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Research Article
Performance of Peach Trees cv. Florida Prince under Different Foliar Concentrations of NPK-humate in Presence or Absence of Adjuvants

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Abstract

Background: The experimental trial was consummated throughout two successive seasons (2014 and 2015) at a commercial orchard at El-Khatatba city, Monifia Governorate, Egypt. It intended to find out the possibility of enhancing Florida prince peach trees productivity under local condition in the newly reclaimed lands by using NPK-humate. **Materials and Methods:** The NPK-humate in presence or absence of adjuvants (methanol and glycerol) applied as foliar application four times at 2 weeks intervals from the beginning of fruit set after petal fall (18 February) during both seasons to study their effect on vegetative growth, nutrient availability, yield and fruit quality of Florida prince peach trees and the obtained data were statistically analyzed as a randomized complete design by analysis of variance (ANOVA). **Results:** Data indicated that foliar applications of NPK-humate in presence of adjuvants were better than absence of it, for enhancing peach trees cv. Florida prince production. **Conclusion:** Specifically, the rate of NPK-humate (1.5%)+methanol (3%) showed the best significant effect on various estimated parameters under this study unless fruit firmness during both seasons. The treatment of NPK-humate at 1.5% with methanol at 3% gave the highest significant values for vegetative growth parameters which reflected positively on yield of peach trees and fruit quality.

Key words: *Prunus persica*, foliar application, methanol, glycerol

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Peach (*Prunus persica* (L.) Batsch) is a deciduous fruit tree widespread in Egypt and total cultivated area of peach trees reached about 25183 ha (59935.45 feddan) and produced annually[1] about 281256 t. Nowadays, the harvested area of peach trees increased because of growing cultivars of peach trees need low chilling, exporting interest and important economic value. Florida prince is also one of the cultivars, which matches local Egyptian conditions and ripens early[2].

It has high fruit quality and productivity compared with other peach cultivars[3].

Humic substances like NPK-humate is preferable to plant growth for its lower molecular size fraction which make it easily reaches the plasma lemma of plant cells and have later effect on respiration and photosynthesis[4].

Moreover, addition of humus decreased Fe-deficient and increased chlorophyll content and photosynthesis in humus-treated plants, for its surfactant because it has phenolic and carboxylic groups. Furthermore, humic substances have an important impact on fruit trees; for instance, they improve yield and enhance fruit quality by effect on photosynthesis, protein synthesis, enzyme activities[5,6] and increase cells permeability[7].

In present studies, humic substances like NPK-humate improved dry weight of the fruits[8], stimulate growth, chlorophyll and leaf N content in olive trees[9], improved yield, enhanced fruit quality and increased income for growing of peach and apple trees[10]. Finally, they enhance vegetative growth, yield and fruit quality of 'Le Conte' pear trees[11].

The presence of NPK with humate is important for fruit trees because it contains organic acid, fulvic acid, nutrients and phenolic acid, which enhance growth. Furthermore, it has nitrogen (N), which enhance productivity of trees and fruit weight, phosphorus (P), which enhanced fruit quality and yield in fruit trees and potassium (k), which has a great importance by effect in photosynthesis, oxidative metabolism, protein synthesis, enhance vegetative growth and characteristics of quality and yield[12].

Recently, using adjuvants such as methanol and glycerol, which enhance photosynthesis and reduce photo respiration had a great effect on growth and yield[13]. Also, adjuvants increased abundance and evolving at an accelerated in agriculture and future use based on the decision of several apparent dichotomies[14].

The use of methanol compound by foliar applications has many advantage; indeed, it enhance yield by increasing productivity in the unit of leaf area[15], sugar accumulation by reducing photorespiration[16], alternative carbon source[17], improved fruit quality such colour, early maturity[18] and growth regulator of plant[19]. Hence, methanol chemisterical isomerilly is smaller than CO_2 molecule, so absorb easily to increase photosynthesis[20]. Also, it decrease the inducted tensions during photorespiration to plants[21].

Glycerol as an adjuvant is important factor in penetrating with plant regulators and stimulating vegetative growth in trees[22] also, it improved chlorophyll content in leaves[23].

Actually, using NPK-humate as foliar application for enhancing Florida prince peach trees production is still limited. Thus, the main objective of this study was to observe the behavior of Florida prince peach trees under different concentration of NPK-humate foliar application either in presence or absence of adjuvants (methanol and glycerol).

MATERIALS AND METHODS

This experiment was conducted during two successive seasons 2014 and 2015 to studied the impact of NPK-humate as foliar application in the presence or absence of adjuvants (methanol and glycerol) on vegetative growth (leaf area, leaf mineral content (NPK), total Chlorophyll (a+b), length and diameter of shoots), yield and fruit quality of Florida prince peach trees.

The NPK-humate is an amendment produced by Horticultural Research Institute in Egypt and it consists of 8% N, 8% P_2O_5, 8% K_2O and 10% humate.

These trees used in this investigation were eight years old, budded on Nemaguard rootstock, spaced at 4×5 m apart grown in sandy loam soil under drip irrigation system, which were nearly similar in their vigor and treated with common agricultural practices in both seasons in a commercial orchard at El-Khatatba city, Monifia Governorate, Egypt.

Ninety nine trees were selected for the purpose of this experiment which was designed as a completely randomized design with three replicates (three trees for each replicate) to represent treatments during both seasons as follows:

- NPK humate (1%)
- NPK humate (1.5%)
- NPK humate (1%)+glycerol (1%)
- NPK humate (1%)+glycerol (3%)
- NPK humate (1%)+methanol (1%)
- NPK humate (1%)+methanol (3%)
- NPK humate (1.5%)+glycerol (1%)
- NPK humate (1.5%)+glycerol (3%)
- NPK humate (1.5%)+methanol (1%)
- NPK humate (1.5%)+methanol (3%)
- Control (sprayed with well water)

The foliar application of these treatments were conducted four times at 15 days intervals by the same concentration in each time from the beginning of fruit set after petal fall (18 February) during both seasons.

Vegetative growth: Two weeks after each application, 30 leaves from each replicate in the middle of the current growing shoots per selected branches of each trees were taken to determine the following parameters:

Average leaf area (cm^{-2}): The average Leaf area was determined using the following equation which adapted by Demirsoy *et al.*[24]:

$$LA = -0.5 + \left(0.23 \times \frac{L}{W}\right) + (0.67 \times L \times W)$$

where, LA is leaf area (cm^2), W is leaf width (cm) and L is leaf length (cm).

Length and diameter of shoots: In each growing season, 4 main branches as uniform as possible were chosen at the 4 points of each experimented tree and the average lengths and diameters of the current shoots per selected branches were measured in centimeter after 2 weeks of the last foliar applications during both seasons.

Nitrogen (N), phosphorus (P) and potassium (K) leaf content: Leaf samples were washed with tap water, rinsed twice in distilled water, oven dried at 70°C till a constant weight and then grinded. Macro nutrient was determined according to the method described by Jones[25] by using micro-kjeldahl for determining total nitrogen percentage, chorotannus-reduse molybdo phosphoric blue color method in sulphoric system for determining phosphorus percentage which estimated calorimetrically and for determining potassium percentage, flame photometer was used.

Total chlorophyll (a+b) leaf content (mg g^{-1}) FM: Total chlorophyll content was determined by extracting in 80% acetone. The absorption at 663 and 645 nm were read in spectrophotometer using the absorption coefficients and the amount of chlorophyll is calculated as follow according to the method described by Goodwine[26]:

$$\text{Chlorophyll a (mg g}^{-1}\text{) tissues} = 12.7\,(A663) - 2.69\,(A645) \times \left(\frac{V}{1000W}\right)$$

$$\text{Chlorophyll b (mg g}^{-1}\text{) tissues} = 22.9\,(A645) - 2.68\,(A663) \times \left(\frac{V}{1000W}\right)$$

where, A is absorbance at specific wave length, V is Final volume of chlorophyll extracted in 80% acetone and W is fresh weight of tissues extracted.

$$\text{Total chlorophyll (A+B)} = \text{Chlorophyll a+chlorophyll b}$$

Yield and fruit quality: At harvesting date, average yield per each treatment was recorded as kg fruits per tree by counting number of fruits per tree multiplied by average fruit weight. Average yield per feddan was estimated by multiplying yield per tree by the number of trees per feddan in tones.

Regarding to fruit quality, about 90 fruits were collected from each treatment (22 April) when the skin ground color becomes yellow and about 98% of external surface of fruits covering with red blushes as well as firmness reaches 14.0-16.0 lb $inch^{-2}$ according to Shaltout[27]. These fruits were transported immediately to the Laboratory of Faculty of Agriculture, Pomology Department, Mansoura University to determine the following parameters:

Fruit size (cm^3): Fruit size was measured by using the volume of replacement water as cm^3 after dipping fruit in it.

Fruit height and diameter (cm): Fruit height and diameter were measured by using a vernier calipers as centimeter; whereas, fruit diameter was measured from the middle of the fruit.

Soluble Solids Content (SSC): It was measured in fruit juice by using a Carl-Zeiss hand refractometer[28].

Total titratable acidity (%): It was determined in fruit juice by titration with 0.1 N sodium hydroxide and calculated as malic acid according to the method described in AOAC[28].

Soluble Solids Content (SSC)/acid ratio: The SSC/acid ratio was expressed by the ratio between SS content and total titratable acidity.

Total sugars: Total sugars were determined by using phenol 18% and sulphuric acid 96% and the absorbance was recorded with spectrophotometer at 490 nm, according to the method described by Sadasivam and Manickam[29]. A standard curve was prepared by plotting the known concentrations of glucose solution (100 μg mL^{-1} of glucose) against respective Optical Density (OD) value of each. From the standard curve, the amount of total soluble sugars actually present in the sample is determined.

Table 1: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on average leaf area (cm^2) of Florida prince peach trees during the four times of foliar applications at 2014 and 2015 seasons

	Average leaf area (cm^2)							
	After 1st		After 2nd		After 3rd		After 4th	
	Foliar application							
	Seasons		Seasons		Seasons		Seasons	
Treatments	2014	2015	2014	2015	2014	2015	2014	2015
NPK humate (1%)	28.81	25.92	37.19	40.30	39.99	42.88	39.17	42.32
NPK humate (1.5%)	30.22	27.77	39.15	39.50	41.12	43.50	41.42	42.77
NPK humate (1%)+glycerol (1%)	30.41	30.52	39.62	40.75	43.49	45.41	43.48	45.83
NPK humate (1%)+glycerol (3%)	32.51	32.30	41.55	42.35	43.75	46.88	44.44	46.51
NPK humate (1%)+methanol (1%)	31.10	31.03	40.23	41.80	43.71	46.47	43.72	46.14
NPK humate (1%)+methanol (3%)	32.25	32.90	41.69	43.26	44.38	46.76	44.85	47.60
NPK humate (1.5%)+glycerol (1%)	33.24	33.58	41.74	44.03	44.52	47.65	44.88	48.10
NPK humate (1.5%)+glycerol (3%)	35.12	33.77	42.14	45.52	45.15	48.65	45.14	48.56
NPK humate (1.5%)+methanol (1%)	34.73	33.15	41.85	44.91	44.67	48.63	44.91	48.21
NPK humate (1.5%)+methanol (3%)	36.50	34.55	43.00	45.77	46.32	50.31	46.61	50.66
Control	25.15	27.12	34.31	37.22	37.64	39.27	37.12	41.21
N-LSD at (5%)	1.30	1.08	1.46	1.56	1.46	1.47	0.92	0.48

Total anthocyanin content: Total anthocyanin content was measured in fruit skin according to the method of Mazumadar and Majumder[30] hence, half gram was extracted of fresh fruit skin in 10 mL of ethanolic-hydrochloride acid mixture which prepared by mixing 15 parts of hydrochloric acid 1.5 N and mixing 85 parts of ethanol 95%. Then, solution placed at a temperature 4°C for 3 min and then filtered by used filter paper (Whatman No. 1). The filtered aliquot was put under darkness for 2 h and the container was covered. The Optical Density (OD) value of the extract was determined at 535 nm wave length by used a spectrophotometer:

Total absorbance value of anthocyanin in fruit skin was calculated using the following equation:

$$\text{Total absorbance (100 per gm)} = \left(\frac{e \times b \times c}{d \times a}\right)$$

Where:
a = Weight of sample
b = Volume made for color measurement
c = Total volume made
d = Volume of aliquot taken for estimation
e = Specific Optical Density (OD) value at 535 nm wavelength

About 1 mg mL^{-1} of the solution is equivalent to the absorbance of 98.2. Therefore, the amount of total anthocyanin present in the sample (mg 100 g) = Total absorbance for the sample/98.2.

Fruit firmness (lb $inch^{-2}$): It was measured by using a hand Effegi-penetrometers supplemented with plunger 8 mm diameter and the average was estimated[31] as lb $inch^{-2}$.

Statistical analysis: The obtained data were statistically analyzed as a randomized complete design by analysis of variance (ANOVA) according to the procedure outlined by Snedecor and Cochran[32] using the Statistical Package Software SAS (SAS Institute Inc. Cary, NC, USA). Comparisons between means were made by using the Newly Least Significant Differences (NLSD) test at 5% level of probability as mentioned by Waller and Duncan[33].

RESULTS AND DISCUSSION

Average leaf area: Data illustrated in Table 1 showed that all treatments significantly enhanced average leaf area of Florida prince peach trees during the four times of foliar applications compared to the control. Furthermore, combined application of NPK-humate with adjuvants (methanol and glycerol) gave higher values than the individual application of it in this respect. The treatment of NPK-humate at 1.5% with methanol at 3% gave the highest significant values compared to control treatment during the four times of foliar applications in both seasons.

On the contrary, the individual application of NPK-humate at 1% presented a low values in this respect compared to other humate treatments, which recorded 28.81 and 25.92; 37.19 and 40.30; 39.99 and 42.88; 39.17 and 42.32 cm^2 during the four times of foliar applications in both seasons, respectively.

These results confirm the results obtained by Jassem and Obaid[34] who found that foliar application with K-humate improved average leaf area on apricot trees because of K-humate increase cell division and chelation elements.

Table 2: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on shoot length and diameter (cm) of Florida prince peach trees after two weeks of the last foliar application at 2014 and 2015 seasons

	Shoot length (cm)		Shoot diameter (cm)	
	Seasons		Seasons	
Treatments	2014	2015	2014	2015
NPK humate (1%)	39.35	39.75	0.40	0.45
NPK humate (1.5%)	42.90	41.50	0.50	0.60
NPK humate (1%)+glycerol (1%)	45.25	44.20	0.55	0.65
NPK humate (1%)+glycerol (3%)	50.80	60.20	0.80	0.80
NPK humate (1%)+methanol (1%)	45.60	48.20	0.60	0.70
NPK humate (1%)+methanol (3%)	59.10	60.40	0.60	0.70
NPK humate (1.5%)+glycerol (1%)	64.05	60.55	0.75	0.80
NPK humate (1.5%)+glycerol (3%)	67.70	71.80	0.90	0.85
NPK humate (1.5%)+methanol (1%)	65.75	69.40	0.75	0.80
NPK humate (1.5%)+methanol (3%)	70.60	74.50	0.90	0.90
Control	36.50	33.50	0.40	0.50
N-LSD at 5%	2.50	2.09	0.12	0.24

Furthermore, Bahha *et al.*[35] reported that spray humic acid 2 g L^{-1} with a source of nitrogen (urea) increased leaf area on almond trees due to humic acid stimulate new leaves production.

In addition, Fernandez *et al.*[36] observed that spray adjuvants (methanol and glycerol) on peach trees increased leaf area and explained this effect due to adjuvants increase uptake elements and improve leaf penetration for spray solution and impact on foliar fertilization; hence, they reduce surface tension and leaf wetting. But, methanol is better than glycerol as an adjuvant; hence, it increase leaf area due to abundant CO_2 supply from methanol which reduce photo respiration in favor of photosynthesis[37]. Also, Mauney and Gerik[38] reported that application of methanol was found to play an important role in balancing the nutritional status of leaves by acting as a carbon source.

Shoot length and diameter: Data presented in Table 2 showed that all treatments had great effect on shoot length and diameter of Florida prince peach trees. However, NPK-humate foliar applications in presence of adjuvants increased shoot length and diameter significantly compared to control or individual applications of it; particularly, foliar application of NPK-humate (1.5%)+methanol (3%) gave the best effect in this respect; hence, it recorded 70.60 and 74.50 for shoot length and 0.90 and 0.90 cm for shoot diameter.

That may be due to the ambient air around sprayed trees which contains various organic compounds such serine as a result of methanol oxidation[39]; furthermore, the important role of methanol in facilitating the availability of mineral or organic nutrients, direct assimilation of the carbon, which inhibit photo respiration by increasing internal CO_2 and superbly aspect the mechanisms for putative plant-growth responses[40]. Moreover, humic substances like NPK-humate stimulate vegetative growth; as a result they contain amino acids, organic matter and nutrient elements[41].

Conversely, control gave the lowest values in this respect; hence, it recorded values of 36.50 and 33.50 for shoot length and 0.40 and 0.50 cm for shoot diameter in both seasons, respectively. These data are in harmony with those obtained by Eissa *et al.*[42] who found that humic acid had positive effect and increased shoot length and diameter on stone fruit trees; furthermore, Al-Aa'reji[43] demonstrated that using organic fertilizer and source of nitrogen together increased shoot length on peach trees and Jassem and Obaid[34] reported that spraying apricot trees with humate 1.5 mL L^{-1} increased shoots length and diameter.

Nitrogen (N), phosphorus (P) and potassium (k) leaf content: The concerned results from Table 3-5 indicated that all experimental foliar applications significantly raised N, P and K leaf content in ascending order from the first time of application till the second foliar application after that there was a noticeable reduction in the estimated leaf mineral content until the last foliar application. This reduction of N, P and K in leaves during fruit development may be due to translocation of them from leaves to fruits during the last fruit development stages. These results are in line with those found by Rufat and DeJong[44] for N content in peach leaves and Zarei *et al.*[45] for P concentration in apple trees.

In this regard, spraying adjuvants (methanol and glycerol) with NPK-humate specifically methanol gave the highest positive effect on N, P and K leaf content compered to individual foliar application of NPK-humate or control, but the high combined concentration of both NPK-humate (1.5%) and methanol (3%) had a preference in this respect. The values of N, P and K leaf content due to this foliar application treatment were 3.47 and 3.71; 3.66 and 3.92; 2.71 and 3.05; 2.59 and 2.49 for nitrogen, 0.189 and 0.191; 0.195 and 0.199; 0.159 and 0.173; 0.142 and 0.145 for phosphorus and 2.31 and 2.54; 2.50 and 2.66; 1.74 and 2.07; 1.53 and 1.74% for potassium during the four times of foliar applications in both seasons, respectively.

Data in the same table also indicate that control treatment gave the lowest values in that respect comparing to other treatments, which recorded values of 2.60 and 2.30; 2.65 and 2.42; 1.97 and 1.90; 1.55 and 1.66 for nitrogen, 0.105 and 0.107; 0.112 and 0.115; 0.079 and 0.072; 0.061 and 0.061 for phosphorus and 1.17 and 1.35; 1.36 and 1.40; 1.02 and 1.02; 0.70 and 0.66 for potassium during the four times of foliar applications in both seasons, respectively.

Table 3: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on N leaf content (%) of Florida prince peach trees during the four times of foliar applications at 2014 and 2015 seasons

	N leaf content (%)							
	After 1st		After 2nd		After 3rd		After 4th	
	Foliar application							
	Seasons		Seasons		Seasons		Seasons	
Treatments	2014	2015	2014	2015	2014	2015	2014	2015
NPK humate (1%)	2.68	2.37	2.76	2.68	2.03	2.05	1.89	1.78
NPK humate (1.5%)	2.69	2.39	2.88	2.75	2.17	2.32	1.90	2.09
NPK humate (1%)+glycerol (1%)	2.85	2.74	2.96	3.08	2.26	2.33	2.04	2.12
NPK humate (1%)+glycerol (3%)	2.99	3.15	3.27	3.51	2.36	2.52	2.25	2.25
NPK humate (1%)+methanol (1%)	2.91	2.85	3.02	3.22	2.30	2.43	2.12	2.16
NPK humate (1%)+methanol (3%)	3.12	3.28	3.27	3.78	2.41	2.60	2.35	2.34
NPK humate (1.5%)+glycerol (1%)	3.19	3.45	3.37	3.80	2.54	2.86	2.35	2.37
NPK humate (1.5%)+glycerol (3%)	3.35	3.66	3.53	3.84	2.62	2.99	2.41	2.45
NPK humate (1.5%)+methanol (1%)	3.27	3.50	3.49	3.82	2.60	2.97	2.37	2.41
NPK humate (1.5%)+methanol (3%)	3.47	3.71	3.66	3.92	2.71	3.05	2.59	2.49
Control	2.60	2.30	2.65	2.42	1.97	1.90	1.55	1.66
N-LSD at 5%	0.01	0.06	0.02	0.01	0.01	0.02	0.03	0.02

Table 4: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on P leaf content (%) of Florida prince peach trees during the four times of foliar applications at 2014 and 2015 seasons

	P leaf content (%)							
	After 1st		After 2nd		After 3rd		After 4th	
	Foliar application							
	Seasons		Seasons		Seasons		Seasons	
Treatments	2014	2015	2014	2015	2014	2015	2014	2015
NPK humate (1%)	0.109	0.111	0.123	0.130	0.089	0.091	0.076	0.067
NPK humate (1.5%)	0.118	0.125	0.126	0.144	0.092	0.107	0.089	0.082
NPK humate (1%)+glycerol (1%)	0.128	0.132	0.140	0.145	0.099	0.112	0.095	0.105
NPK humate (1%)+glycerol (3%)	0.148	0.146	0.153	0.157	0.112	0.122	0.106	0.111
NPK humate (1%)+methanol (1%)	0.142	0.136	0.146	0.148	0.104	0.115	0.101	0.108
NPK humate (1%)+methanol (3%)	0.157	0.152	0.167	0.166	0.117	0.133	0.109	0.119
NPK humate (1.5%)+glycerol (1%)	0.167	0.163	0.185	0.181	0.125	0.165	0.118	0.126
NPK humate (1.5%)+glycerol (3%)	0.179	0.186	0.188	0.191	0.142	0.175	0.130	0.134
NPK humate (1.5%)+methanol (1%)	0.175	0.177	0.187	0.183	0.129	0.168	0.123	0.130
NPK humate (1.5%)+methanol (3%)	0.189	0.191	0.195	0.199	0.159	0.173	0.142	0.145
Control	0.105	0.107	0.112	0.115	0.079	0.072	0.061	0.061
N-LSD at (5%)	0.003	0.001	0.005	0.002	0.003	0.001	0.002	0.002

Table 5: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on K leaf content (%) of Florida prince peach trees during the four times of foliar applications at 2014 and 2015 seasons

	K leaf content (%)							
	After 1st		After 2nd		After 3rd		After 4th	
	Foliar application							
	Seasons		Seasons		Seasons		Seasons	
Treatments	2014	2015	2014	2015	2014	2015	2014	2015
NPK humate (1%)	1.33	1.43	1.44	1.51	1.12	1.08	1.03	1.02
NPK humate (1.5%)	1.40	1.52	1.48	1.55	1.19	1.16	1.09	1.08
NPK humate (1%)+glycerol (1%)	1.41	1.64	1.51	1.71	1.26	1.25	1.11	1.09
NPK humate (1%)+glycerol (3%)	1.60	1.78	1.79	1.82	1.41	1.33	1.24	1.12
NPK humate (1%)+methanol (1%)	1.48	1.70	1.70	1.77	1.38	1.28	1.19	1.11
NPK humate (1%)+methanol (3%)	1.65	1.83	1.90	2.01	1.42	1.55	1.30	1.17
NPK humate (1.5%)+glycerol (1%)	1.68	1.93	1.92	2.05	1.45	1.77	1.30	1.20
NPK humate (1.5%)+glycerol (3%)	1.88	2.45	2.13	2.50	1.63	2.01	1.47	1.51
NPK humate (1.5%)+methanol (1%)	1.85	2.19	2.05	2.29	1.61	196	1.38	1.25
NPK humate (1.5%)+methanol (3%)	2.31	2.54	2.50	2.66	1.74	2.07	1.53	1.74
Control	1.17	1.35	1.36	1.40	1.02	1.02	0.70	0.66
N-LSD at (5%)	0.07	0.04	0.06	0.02	0.02	0.02	0.05	0.03

Table 6: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on total chlorophyll (a+b) leaf content (mg g^{-1}) FM of Florida prince peach trees during the four times of foliar applications at 2014 and 2015 seasons

	Total chlorophyll (a+b) mg g^{-1} FM							
	After 1st		After 2nd		After 3rd		After 4th	
	Foliar application							
	Seasons		Seasons		Seasons		Seasons	
Treatments	2014	2015	2014	2015	2014	2015	2014	2015
NPK humate (1%)	1.017	1.037	1.065	1.083	0.786	0.784	0.703	0.701
NPK humate (1.5%)	1.046	1.041	1.087	1.115	0.801	0.807	0.711	0.707
NPK humate (1%)+glycerol (1%)	1.068	1.073	1.104	1.124	0.818	0.828	0.761	0.743
NPK humate (1%)+glycerol (3%)	1.106	1.114	1.148	1.149	0.849	0.877	0.770	0.788
NPK humate (1%)+methanol (1%)	1.085	1.085	1.131	1.136	0.835	0.832	0.742	0.764
NPK humate (1%)+methanol (3%)	1.122	1.118	1.159	1.154	0.869	0.885	0.790	0.790
NPK humate (1.5%)+glycerol (1%)	1.144	1.131	1.192	1.178	0.873	0.897	0.804	0.799
NPK humate (1.5%)+glycerol (3%)	1.173	1.188	1.224	1.243	0.906	0.917	0.825	0.823
NPK humate (1.5%)+methanol (1%)	1.154	1.190	1.192	1.196	0.889	0.901	0.806	0.813
NPK humate (1.5%)+methanol (3%)	1.193	1.192	1.250	1.261	0.915	0.977	0.850	0.857
Control	1.005	1.007	1.023	1.074	0.761	0.753	0.614	0.619
N-LSD at (5%)	0.004	0.005	0.004	0.002	0.003	0.003	0.014	0.013

That is may be due to that addition of adjuvants in spray solution increased intimate contact between the layer of the leaf surface and droplets aqueous solution[46] and increased leaf penetration for nutrients which improved efficiency spray[47]. In addition, foliar application of humic substances like NPK-humate increase phosphorus of leaf content due to humic substances stimulate vegetative growth and contain amino acids, organic matter and nutrient elements[41], finally; they increase the uptake of nutrient elements[48] on peach trees.

These data are inagreement with those obtained by Jasim[49] on apricot and Sherif *et al.*[50] on Le-conte Pear.

Total chlorophyll (a+b) leaf content: It is clear from Table 6 that all tested foliar application improved total chlorophyll (a+b) leaf content significantly of Florida prince peach trees compared to control. Moreover, foliar application of NPK-humate in presence of adjuvants (methanol and glycerol) enhanced total chlorophyll (a+b) leaf content compared to foliar application at different individual rates of NPK-humate.

Also, it is observed that total chlorophyll (a+b) leaf content reached its highest values after second foliar application then descending down till the fourth foliar application and that is may be due to chlorophyll content increase with leaf expansion and photosynthesis varied with leaf development and CO_2 assimilation rates which are reflected in their chlorophyll concentration in leaves, then total chlorophyll in leaves decreasing during fruit growing of peach trees[51].

However, the best foliar application in this respect was NPK humate (1.5%)+methanol (3%), which gave the highest values of total chlorophyll (a+b) leaf content; hence, it recorded 1.193 and 1.192; 1.250 and 1.261; 0.915 and 0.977; 0.850 and 0.857 mg g^{-1} FM while the control gave the lowest values hence, it recorded 1.005 and 1.007; 1.023 and 1.074; 0.761 and 0.753; 0.614 and 0.619 mg g^{-1} FM during the four times of foliar applications in both seasons, respectively.

These data are in harmony with results of Jasim[49] who reported that spray K-humate 1 mL L^{-1} increased chlorophyll (a+b) in leaves on apricot trees and Joody[52] who mentioned that spray K-humate 2 mL L^{-1} increased chlorophyll in leaves in plum seedling due to potassium (K) regulates the open stomata and humic substance increase the force of the cell membrane and the absorption of nutrients and enhance photosynthesis; furthermore, methanol give the best performance of the spray solution and increase total chlorophyll of green leaf surface[36].

Fruit number/tree, fruit weight, yield/tree and yield/feddan: Data in Table 7 cleared that all experiential treatments increased significantly fruit number per tree and fruit weight compared to control. Meanwhile, foliar application with NPK-humate in the presence of adjuvants had the priority in this respect specifically, NPK-humate at 1.5%+methanol at 3%, which recorded 330.00 and 350.00 fruit number/tree and 133.00 and 138.00 g for fruit weight followed by NPK-humate at 1.5%+glycerol 3%, which recorded 295.00 and 331.00 fruit number/tree and 131.00 and 131.00 g for fruit weight during both season, respectively. On the contrary, control trees gave the lowest values in this respect; hence, it recorded 253.00 and 251.00 fruit number/tree and 86.00 and 81.00 g for fruit weight in both season, respectively.

Table 7: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on fruit number/tree, fruit weight (g) , yield/tree (kg) and yield/feddan (t) of Florida prince peach trees after two weeks of the last foliar application at 2014 and 2015 seasons

	Fruit number/tree		Fruit weight (g)		Yield/tree (kg)		Yield/Fed (t)	
	Seasons		Seasons		Seasons		Seasons	
Treatments	2014	2015	2014	2015	2014	2015	2014	2015
NPK humate (1%)	270.00	283.00	102.00	102.00	27.54	28.86	5.78	6.06
NPK humate (1.5%)	280.00	290.00	104.00	105.00	29.12	30.45	6.11	6.39
NPK humate (1%)+glycerol (1%)	277.00	291.00	108.50	109.50	30.05	31.71	6.31	6.65
NPK humate (1%)+glycerol (3%)	285.00	311.00	116.00	117.00	33.06	36.38	6.94	7.63
NPK humate (1%)+methanol (1%)	280.00	296.00	111.50	113.00	31.22	33.44	6.55	7.02
NPK humate (1%)+methanol (3%)	287.00	309.00	116.00	120.00	33.29	37.08	6.99	7.78
NPK humate (1.5%)+glycerol (1%)	290.00	310.00	123.00	125.00	35.67	38.75	7.49	8.13
NPK humate (1.5%)+glycerol (3%)	295.00	331.00	131.00	131.00	38.64	43.36	8.11	9.10
NPK humate (1.5%)+methanol (1%)	290.00	324.00	125.00	127.00	36.25	41.14	7.61	8.63
NPK humate (1.5%)+methanol (3%)	330.00	350.00	133.00	138.00	43.89	48.30	9.21	10.14
Control	253.00	251.00	86.00	81.00	21.75	20.33	4.56	4.26
N-LSD at (5%)	3.12	3.67	3.80	1.92	1.06	1.05	0.21	0.19

Concerning to the effect of foliar application with NPK-humate in the presence or absence of adjuvants on yield/tree and yield/feddan, Data in Table 7 showed that both yield per tree and feddan of Florida prince peach trees were significantly increased, as soon as they treated with foliar application of NPK-humate in the presence of adjuvants (methanol and glycerol) compared to other foliar application of NPK-humate or control. The best foliar application, which yielded the highest values in this respect was NPK-humate (1.5%)+methanol (3%) which resulted in 43.89 and 48.30 kg for yield per tree and 9.21 and 10.14 t for yield per feddan followed by NPK humate (1.5%)+glycerol (3%), which resulted in 38.64 and 43.36 kg for yield per tree and 8.11 and 9.10 for yield per feddan in both season, respectively. The increment due to these treatments was entirely a result of increased fruit weight. On the contrary, control yielded the lowest values in this respect; hence, it resulted in 21.75 and 20.33 kg for yield per tree and 4.56 and 4.26 t for yield per feddan in both season, respectively.

These results may be due to greater significant positive correlations which were found between total yield and chlorophyll in leaves[18]. As soon as foliar application of NPK-humate in the presence or absence of adjuvants increase chlorophyll level in leaves of Folirda prince peach trees, fruit weight and yield per tree or feddan increase and that was observed under this study.

Results go in the same line with those reported by El-Khawaga[53] who reported that humic substances improved fruit weight and enhanced the yield per tree and per feddan of peach trees; also, Abd El-Razek *et al.*[48] revealed that spray K-humate increased fruit weight and enhanced the yield per tree and per feddan of apricot trees. In addition, Sherif *et al.*[50] found that methanol increased fruit weight and enhanced the yield per tree and per feddan of pear trees. Finally, Milosevic *et al.*[54] reported that NPK+humic acid improved total yield of apricot trees.

Fruit size, height and diameter: Data in Table 8 illustrated that foliar application of NPK-humate in the presence of adjuvants at high concentration yielded the largest fruit size, height and diameter compared to the low concentration of these combinations or the individual foliar application of NPK-humate and control during both seasons. Consequently, Florida prince peach fruit size, height and diameter were increased significantly by the foliar application of NPK-humate (1.5%)+methanol (3%) compared to control which had fruit size, height and diameter of 138.00 and 142.00 cm^3; 6.38 and 6.49 and 5.90 and 6.24 cm and control treatment recorded values of 83.00 and 85.00 cm^3; 4.76 and 5.26; 4.02 and 5.33 cm, respectively during both seasons.

These data coincides with results obtained by Abd El-Razek *et al.*[48] who found that spray (k-humate) on Florida prince peach trees increased fruit size and El-Khawaga[53] reported that used humic acid increased fruit height and diameter of peach trees. Furthermore, El-Kosary *et al.*[55] reported that spray humic substances include humic acid with N increased height and diameter in mango fruits. Also, Fathy *et al.*[56] found that spray humic substances (contains 2.9% humic acid+10.10.10% NPK) increased fruit size on apricot trees. Finally, Sherif *et al.*[50] reported that methanol 30% improved fruit size on pear trees.

Soluble Solids Content (SSC %), titratable acidity (%) and SSC/acid ratio: Data in Table 9 revealed that all foliar application of NPK-humate in the presence or absence of adjuvants increased SSC% and SSC/acid ratio but they

Table 8: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on fruit size (cm^3), height (cm) and diameter (cm) of Florida prince peach trees during 2014 and 2015 seasons

	Fruit size (cm^3)		Fruit height (cm)		Fruit diameter (cm)	
	Seasons		Seasons		Seasons	
Treatments	2014	2015	2014	2015	2014	2015
NPK humate (1%)	97.00	101.00	5.37	5.66	5.32	5.54
NPK humate (1.5%)	106.00	110.00	5.58	5.89	5.38	5.78
NPK humate (1%)+glycerol (1%)	108.00	112.00	5.59	6.06	5.48	5.87
NPK humate (1%)+glycerol (3%)	118.00	122.00	5.64	6.12	5.64	6.01
NPK humate (1%)+methanol (1%)	111.00	117.00	5.61	6.08	5.57	5.98
NPK humate (1%)+methanol (3%)	122.00	124.00	5.69	6.36	5.70	6.03
NPK humate (1.5%)+glycerol (1%)	125.00	131.00	5.73	6.38	5.75	6.06
NPK humate (1.5%)+glycerol (3%)	132.00	138.00	6.26	6.55	5.86	6.13
NPK humate (1.5%)+methanol (1%)	127.00	134.00	6.06	6.43	5.78	6.08
NPK humate (1.5%)+methanol (3%)	138.00	142.00	6.38	6.49	5.90	6.24
Control	83.00	85.00	4.76	5.26	4.02	5.33
N-LSD at (5%)	3.01	2.46	0.12	0.02	0.04	0.11

Table 9: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on soluble solids content (SSC%), titratable acidity (%) and SSC/acid ratio of Florida prince peach fruit juice during 2014 and 2015 seasons

	Soluble solids content (SSC %)		Titratable acidity (%)		SSC/acid ratio	
	Seasons		Seasons		Seasons	
Treatments	2014	2015	2014	2015	2014	2015
NPK humate (1%)	9.60	9.70	0.96	1.16	10.00	8.36
NPK humate (1.5%)	9.40	10.20	0.91	1.12	10.32	9.10
NPK humate (1%)+glycerol (1%)	9.75	10.50	0.89	1.07	10.95	9.81
NPK humate (1%)+glycerol (3%)	10.20	10.70	0.83	1.04	12.28	10.28
NPK humate (1%)+methanol (1%)	10.15	10.80	0.84	1.05	12.28	10.28
NPK humate (1%)+methanol (3%)	10.70	11.80	0.78	0.95	13.71	12.42
NPK humate (1.5%)+glycerol (1%)	10.75	11.80	0.77	0.87	13.96	13.56
NPK humate (1.5%)+glycerol (3%)	10.80	12.40	0.68	0.78	15.88	15.89
NPK humate (1.5%)+methanol (1%)	10.77	12.00	0.69	0.81	15.60	14.81
NPK humate (1.5%)+methanol (3%)	11.00	12.90	0.68	0.68	16.17	18.97
Control	8.40	8.70	0.97	1.19	8.65	7.31
N-LSD at (5%)	0.29	0.11	0.01	0.02	0.32	0.25

reduced titratable acidity percentage of Florida prince peach fruit juice compared to the control during both seasons of study. Furthermore, it is clear that foliar application of NPK-humate (1.5%)+methanol (3%) presented the highest value of SSC%; it resulted in 11.00 and 12.90% and presented the lowest value of titratable acidity percentage; it resulted in 0.68 and 0.68%; therefore, it presented the highest value of SSC/acid ratio; it resulted in 16.17 and 18.97 during the two seasons of study, respectively. That may be due to this treatment gave the highest values of average leaf area (Table 1) and potassium leaf content (Table 5).

On the contrary, the control presented the lowest value of SSC%. It resulted in 8.40 and 8.70 and presented the highest value of titratable acidity percentage, which recorded in 0.97 and 1.19%. Therefore, it presented the lowest value of SSC/acid ratio; it resulted in 8.65 and 7.31 during the two seasons of study, respectively.

In this respect, Fathy *et al*.[56] reported that sprayed actosol (contains 2.9% humic acid+10,10,10% NPK) reduced acidity on peach trees. Also, Mansour *et al*.[57] found that humic acid 5 cm^{-3} tree+amino acid 0.1% increased SSC % of Florida prince peach trees.

Total sugars, anthocyanin and fruit firmness: Foliar application treatments affected significantly total sugars, anthocyanin and fruit firmness of Florida prince peach fruit and it is obvious from data in Table 10 that all foliar application under this study improved these parameters on peach fruits compared to control which gave the lowest significant effect in this respect; hence, it resulted in 5.99 and 6.21 (100 μg mL^{-1} of glucose) for total sugar and 19.08 and 20.44 (mg 100 g^{-1} fresh weight) for anthocyanin and it gave the highest value of fruit firmness which resulted 15.68 and 16.08 (lb $inch^{-2}$) during both seasons, respectively. In

Table 10: Effect of foliar application with NPK-humate in the presence or absence of adjuvants (methanol and glycerol) on total sugars (100 μg mL^{-1} of glucose), anthocyanin (mg 100 g^{-1} fresh weight) and Fruit firmness (lb $inch^{-2}$) of Florida prince peach trees during 2014 and 2015 seasons

	Total soluble sugars (100 μg mL^{-1} of glucose)		Anthocyanin (mg 100 g fresh weight)		Fruit firmness (lb $inch^{-2}$)	
	Seasons		Seasons		Seasons	
Treatments	2014	2015	2014	2015	2014	2015
NPK humate (1%)	6.06	6.36	19.67	21.06	14.81	14.55
NPK humate (1.5%)	6.24	6.49	20.13	21.71	14.20	14.23
NPK humate (1%)+glycerol (1%)	6.42	6.71	20.61	22.17	14.35	14.13
NPK humate (1%)+glycerol (3%)	6.72	7.01	21.74	23.21	14.02	14.05
NPK humate (1%)+methanol (1%)	6.55	6.86	21.17	22.55	14.08	14.08
NPK humate (1%)+methanol (3%)	6.99	7.29	22.19	23.63	13.30	13.88
NPK humate (1.5%)+glycerol (1%)	7.17	7.49	22.81	24.26	13.23	13.77
NPK humate (1.5%)+glycerol (3%)	7.69	8.03	23.98	26.05	13.08	12.55
NPK humate (1.5%)+methanol (1%)	7.55	7.98	23.45	25.14	13.17	13.63
NPK humate (1.5%)+methanol (3%)	7.83	8.14	24.43	26.13	13.21	12.22
Control	5.99	6.21	19.08	20.44	15.68	16.08
N-LSD at (5%)	0.01	0.03	0.01	0.02	0.29	0.03

contrary, foliar application of NPK-humate (1.5%)+methanol (3%) presented the highest effect for total sugar and anthocyanin; it recorded 7.83 and 8.14 (100 μg mL^{-1} of glucose) for total sugar and 24.43 and 26.13 (mg 100 g^{-1} fresh weight) for anthocyanin while this application gave the lowest value of fruit firmness; hence, it recorded 13.21 and 12.22 lb $inch^{-2}$ during both seasons, respectively but acceptable for peaches.

That is may be due to the clearly effect of NPK-humate (1.5%)+methanol (3%) foliar application on enhancing average leaf area (Table 1) and total chlorophyll (Table 6) under this study which advanced Florida prince peach fruit maturity; as a result of, the positive correlation between carbohydrates content in fruits and total chlorophyll (a+b) in leaves and total yield and this results may be due to humic substance enhanced photosynthesis which effect on total sugar[58] and that was confirmed by Mansour *et al.*[57] who revealed that humic substance increased total sugars percentage in Florida prince peach fruits; furthermore, Zhang *et al.*[59] observed that sprayed humic substance with adjuvant increased soluble sugar content of apple trees. Finally, the decreased of fruit firmness due to foliar application of NPK-humate (1.5%)+methanol (3%) may be also due to the positive impact of methanol on hasten fruit maturity and ripening[60].

The improvement of total sugar in fruit peach after foliar application NPK-humate (1.5%)+methanol (3%) may be due to that metabolism of methanol in leaves inhibited photo respiration and then result in increased leaf water-use efficiency, since there would be an increase in assimilation rate and internal CO_2 concentration[61] which enhanced photosynthesis and reflex positive on fruit sugar content.

Regarding to the data of anthocyanin, it was in harmony with results of Stino *et al.*[62] who found that spray amino acids and KNO_3 with organic fertilizers improved anthocyanin pigment in fruits compared with control fruit peach; moreover, Nikolaou *et al.*[63] found that spraying vines with methanol advanced and increased the anthocyanin in skin of berries. The increased of anthocyanin in peach fruit may be due to that methanol release CO_2 and enhanced photosynthesis which increased accumulation of carbohydrates after methanol application[64].

CONCLUSION

The results of the experiment revealed that foliar application of NPK-humate in presence of adjuvants were effective in increasing peach tree cropping and improving fruit quality. The effectiveness of NPK-humate in presence of adjuvants resulted from improved leaf area and its chlorophyll content which causing better photosynthesis status of peach trees. However, foliar application of NPK-humate (1.5%)+methanol (3%) was the best treatment in this respect; hence, it showed the best significant effect on various estimated parameters under this study unless fruit firmness during both seasons. Finally, it is necessary to conduct a further study for modifying foliar spraying concentration especially during the third and fourth times of application to compensate the shortage in the leaves content of nutrients and chlorophyll in these stages.

SIGNIFICANT STATEMENT

- The NPK-humate enhanced vegetative growth of peach trees in presence of adjuvants
- Methanol as an adjuvants improves the efficiency of the spray solution

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