.43	22.86	36.18
Gliocladium sp.	-	31.25	9.52	4.67	18.52	-	17.14	11.59
Mucor mucedo	10.00	6.25	9.52	11.90	5.56	-	-	6.18
Penicillium funiculosum	-	3.13	9.52	-	-	-	-	1.81
Penicillium sp.	-	15.63	-	7.14	18.52	21.43	5.72	9.78
Phycomycetes fungi	-	-	-	7.14	-	-	11.43	2.65
Rhizoctonia solani	-	-	-	7.14	-	-	-	1.02
Rhizopus nigricans	10.00	-	4.27	4.76	7.41	-	8.57	4.62
Trichoderma harzianum	-	-	-	-	-	-	-	-
T. viride	-	-	-	9.52	3.70	-	-	1.89

3- Quantity and quality of date fruits:

The fruit quality criteria i.e. fruit weight, fruit diameter and length, pulp thickness, flesh weight, pulp/seed ratio were significantly affected by the intercropping. Monoculture of date palm produced the highest fruit yield/palm, followed by date palm intercropped with mango and mandarin and the lowest fruit yield/palm was obtained from date palms intercropped with clover (Table 3). Data also indicated that no significant differences between sole date palm and that intercropped with mango in number and weight of bunch. This result may be due to that palm tree has a big root system that may extend to 10m from trunk and 3-7m deep or to the water table level. This huge root system makes palm tree resistant to unfavorable conditions (Al-Rawi, 1998).

Concerning intercropping system, growing mango or mandarin under date palm resulted in the highest fruit yield/palm, compared to intercropping with clover. Intercropping Egyptian clover with date palm caused a significant reduction in fruit diameter. Monoculture date palm had the maximum fruit weight (25.8g), which significantly higher than other intercropping system. Intercropping mandarin with date palm caused a significant reduction in fruit diameter, weight and size by 6.2, 6.9 and 5.0%, respectively, compared to sole cropping.

Table 3: Effect of intercropping on date fruits characters(Average of two seasons).

Treatments	Number of bunches /palm	Weight of bunch (kg)	Yield of Palm (kg)	Fruit characters						Stone characters		
				D. (cm)	L. (cm)	D/L	Weight (g)	Size (cm^2)	% of fresh weight	Weight (g)	D. (cm)	L. (cm)
Palm only	9.8	14.86	145.6	2.9	5.2	0.56	25.8	26.50	90.1	2.55	1.1	3.3
Palm with mango	9.4	14.51	136.4	2.7	5.9	0.46	25.7	27.62	91.3	2.23	1.1	3.3
Palm with mandarin	9.4	14.38	135.2	2.7	5.7	0.47	24.2	25.18	90.0	2.43	1.0	3.4
Palm with clover	9.1	13.98	127.2	2.6	6.0	0.43	25.6	26.66	90.8	2.36	0.8	3.5
LSD at 0.05	NS	0.43	7.4	0.3	0.4	0.07	1.1	1.76	0.5	0.16	NS	NS

Abbreviations: D., Diameter; L., Length;

The lowest stone weight (2.23 g) was recorded when date palm intercropped with mango. Intercropping of mango, mandarin or clover had insignificant effect on bunches number/palm and mean weight of bunch as well as on stone diameter and length (Table, 3). These results may be due to that the date palms were planted 7 meters apart, which provides ample space for intercropping. Steiner (1982) reported that the competition for resources between the crops in an intercropping system could be non-competitive, competitive or complementary.

Data in Table 4 indicated that higher and lower total sugars in fruits were obtained from pure stand date palm (85.3%) and date palm intercropped with mandarin, (68.8%). While higher tannins and total soluble solids were obtained from palms intercropped with Egyptian clover and mango, respectively (Table 4).

Data in Table 4 indicated that intercropping mango gave the highest net profit ($8213/ha./yr), followed by the same area (hectare) intercropped with mandarin ($ 3992/ha/yr) which caused increment by 139% and 16 %, over that date palm (pure stand=$3442/ha./yr), respectively. From our results, it could be concluded that intercrops with date palm can be more profitable than growing pure stands.

Similar finding was reported by Elmakki (2006) who stated that intercropping of alfalfa with date palm increases the income of one hectare up to US$ 3085/yr. they added that tomato gained the second most profitable crop that increase the date palm hectare net income to US$2,740. While, okra is the third profitable crops when intercropped with dates in canal irrigation that increases the income of 1 ha up to US$ 1621/yr.

Traditionally, intercropping with other fruit trees (citrus, pomegranates, olives, grapes, guava) or arable crops (alfalfa, barley, beans etc.) is practiced in many of the main production areas. Without the shade provided by the date palms other crops very often cannot grow.

Al-Yahyai (2009) reported that to make the best use of the farm, it was and still a common practice to grow cotton, maize, alfalfa, wheat, vegetables, and fruits between and under the palm trees. Most commonly in the level land is to interplant palms with citrus and alfalfa. According to the FAO paper, conditions in the old world often favor inter-planting. First, the sensitivity of some fruit crops like citrus to harsh conditions, such as the high temperature, extremely cold or hot dry winds, and the strong sun make the date palm plantation shade the best way of producing high value fruit trees. Second, inter-planted is favored by small poor farmers who own an inherited a small date garden, thus planting some other fruit trees would provide an alternative income source. In addition, growing some of the fruit or fodder crop to be consumed by the household or provide income throughout the year is another perspective of practicing inter-planting in old palm orchards especially at early years of orchard establishment when the return from it is low. These inter-crops also improve nutrition status and the physical properties of the soil.

Table 4: Effect of intercropping on chemical constituents of date fruits and return per hectare/ year (Average of two seasons).

Treatments	Chemical properties						Return ($/ha/yr)				
	Sugars %			Acidity (%)	Tannins (g/100g FW)	Total soluble solids (%)	Date fruits	Second crop	Total	Costs	Net profit
	Total	Reducing	Non reducing								
Date palm	85.3	55.3	30.0	0.35	0.53	15.47	4459	-	4459	1017	3442
Date palm with mango	80.5	50.5	30.0	0.36	0.54	16.30	4177	6664	10841	2628	8213
Palm with mandarin	68.8	48.1	20.7	0.46	0.64	13.63	4140	2352	6492	2500	3992
Date palm with clover	73.3	41.7	31.6	0.46	0.65	12.35	3895	381	4276	1144	3132
LSD at 0.05	3.7	4.5	2.8	0.07	0.08	1.74	360	521	1215	210	472

Abbreviations: yr, year; FW, fresh weight
Return /hectare = number of trees/hectare X average yield in two seasons X mean price ($/ kg)
Income was calculated as: 204 palms x mean yield per palm for date palm X$0.151 , 204 trees X 74 kg X $0.445, for mango, 600 trees X 37 kg X $ 0.107 for mandarin, and for clover 4 cuttings X $ 128.16/ha.

The data in Table 4 showed that intercropping date palm with Egyptian clover resulted in decrement the net profitable per hectare by 9% (from $3442 to $3132). This reduction was attributed to the decrement of bunch number and weight and consequently decreased the total yield/palm. El –Halawany and Shaltout (1993) reported that date palm plantation which is intercropped with alfalfa, vegetables and fruit trees either lake of weed control or have some hand weeding.

4. Conclusion:

Evaluation of growing mango, mandarin or Egyptian clover with date palm indicated that growing mango with date palm as intercropping could be used for combating desertification in the sandy soil and significant cropping techniques in sustainable agriculture. Intercropping is utilized a number of environmental benefits, from promoting land biodiversity to diversifying agricultural outcome. This model integrates low (Egyptian clover), medium (mandarin or mango), and tall plants (date palm), as well as plants of short, medium, and long life cycles, including trees.

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5. References:

1. Agricultural Economic Bulletin. 2005. Ministry of Agriculture and Land Reclamation, A.R.E., Acreage and total production of fruits, pp.177 (in Arabic).
2. Akyurt, M., E. Rehbini, H. Bogis, A.A. Aljinaidi. 2002. A survey of mechanization efforts on date palm crown operations. The 6th Saudi Engineering Conf., KFUPM, Dhahran, December 2002 Vol. 5, 475 - 489.
3. Ali G. A., Karibl A. K., Ibn- Aoof M. 1998. Survey on production, handling, storage and marketing of dates in the northern region. First Inter. Conf. on Date Palms (Al-Ain, UAE, March 8-10, 1998).
4. Allen O. N. 1961. Experiments on soil bacteriology. Burgess Pub. Co. Minneapolis, Minnesota, USA.
5. Al-Rawi A.A.H. 1998.Fertilization of date palm tree (*Phoenix dactylifera* L.) in Iraq. Proc. the 1st Inter. Conf. on date palm, Al-Ain, U.A.E. pp: 320-328.
6. Al Yahyai R. 2009. The Traditional Date Palm Cultivation in Oman: Intercropping. Available from:

http://www.nizwa.net/agr/dates/dates/palm/datepalm3.html [Accessed 14 March 2010].
7. Anon- 1 2008. Pakistan: Stagnant date production. Available from: http://www.freshplaza.com/news_detail.asp?id=29144 [Accessed 14 March 2010].
8. A.O.A.C. 1995. Association of Offical Agricultural Chemists. Official Methods of Analysis. 15th Ed. Published by A.O.A.C. Washington, D.C. (U.S.A).
9. Barnett H.L., Hunter B.B. 1986. Illustrated genera of fungi. 3 ed. Burgess Co. and Minneapolis, Minnesota, USA.
10. Carpenter J.B., Klotz L.J. 1966. Diseases of the date palm. Date Growers Inst. Rep. 43:15-21.
11. Cottenie A., Verloo M., Velghe G., Comerlynk R. 1982. Chemical analysis of plant and soil. Ghent, Belgium, Laboratory of Analytical and Agro-chemistry State University.
12. Darcy A.L. 1982. Study of soya and lens exudates. Kinetics of fenolic compounds, amino acids and sugars in the first days of plant growth. Plant and Soil, 68, 399-403. Available from: http://www.springerlink.com/content/f2235055186781t0/?p=52af615c93fe4812a8355b879c6bf99f&pi=11[Accessed 14 March 2010].
13. El-Deeb H.M., Lashin S.M., Arab Y. A. 2008. Distribution and pathogenesis of date palm fungi in Egypt. Acta Horticultrae, 736: 421-429. Available from: http://www.actahort.org/books/736/736_39.htm [Accessed 14 March 2010].
14. El-Halawany E.F., Shaltout K.H..1993. Weed flora of the date Palm orchards in eastern Saudi Arabia. J. Saudi Arabia Univ.5, Science (1):25-37. Available from: http://repository.ksu.edu.sa/jspui/bitstream/123456789/492/1/Weed%20Flora%20of%20the%20Date%20Palm%20Orchards.pdf [Accessed 14 March 2010].
15. Elmakki O.A.O. 2006. Challenges and Possibilities of Drip and Canal Irrigation in Northern Sudan. Master Sci. Thesis, Norwegian Univ. of Life Sci., Norway
16. Funck J. D., Hockenhull J. 1984. Root exudation, rhizosphere microorganism and disease control. Vaxtskyddsnotiser, 48: 49-54. Available from: http://chaos.bibul.slu.se/sll/slu/vaxtskyddsnotiser/VSN84-3/VSN84-3B.HTM [Accessed 14 March 2010].
17. Gilman J.C. 1957. A manual of soil fungi. Second Ed. The Iowa State Univ. Press, Ames, Iowa, USA, 450pp.
18. Gomez K.A., Gomez A.A. 1984. Statistical Procedure for Agricultural Research. New York: John Wiley and Son.
19. Hakkou A., Bouakka M. 2004. Present state of the Figuig oasis date palm grove and incidence of the Fusarium wilt. Secheresse 15 (2)147-158. Available from: http://www.john-libbey-eurotext.fr/en/revues/agro_biotech/sec/e-docs/ 00/04/04/05/article.phtml [Accessed 14 March 2010].
20. Johnson L.F., Curl E.A. 1972. Methods for research on the ecology of soil- borne plant pathogens. Burgess, Minneapolis.
21. Kristensen E.S., Høgh-Jensen H., Kristensen I. S. 1995. A simple model for estimation of atmospherically-derived nitrogen in grass-clover swards. Biol., Agric. and Hortic., 2, 263-276.
22. Kurek E., Kobus J. 1990. Benificia and harmful effects of rhizosphere microflora on growth and development of plants. Mikrobiol., 24: 103-123. Cited From: AbdElMotty, E. Z., M.F.M.Shahin, M.M.M.Abd El-Migeed and A.F. Sahab. 2009. Comparative Studies of Using Compost Combined with Plant Guard and flespar on the morphological , physiological and rhizosphere microflora of olive seedlings. American-Eurasian J. Agric. & Environ. Sci., 6 (4): 372-382. Available from: http://idosi.org/aejaes/jaes6(4)/1.pdf [Accessed 14 March 2010].
23. Mahmoud S A.Z., Abou El-Fadle M., El-Mofty M. 1964. Studied on the rhizosphere microflora of a desert plants. Folia Microbiologica, 9: 1-8. Available from: http://www.springerlink.com/content/jqw42v35781tx018/ fulltext.pdf?page=1 [Accessed 14 March 2010].
24. Mahmoudi H., Hosseininia G., Azadi H., Fatemi M. 2008. Enhancing date palm processing, marketing and pest control through organic culture. J. of Organic Systems, 3 (2):29-39. Available from: http://www.organic-systems.org/journal/Vol_3(2)/pdf/29-39_Mahmoudi_et_al.pdf [Accessed 14 March 2010].
25. Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being: Desertification Synthesis. World Resources Institute, Washington, DC.
26. Morton J. 1987. Date *Phoenix Dactylifera* p. 5–11. In: Fruits of warm climates. Julia F. Morton, Miami, FL. Available from: http://www.hort.purdue.edu/newcropmorton/index.html [Accessed 14 March 2010].

27. Nilson P.E., Toussoun T. A, Marasas W.F.O. 1983. *Fusarium* species. Am. Illustrated Manual for identification. Pennsylvania State Univ., Press Park and London, 193pp.
28. Obied M.M.A. 2000. Production and protection of date palms in Sudan. Seventh Arab Congress of Plant Prot., 22-26 October.455-460.
29. Ong K.P., Lee Y.M., Teo L. 2000. Commercial experiences of oil palm intercropping with Cavendish banana. In: Proc. International Planters Conf. 2000 (ed. Pushparajah). Incorporated Soc. of Planters.
30. Peterburgski A.V. 1968. Handbook of Agronomic Chemistry. Kolop Publishing House, Moscow, Russia
31. Rovira A.D. 1969. Plant root exudates. Bot. Rev., 35: 35-57. Available from: http://www.springerlink.com/content/915681q331171781/fulltext.pdf?page=1 [Accessed 14 March 2010].
32. Shirazi M.P., Izadi M., Khademi R. 2008. Study the climatical factors effects on bunch fading disorder of date palm in southern Iran and the methods of its control. American-Eurasian J. Agric. & Environ. Sci., 4 (5): 570-574. Available from: http://www.idosi.org/aejaes/jaes4(5)/8.pdf [Accessed 14 March 2010].
33. Steiner K.G. 1982. Intercropping in tropical smallholder agriculture with special reference to West Africa. Deutsche Gesellsaft fur Technische, Zusammenarbeit, Eschborn, Germany
34. Sulia S.B. 1973. Effect of root exudates and extracts on rhizosphere fungi. Plant and Soil, 39: 197-200. Available from: http://www.springerlink.com/content/t8020802068v7172/ [Accessed 14 March 2010].
35. Thorup-Kristensen, K. and Sørensen, J.N. 1999. Soil Nitrogen Depletion by Vegetable Crops with Variable Root Growth. Acta Agric.Scand., Sect.B, Soil and Plant Sci. 49:92-97.
36. Tyner L. E. 1940. The effect of crop debris on the pathogenicity of cereal root-rotting fungi. Canad. J. Research 18:289-306.
37. Winton A.L., Winton K.B.1958. The analysis of foods. John Wiley and Sones, INC, Lo

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