Fruit Yield, Quality and Shelf Life of "Anna" Apple Trees as Affected by Soil Mulching and Foliar Application of Natural Materials

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ABSTRACT: rootstock, in a sandy soil under drip irrigation system in a private orchard This study was carried out during the two successive seasons 2015 and 2016 on seven years old "Anna" apple trees (*Malus domestica* L.) budded on Balady located at El-Nubaria, Beheira governorate, Egypt. The aim of this research was to investigate the effect of soil mulching and foliar application of natural materials (Lisophos or nutrient elements compound) treatments as a preharvest treatments on yield, fruit quality and shelf-life of "Anna" apple trees. The experimental design was randomized complete block design with four replicates. Results indicated that soil mulching with polyethylene significantly increased vegetative growth and reproductive growth as fruit size, length, diameter, weight, yield per tree and total yield per feddan. Moreover, all treatments significantly, increased fruits chemical compositions as total soluble solids; total sugars percent, but decreased fruit juice acidity (%) as compared with control. On the other hand, Lisophos treatments, significantly, increased fruit firmness. Aluminum foil sheet treatment and the six foliar applications of natural materials, Lisophos or Landamine (nutrient elements compound) treatments, significantly, increased anthocyanin and fruit juice vitamin C content as compared with control. Concerning shelf-life parameters, it was noticed that Lisophos and nutrient elements compound treatments, significantly, decreased fruit weight loss percentage and increased fruit firmness after 12 days shelf-life. On the other hand, all treatments significantly increased total soluble solids, but decreased fruit juice acidity (%) after shelf-life as compared with control.

Key words: "Anna" apple, soil mulching, mulch color, Lisophos, Landamine, yield, fruit quality, shelf-life

INTRODUCTION

Anna apple (*Malus domestica* L.) is one of the most important deciduous fruit crops grown in Egypt. Apple quality depends strongly on orchard management, such as fertilization and soil mulching. Reflective mulch is being studied on many fruit crops as a way to increase light availability inside the canopy in addition to reduce weed growth and water evaporation from the soil. Several studies have, also, been reported using the reflective mulch for improving leaf photosynthetic rate, fruit quality and yield (Layne *et al*., 2002 and Costa, 2003). Aluminum mulching on the tree row controlled annual weeds, increased soil temperature, light reflection, yield and improved fruit quality of ‘Aroma’ apples (Tahir *et al*., 2005). Mulch color determines its energy-radiating behavior, the underlying soil temperature and the surface of the mulch were affected by the color of the mulch (Lamont, 1993; Franquera, 2011).

Lipids are known to play important roles in membrane structure and energy reserves. It is evident that lipids and their metabolites play important roles in other critical cellular functions, particularly as mediators in signal transduction, cell activation, and cell proliferation (Ryu *et al.,* 1997; Cowan *et al.*, 2006). Lyso-phosphatidylethanolamine (LPE) is a minor glycerolipid present in all extra-chloroplastic membranes and is formed from the parent phospholipid, phosphatidylethanolamine (PE) by the action of phospholipase A_2 (PLA_2). Previous studies showed that lyso-phosphatidylethanolamine (LPE) has the potential to enhance anthocyanin production in the skin of ‘McIntosh’ apple trees and to delay the loss of firmness, reduce senescence of fruits, higher marketable fruits and stimulate ethylene production, while keeping the respiration rate low. However, LPE appeared to do this by reducing CO_2 and ethylene evolution, delaying chlorophyll breakdown, and by reducing electrolyte leakage (Farag and Palta, 1993a; Kaur and Palta, 1997; Özgen *et al.,* 2005; Ahmed and Palta, 2011). Further, LPE is a natural phospholipid currently being purified from egg yolk or brain tissue and could provide environmentally safe means for control of fruit ripening and leaf senescence.

Boron (B) and molybdenum (Mo), two of the seven essential micronutrients, also known as trace elements, are required for the normal growth of most plants. The principal functions of B include its role in membrane integrity, root elongation and sugar metabolism **(**Gupta *et al.,* 2011)**.** Boron is known to be essential for plant growth as it functions as a crosslinking molecule in the cell wall and participates in other processes, such as maintenance of plasma membrane function and anthocyanin biosynthesis (Camacho *et al.*, 2008; Voxeur and Fry, 2014). Among the major nutrients, potassium not only improves yields but also benefits various aspects of quality. K increases sugar translocation to sink tissues, promoting their growth (Taiz and Zeiger, 2004). Also, Nagwa *et al.* (2015) on 'Anna' apple trees cleared that spraying with Landamine (32% P_2O_5 + 35% K_2O + 1.6% B + 0.4% Mo) increased red skin color and total soluble solids, but decreased acidity and the weight loss of fruits.

The aim of this study is to investigate the effects of various soil mulches and foliar application of natural materials (lyso-phosphatidylethanolamine and nutrient elements compound as preharvest treatments) on yield, fruit quality and shelf-life of "Anna" apple trees.

MATERIALS AND METHODS

This study was carried out during the two successive seasons 2015 and 2016 on seven years old "Anna" apple trees (*Malus domestica* L.) budded on Balady rootstock, planted at 4 x 4 meters apart (262 tree/feddan) in a sandy soil under drip irrigation system in a private orchard located at El-Nubaria, Beheira governorate, Egypt. The physiochemical analysis of experimental soil was indicated in (Table 1).

Table (1). Some physical and chemical properties of the experimental soil

Parameter	Soil depth, cm	
	0 - 30	30 - 60
Mechanical analysis %		
Sand	93.0	92.0
Silt	5.0	4.0
Clay	2.0	4.0
Textural class	Sandy	Sandy
$Caco_3$ %	5.4	4.2
Organic matter , %	0.35	0.20
pH	8.25	8.28
EC, dS/m	0.801	0823
Available Nutrients , mg/ kg		
N	117.5	117.5
P	18.4	18.0
K	405	190
Soluble cations, meq / L		
Ca^{++}	2.30	2.15
Mg^{++}	1.70	1.30
Na^{+}	3.78	3.54
K^{+}	0.45	0.40
Soluble Anions, meq / L		
Hco_3^-	3.22	3.02
CL-	4.80	4.35
So_4--	5.20	4.63

Forty eight uniform trees, more or less, were selected for this study and all of them were subjected to the same cultural practices during both successive seasons. The treatments were as follows:

T_1- Control (foliar application of distilled water)
T_2- Soil mulching with aluminum foil sheet on a plastic foil.
T_3- Soil mulching with black polyethylene sheet.
T_4- Soil mulching with blue polyethylene sheet.
T_5- Soil mulching with red polyethylene sheet.
T_6- Soil mulching with green polyethylene sheet.
T_7- Lisophos 1 cm^3/l
T_8- Lisophos 1.5 cm^3/l
T_9- Lisophos 2 cm^3/l
T_{10}- Landmine 2 cm^3/l
T_{11}- Landmine 3 cm^3/l
T_{12}- Landmine 4 cm^3/l

Regarding soil mulching treatments, soil mulching from the tree trunk to the tree canopy, with aluminum foil sheet, black, blue, red and green polyethylene sheets, was applied from February, except aluminum foil treatment, which was applied at 6 weeks before anticipated harvest.

Pertinence foliar application of natural materials treatments Lyso-phospholipid; named commercially as Lisophos (70 % lyso-phosphatidylethanolamine) and Landmine (nutrient elements compound 32%P_2O_5 + 35%K_2O + 1.6%B + 0.4%Mo) were used as pre-harvest treatments at two application times; the first application time was taken place at the beginning of fruit coloration, while the second application was 15 days after first.

The previous treatments were applied and arranged in a randomized complete block design. Each treatment included four replicates with one tree for each replicate. The effect of the previous treatments was investigated via evaluating their influence on the following parameters:

1. Vegetative growth:

At the end of growing seasons, the selected shoots were measured for the average of shoot length (cm), shoot diameter (cm) using hand caliber and leaf area according to this formula, leaf area (cm^2) = 0.49 (length of leaf × width of leaf) + 19.69 (Ahmed and Morsy,1999).

2. Fruit set percentage:

Two main branches with 1 inch diameter from two directions (east and west) of each tree were chosen and tagged during both experimental seasons, the number of flowers was recorded and those set fruits on the selected branches were counted for calculating the percentage of fruit set according to this formula:

$$\text{Fruit set \%} = \frac{\textit{Number of set fruitlets}}{\textit{Number of opened flowers}} \times 100$$

3. Yield:

The fruit yield on each replicate tree resulting from the applied treatments were expressed as number of fruits per tree and weight of fruits as kg per tree which was attained at harvest stage. This was determined 110 days after flowering in both seasons of the study. Also, yield produced as ton/feddan was expressed by multiplying the weight of fruits/tree x number of trees/feddan.

4. Fruit quality:

Samples of 10 fruits per tree from each replicate was collected randomly at 20th June during both seasons, and then transferred quickly to the laboratory to determine physical and chemical fruit characteristics.

Physical fruit characteristics: Fruit samples were weight and the average fruit weight for each replicate was calculated. Average fruit length (L) and diameter (D) were measured using hand caliper to obtain fruit shape index (L/D) calculated mathematically as a ratio. Fruit firmness was expressed as (lb/Inch^2) according to Magness and Taylor (1982). Flesh firmness was measured in two opposite sides of the fruit using the Magness Taylor pressure.

Chemical fruit characteristics: Samples of 10 fruits were picked, randomly, at harvesting time to determine the following parameters: Total soluble solids of fruit juice (TSS %) using hand refractometer according to Chen and Mellenthin (1981). Total acidity was determined in fruit juice according to AOAC (1985) using titration with 0.1N sodium hydroxide. Acidity was expressed as a percent of malic acid in fruit juice. Vitamin C (Ascorbic acid) was determined in the juice by titration with 2, 6- dichlorophenol-indo-phenol (AOAC, 1985) and calculated as mg /100 ml of juice. Total sugars were determined in fresh fruit samples according to procedure of Malik and Singh (1980). Anthocyanin content was determined at the stage of coloration (mg/100g fresh weight) according to Rabino *et al.* (1977).

5. Shelf-life:

In terms of shelf-life, samples were collected and examined after shelf-life days (12 days) and the following parameters were estimated: weight loss percentage, titratable acidity (TA), fruit firmness and total soluble solids (TSS).

Statistical analysis:

Results of the measured parameters were subjected to computerized statistical analysis using COSTAT package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 level of possibility according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Effect of soil mulching and foliar application of natural materials on vegetative and reproductive growth (fruit set, yield, fruit quality and shelf life) of "Anna" apple trees are presented in Tables (2-6).

1. Vegetative growth characters:

The results concerning the effect of studied soil mulching and foliar application of natural materials treatments on shoot length, thickness and leaf area of "Anna" apple trees during both seasons 2015 and 2016 are listed in Table (2). The average values of both experimental seasons indicated that all soil mulching treatments; significantly ($P \leq 0.05$) increased shoot length and shoot thickness as compared with control or foliar application of natural materials treatments. While no significant differences were recorded among foliar applications of natural materials treatments and control treatment during both seasons. Leaf area for black, blue and red polyethylene mulching was higher than control while, aluminum foil and foliar application of natural materials did not affect leaf area. Generally, mulching with black polyethylene sheet around the trees; brought about the highest increment in shoot length (51.66 and 54.33 cm), shoot thickness (0.8 and 0.8 cm) and leaf area (35.66 and 36.33 cm^2), respectively, as compared with control treatment (21.66 and 22.66 cm shoot length), (0.50 and 0.50 cm shoot thickness), (32.00 and 33.00 cm^2 leaf area), consecutively during both 2015 and 2016 seasons.

The increment of shoot length, shoot thickness and leaf area comparing to check plot may be taken place due to stimulated root growth caused by increased soil temperature and moisture given under mulching coverings with plastic films leading to early top growth (Jones *et al.,* 1978). Furthermore, Lindhard *et al.* (2007) revealed that mulch application most consistently affected tree growth, as indicated in a long term field trial where cumulative yield after 5 crop years was increased by surface application of bio-solid mulches. Also, Mika (2007) and Neilsen *et al.* (2008) on apple trees found that all treatments of mulching increased the performance of tree growth.

Table (2). Average values of some vegetative growth parameters of "Anna" apple trees as affected by soil mulching and foliar application of natural materials during 2015 and 2016 seasons

Treatments	Shoot length (cm)		Shoot thickness (cm)		Leaf area (cm^2)	
	2015	2016	2015	2016	2015	2016
Aluminum foil sheet	37.02 ^{c}	35.07 ^{d}	0.60 ^{c}	0.60 ^{c}	28.83^{d}	29.32 ^{d}
Black polyethylene sheet	51.66 ^{a}	54.33 ^{a}	0.80 ^{a}	0.80 ^{a}	35.66^{a}	36.33 ^{a}
Blue polyethylene sheet	49.05 ^{a}	50.03 ^{b}	0.73 ^{ab}	0.70 ^{b}	35.50^{a}	36.00 ^{a}
Red polyethylene sheet	49.66 ^{a}	49.06^{bc}	0.70 ^{b}	0.70 ^{b}	35.35^{a}	35.00^{ab}
Green polyethylene sheet	46.08 ^{b}	45.66 ^{c}	0.72 ^{b}	0.70 ^{b}	34.47^{ab}	34.18^{bc}
Lisophos (LPE) 1 cm^3/l	23.09 ^{d}	24.66 ^{e}	0.55 ^{cd}	0.53 ^{d}	32.90^{bc}	32.66 ^{c}
Lisophos (LPE) 1.5 cm^3/l	24.33 ^{d}	24.11 ^{e}	0.53 ^{cd}	0.54 ^{d}	32.17^{c}	32.66 ^{c}
Lisophos (LPE) 2 cm^3/l	22.66 ^{d}	24.08 ^{e}	0.53 ^{cd}	0.53 ^{d}	32.65^{c}	33.00 ^{c}
Landamin (Lm) 2 cm^3/l	22.66 ^{d}	23.07 ^{e}	0.53 ^{cd}	0.50 ^{d}	32.18^{c}	33.00 ^{c}
Landamin (Lm) 3 cm^3/l	22.66 ^{d}	23.33 ^{e}	0.53 ^{cd}	0.56 ^{d}	32.00^{c}	33.00 ^{c}
Landamin (Lm) 4 cm^3/l	23.04 ^{d}	23.33 ^{e}	0.50 ^{d}	0.53 ^{d}	32.00^{c}	33.00 ^{c}
Control	21.66 ^{d}	22.66 ^{e}	0.50 ^{d}	0.50 ^{d}	32.00^{c}	33.00 ^{c}

Means not sharing the same letter(s) with each column are significantly different at 0.05 level of probability.

2. Fruit set and yield components:

Pertaining the results of fruit set and yield components (fruit weight, yield per tree and total yield per feddan) of "Anna" apple trees as affected by soil mulching and foliar application of natural materials treatments, the results of Table (3) revealed that there was no significant effect of reflective mulch or other treatments on fruit set or number of fruits per tree as compared with the control treatment during both 2015 and 2016 seasons. On the other hand, all soil mulching treatments, except aluminum foil significantly ($P \leq 0.05$) increased fruit weight, yield per tree and total yield as compared with the control treatment during both seasons. A gradual increase in fruit weight (229.00 and 230.66 g), yield per tree (88.15 and 89.80 kg/tree) and total yield (23.09 and 23.52 ton/feddan) were observed with trees mulched with black polyethylene sheets, consecutively during both 2015 and 2016 seasons. Also, Lisophos (2 cm^3/l) treatment, significantly ($P \leq 0.05$) increased fruit yield per tree (70.45 and 69.60 kg/tree) and total yield (18.54 and 18.23 ton/feddan) as compared with control treatment (65.42 and 65.32 kg/tree), (17.14 and 17.11 ton/feddan), respectively during both seasons of study. While in general, no significant differences in fruit weight and yield were recorded between the other spraying treatments and control during both seasons. Moreover, the increase of yield by mulching with plastic films with the two colors black (23.09 and 23.52 ton/feddan) and blue

(22.92 and 22.80 ton/feddan) were more significant than that obtained with mulching with plastic films with the other two colors red (19.71 and 19.65 ton/feddan) and green(19.17 and 19.28 ton/feddan) during both seasons. Generally, mulching with black or blue polyethylene sheets around the trees caused higher yield by 26.21 and 33.53 % in the first season and by 29.15 and 33.59 % in the second season, respectively, as compared with control. These increases in yield could be attributed to the increase in soil temperature and moisture given under mulching coverings with plastic films or due to increased leaf vigor induced by the Lysophosolipid; namely, Lisophos. The above mentioned results of soil mulching treatments agree with the findings of Aly *et al.* (2010); Tahir and Gustavsson (2010); Prive *et al.* (2011); Tahir and Nybom (2013). On the other hand, the same trends of these results of Lisophos treatments were found by Özgen and Palta (2003); Hong *et al*. (2007). Likewise, the similar trends of these results of Landamin treatments were found by Rashid *et al*. (2008); Nava and Dechen (2009); Mosa *et al.* (2015).

Table (3). Average values of reproductive growth parameters of "Anna" apple trees as affected by soil mulching and foliar application of natural materials during 2015 and 2016 seasons

Treatments	Fruit set (%)		Number of fruits/tree		Fruit weight (g)		Yield (kg/tree)		Yield (ton/feddan)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Aluminum foil sheet	16.06^{a}	16.46^{a}	385.00^{a}	395.00^{a}	175.0^{def}	176.33^{cd}	67.21^{de}	69.63^{c}	17.6^{de}	18.24^{c}
Black polyethylene sheet	17.36^{a}	17.00^{a}	385.00^{a}	389.33^{a}	229.00^{a}	230.66^{a}	88.15^{a}	89.80^{a}	23.09^{a}	23.52^{a}
Blue polyethylene sheet	17.50^{a}	17.70^{a}	403.66^{a}	390.33^{a}	216.66^{b}	223.00^{a}	87.48^{a}	87.06^{a}	22.92^{a}	22.80^{a}
Red polyethylene sheet	17.03^{a}	18.06^{a}	387.66^{a}	390.66^{a}	193.00^{c}	190.00^{b}	75.24^{b}	75.04^{b}	19.71^{b}	19.65^{b}
Green polyethylene sheet	17.66^{a}	17.30^{a}	385.33^{a}	389.33^{a}	190.00^{c}	189.00^{b}	73.20^{bc}	73.58^{b}	19.17^{bc}	19.28^{b}
Lisophos (LPE) 1 cm^3/l	16.83^{a}	17.06^{a}	386.66^{a}	385.33^{a}	169.66^{f}	172.66^{cd}	65.57^{e}	66.52^{cd}	17.18^{e}	17.42^{cd}
Lisophos (LPE) 1.5 cm^3/l	18.00^{a}	17.60^{a}	393.66^{a}	394.66^{a}	171.00^{ef}	171.00^{d}	67.27^{de}	67.48^{cd}	17.62^{de}	17.68^{cd}
Lisophos (LPE) 2 cm^3/l	16.40^{a}	16.26^{a}	393.66^{a}	387.66^{a}	179.00^{de}	179.66^{c}	70.45^{cd}	69.6^{c}	18.54^{cd}	18.23^{c}
Landamin (Lm) 2 cm^3/l	17.00^{a}	16.46^{a}	375.00^{a}	353.33^{a}	178.66^{de}	179.00^{cd}	66.98^{de}	66.53^{cd}	17.55^{de}	17.43^{cd}
Landamin (Lm) 3 cm^3/l	17.33^{a}	16.70^{a}	387.66^{a}	390.00^{a}	176.33^{e}	178.33^{cd}	69.87^{cd}	69.50^{c}	18.30^{cd}	18.21^{c}
Landamin (Lm) 4 cm^3/l	16.50^{a}	17.00^{a}	389.00^{a}	386.33^{a}	182.33^{d}	180.33^{c}	68.57^{de}	69.26^{c}	17.96^{de}	18.14^{c}
Control	17.00^{a}	16.00^{a}	381.00^{a}	380.16^{a}	171.66^{ef}	172.66^{cd}	65.42^{e}	65.32^{d}	17.14^{e}	17.11^{d}

Means not sharing the same letter(s) with each column are significantly different at 0.05 level of probability.

3. Fruit physical parameters:

The effect of various applied treatments on fruit size, length, diameter, shape and firmness of "Anna" apple trees was calculated and tabulated in Table (4). The results indicated that all soil mulching treatments except aluminum foil, significantly (*P*≤0.05) increased fruit size, length and diameter as compared with control treatment during both 2015 and 2016 seasons, while no significant differences were recorded between foliar application of natural materials (Lisophos or Landamin) treatments and control treatment during both seasons. Mulching the trees with blue polyethylene sheet around the trees gave rise to the highest fruit size (284.66 and 290.33 cm^3, each in turn), length (9.10 and 9.03 cm, serially) and diameter (7.33 and 7.26 cm, each in turn) as compared with check plot treatment (193.33 and 197.33 cm^3 fruit size), (7.02 and 7.07 cm fruit length), (6.05 and 6.03 cm fruit diameter), respectively during both experimental seasons. As for the effects of various applied treatments on fruit shape, the differences between treatments in general were not significant during both seasons. With regard to the results of fruit firmness, results showed that Lisophos and Landamin treatments significantly (P≤0.05) increased fruit firmness as compared with control treatment, while no significant differences were recorded between soil mulching treatments and control treatment during both seasons. Gradual increase in fruit firmness was observed with trees treated with Lisophos (LPE) 2 cm^3/l application treatment, followed by Lisophos (LPE) 1.5 cm^3/l. The above mentioned results of soil mulching treatments were supported by the findings of Aly *et al.* (2010); Tahir and Gustavsson (2010); Prive *et al*. (2011); Tahir and Nybom (2013). On contrast, the results of Lisophos treatments disagreed with those previously reported by Özgen and Palta (2003); Hong *et al*. (2007). Also, the results of Landamin treatments disagreed with those previously reported by (Rashid *et al*., 2008; Nava and Dechen, 2009; Mosa *et al.,* 2015).

Table (4). Average values of some fruit parameters of "Anna" apple trees as affected by soil mulching and foliar application of natural materials during 2015 and 2016 seasons

Treatments	Fruit size $(cm)^3$		Fruit length (cm)		Fruit diameter (cm)		L/D ratio		Fruit firmness ($lb/inch^2$)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Aluminum foil sheet	200.66^{d}	198.33^{c}	7.16^{c}	7.46^{c}	6.16^{b}	6.06^{c}	1.16^{bc}	1.24^{a}	10.50^{d}	11.50^{bcd}
Black polyethylene sheet	277.00^{a}	289.00^{a}	9.06^{a}	8.83^{a}	7.33^{a}	7.33^{a}	1.23^{ab}	1.20^{abc}	10.33^{d}	10.33^{d}
Blue polyethylene sheet	284.66^{a}	290.33^{a}	9.10^{a}	9.03^{a}	7.33^{a}	7.26^{ab}	1.24^{a}	1.24^{ab}	10.00^{d}	10.83^{cd}
Red polyethylene sheet	221.33^{b}	225.33^{b}	8.10^{b}	8.05^{b}	7.03^{a}	7.04^{b}	1.15^{c}	1.14^{c}	10.33^{d}	10.16^{d}
Green polyethylene sheet	217.00^{bc}	224.00^{b}	8.10^{b}	8.07^{b}	7.09^{a}	7.08^{b}	1.15^{c}	1.14^{c}	10.66^{cd}	10.16^{d}
Lisophos (LPE) 1 cm^3/l	197.33^{d}	194.00^{c}	7.03^{c}	7.03^{d}	6.03^{b}	6.16^{c}	1.16^{bc}	1.14^{c}	12.50^{ab}	12.83^{ab}
Lisophos (LPE) 1.5 cm^3/l	192.66^{d}	197.33^{c}	7.16^{c}	7.06^{d}	5.96^{b}	6.10^{c}	1.20^{abc}	1.18^{abc}	13.16^{ab}	12.66^{ab}
Lisophos (LPE) 2 cm^3/l	202.00^{d}	203.00^{c}	7.06^{c}	7.03^{d}	5.96^{b}	6.11^{c}	1.19^{abc}	1.17^{bc}	13.83^{a}	13.33^{a}
Landamin (Lm) 2 cm^3/l	203.66^{cd}	201.33^{c}	7.06^{c}	7.06^{d}	6.06^{b}	6.10^{c}	1.16^{abc}	1.16^{c}	12.33^{b}	12.00^{abc}
Landamin (Lm) 3 cm^3/l	203.33^{cd}	205.33^{c}	7.10^{c}	7.10^{d}	6.06^{b}	5.96^{c}	1.17^{abc}	1.19^{abc}	12.00^{bc}	12.33^{abc}
Landamin (Lm) 4 cm^3/l	198.00^{d}	201.66^{c}	7.06^{c}	7.06^{d}	6.03^{b}	6.06^{c}	1.17^{abc}	1.16^{c}	12.83^{ab}	12.00^{abc}
Control	193.33^{d}	197.33^{c}	7.02^{c}	7.07^{d}	6.05^{b}	6.03^{c}	1.17^{abc}	1.17^{c}	10.46^{d}	10.33^{d}

Means not sharing the same letter(s) with each column are significantly different at 0.05 level of probability.

4. Fruit chemical parameters:

Results express the effect of experimental treatments on fruit chemical parameters of "Anna" apple fruits during both 2015 and 2016 seasons are shown in Table (5). The obtained results indicated that all soil mulching treatments and foliar application of natural materials (Lisophos or Landamin) treatments, significantly ($P≤0.05$) increased total soluble solids and total sugars percentages, but decreased fruit juice acidity (%) as compared with control treatment. A gradual increase in total soluble solids (13.83 and 14.02 %, each in turn) was observed with trees treated with Landamin 4 cm^3/l application treatment, while a gradual increase in total sugars (8.86 and 9.10 %, serially) was observed with trees treated with Lisophos 1.5 cm^3/l application treatment, but a gradual decreased in fruit juice acidity (0.27 and 0.27 %, serially) was observed with trees treated with Landamin 2 cm^3/l application treatment during both seasons. Regarding the results of anthocyanin, it was noticed that aluminum foil sheet treatment and the six foliar applications of natural materials, Lisophos or Landamine treatments, significantly ($P≤0.05$) increased anthocyanin as compared with control treatment, while the differences between plastic mulching treatments and control treatment were not significant during both seasons of study. A gradual increase in anthocyanin (17.33 and 16.33 mg/100g, each in turn) was observed with trees treated with Landamin 4 cm^3/l application treatment during both seasons of study. On the other hand, aluminum foil, blue and green polyethylene mulching treatments and the three foliar applications of Landamine treatments; significantly ($P≤0.05$) increased fruit juice vitamin C content as compared with control during both seasons of study, while no significant differences were recorded between the three foliar application of Lisophos treatments and control treatment in both seasons. A gradual increase in fruit juice vitamin C content (16.77 and 16.90 mg/100ml juice, each in turn) was observed with trees treated with Landamin 4 cm^3/l application treatment during both seasons of study. These findings of aluminum foil treatment agree with those obtained by Elzayat and Allam (2006); Iglesias and Alegre (2009); Aly *et al.* (2010); Jakopic *et al.* (2010); Funke and Blanke (2011); Tahir and Nybom (2013). On the other hand, similar trends of these results of Lisophos treatments were found by Farag and Palta (199l); Özgen *et al.* (2004); Hong *et al.* (2007). Also, the same trends of these results of Landamin treatments were found by Ramesh *et al.* (2006); Rashid *et al.* (2008); Mosa *et al.* (2015); Nagwa *et al*. (2015).

Table (5). Averages of some fruit chemical parameters of "Anna" apple trees as affected by soil mulching and foliar application of natural materials during 2015 and 2016 seasons

Treatments	T.S.S (%)		Acidity (%)		Total sugars (%)		Anthocyanin (mg/100g)		Vitamin C mg/100ml juice	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Aluminum foil sheet	13.33^{ab}	14.00^{a}	0.32^{b}	0.35^{b}	8.63^{abc}	8.63^{ab}	16.50^{ab}	16.36^{a}	16.69^{a}	16.49^{ab}
Black polyethylene sheet	13.66^{ab}	13.57^{ab}	0.31^{b}	0.28^{bc}	8.86^{ab}	8.47^{ab}	14.50^{c}	14.43^{bc}	15.67^{bcd}	15.79^{bcd}
Blue polyethylene sheet	13.16^{ab}	13.01^{abc}	0.29^{b}	0.31^{bc}	8.51^{abc}	8.40^{b}	14.33^{c}	14.83^{b}	15.88^{bc}	15.81^{bcd}
Red polyethylene sheet	12.66^{ab}	13.10^{abc}	0.32^{b}	0.32^{bc}	8.16^{bc}	8.44^{ab}	14.83^{c}	14.50^{bc}	15.21^{cd}	15.23^{de}
Green polyethylene sheet	13.02^{ab}	12.50^{c}	0.30^{b}	0.31^{bc}	8.40^{abc}	8.63^{ab}	14.00^{c}	13.66^{c}	15.82^{bc}	15.46^{cde}
Lisophos (LPE) 1 cm^3/l	12.66^{ab}	13.30^{abc}	0.30^{b}	0.27^{c}	8.16^{bc}	8.60^{ab}	16.17^{b}	16.33^{a}	15.40^{bcd}	15.76^{bcd}
Lisophos (LPE) 1.5 cm^3/l	13.66^{ab}	13.33^{abc}	0.29^{b}	0.26^{c}	8.86^{ab}	9.10^{a}	16.66^{ab}	16.66^{a}	15.24^{cd}	15.43^{cde}
Lisophos (LPE) 2 cm^3/l	12.66^{ab}	13.33^{abc}	0.30^{b}	0.31^{bc}	8.16^{bc}	8.40^{b}	17.14^{a}	16.83^{a}	15.62^{bcd}	15.23^{de}
Landamin (Lm) 2 cm^3/l	12.51^{b}	13.04^{abc}	0.27^{b}	0.27^{c}	8.98^{a}	8.63^{ab}	16.17^{b}	16.66^{a}	16.06^{ab}	16.09^{abc}
Landamin (Lm) 3 cm^3/l	13.02^{ab}	12.93^{bc}	0.30^{b}	0.31^{bc}	8.05^{c}	8.40^{b}	16.83^{ab}	17.16^{a}	16.73^{a}	16.57^{ab}
Landamin (Lm) 4 cm^3/l	13.83^{a}	14.02^{a}	0.28^{b}	0.26^{c}	8.40^{abc}	8.35^{b}	17.33^{a}	16.33^{a}	16.77^{a}	16.90^{a}
Control	11.16^{c}	11.33^{d}	0.42^{a}	0.43^{a}	7.09^{d}	7.23^{c}	14.50^{c}	14.56^{bc}	14.98^{d}	14.83^{e}

Means not sharing the same letter(s) with each column are significantly different at 0.05 level of probability.

5. Shelf-life parameters:

The results given in Table (6) represent the effect of used treatments on shelf-life parameters (fruit weight loss percentage, fruit firmness, fruit juice acidity and total soluble solids) of "Anna" apple fruits during both studied seasons. The gained results indicated that Lisophos treatment at 2 (cm^3/l) significantly ($P \leq 0.05$) decreased fruit weight loss percentage (13.45 and 13.03 %, serially) and increased fruit firmness (9.67 and 9.16 $lb/inch^2$, each in turn) after shelf-life as compared with control fruits (17.98 and 17.84% weight loss), (7.00 and 6.83 $lb/inch^2$ firmness) respectively during both seasons of study. On the other hand, no significant differences regarding fruit weight loss percentage and fruit firmness after shelf-life were recorded between soil mulching treatments and control treatment during both seasons. Concerning fruit juice acidity and total soluble solids, it was noticed that Landamin treatment at 4 (cm^3/l) significantly ($P \leq 0.05$) increased total soluble solids (14.66 and 14.54 %, each in turn), but decreased fruit juice acidity (0.20 and 0.19%, serially) as compared with control (12.16 and 12.33% T.S.S), (0.31 and 0.30% acidity) during both seasons of study. The decrease in fruit weight loss percentage and increase in fruit firmness after shelf-life of Lisophos treatments might be due to the effect of Lyso-phosphatidylethanolamine (LPE) on delaying senescence of cells. Also, LPE stimulated ethylene production, had no effect on respiration rate, and reduced fruit softening. The above mentioned results of soil mulching (plastic mulch or aluminum foil) treatments were supported by the findings of Iglesias and Alegre (2009); Aly *et al.* (2010); Tahir and Nybom (2013). On the other hand, the same trend of these results of Lisophos treatments were found by Farag and Palta (1993b); Ryu *et al.* (1997); Özgen *et al.* (2005); Hong *et al.* (2007) Alferez *et al.* (2008); Ahmed and Palta (2011). Also, the same trends of these results of Landamin treatments were found by Ramesh *et al.* (2006); Rashid *et al.* (2008); Mosa *et al.* (2015); Nagwa *et al.* (2015); Brackmann *et al.* (2016).

Table (6). Averages of some shelf life parameters of "Anna" apple trees as affected by soil mulching and foliar application of natural materials during 2015 and 2016 seasons

Treatments	Fruit weight loss (%)		Fruit firmness (lb/inch^2)		Acidity (%)		T.S.S (%)	
	2015	2016	2015	2016	2015	2016	2015	2016
Aluminum foil sheet	17.47^{a}	17.01^{a}	7.03^{d}	7.17^{d}	0.24^{bc}	0.24^{bc}	14.08^{ab}	13.93^{ab}
Black polyethylene sheet	16.74^{ab}	16.79^{ab}	7.00^{d}	6.83^{d}	0.24^{bcd}	0.24^{bc}	14.41^{ab}	14.16^{ab}
Blue polyethylene sheet	17.29^{a}	16.76^{ab}	7.00^{d}	7.00^{d}	0.26^{b}	0.23^{bcd}	13.66^{ab}	14.00^{ab}
Red polyethylene sheet	16.98^{ab}	17.00^{a}	7.00^{d}	7.33^{d}	0.24^{bc}	0.26^{ab}	13.66^{ab}	14.00^{ab}
Green polyethylene sheet	17.33^{a}	17.05^{a}	6.83^{d}	7.16^{d}	0.26^{b}	0.24^{bc}	13.75^{ab}	14.00^{ab}
Lisophos (LPE) 1 cm^3/l	14.26^{cd}	14.29^{cde}	9.17^{ab}	9.50^{a}	0.23^{bcd}	0.19^{d}	13.50^{ab}	13.50^{b}
Lisophos (LPE) 1.5 cm^3/l	14.06^{cd}	13.78^{de}	9.50^{a}	9.50^{a}	0.22^{cd}	0.20^{cd}	13.50^{ab}	14.16^{ab}
Lisophos (LPE) 2 cm^3/l	13.45^{d}	13.03^{e}	9.67^{a}	9.16^{ab}	0.22^{cd}	0.21^{cd}	14.41^{ab}	14.32^{b}
Landamin (Lm) 2 cm^3/l	15.62^{bc}	15.53^{bc}	8.00^{c}	9.16^{a}	0.21^{cd}	0.19^{d}	13.33^{bc}	14.25^{ab}
Landamin (Lm) 3 cm^3/l	15.02^{cd}	14.55^{cd}	8.50^{bc}	8.33^{bc}	0.22^{cd}	0.22^{bcd}	14.00^{ab}	13.83^{ab}
Landamin (Lm) 4 cm^3/l	14.86^{cd}	14.51^{cd}	9.33^{ab}	7.67^{cd}	0.20^{d}	0.19^{d}	14.66^{a}	14.54^{a}
Control	17.98^{a}	17.84^{a}	7.00^{d}	6.83^{d}	0.31^{a}	0.30^{a}	12.16^{c}	12.33^{c}

Means not sharing the same letter(s) with each column are significantly different at 0.05 level of probability.

CONCLUSION

This study led to conclude that mulch color affected total yield. Yields in black polyethylene sheet were greater than in the other treatments. Lisophos and Landamin treatments significantly ($P \leq 0.05$) increased total soluble solids, total sugars percentages and fruit firmness after shelf-life, but decreased fruit juice acidity and fruit weight loss percentage after shelf-life as compared with control treatment during both seasons.

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الملخص العربي

محصول الثمار وجودته والفترة التسويقية فى التفاح صنف "آنا" تأثراً بتغطية التربة والرش الورقي بمواد طبيعية

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أجريت هذه الدراسة خلال موسمى ٢٠١٥ و ٢٠١٦ على أشجار التفاح صنف'' آنا '' مطعومة على أصل البلدى عمرها سبع سنوات منزرعة فى تربة رملية تروى بنظام الرى بالتنقيط بمزرعة خاصة فى منطقة النوبارية بمحافظة البحيرة – مصر بهدف دراسة تأثير تغطية التربة والرش الورقي بمواد طبيعية (ليزوفوس أو لندامين وهو مركب يحتوى عناصر غذائية) كمعاملات ما قبل الحصاد على المحصول وجودة الثمار والفترة التسويقية فى التفاح صنف آنا. وكان التصميم الإحصائى المستخدم هو القطاعات العشوائية الكاملة وقد أظهرت النتائج أن معاملات تغطية التربة بالبولى إيثيلين أدت الى زيادة معنوية فى النمو الخضرى وطول وعرض وحجم ووزن الثمرة ومحصول الشجرة وكذلك المحصول الكلى للفدان. علاوة على ذلك أدت كل المعاملات الى زيادة معنوية فى نسبة المواد الصلبة الذائبة ونسبة السكريات الكلية وأدت الى إنخفاض معنوى فى نسبة حموضة العصير مقارنة بمعاملة الكنترول. على جانب آخر معاملات الرش الورقى بمادة الليزوفوس أدت الى زيادة معنوية فى صلابة الثمار وفى صبغة الأنثوسيانين كما أن معاملة تغطية التربة بورق الالومنيوم و معاملات الرش الورقى بمادة اللندامين أدت الى زيادة معنوية فى صبغة الأنثوسيانين وفى محتوى الثمار من فيتامين ج مقارنة بمعاملة الكنترول وفيما يتعلق بالفترة التسويقية لوحظ أن معاملات الرش الورقى بمادة الليزوفوس وكذلك مادة اللندامين أدت الى إنخفاض معنوي فى نسبة الفقد فى الوزن للثمار كما أدت إلى زيادة معنوية فى صلابة الثمار بعد بقائها على الرف مدة ١٢ يوم. ومن ناحية أخرى أدت كل المعاملات إلى زيادة معنوية فى نسبة المواد الصلبة الذائبة وأدت الى إنخفاض معنوى فى نسبة حموضة العصير بعد بقائها على الرف مقارنة بمعاملة الكنترول.