Influence of Training Systems on Leaf Mineral Contents, Growth, Yield and Fruit Quality of "Anna" Apple Trees

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Abstract: The influence of two training systems (tiller, and open central leader) on leaf mineral contents, growth, fruit set, yield, and fruit quality of "Anna" apples cultivar was estimated in the experiment conducted during two successive seasons at private orchard located Cairo Alexandria desert road about 80 Km from Cairo. Results indicated that, tiller training system significantly increased leaf Nitrogen, and Potassium contents. Moreover, shoots length, diameter, and leaf area were increased significantly under tiller training system as compared with open central leader training system (control). Also, fruit set, yield, and fruit quality increased significantly with tiller training system compared with control. Present study can lead to conclude that tiller training system significantly affect growth, yield, and fruit quality, and it is recommended to apply cultural practices for improving irradiance conditions which consequently enhance production in apple orchards.

Key words: Anna apple tress, training system, leaf mineral contents, fruit set, yield, fruit quality.

INTRODUCTION

Apple fruits are one of the most favorite fruits of the temperate zone deciduous fruit. The main apple cultivar in Egypt is "Anna" apple cultivar [a hybrid between "Red Hadassiya" (a local cultivar) X "Golden Delicious"]. This cultivar was introduced in Egypt since 1987 by agricultural development system project (ADS). The total cultivated area reached about 60684 Feddans with fruiting area about 56865 Feddans, producing about 9.69 Tons/Feddan with total production 550743 Tons according to the statics of ministry of agriculture, Egypt (2008)[1].

In fruit trees, yield and fruit quality depend on the light microclimate at the orchard and tree scales, fruit yield of healthy and well watered trees is related to total light interception[2,3,4]. Photosynthetic carbon fixation mainly depends on the sun light captured by a tree or orchard usually, while shading reduce fruit mass and fruit quality attributes like color and soluble sugar and secondary metabolite concentrations[5]. Also, shading decreases shoot photosynthesis, fruit temperature, and may change the light spectrum.

Local irradiance may also affect flower bud initiation and development[2,3]. Leaf attributes affecting photosynthetic capacity, namely specific leaf area[6]. Also, the main goal of tree training is to promote favorable growth patterns, where as training is used to bring trees into production earlier, develop a strong structural frame work that will support heavy crop loads with out breaking, promote good sun light penetration through the canopy, and make the trees easier to manage.

The aim of this study is to evaluate leaf mineral contents, vegetative growth, yield, and fruit quality of "Anna" apple trees grown in sandy soil under tiller training system as compared to open central leader system (control).

MATERIALS AND METHODS

This investigation was carried out during two successive seasons 2008 and 2009 on "Anna" apple trees budded on MM106 rootstock at private orchard located Cairo Alexandria desert road about 80 Km from Cairo. Trees were about 4 years old planted 2 X 3 m, apart in sandy soil. The selected trees were diseases free, uniform in shape and size, irrigated under drip system, and received the normal cultural practices usually followed in commercial orchards. Cross pollination was secured by planting "Dorset Golden" and "Ein Shemir" as pollinizers, which were distributed in the whole orchard.

The experiment was laid out by following a complete randomized block design with 5 replications for each treatment to study the effect of two training system:
1. Open central leader system (control).
2. Tiller system.
The following determinations were carried out as follow:

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1- Leaf Mineral and Chlorophyll Contents: Samples of twenty leaves from middle part of shoots were selected at random from each replicate in early of June to measure leaf mineral contents. N, P and K% were determined in leaves according to Wilde *et al.*[7].

Leaf chlorophyll contents expressed as SPAD reading using a chlorophyll meter (Model SPAD 502, Minolto Corporation, N.J.; USA).

2- Vegetative Growth: Samples of twenty leaves from middle part of shoots were selected at random from each replicate in early of June to measure leaf area (cm^2) according to Jain and Misra[8]. Ten shoots from each replicate were tagged to measure shoot length and diameter (cm) at growth cessation. Also, spurs were counted from each replicate to calculate spurs percentage.

3- Fruit Set and Yield: Setting fruits from each shoots were counted during mid July, and calculated fruit set percentage (%) with the following formula:

Fruit set % = Total number of setting fruits / Total number of flowers X 100

The yield expressed as number and weight of fruits attained the harvest stage was determined for each training system in both seasons. Yield as weight in Kg was estimated as a number of fruits/tree X average of fruit weight at harvest time.

4- Fruit Physical and Chemical Characteristics: Samples of 20 mature fruits were taken from each replicate at the harvest time, and their used to determine both physical characteristics [Average of fruit weight (gm), Average of fruit volume (cm^3), Average of fruit length and diameter (cm), and Firmness], and fruit chemical characteristics [Total soluble solids (TSS%), Acidity as malic acid according to A.O.A.C.[9], Total soluble solids / Acidity ratio].

The obtained data was subjected to analysis of variance (ANOVA). Means were compared by L.S.D at (0.05) test according to Snedecor and Cochran[10].

RESULTS AND DISCISSION

Leaf Mineral and Chlorophyll Contents: Table (1) present the effect of two training system on N, P, and K contents in leaves. Nitrogen content was significantly affected as results of tiller training system comparing with open central leader training system (control). This was true in both experimental seasons. Nitrogen percentage significantly increased due to training system, the highest significant N% was obtained in tiller training system as it averaged 1.24 and 1.32% in the first and second seasons, respectively; whereas the lowest significant N% averaged 1.03 and 1.25% in control in the two seasons respectively.

Concerning phosphorus percentage, it was not significantly affected by different training system although it tended to decrease at control compared with tiller training system in both experimental seasons.

Regarding Potassium percentage, it observed that central leader training system (control) reduced significantly potassium percentage in the leaves (1.20, and 1.36 in the two seasons, respectively) than those obtained from tiller training system (1.45, and 1.49 in both seasons, respectively).

This observations were agree with the results obtained by Chen *et al.*[11] on peach who reported that leaves of plants grown under shelter had lower total N content compared with leaves from trees grown in open. Moreover, the previous results are harmony with that found by Iacono *et al.*[12] on *vitis vinifera* who decided that shading affect on both the increase and decrease of leaf N, and P respectively, may be explained by the necessity of the photosynthetic system to guarantee high enzymatic activity.

It is obvious from Table (1) that chlorophyll (SPAD reading) in leaves was significantly affected as a result of tiller training system compared with control. The highest significant chlorophyll was obtained in the tiller training system as it averaged 59 and 60.4 in the two seasons, respectively. Whereas the lowest significant chlorophyll resulted from open central leader training system (control) as it averaged 46.6 and 48.2 in both seasons, respectively. The finding of Safia *et al.*[13] is in line with the result of our study. The increase of pigments contents under shading treatments may be due to the photo oxidation conditions which occur under high illumination[14].

2- Vegetative Growth: Data in Table (2) showed that tiller training system increased significantly shoot length, and diameter as compared to open central leader training system (control). This result was detected in the two seasons. The highest shoot length and diameter were obtained by tiller training system; since it was (49.70 and 55.30 cm) as shoot length, and (0.61 and 0.62 cm) as shoot diameter in the both seasons respectively. Meanwhile, open central leader training system recorded 37.00 and 36.00 cm as shoot length; and 0.41 and 0.46 cm as a shoot diameter during the two studied seasons respectively.

Concerning to leaf area, data in Table (2) cleared that leaf area of tiller training system trees increased significantly than that of control trees in both seasons. The highest leaf areas in the two seasons (49.2 and 49.9cm^2) were recorded by tiller training system, respectively. However, control trees produced the

smaller leaf areas (45.7 and 45.8 cm^2) in the first and second seasons, respectively. The results are agree with that reported by Maggs[15] who found that shading of apple leaves reduced length of new stem, number of leaves, internodes length, and total leaf area. The decrease of leaf area under shading may be due to limited translocation of growth factors such as nitrogen to the expanding tissues as it were correlated with a reduced concentration of amino nitrogen bleeding sap. On the other hand, Hegazi et al.[16] showed that olives leaves were slightly affected by shading treatments. Also, the decrease of grapevines leaves under shading may be due to limited translocation of growth factors such as nitrogen to the expanding tissues in the year after treatments[17]. Moreover, final leaf size may also correlate with the number of cells present at the onset of unfolding[18]. On contrary, Chen et al.[11] found that peach leaves grown under rain shelter had significantly larger average leaf area as compared to those grown in open

As for spurs percentage, Table (2) revealed that tiller training system recorded the highest spurs percentage as 21.36 and 22.64 % in the both seasons, respectively; while, open central leader training system recorded the lowest spurs percentage since it was 13.9 and 14.82% in the two seasons, respectively. The enhancement of spurs formation is positively correlated to total light interception[3,4] because photosynthetic carbon fixation depends mainly on the sun light captured by a tree or an orchard.

Fruit Set and Yield: Data of fruit set (%) as shown in Table (3) revealed that tiller training system recorded the highest fruit set percentage (12.30 and 17.72%) in both seasons, respectively. Meanwhile, open central leader training system (control) evidence the lowest fruit set percentage (8.62 and 10.20%) in the two seasons, respectively.

Our finding is closely related to the work featured by Marini et al.[19] and George et al.[20] who stated that sun light distribution influences flower initiation and fruit set. In general, these results are in line with those reported by El-Seginy et al.[21] who worked on pear and apple.

Regarding to yield, data in Table (3) expressed that yield in weight and number of fruits per tree was positively affected by training system of "Anna" apple trees. The highest fruit yield was obtained from tiller training system as it average 25.6 and 26.5 Kg/tree in the first and second seasons, respectively. Whereas, the lowest fruit yield was recorded from open central leader system (control) since, it was 21.1 and 21.4 Kg/tree in the two seasons, respectively. Like wise, open central training system (control) showed that the highest number of fruits per tree (155.3 and 153.2

fruits/tree) in the two seasons respectively as compared with tiller training system (138 and 142 fruits/tree) in both seasons, respectively.

These results are in agreement with Jackson[22] who decided that yield of apple trees greatly depends on light interception. Moreover, Lakso et al.[23] reported that fruit yield is related to light interception by spurs. The greater sun light leaf area of "Granny" likely explains the higher regularity of bearing of this cultivar[24].

Fruit Physical and Chemical characteristics: Data in Table (4) cleared that fruit weight increased significantly by tiller training system compared to control. The highest fruit weights were 185.5 and 186.3 gm in the first and second season, respectively under tiller training system. Whereas the lowest fruit weights were recorded under open central leader training system (control) (135.9 and 139.7 gm in both experimental seasons, respectively). The same, Fruit volume was increased significantly by tiller training system as compared to control. This is true in the both studied seasons.

Fruit length and diameter were increased significantly by tiller training system (6.87 and 7.27 cm as fruit length; and 7.20 and 7.60 cm as fruit diameter) during both seasons, respectively. Whereas, open central leader training system (control) recorded the lowest fruit length and diameter (6.23 and 6.10 cm as fruit length; and 6.30 and 6.60 as fruit diameter) in the two seasons, respectively. On the other hand, data in the Table (4) indicated that fruit firmness was not affected significantly by the two training system in both seasons.

Similar results were obtained by Jackson[2,25,26,27]; Plamer[3]; Robinson and Lakso et al.[23] Iglesias et al.[25], Sosna[26] and Ireneusz Sosna and Marta Czapilicka[27] where they reported that, fruit quality depend on the light microclimate at the orchard and tree scales.

As for fruit chemicals, It is evident from data in Table (5) that tiller training system of "Anna" apple trees significantly improved quality of fruits in terms of increasing total soluble solids (11.60 and 12%) in the two studied seasons, respectively compared to control which recorded 9.80 and 10.20% in the first and second seasons, respectively. Regarding to acidity, data in the same table clear that acidity was not significant affected with different training system in the two seasons of study. On the other hand, T.S.S to acidity ratio showed in table (5) revealed that tiller training system recorded the highest T.S.S / Acidity ratio (18.70 and 19) during both studied seasons, respectively; while, open central leader training system recorded the lowest value in this respect (16.90 and 17) in the two seasons, respectively.

Table 1: Influence of Training Systems on Leaf Mineral, and Chlorophyll Content of "Anna" Apple Trees.

Treatments	N %		P %		K %		Chlorophyll (SPAD Reading)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Open Central Leader Training System	1.03	1.25	0.36	0.38	1.20	1.36	46.60	48.20
Tiller Training System	1.24	1.32	0.45	0.42	1.45	1.49	59.00	60.40
L.S.D	0.07	0.09	NS	NS	0.06	0.06	3.80	4.60

Table 2: Influence of Training Systems on Vegetative Growth of "Anna" Apple Trees.

Treatments	Leaf area (cm^2)		Shoot length (cm)		Shoot diameter (cm)		Spurs (%)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Open Central Leader Training System	45.70	45.80	37.00	36.00	0.41	.046	13.9	14.82
Tiller Training System	49.20	49.90	49.70	55.30	.61	0.62	21.36	22.64
L.S.D	0.3	0.9	6.8	8.4	0.1	0.09	1.8	2.4

Table 3: Influence of Training Systems on Fruit Set (%), Yield (Kg/tree) and Number of Fruits per Tree of "Anna" Apple Trees.

Treatments	Fruit set (%)		Yield (Kg/tree)		No. of fruits/tree	
	1st season	1st season	2nd season	1st season	2nd season	2nd season
Open Central Leader Training System	8.62	10.20	21.10	21.40	155.30	153.20
Tiller Training System	12.30	14.72	25.60	26.50	138.00	142.20
L.S.D	0.5	1.3	1.4	1.6	5.8	6.4

Table 4: Influence of Training Systems on Physical Characteristics of "Anna" Apple Trees.

Treatments	Fruit weight (gm)		Fruit volume (cm^3)		Fruit length (cm)		Fruit diameter (cm)		Fruit firmness (Ib/inch)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Open Central Leader Training System	135.90	139.70	150.60	154.20	6.23	6.10	6.30	6.60	10.10	10.30
Tiller Training System	185.50	186.30	207.00	210.30	6.87	7.27	7.20	7.60	11.10	11.30
L.S.D	34.0	22.9	1.3	0.9	0.4	0.3	0.3	0.5	ns	ns

Table 5: Influence of Training Systems on Chemical Characteristics of "Anna" Apple Trees.

Treatments	TSS (%)		Acidity		TSS/Acidity ratio		Reducing sugars (%)		Total sugars (%)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Open central Leader Training System	9.80	10.20	0.56	0.60	16.90	17.00	6.50	7.00	9.20	10.40
Tiller Training System	11.60	12.00	0.62	0.63	18.70	19.00	7.00	7.80	9.60	10.70
L.S.D	0.4	0.4	ns	ns	0.3	0.4	0.2	0.2	ns	ns

In addition to reducing sugars, the highest value of reducing sugar was obtained from tiller training system since it was 7.00 and 7.80 % in the first and second seasons respectively; whereas, open central leader training system trees recorded the lowest value of reducing sugar (6.50 and 7.00 %) in both seasons respectively (Table 5). As for total sugar percentage, it is obvious from data in Table (5) that no significant differences were observed among the two training system in both seasons.

The improvement occurred in fruit chemical characteristics due to training system could be attributed their effect on enhancing the biosynthesis and translocation of carbohydrates and advancing fruit maturity[28]. Also, the same results found with Awad *et al.*[5] who reported that Photosynthetic carbon fixation

mainly depends on the sun light captured by a tree or orchard usually, while shading reduce fruit mass and fruit quality attributes like color and soluble sugar and secondary metabolite concentrations.

Conclusions: The present study cleared that using of proper training system which helps to open the inner of canopy of "Anna" apple tree is necessary for growth, fruit set, yield, and fruit quality which were affected with light conditions. Reduced light intensity caused significant reduction in shoot length, diameter, leaf area, fruit set, and fruit characteristics. Therefore, it is necessary for the inner and lower parts of tree canopy revive sufficient light intensity. This will be obtained may be through some recommendation such as proper planting spacing, choice of relevant training system, regular pruning, balanced culture practices such as irrigation and fertilization.

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