The Effect of Intercropping Wheat Under Olive Trees on The Productivity and Quality of Olive Fruits

Amro S.M. Salama [1], Osama H.M. El Gammal [1], Mohamed Abdelhamied Attia[2]

ABSTRACT

This trial was carried out on olive trees grown in the private orchard, Siwa oasis, Matrouh governorate, Egypt, during 2017, 2018 seasons. Trees were planted at 5x5 meters apart in sandy soil and irrigated by a flood system from agricultural drainage canal. This study aimed at studying the effect of olive–wheat in intercropping system and the application of humic acid on tree growth, yield and fruit quality of "Manzanillo" olive. The experiment was designed as a randomized complete block design with five replicates for each treatment and each replicate was represented by one tree. The results showed that vegetative growth i.e. tree dimensions, shoot growth, leaf characteristics, blooming and yield recorded the highest values in intercropping olive fertilized (30g) humic acid with wheat crop fertilized (4kg) humic acid/fed treatment. Furthermore intercropped olive with wheat produced less vegetative growth, blooming and yields of Manzanillo olive trees as compared with monoculture. Moreover, high level treatment of humic acid increased vegetative growth, blooming and yield of Manzanillo olive trees as compared with non-humic acid treatment in both seasons. The intercropping Manzanillo of olive trees treated with humic acid with wheat plants fertilized with humic acid system could be valuable for sustainable farming a source of income to the farmers in this region.

Key word: "Manzanillo" olive; Wheat; Intercropping; Humic acid

INTRODUCTION

Olive (*Olea europaea* L.) is considered one of the best adapted fruit species, in many arid and semi-arid regions around the Mediterranean. It is one of the main crops in this area (Villalobes *et al.*, 2000 and Moriana *et al.*, 2002). Olive has been regarded as a part of the social and culture tradition of some governorates of Egypt especially Siwa oasis, Matrouh and Sinai ((Hedia and Abd Elkawy, 2016). The Egyptian olive total area is about 248440 feddan, olive farmers in Siwa oasis produced 174777 tons represented 16.13% of total olive production 1083771 tons according to Agriculture statistics (2018). Egypt Alternate bearing is a built in character of olive trees. It is over all controlled by an interaction between vegetative growth and fruit load. Alternate bearing is a major problem for olive farmers and it had negative effect on production and oil olives industry (Dag *et al.*, 2010 and Lavee, 2006). Olive farmers need to the stability of their annual production. Intercropping can be used by small farmers to increase the diversity of their products and the stability of their annual production through efficient use of land and other resources (Okonji *et al*., 2012). In the Siwa oasis, growers resort to growing crops among fruit trees, especially alfalfa and legumes. Recently, wheat crop is cultivated under the olive trees in Siwa oasis. This cultivation technique is known as intercropping. Intercropping can maximize the benefit from the area of land as well as diversity of agricultural production to increase income from the area unit. Egypt imports wheat annually to meet its requirements and insure food security. Wheat is imported into Egypt and it need more attention must be paid to expanding its in cultivation in the Siwa oasis. Intercropping is the most important techniques sustainable agriculture because it has many environmental benefits. It is promotes land biodiversity to diversifying agricultural outcome (Abouziena *et al*., 2010). Intercropping is cultivation of two or more crops simultaneously in the same field (Sangakkara *et al.*, 2003 and Belal *et al.*, 2014). Abouziena *et al.* (2010) reported that intercropping is one of the most significant cropping techniques in sustainable agriculture. It has utilization a number of environmental benefits in promoting land biodiversity to diversifying agricultural outcome. Intercropping has many benefits in fruit tree orchards, such as reducing soil erosion, improving soil structure, suppressing weed growth, increasing water infiltration, reducing groundwater pollution, reducing input costs and increasing orchard profitability (Miller *et al.*, 1989, Smith, 1993 and Amjad *et al.*, 2015). Besides, cultivation of annual crops acts as cover crops which improve soil fertility and physical properties (Hubbard *et al.*, 2013), and reduce erosion (Baets *et al.*, 2011). The most common goal of intercropping is to produce greater yield on a given agricultural area (Ouma and Jeruto, 2010). Pantera *et al.* (2016) reported that olive trees intercropped with a leguminous crop appears to be a promising practice that may contribute not only to increase economic returns to the farmer but also to the environment by decreasing fertilizers use and soil and water contamination. Razouk *et al.* (2016a) worked on the optimal distances for sowing wheat, faba

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[1]Pomology Unit, Plant Production Department,
Desert Research Center, Egypt.
[2] Agronomy Unit, Plant Production Department, Desert Research Center, Egypt
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bean and coriander in intercropping systems with olive tree under rain-fed conditions in northern Morocco. They found that for olive trees having a height of 7 m, this distance is estimated to be 2 m outside the tree canopy, moreover sowing wheat at a lower distance from the olive trees canopy induces considerable reduction in growth and yield for both crops. Also, the intercropping system based on olive trees is an effective method to improve land use efficiency and economic returns, moreover, annual crops are particularly important for the small farmers. And they found that for sowing wheat, the optimal distance depends not only on tree shading, but also on the competition for soil moisture and nutrients because the growth cycle of wheat overlaps with the growth of the shoots and fruits of the olive trees. In addition, for sowing faba bean and coriander, the optimal distances corresponded to the limit where the shading effect becomes insignificant which is correlated with tree height. Panozzo and Desclaux (2018) mentioned that if durum wheat varieties adapted to agroforestry conditions would be provided by breeders, they could reach higher yield when associated with olives and thus increasing the orchard sustainability. Since they are yearly pruned, olive trees increased progressively their productivity and the associated durum wheat provides an additional source of income to the farmer. Panozzo and Desclaux (2020) reported that olive trees associated with durum wheat reduced olive yield. Besides, it is an additional source of income. Humic acid is a commercial product contains many elements which improve the soil fertility and increase the availability of nutrients (Javanmard *et al.,* 2009). It is a promising natural resource that can be used as an alternative to synthetic fertilizers. Humic acid is an important constituent and an intimate part of the soil organic structure which is highly effective in improving soil condition and plant growth (Pettit, 2004). It is one of the main components of humic substances. Humic acid (HA) are the most significant constituents of organic matter in soils. It increases the water holding capacity of soils. It also improves the soil structure and physical properties. Besides, it is promoting the chelation of many elements and making these available to plants (Biondi *et al.,* 1994; Elkhatib *et al.,* 2013). Humic acid may be utilized in agriculture as a fertilizer, plant growth promoter, nutrient carrier and soil conditioner (Bidegain *et al.,* 2000). It has been reported to enhance shoot growth length, plant growth, root length, moisture and nutrient uptake significantly (Yilmaz, 2007). It has similar effect like cytokining and gibberellin on olive trees, and pear trees (Fawzi *et al.,* 2007). Moreover, humic acid have similar effect like IAA in plants (O'Donnell, 1973). Furthermore, applying humic acid (HA) can be used on minimizing the intensive amounts of mineral nitrogen fertilization (Mohamed and Ashraf, 2016). Application of humic acid stimulates growth, nutrient uptake and yield in olive trees (Fernández-Escobar *et al.,* 1996). The objective of this study was the evaluation of intercropping olive trees with wheat and the application of humic acid on tree growth, yield and fruit quality of Manzanillo olive under Siwa oasis, Matrouh governorate, Egypt.

MATERIALS AND METHODS

This investigation was carried out during two successive seasons 2017 and 2018 at private orchard in Siwa oasis, Matrouh governorate, Egypt. Nine years old Manzanillo olive trees grown in sandy soil, and spaced 5x5 m apart and irrigated by flood system from agricultural drainage canal. Physical and chemical analysis of the experimental soil shown in (Table 1) and chemical analysis of used water from irrigation is present in (Table 2).

Table 1. Analysis of the experimental soil in 2017 and 2018 seasons

Physical analysis:

Soil Depth (cm)	Particle size distribution				Texture class	Bulk Density (g/cm)	Organic matter (%)	Moisture content (%)	
	Coarse sand	Fine sandy	Silt	Clay				Field Capacity	Wilting Point
0-60	0.00	97.50	1.50	1.00	sand	1.52	0.20	9.21	4.44

chemical analysis:

Soil Depth cm	$CaCO_3$	pH Soil past	E.Ce (dSm^{-1})	Soluble cations (meq/l)				soluble anions (meq/l)			
				Ca^{++}	K^{+}	Na^{+}	Mg^{++}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	$CO_3^{=}$
0-60	9.6	6.7	1.5	5.4	0.3	5.8	3.5	4.9	6	4.1	-

Table 2. Chemical analysis of water used for irrigation in 2017 and 2018 seasons

pH	E.C.	O.M	Soluble cations (meq/l)				soluble anions (meq/l)			
	dSm^{-1}	(%)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
7.2	2.0	0.85	4.8	2.9	11.8	0.5	-	1.9	12	6.1

Sixty olives healthy trees, nearly uniform in shape, size, productivity and received the same horticulture practice and were selected to a conduct this experiment twelve treatments as:

1. Olive tree without intercropping (control).
2. 20g humic acid (HA)/tree without intercropping.
3. 30g HA/tree without intercropping.
4. Intercropping 0g HA/olive tree with 0kg HA/fed wheat crop.
5. Intercropping 0g HA/olive tree with 2kg HA/fed wheat crop.
6. Intercropping 0g HA/olive tree with 4kg HA/fed wheat crop.
7. Intercropping 20g HA/olive tree with 0kg HA/fed wheat crop
8. Intercropping 20g HA/olive tree with 2kg HA/fed wheat crop.
9. Intercropping 20g HA/olive tree with 4kg HA/fed wheat crop.
10. Intercropping 30g HA/olive tree with 0kg HA/fed wheat crop.
11. Intercropping 30g HA/olive tree with 2kg HA/fed wheat crop.
12. Intercropping 30g HA/olive tree with 4kg HA/fed wheat crop.

Moreover, Humic acid from China imported by Technogene company was divided in two equal doses and added as soil application in 15 cm depth and 1 m from the trunk at two times in the first week of March, and second at the first week of July in both seasons. The tested intercropping olive and wheat received cultural managements as recommended by the Egyptian Ministry of Agriculture. A part of this orchard was in association with wheat the inter-rows were cultivated with bread wheat *(Triticum aestivum)* with olive trees in the study area. Wheat seeds were sowed from the limit of the olive tree canopies among the inter-rows of trees. The control for tree growth was a monoculture standalone of olive trees. Wheat was sown also during the dormancy period of olive tree (just after olive fruit harvest) at the end of November, but wheat crop were harvested in mid-June after the growth departure of shoot and fruit of olive tree. For wheat crop yield, there was no monoculture control. The experiment was designed as randomized complete block design with five replicates for each treatment and each replicate was represented by one tree. Response of the tested intercropping "Manzanillo" olive trees with wheat crop and humic acid application treatments were evaluated and presented by the following parameters.

Vegetative growth:

Tree dimensions

Tree height, canopy circumference and diameter were measured using a meter scale and initial measurement in early February and final measure in early November were taken annually.

Shoot growth

To estimate rate of shoot elongation, 20 new springs per tree were randomly selected and tagged in early February till growth cessation in early November and total number of leaves per shoot were counted and recorded.

Leaf characteristics

Area of leaf blade were recorded for 20 mature leaves on spring cycle shoots, were estimated by using portable area mod Li 3100 Ali (Li-cor) in November.

Blooming characteristics:

Panicles number per shoot

Pre - full bloom stage 20 shoots one year- old were randomly chosen at on each tree. The number of panicles on each shoot was counted and average was calculated.

Number of flower per panicle

Samples of 30 panicles from each tree (just before flower opening) were picked to determine average number of flowers per panicle.

Perfect flower

Samples of 30 panicles for each tree were taken at full bloom stage to count the number of perfect/panicle and the percentage of perfect flowers to total number of flowers was calculated.

Yield Kg/tree.

Fruits were harvested at the second week of October. Fruit harvesting was conducted manually. Fruit yield were weighted in Kg and recorded.

Fruit quality:

Representative fruit sample were taken at harvest from each treated tree for determination of the following physical parameters. Fruit weight (g), fruit volume (cm^3), fruit length (cm), fruit diameter (cm) and pulp thickness (cm) were measured.

Moisture content

Proper fruit sample 30 fruits replicate per each tested treatment was dried at 60°C in electric oven until constant weight and then fruit moisture content was calculated.

Oil content

Oil content was determined by extracting the oil from dried fresh samples of treatments using pertroleum ether at 40 – 60°C boiling point by soxhlet fat extraction apparatus as described in the A.O.A.C. (1995).

Acid value

Five grams of oil were weighed in 250 ml dry conical flask with 100 of neutralized “50% ethanl + 50% petroleum ether” to dissolve the oil sample. Acid value was determind by titration with 0.1 N potassium hydroxide solutions in the presence of phenol phthalein as an indicator (A.O.A.C., 1995)

Statistical analysis

The obtained data in 2017 and 2018 seasons were subjected to analysis of variance according to Clarke and Kempson (1997). Means were differentiated using Duncan multiple rang test at the 0.05 level (Duncan, 1955).

RESULTS AND DISCUSSION

Vegetative growth:

Tree dimensions:

Increment tree height (cm)

Table (3) illustrates that all tested treatments gave a significant effect in increment tree height value. In addition, the highest increment tree height was recorded with 30g HA/olive tree with 4kg HA/fed wheat crop treatment as compared with 0g HA/olive tree with 0kg HA/fed wheat crop treatment and olive trees alone (control) treatment in both seasons. Furthermore, 30g HA/olive tree with 4kg HA/fed wheat crop treatment proved to be the best treatment in this regard. Moreover, the intercropping olive with wheat treatment gave lower in increment tree height value than the corresponding monoculture one. Furthermore, the highest level of humic acid application increased in increment tree height value as compared with non-humic acid ones in both seasons.

Increment in tree circumference (cm)

Table (3) shows that the lowest increment in tree circumference value was recorded with 0g HA/olive tree with 0kg HA/fed wheat treatment in both seasons. However, 30g HA/olive tree with 4kg HA/fed wheat treatment gave the highest increment in tree circumference value as compared with 0g HA/olive tree with 0kg HA/fed wheat crop treatment and olive tree alone treatment in first seasons. In addition, 30g HA/olive tree with 4kg HA/fed wheat crop and 30g HA/olive tree with 2kg HA/fed wheat crop treatments gave the highest increment in tree circumference value in the second season. On the other hand, 30g humic acid/tree treatment increased the tree circumference value as compared with non-humic acid ones in both seasons.

Increment in tree diameter (cm)

Table (3) indicates that 30g HA/olive tree with 4kg HA/fed wheat crops treatment recorded the highest increment in tree diameter value as compared with olive trees of control treatment and 0g HA/olive with 0kg HA/fed wheat crop treatment in the first season. Moreover, 30g HA/olive tree with 4kg HA/fed wheat crop and 30g HA/olive tree with 2kg HA/fed wheat crop treatments gave the highest increment in tree diameter as compared with olives of control tree alone treatment and 0g HA/olive with 0kg HA/fed wheat crop treatment in the second season. Evidently, 30g humic acid/tree treatment enhanced the increment of tree diameter as compared with non-humic acid ones in both seasons.

Table 3. Effect of the intercropping olive trees with wheat crop on increment tree height (cm), increment in circumference (cm) and increment in diameter (cm) of "Manzanillo" olive trees during 2017 and 2018 seasons

Treatments	increment tree height (cm)		increment in circumference (cm)		Increment in diameter (cm)	
	2017	2018	2017	2018	2017	2018
Olive alone	18.69 gh	9.64 i	11.88GH	8.55 fg	15.93 h	7.20 h
Olive + 20g HA	20.41 e	11.62 gh	13.51 f	9.37 e	17.64 f	8.30 fg
Olive + 30g HA	20.42 e	12.08 fg	14.28 e	10.07 d	17.88 ef	8.71 ef
Olive + 0g HA with wheat + 0k HA/fed	18.25 h	8.69 j	11.79 h	8.34 g	15.80 h	7.09 h
Olive + 0g HA with wheat + 2k HA /fed	18.92 g	9.84 i	12.38 g	8.89 ef	16.30 h	7.22 h
Olive + 0g HA with wheat + 4k HA /fed	19.80 f	11.33 h	12.98 f	9.35 e	17.05 g	8.00 g
Olive + 20g HA with wheat + 0k HA /fed	21.27 d	12.37 ef	14.98 d	10.30 cd	18.81 d	9.07 de
Olive + 20g HA with wheat + 2k/ HA fed	21.17 d	12.78 de	15.99 c	10.61 c	18.20 e	9.60 cd
Olive + 20g HA with wheat + 4k HA /fed	22.62 c	13.30 cd	16.51 bc	10.75 bc	19.30 d	9.97 bc
Olive + 30g HA with wheat + 0k HA /fed	23.72 b	13.71 c	16.60 b	10.79 bc	20.62 c	10.28 b
Olive + 30g HA with wheat + 2k HA /fed	24.18 ab	14.38 b	18.29 a	11.25 ab	21.31 b	11.26 a
Olive + 30g HA with wheat + 4k HA /fed	24.68 a	15.08 a	18.35 a	11.33 a	22.57 a	11.55 a

Means within each column or row followed by the same letter (s) are not significantly at 5% level

Increment in shoot length (cm)

Table (4) indicates that 30g HA/olive tree with 4kg HA/fed wheat crop treatment gave the highest increment in shoot length as compared with the intercropping olive tree with 0kg HA/fed wheat crop treatment and olive tree alone treatment in both seasons. Furthermore, the other treatments gave an intermediate effect in this respect.

Increment in number of leaves per shoot

Data presented in Table, 4 shows that all tested treatments gave a significant effect on number of leaves per shoot values of olive trees in both seasons. In addition, 30g HA/olive tree with 4kg HA/fed wheat crop treatment gave the highest increment in number of leaves per shoot as compared with olive tree with 0kg HA/fed wheat crop treatment and olive tree alone treatment in both seasons.

Leaf surface area

Data in table (4) indicates that all tested treatments gave a significant effect on leaf surface area. Moreover, 30g HA/olive tree with 4kg HA/fed wheat crop treatment gave the highest leaf surface area and it surpassed other treatments in this respect. Moreover, the intercropping olive with wheat treatment gave lower leaf surface area than the corresponding monoculture one. Furthermore, higher level of humic acid application increased leaf surface area as compared with non-humic acid ones in both seasons.

The effect of intercropping system based on olive and wheat on regarding his negative effect on vegetative growth may be attributed that wheat crop has overlapped with olive. Wheat plants exert a severe competition for soil moisture and nutrients during the critical period of olive shoot growth which reduced in vegetative growth of olive tree (Bendidi *et al.,* 2013 and Razouk *et al.,* 2013).

This competition between wheat and olive induced water stress occurring during the rapid shoots growth of olive tree and it induce a significant reduction on shoots growth, thereby affecting their final shoot length (Girona *et al.,* 2000 and Pérez *et al.,* 2004). All of this referred to the olive root system cover an area exceeding the limit of the tree canopy which making them in partially competition induced by wheat for soil water and nutrient. In addition, the negative effect of wheat on the vegetative growth of the olive tree during vegetative growth may be also linked to the liberation of ethylene from wheat grains, which is known for its inhibitory effect on shoot elongation in most plant species (Kim and Mulkey, 1997). The obtained results of the intercropping olive with wheat regarding their negative effect on tree growth are in harmony with the findings of Razouk *et al.* (2016a) and Razouk *et al.* (2016b) on the intercropping olive with wheat and annual crops. They mentioned that vegetative growth of olive tree was reduced by growing wheat even from the canopy limit in intercropping system based on olive-wheat. Moreover, Mantzanas *et al.* (2021) on Intercrop of olive trees with cereals and legumes.

Table 4. Effect of the intercropping olive trees with wheat crop on increment in shoot length (cm), number of leaves per shoot (cm) and leaf surface area of "Manzanillo" olive trees during 2017 and 2018 seasons

Treatments	Increment in shoot length (cm)		Increment in number of leaves per shoot (cm)		Leaf surface area (cm^2)	
	2017	2018	2017	2018	2017	2018
Olive alone	6.07 e	1.79 cd	16.49 gh	3.30 f	3.34 f	3.23 hi
Olive + 20g HA	6.42 e	1.94 bcd	17.28 f	4.12 de	3.51 e	3.38 g
Olive + 30g HA	6.50 de	1.99 bcd	17.95 e	4.42 cde	3.63 d	3.48 f
Olive + 0g HA with wheat + 0k HA/fed	6.04 e	1.61 d	15.99 h	3.10 f	3.32 f	3.20 i
Olive + 0g HA with wheat + 2k HA /fed	6.11 e	1.84 cd	16.60 g	3.350 f	3.37 f	3.26 h
Olive + 0g HA with wheat + 4k HA /fed	6.27 e	1.90 bcd	16.57 g	3.98 e	3.48 e	3.35 g
Olive + 20g HA with wheat + 0k HA /fed	6.96 cd	2.01 abcd	18.51 d	4.60 bcd	3.69 cd	3.55 e
Olive + 20g HA with wheat + 2k/ HA fed	7.46 bc	2.07 abcd	19.57 c	4.74 bc	3.71 c	3.60 d
Olive + 20g HA with wheat + 4k HA /fed	7.61 ab	2.09 abcd	20.05 bc	5.01 b	3.84 b	3.71 c
Olive + 30g HA with wheat + 0k HA /fed	7.84 ab	2.23 abc	20.31 b	5.09 b	3.86 b	3.73 c
Olive + 30g HA with wheat + 2k HA /fed	7.97 ab	2.39 ab	21.10 a	5.64 a	3.90 b	3.78 b
Olive + 30g HA with wheat + 4k HA /fed	8.02 a	2.53 a	21.28 a	5.90 a	3.99 a	3.85 a

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

The enhancement effect of humic acid on vegetative growth may be attributed that humic acid stimulation plant growth through accelerated cell division and it enhanced uptake of nutrients and water and it make plant tolerance to drought (Sanchez-Andreu *et al.*, 1994; Chen *et al.*, 2004 and Hussein and Hassan, 2011) and humic acid have similar effect like IAA on plants in this concern (O'Donnell, 1973). On the other hand, humic acid reduced the competition for soil moisture and nutrients between olive tree and wheat crop in intercropping system. It induced improvement in soil water and nutrient reserves under intercropping system based on olive and wheat in treatments which added humic acid for olive tree and/or for wheat. The obtained results of humic acids are in agreement with the findings of Fernández-Escobar *et al.* (1996) olive trees. Moreover, El-Sayed (2013) on Aggizy olive and Hagagg *et al.* (2013b) on Aggizi olive trees mentioned that humic acid application improved tree growth of olive.

Blooming characteristics

Number of panicles per shoot

Table (5) shows that number of panicles per shoot was significantly affected by all treatments. Furthermore, 30g HA/olive tree with 4kg HA/fed wheat crop treatment proved to be the most effective treatment in increasing number panicles per shoot. On the contrary, olive tree with 0kg HA/fed wheat crop and olive tree alone treatments gave comparatively the lowest value in this concern. 30g HA/olive tree with 4kg HA/fed wheat crop treatment surpassed other treatments in this respect.

Number of flower per panicle

Table (5) illustrate 30g HA/olive tree with 4kg HA/fed wheat crop treatment and 30g HA/olive tree with 2kg HA/fed wheat crop treatment increasing number of flower per panicle value as compared with 0g HA/olive tree with 0kg HA/fed wheat crop treatment and olive tree alone treatment in both seasons.

Number perfect flower per panicle

Table (5) indicates that the number of perfect flowers per panicle was significantly affected by all treatments. Finally, 30g HA/olive tree with 4kg HA/fed wheat crop treatment was the most effective treatment in increasing number of perfect flowers per panicle.

Yield (kg/tree)

Table (6) shows that the two treatments of 30g HA/olive tree with 4kg HA/fed wheat crop treatment and 30g HA/tree with 2kg HA/fed wheat crop treatment gave the same values and surpassed other treatments in this respect in both seasons. Moreover, olive trees alone or supported with humic acid and the intercropping olive trees with wheat crops fertilized with humic acid take the same letter and gave the same values on olive fruit yield as compared with the other treatments in the second season. Shortly, 20g HA/olive tree with 2kg HA/fed wheat crop and 30 g HA/olive tree with 4kg HA/fed wheat crop treatments proved to be the most efficient treatment in first season in this concern.

Table 5. Effect of the intercropping olive trees with wheat crop on number of panicles per shoot, number of flower per panicle and number perfect flower per panicle of "Manzanillo" olive trees during 2017 and 2018 seasons

Treatments	Number of panicles per shoot		Number of flower per panicle		Number perfect flower per panicle	
	2017	2018	2017	2018	2017	2018
Olive alone	13.86 ef	8.01 c	8.76 e	14.15 de	7.29 e	6.93 e
Olive + 20g HA	14.15cdef	8.79 ab	9.38 cd	14.35bcde	7.63 cde	7.08 de
Olive + 30g HA	14.19bcdef	8.88 ab	9.49 bcd	14.36bcde	7.68 bcde	7.32 cde
Olive + 0g HA with wheat + 0k HA/fed	13.82 f	7.69 c	8.72 e	14.05 e	7.27 e	6.87 e
Olive + 0g HA with wheat + 2k HA /fed	13.89 ef	8.02 c	8.81 e	14.22 cde	7.41 de	6.97 e
Olive + 0g HA with wheat + 4k HA /fed	14.01 def	8.69 b	9.04 de	14.3bcde	7.53 de	6.99 e
Olive + 20g HA with wheat + 0k HA /fed	14.21 bcde	8.99 ab	9.54 bcd	14.39 bcde	7.94 abcd	7.16 de
Olive + 20g HA with wheat + 2k/ HA fed	14.37abcde	9.05 ab	9.62 bc	14.62 abcd	8.07 abc	7.22 cde
Olive + 20g HA with wheat + 4k HA /fed	14.48 abcd	9.05 ab	9.80 abc	14.73 abc	8.12 abc	7.54 bcd
Olive + 30g HA with wheat + 0k HA /fed	14.58 abc	9.17 ab	10.01 ab	14.83 ab	8.17 ab	7.71 abc
Olive + 30g HA with wheat + 2k HA /fed	14.72 ab	9.22 ab	10.17 a	14.98 a	8.21 ab	7.91 ab
Olive + 30g HA with wheat + 4k HA /fed	14.87 a	9.29 a	10.22 a	15.10 a	8.35 a	8.23 a

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

The effect of intercropping system based on olive and wheat on regarding his negative effect on blooming and olive yield may be attributed that wheat has overlapped with olive that made drought stress on olive tree and these stress were resulting to the severe competition for soil moisture and nutrients during bud burst, blooming and early growth of olives, from March to early June, which overlap with the filling phase of wheat grains and their maturation (Bendidi *et al.*, 2013 and Razouk *et al.,* 2016a). Besides, which in turn reduces the rate of metabolism, consequently there will be less synthesis of carbohydrates and less flower bud formation and due to the deficiency of nutrients opening of buds occur slowly taking more time to come into full bloom. Furthermore, the other reason may be linked to the liberation of ethylene from wheat grains during their maturation that is known to be an inhibitor of flowering for the most plants (Reid and Wu, 1992). The obtained results of the intercropping olive with wheat regarding their negative effect on blooming and yield are in harmony with the findings of Razouk *et al.* (2016a) and Razouk *et al.* (2016b) on the intercropping olive with wheat and annual crops. They reveal that yield of olive tree were reduced by growing wheat even from the canopy limit in intercropping system based on olive-wheat. Furthermore, Mantzanas *et al.* (2021) on intercrop of olive trees with cereals and legumes and panozzo *et al.* (2020) on intercrop of olive trees with durum wheat. The enhancement effect of humic acid on blooming and yield may be attributed that humic acid reduced competition for soil moisture and nutrients between olive tree and wheat crop in intercropping system. It induced improvement in soil water and nutrient reserves under intercropping system based on olive and wheat in treatments which added humic acid for olive tree and/or for wheat. Furthermore, humic acid stimulation plant growth and consequently blooming and yield through accelerated cell division and it enhanced uptake of nutrients and water and it make plant tolerance to drought (Sanchez-Andreu *et al.*, 1994; Chen *et al.*, 2004 and Hussein and Hassan, 2011). Also, humic acid have similar effect like IAA on plants (O’Donnell, 1973), which required for preventing the abscission layer formation which lead to reduce fruit drop and increase fruit retention subsequently, increased number of fruits per tree and improved yield per tree. The obtained results of humic acids are in agreement with the findings of Fernández-Escobar *et al.* (1996) They reported that humic acid applications increased yield of olive trees. Furthermore, El-Sayed (2013) reveal that soil applications of yeast at 10g/tree combined with humic acid at 60g/tree gave the high positive effect on yield of Aggizy olive. On the other hand, Hagagg *et al.* (2013a) on Manzanillo olive trees and Hagagg *et al.* (2013b) on Aggizi olive trees, they found that humic acid application induced high positive effect on yield of Aggizi olive trees.

Fruit quality:

Fruit weight

Data in table (6) indicates that all tested treatments induced a significant effect on fruit weight. However, 30g HA/olive tree with 4kg HA/fed wheat crop treatment gave the highest fruit weight and it surpassed other treatments in this concern. Moreover, the intercropping olive with wheat plant treatment gave lower olive fruit weight than the corresponding monoculture one. Besides, higher level of humic acid application exhibited marked significant increases in olive fruit weight as compared with non-fertilized ones in both seasons.

Table 6. Effect of the intercropping olive trees with wheat crop on yield fruit weight and fruit volume of "Manzanillo" olive trees during 2017 and 2018 seasons

Treatments	Yield (kg/tree)		Fruit weight (g)		Fruit volume (cm^3)	
	2017	2018	2017	2018	2017	2018
Olive alone	15.99 j	50.33 b	6.23 hi	5.25 k	7.21 fg	6.01 ij
Olive + 20g HA	16.41 g	50.27 b	6.59 efg	5.62 h	7.23 de	6.15 fg
Olive + 30g HA	16.62 f	50.33 b	6.73 def	5.75 g	7.26 d	6.19 ef
Olive + 0g HA with wheat + 0k HA/fed	15.96 j	50.27 b	6.11 i	5.19 k	7.08 g	5.95 j
Olive + 0g HA with wheat + 2k HA /fed	16.13 i	50.39 b	6.35 ghi	5.40 j	7.17 ef	6.06 hi
Olive + 0g HA with wheat + 4k HA /fed	16.23 h	50.39 b	6.46 fgh	5.48 i	7.22 de	6.10 gh
Olive + 20g HA with wheat + 0k HA /fed	16.86 e	51.42 ab	6.92 cde	5.92 f	7.34 c	6.25 de
Olive + 20g HA with wheat + 2k/ HA fed	16.92 e	51.46 ab	7.05 cd	6.04 e	7.35 c	6.30 cd
Olive + 20g HA with wheat + 4k HA /fed	17.08 d	52.47 ab	7.19 bc	6.15 d	7.38 c	6.33 c
Olive + 30g HA with wheat + 0k HA /fed	17.31 c	52.72 ab	7.26 bc	6.30 c	7.49 b	6.40 b
Olive + 30g HA with wheat + 2k HA /fed	17.88 a	53.79 a	7.53 ab	6.45 b	7.82 a	6.51 a
Olive + 30g HA with wheat + 4k HA /fed	17.99 a	53.81 a	7.67 a	6.60 a	7.86 a	6.53 a

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

Fruit volume (cm^3)

Table (6) indicates that all tested treatments gave a significant effect on fruit volume. Moreover, 20g HA/olive tree with 2kg HA/fed wheat crop treatment and 30g HA/olive tree with 4kg HA/fed wheat crop treatment gave the same values and surpassed other treatments as well as proved to be the most efficient treatments in both seasons in this respect. On the other hand, the olive monoculture one gave higher olive fruit volume than the corresponding the intercropped olive with wheat treatment in both seasons. Besides, 30g humic acid/olive tree application increased olive fruit volume as compared with non-fertilized ones in both seasons.

Fruit length (cm)

Table (7) shows that 20g HA/olive tree with 4kg HA/fed wheat crop also, 30g HA/olive tree with 0, 2 and 4 kg/fed wheat crop treatments gave the same positive effect on fruit length in the first season. However, all tested treatments gave a significant effect on fruit length. Moreover, 30g HA/olive tree with 4kg HA/fed wheat crop treatment gave the highest fruit length and it surpassed other treatments in the second season in this respect.

Fruit diameter (cm)

Table (7) indicates that all tested treatments produced a similar significant effect as fruit length with fruit diameter of olive trees in both seasons.

Pulp thickness (cm)

Table (7) demonstrates all treatments produced a similar effect on pulp thickness of olive in both seasons.

Fruit moisture content (%)

Table (8) illustrates that 30g HA/olive tree with 4kg HA/fed wheat crop treatment have higher percentage of moisture as compared with olive trees with 4kg HA/fed wheat crop and olive trees alone (control) treatment in both seasons. Moreover, the olive monoculture one has higher percentage of moisture than the corresponding the intercropping olive with wheat treatment in both seasons. Furthermore, the two levels of humic acid applications increased percentage of moisture as compared with non-humic acid ones in both season.

Fruit oil content (%)

Table (8) reveals that 30g HA/olive tree with 4kg HA/fed wheat crop treatment have higher percentage of olive fruit oil as compared with the intercropping olive trees with 4kg HA/fed wheat crop and olive trees alone (control) treatment in both seasons. On the other hand, the olive monoculture one gave higher percentage of olive fruit oil than the corresponding the intercropped olive with wheat treatment in both seasons. Besides, 30g humic acid/olive tree application improved the percentage of olive fruit oil as compared with non-humic acid ones in both seasons.

Acidity

Table (8) indicates that no significant response to all tested treatment in both seasons. The effect of intercropping system based on olive and wheat on regarding his negative effect on fruit chemical properties may be attributed that the reduction in vegetative growth reflected on fruit chemical properties. The obtained results of the intercropping olive with wheat regarding their negative effect on fruit chemical properties are in harmony with the findings of Rifat *et al.* (2015) and Rifat *et al.* (2018) on intercrop of apple trees with maize and other crops.

Table 7. Effect of the intercropping olive trees with wheat crop on fruit length, fruit diameter and pulp thickness of "Manzanillo" olive trees during 2017 and 2018 seasons

Treatments	Fruit length (cm)		Fruit diameter (cm)		Pulp thickness (cm)	
	2017	2018	2017	2018	2017	2018
Olive alone	2.29 c	2.30 fg	2.21a	2.31 a	0.67 a	0.76 a
Olive + 20g HA	2.38 ab	2.35 def	2.22 a	2.32 a	0.67 a	0.78 a
Olive + 30g HA	2.38 ab	2.37 cde	2.23 a	2.32 a	0.68 a	0.79 a
Olive + 0g HA with wheat + 0k HA/fed	2.29 c	2.28 g	2.21 a	2.30 a	0.68 a	0.75 a
Olive + 0g HA with wheat + 2k HA /fed	2.33 bc	2.31 feg	2.21 a	2.31 a	0.67 a	0.76 a
Olive + 0g HA with wheat + 4k HA /fed	2.37 ab	2.33 defg	2.22 a	2.32 a	0.68 a	0.77 a
Olive + 20g HA with wheat + 0k HA /fed	2.39 ab	2.39 cd	2.23 a	2.33 a	0.69 a	0.79 a
Olive + 20g HA with wheat + 2k/ HA fed	2.39 ab	2.39 cd	2.21 a	2.34 a	0.69 a	0.80 a
Olive + 20g HA with wheat + 4k HA /fed	2.40 a	2.93 cd	2.25 a	2.35 a	0.69 a	0.80 a
Olive + 30g HA with wheat + 0k HA /fed	2.41 a	2.43 bc	2.26 a	2.37 a	0.69 a	0.81 a
Olive + 30g HA with wheat + 2k HA /fed	2.34 a	2.46 ab	2.28 a	2.38 a	0.70 a	0.82 a
Olive + 30g HA with wheat + 4k HA /fed	2.34 a	2.50 a	2.30 a	2.41 a	0.67 a	0.76 a

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

Table 8. Effect of the intercropping olive trees with wheat crop on fruit moisture content, fruit oil content and acidity of "Manzanillo" olive trees during 2017 and 2018 seasons

Treatments	Moisture content (%)		Oil content (%)		Acidity	
	2017	2018	2017	2018	2017	2018
Olive alone	49.50 i	49.96 k	34.42 j	35.87 j	0.90 a	0.86 a
Olive + 20g HA	50.21 fg	50.42 h	36.22 h	37.36 h	0.92 a	0.88 a
Olive + 30g HA	50.26 f	50.59 g	36.43 g	37.47 g	0.93 a	0.89 a
Olive + 0g HA with wheat + 0k HA/fed	49.23 j	49.82 l	33.71 k	34.53 k	0.90 a	0.85 a
Olive + 0g HA with wheat + 2k HA /fed	50.04 h	50.09 j	35.83 i	36.95 i	0.91 a	0.86 a
Olive + 0g HA with wheat + 4k HA /fed	50.18 g	50.30 i	36.16 h	37.30 h	0.91 a	0.87 a
Olive + 20g HA with wheat + 0k HA /fed	50.42 e	51.73 f	36.59 f	37.80 f	0.93 a	0.90 a
Olive + 20g HA with wheat + 2k/ HA fed	50.45 e	52.84 e	37.35 e	38.56 e	0.94 a	0.90 a
Olive + 20g HA with wheat + 4k HA /fed	50.75 d	53.15 d	37.53 d	38.68 d	0.95 a	0.91 a
Olive + 30g HA with wheat + 0k HA /fed	51.34 c	53.99 c	38.05 c	39.17 c	0.95 a	0.92 a
Olive + 30g HA with wheat + 2k HA /fed	52.45 b	54.30 b	39.54 b	39.66 b	0.97 a	0.92 a
Olive + 30g HA with wheat + 4k HA /fed	53.44 a	55.36 a	40.85 a	41.16 a	0.97 a	0.93 a

Means within each column or row followed by the same letter (s) are not significantly at 5% level.

The enhancement effect of humic acids on fruit quality may be attributed that humic acid play an important role to enhance plant growth by improving soil texture and increase water holding in soil and stimulate soil microorganisms activity (Jensen, 2004). In addition, humic acid reduced competition for soil moisture and nutrients between olive tree and wheat crop in intercropping system. It induced improvement in soil water and nutrient reserves under intercropping system. Humic acid stimulation plant growth (Nardi *et al.,* 2002 and Pizzeghello *et al.,* 2002). Humic acid can be used as a growth regulator to improve plant growth and enhance stress tolerance (Çimrin *et al.,* 2010) and humic acid have similar effect like IAA on plants in this concern (O'Donnell, 1973). All of these reflected in increasing rate of photosynthesis rate and accumulation of carbohydrates reserves which lead to positive effect on fruit quality.

The obtained results of humic acids are in agreement with the findings of Fayed (2010) on olive trees. Furthermore, El-Sayed (2013) who reveal that soil applications of yeast at 10g/tree combined with humic acid at 60g/tree gave the high positive effect on fruit quality. Moreover, it induced high fruit oil percentage, iodine values and the lowest acidity percentage of Aggizy olive. On the other hand, Hagagg *et al.* (2013a) on Manzanillo olive trees and Hagagg *et al.* (2013b) on Aggizi olive trees, they found that humic acid application induced high positive effect on fruit quality of Aggizi olive trees.

CONCLUSION

A field experiment to study the effect of olive – wheat based on the intercropping system and the application of humic acid on the intercropped olive with wheat crop on growth, yield and fruit quality of olive.

The intercropping systems based on olive trees and annual crops are especially important for smallholder farming in the Siwa oasis, Egypt.

Wheat sowing from the limit of the olive tree canopies among the inter-rows of trees.

Wheat has overlapped with olive and it exerts a severe competition for soil moisture and nutrients during the critical period of olive shoot growth.

The intercropping system based on olive and wheat gave reduction in vegetative growth, blooming and yield of Manzanillo olive trees than the corresponding monoculture one.

Humic acid improved vegetative growth, blooming and yield of Manzanillo olive trees as compared with non-humic acid ones in both seasons, especially in higher rate.

Humic acid reduced the negative effect of both olive and wheat in intercropping system the competition for soil moisture and nutrients between olive tree and wheat and humic acid improved productivity of olive and wheat. Therefore, olive fertilized with 30g humic acid with wheat fertilized with 4kg humic acid/fed treatment is the best treatment to improve yield and fruit quality of Manzanillo olive as well as wheat provides an additional source of income to the farmer.

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الملخص العربي

تأثير زراعة القمح تحت أشجار الزيتون على إنتاجية وجودة ثمار الزيتون

عمرو سلامه محمد ، اسامه حلمى محمد الجمال ، محمد عبد الحميد عطية

أجريت هذه التجربة على أشجار زيتون منزانيللو المزروعة في بستان خاص بواحة سيوة بمحافظة مطروح ، مصر خلال مواسم ٢٠١٧ ، ٢٠١٨ . الاشجار منزرعة على مسافة ٥ × ٥ متر في تربة رملية وتم ريها بنظام الغمر من قناة الصرف الزراعي. تهدف التجربة لدراسة تأثير تحميل القمح على اشجار الزيتون في نظام زراعة التحميل مع إضافة الهيوميك على أشجار الزيتون والقمح على نمو الأشجار والمحصول وجودة ثمار الزيتون. صممت التجربة بنظام القطاعات الكاملة العشوائية بخمس مكررات لكل معاملة وتم تمثيل كل مكرر بشجرة واحدة. أظهرت النتائج أن النمو الخضري المتمثل فى محيط الشجرة ، نمو الافرع ، القياسات الورقية ، التزهير والمحصول ، سجلت أعلى القيم في اشجار الزيتون المعامل ب ٣٠ جم هيوميك والمحمل مع محصول القمح المعامل ب ٤ كجم الهيوميك / فدان. علاوة على ذلك ، أعطت اشجار الزيتون المحمل مع محصول القمح انخفاضا فى النمو الخضري ، التزهير والمحصول لأشجار الزيتون المنزانيللو مقارنة مع اشجار الزيتون المنزرعة بمفردها بدون تحميل (المقارنة). علاوة على ذلك ، أدى المستوى العالى من الهيوميك إلى زيادة النمو الخضري ، التزهير والمحصول لأشجار الزيتون المنزانيللو مقارنة بالأشجار غير معاملة بالهيوميك في كلا الموسمين. يمكن أن تكون زراعة التحميل لكلا من أشجار الزيتون المنزانيللو والقمح والمعاملين بالهيوميك مفيد لنظام الزراعة المستدامة. من ناحية أخرى ، يمكن تحسين إنتاجية الزيتون والقمح عن طريق إضافة الهيوميك في نظام زراعة التحميل ، كما ان القمح يعطى مصدر دخل إضافي للمزارع فى هذه المنطقة.

الكلمات المفتاحية: زيتون المنزانيللو – القمح – التحميل – حمض الهيومك.