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Response of Two Eggplant Cultivars to Irrigation Intervals and Foliar Application with some Antitranspirants.

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ABSTRACT

Two field experiments were conducted at the Experimental Station Farm, Faculty of Agriculture, Mansoura University, Egypt, during summer seasons of 2015 and 2016 to study the effect of three irrigation intervals (10, 15 and 20 days) and five antitranspirants as a foliar application (Control, Kaolin, Jojoba oil, Glycerol and Green miracle) on two cultivars of eggplant (long white and long black) and their interactions on vegetative growth, yield and fruits quality. Obtained data revealed that long blackcultivar gave significantly increases in vegetative growth parameters, in the contrary; concerning number of fruits/plant, early yield, total yield and quality parameters *i.e.* crude protein in the first season and crude fiber in both seasons; long white cultivar was more superior with significant differences. Moreover irrigation intervals every 10 days gave significant increments in vegetative growth, yield and its component, while quality determinations values *i.e.* crude protein, total carbohydrates, crude fiber and vitamin c were increased significantly when irrigation intervals were every 15 days. Concerning foliar application treatments, jojoba oil spraying gave significant superiority comparing to other spraying treatments in vegetative growth measurements, yield and its components while green miracle produced the highest significant values of quality parameters *i.e.* crude protein, total carbohydrates, crude fiber and vitamin C. It could be recommended that using antitranspirants would improve eggplant cultivars productivity and quality under prolongation of irrigation intervals (every 15 days) especially in the dry hot weather.

Keywords: eggplant, antitranspirant, kaolin, jojoba oil, glycerol, green miracle, *irrigation intervals*.

INTRODUCTION

Eggplant (Solanum melongena L.) is one of the most important and popular vegetable crops belong to the family Solanaceae. The cultivated area of eggplant at 2015 in Egypt was 115855 feddan producing 1200957 ton with an average yield 10.366 ton/feddan.

The appropriate times of irrigation play main role in enhancing the productivity and yield quality. Meanwhile, prolongation the irrigation intervals especially during the hot and dry summer period of the Mediterranean sea region cause temporary wilting and decrease vegetative growth characters, yield, and its components and fruits quality of eggplant (Shalata, 2013 and El-Said, 2015).

Müller *et al.* (2016) and Mohawesh (2016) revealed that eggplant can be produced at moderate levels of drought stress without major impact on fruits yield.

One of the substantial methods that used to decrease water loss by plant and increase the plants resistant to water deficiency are antitranspirants, which are materials coating film on the leaves and mitigate the harmful effects of water deficiency and improve plant growth and productivity of pepper and eggplant. (Kamal, 2013; Shalata, 2013 and El-Said, 2015)

It is known that antitranspirants are the materials or chemicals, which decrease the amount of water loss from plant leaves by reducing the size and number of stomata. The majority quantity of water absorbed by the plant is lost in transpiration. Antitranspirants, which reduce water loss from plants are three categories *i.e.* stomatal closing, film forming and reflection of the sun rays category.

The mechanism of action is the protective coating on the plant leaves surfaces which reduce transpiration of plant, this lead to counteract the adverse impact of water deficiency, where prevent or reduce greatly excessive water loss from plants through transpiration and evaporation by reflecting a great amount of sun light and therefore reduce the temperature of plant (Abdel Gawad, 2015).

Kaolin as an antitranspirant material could be one of the options for mitigating drought effect and saving water in plant tissues. The use of kaolin creates a canopy cover, which reduces the temperature of the crop and the water loss by transpiration (Boari *et al*., 2015). Also, Boari *et al.* (2013) monitored that kaolin cause the great impact on eggplant growth by decreasing stomatal conductance, which contributes to reduced transpiration, improves plant water status and lower net assimilation. In addition, performing well in pest control and heat stress mitigation, kaolin can effectively be used as an antitranspirant to decrease the impact of salinity, heat stress and to save water.

Jojoba oil also is one of the antitranspirants, which create a thin wax layer on the plant leaves thus cause decreasing water loss by transpiration and evaporation from plant foliage.

Nermeen and Emad (2011) found that, glycerol treatment showed the lowest reduction rate of leaves weight of *Monstera deliciosa*, as well as water loss rate, which obviously reflected on extend leaves life.

Green Miracle is anti-stress product and considered a reflective type of anti-transpirant. It is based on long chain fatty alcohol non-edible vegetable oil. Green Miracle functions primarily on the principle of reflecting the sun's rays. Hafez *et al*. (2015) on eggplant found that the maximum values of plant height and plant weight recorded with green miracle at the rate of 5m/L.

Therefore, the objective of this investigation was to study the effect of irrigation intervals, some antitranspirants and their interactions on growth, yield and fruits quality of long white and black eggplant.

MATERIALS AND METHODS

The factorial experiment in strip split-plot design was used with three replicates for each treatment. The experiment contained 30 treatments; two cultivars (long white Soma and long black Anan), three irrigation intervals (10, 15 and 20 days) and five foliar applications of antitranspirants (Tap water as a control, Kaolin, Jojoba oil, Glycerol and Green miracle as a commercial compounds).

Eggplant seedlings were transplanted on 1st week of May on rows, with 0.8 m width and 7 m length with 0.5 m apart between each plant. Each plot included 2 rows thus plot area was 11.2 m^2. The physical and chemical properties of the experimental soil are presented in Table1 during both seasons.

Water irrigation intervals started after 30 days from transplanting. Five applications of antitranspirants were applied 6 times after 45 days from transplanting and 10 days interval between each one. Kaolin (aluminum silicate) was used at 5%, jojoba oil was used at 20 ml/L, the essential oil suspension was prepared according to the method described by Aly *et al*. (2013), glycerol used at 20 ml/L and green miracle as a commercial compound (consist of fatty alcohol and diluents 80%, neutralizer 10%, stabilizer 5% and emulsifier 5%) was used at 5 ml/L. All other agricultural practices for growing eggplants were followed according to the recommendation of Egyptian Ministry of Agriculture and reclaimed soils.

Table 1. Physical and chemical analysis of experimental soil during 2015 and 2016 seasons:

seasons	Mechanical analysis (%)				Texture class	OM (%)	FC	$CaCO_3$ %	EC $dS.m^{-1}$ 1:5	pH (1:2.5)	Available (ppm)		
	Coarse Sand	Fine Sand	silt	clay							N	P	K
1st	5.7	34.1	32.7	27.5	SCL	1.47	41.5	3.93	0.83	8.20	42.6	4.87	188
2nd	5.1	35.6	33.4	25.9	SCL	1.56	42.7	2.87	0.92	7.92	43.2	5.04	196

SCL: sandy clay loamy OM: Organic matter FC: field capacity EC: Electrical conductivity

Data recorded:

After 100 days from transplanting 5 plants were randomly taken from each plot and the following data were recorded:

Vegetative growth characters:

Plant heights (cm), number of leaves/ plant, fresh and dry weights (g/plant) were measured.

Yield and its components:

- Number of fruits/plant
- Early yield (ton/fed.): It was calculated from the first four picking.
- Total yield (ton/fed.).

Fruit quality parameters

- Crude protein percentage: It was calculated by multiplying the total N by 6.25 (AOAC 2000).
- Carbohydrates percentage: It was estimated in Eggplant fruits according to the method described by Hedge and Hofreiter (1962).
- Vitamin C (mg/100g): It was determined according to the method reported in AOAC (2000).
- Crude fiber percentage: it was determined according to the method described in AOAC (2000).
- Nitrate (NO_3-N): It was measured as the method described by Sing (1988).

Statistical analysis:

Data were statistically analyzed according to the technique of ANOVA for strip split-plot design according to Gomez and Gomez (1984). Means of treatments were compared using Duncan's multiple range tests at 5 % level of probability according to Duncan (1955).

RESULTS AND DISCUSSION

Effect of cultivars:

Results in Tables 2, 3 and 4 indicate that all measured parameters, i.e. plant height, number of leaves/plant, plant fresh and dry weights, number of fruits/plant, early and total yield, crude protein, total carbohydrates, crude fiber, vitamin C and nitrate are affect significantly by two cultivars except plant height and number of leaves/plant in the first season, where black cultivar Soma increase in vegetative growth and chemical constituents parameters previously mentioned, while white cultivar Anan give significant increments in yield measurements.

Table 2. Plant height, number of leaves/plant, plant fresh and dry weights as affected by eggplant cultivars, irrigation intervals and antitranspirants treatments as well as their interactions during 2015 and 2016 seasons.

Characters	Plant height (cm)		Number of leaves/plant		Plant fresh weight (g)		Plant dry weight (g)	
Treatments	2015	2016	2015	2016	2015	2016	2015	2016
A- Cultivars:								
White	80.62	76.82	36.66	30.00	407.1	406.8	60.60	59.62
Black	82.04	78.46	36.26	33.51	433.5	440.3	61.71	63.37
F. test	NS	*	NS	*	*	*	*	*
B- Irrigation intervals:								
10 days	98.90 a	83.06 a	51.03 a	36.86 a	502.2 a	481.6 a	72.70 a	72.50 a
15 days	81.56 b	77.10 b	34.46 b	31.83 b	421.4 b	425.1 b	63.03 b	61.46 b
20 days	63.53 c	72.76 c	23.90 c	26.56 c	337.4 c	364.1 c	47.73 c	50.53 c
C- Foliar application treatments:								
Control	73.22 c	67.88 e	30.22 e	25.05 e	386.3 e	396.4 e	58.27 c	57.05 d
Kaolin	82.33 b	77.88 c	36.00 c	31.94 c	420.9 c	425.6 c	60.38 b	61.83 b
Jojoba oil	90.55 a	87.88 a	42.66 a	37.77 a	447.3 a	443.3 a	64.94 a	65.11 a
Glycerol	73.66 c	72.66 d	33.66 d	29.05 d	409.5 d	412.1 d	59.00 bc	59.61 c
Green miracle	86.88 ab	81.88 b	39.77 b	34.94 b	437.6 b	440.4 b	63.16 a	63.88 a
D- Interactions:								
A × B	*	NS	*	*	*	*	*	NS
A × C	NS	NS	NS	*	*	*	*	NS
B × C	NS	*	*	NS	*	*	*	*
A × B × C	NS	NS	NS	NS	*	NS	*	NS

These results could be due to the genetically differences between the two cultivars used which led to the presence of many variations in shape, vegetative growth strength, yield and chemical constituents. These results are in harmony with those obtained by El-Kady (2017).

Effect of irrigation intervals:

As shown in Table 1 data indicate that the experimental soil is moderate in its properties and field capacity, but it is low in its content of organic matter, for this the soils ability to retain irrigation water is reasonable.

Regarding the effect of irrigation intervals on the aforementioned characters and eggplant yield, data in Tables 2, 3 and 4 indicate that irrigation every 10 days give the highest significant values; on the other hand, irrigation every 15 days recorded the highest values of crude protein, total carbohydrates, crude fiber and vitamin C, while NO3-N recorded the lowest value.

These results may be due to increasing water quantity applied by shortage the irrigation periods, give a good opportunity to increase nutrients movement in the soil solution, which raised the availability to plant roots absorption and the translocation through plant tissues and consequently reflect on plant growth, development and chemical constituents. These results are in harmony with those obtained by Shalata (2013) and El-Said (2015) on eggplant.

The decrease of the measurements values under the highest irrigation interval (20 days) especially during hot and dry weather on eggplant growth yield and quality may be attributed to decreasing nutrients absorption from the soil solution, which cause minimizing elements penetration through translocation tissues, which reflected on photothynensis and in turn affect negatively vegetative growth, yield and chemical composition. These results are in the same line with those reported by Kamal (2013) on sweet pepper and Okunlola *et al*. (2017) on pepper species.

Table 3. Number of fruits/plant, early and total yield/fed. as affected by eggplant cultivars, irrigation intervals and antitranspirants treatments as well as their interactions during 2015 and 2016 seasons.

Characters	Number of fruits/plant		Early yield (ton/fed)		Total yield (ton/fed)	
Treatments	2015	2016	2015	2016	2015	2016
A- Cultivars:						
White	10.51	11.97	2.758	3.575	9.553	10.486
Black	8.17	8.66	2.628	3.397	9.007	9.744
F. test	*	*	*	*	*	*
B- Irrigation intervals:						
10 days	11.23 a	12.80 a	3.451 a	4.313 a	12.048 a	12.938 a
15 days	9.93 b	10.50 b	2.577 b	3.524 b	9.032 b	9.990 b
20 days	6.86 c	7.66 c	2.051 c	2.622 c	6.760 c	7.416 c
C- Foliar application treatments:						
Control	8.11 d	9.00 c	2.282 e	3.023 e	7.873 e	8.674 e
Kaolin	9.38 b	10.66 a	2.723 c	3.486 c	9.527 c	10.395 c
Jojoba oil	10.27 a	11.00 a	3.075 a	3.902 a	10.639 a	11.349 a
Glycerol	8.83 c	10.00 b	2.544 d	3.323 d	8.494 d	9.517 d
Green miracle	10.11 a	10.94 a	2.840 b	3.697 b	9.867 b	10.638 b
D- Interactions:						
A × B	*	*	*	*	*	NS
A × C	*	*	*	*	*	*
B × C	*	*	*	*	*	*
A × B × C	*	*	*	*	*	*

Table 4. Crude protein, total carbohydrates and crude fiber percentages, Vit. C and nitrate (NO_3-N) contents as affected by eggplant cultivars, irrigation intervals and antitranspirants treatments as well as their interactions during 2015 and 2016 seasons.

Characters	Crude protein (%)		Total carbohydrates(%)		Crude fiber (%)		Vit. C (mg/100 g)		NO_3-N (ppm)	
Treatments	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
A- Cultivars:										
White	10.32	8.93	27.07	29.10	7.00	7.10	5.29	5.62	22.78	24.81
Black	10.01	9.09	28.02	30.30	6.19	6.54	5.90	6.60	21.45	26.27
F. test	*	*	*	*	*	*	*	*	*	*
B- Irrigation intervals:										
10 days	10.16 b	8.99 b	27.59 b	29.70 b	6.60 b	6.82 b	5.60 b	6.12 b	22.10 b	25.80 a
15 days	10.33 a	9.13 a	27.99 a	30.29 a	6.75 a	6.96 a	5.68 a	6.21 a	21.57 c	24.78 b
20 days	10.00 c	8.90 c	27.07 c	29.12 c	6.44 c	6.68 c	5.51 c	6.00 c	22.67 a	26.03 a
C- Foliar application treatments:										
Control	9.19 e	8.23 e	24.83 e	25.99 e	5.68 e	5.98 e	5.06 e	5.51 e	25.25 a	29.18 a
Kaolin	10.65 b	9.39 b	28.81 b	31.80 b	7.05 b	7.24 b	5.86 b	6.40 b	20.47 d	23.80 d
Jojoba oil	10.19 c	9.00 c	27.66 c	29.51 c	6.62 c	6.82 c	5.60 c	6.12 c	22.08 c	25.56 c
Glycerol	9.70 d	8.66 d	26.32 d	27.74 d	6.17 d	6.40 d	5.33 d	5.81 d	23.75 b	27.30 b
Green miracle	11.09 a	9.77 a	30.11 a	33.46 a	7.48 a	7.66 a	6.12 a	6.71 a	19.01 e	21.86 e
D- Interactions:										
A × B	NS	NS	NS	NS	NS	NS	*	NS	NS	NS
A × C	*	NS	NS	*	*	*	*	*	NS	NS
B × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
A × B × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Effect of foliar application with antitranspirants:

Data present in the same Tables clarify that all antitranspirants increase significantly vegetative growth and yield of eggplant as compared to control treatments. In this respect, foliar application with jojoba oil give the highest values of vegetative growth characters and yield followed by green miracle, while foliar application with green miracle recorded highest values of fruits quality followed by kaolin.

A number of commercially available chemical spray-on products are currently market to provide some abiotic stresses protection for various crops. Such products include anti-transpirants, biochemical compounds and plant growth regulators. Anti-transpirants based on their mechanism of action, were divided into three categories, stomatal closing types (which affect the metabolic processes in leaf tissues), film-forming types (which coat leaf surface with films that are impervious to water vapor) and reflecting materials (which reflect back a portion of the incident radiation falling on the upper surface of the leaves). (Prakash and Rama chandran, 2000).

The favorable effect of kaolin under water stress may be attributed to its effect to both biotic and abiotic stresses, in addition, improves assimilation of CO2 under heat stress and high absorption of nutrients. These results are in harmony with those obtained by Glenn *et al*. (2002); Shalata (2013) and El-Said (2015).

The efficiency of jojoba oil as antitranspirants may be due to coat the leaf surface and reduce water vapor from stomata which promoting the rate of photosynthesis thus assimilation increase, which reflect on the rate of growth and yield.

The positive effect of glycerol might be due to the effect of the film formed which protect plants from damage induced by high transpiration and evaporation through the plant from stomata and cuticle creaks, consequently increasing plant water use and improving vegetative growth and yield. These results are in parallel with those recorded by Sanbagavalli *et al*. (2017).

The improvement by green miracle may be attributed to improving the water content on the plant tissues by organizing status of stomata and increased photosynthetic activities thus reflect on vegetative growth and yield. These results are in parallel with those recorded by Hafez *et al*. (2015).

Effect of interactions:

As for the effect of interactions among treatments used, jojoba oil with irrigation the black cultivar every 10 days give superiority in plant fresh weight in the first season, while this treatment came after green miracle in plant dry weight as shown in Fig. 1 and 2. The interactions effect on number of fruits/plant as shown in Fig. 3 show that irrigation white eggplant every 10 or 15 days and spraying with jojoba oil gave the highest value in two seasons followed by green miracle. With respect to the interaction on early yield, Fig. 4 shows that white eggplant cultivar irrigated every10 days and sprayed with kaolin give superiority in the first season, while jojoba oil give increase in the second season. Concerning the effect of interactions on total yield, irrigation black eggplant every 10 days and use jojoba oil as a foliar application give the highest yield in the first season, while white cultivar irrigation every 10 days and sprayed with jojoba oil give the highest yield in the second season as shown in Fig. 5. The differences mentioned above were significant.

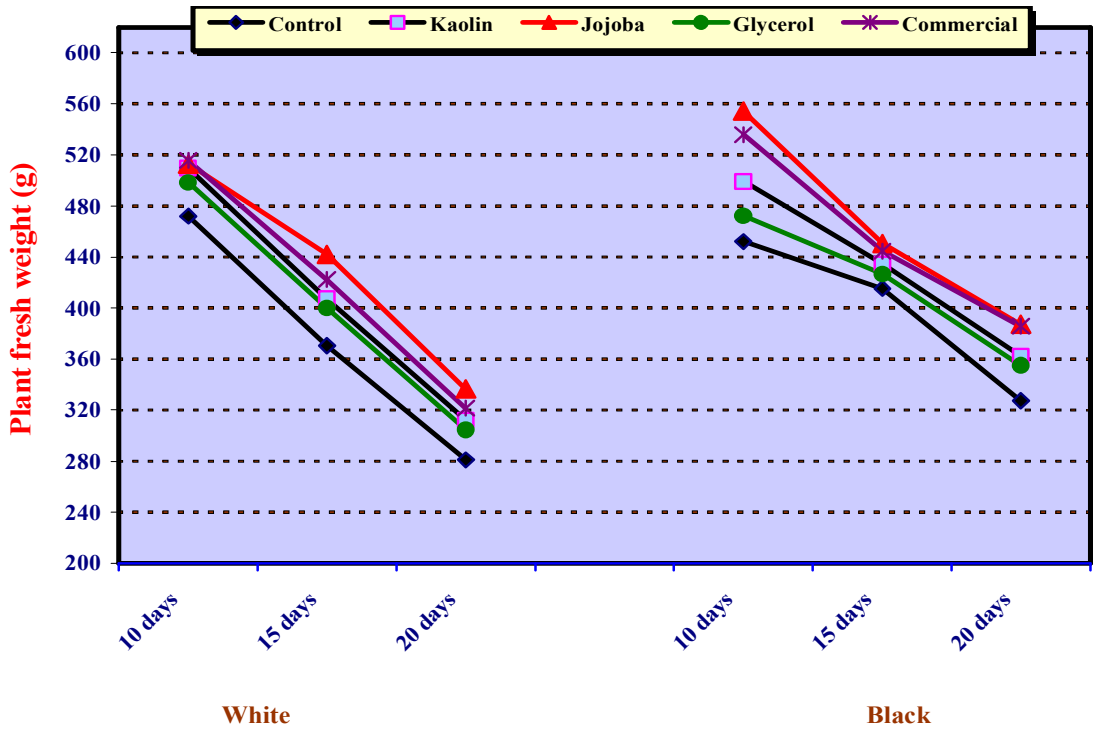

Fig. 1. Plant fresh weight (g) as affected by the interaction among eggplant cultivars, irrigation intervals and antitranspirants treatments during 2015 season.

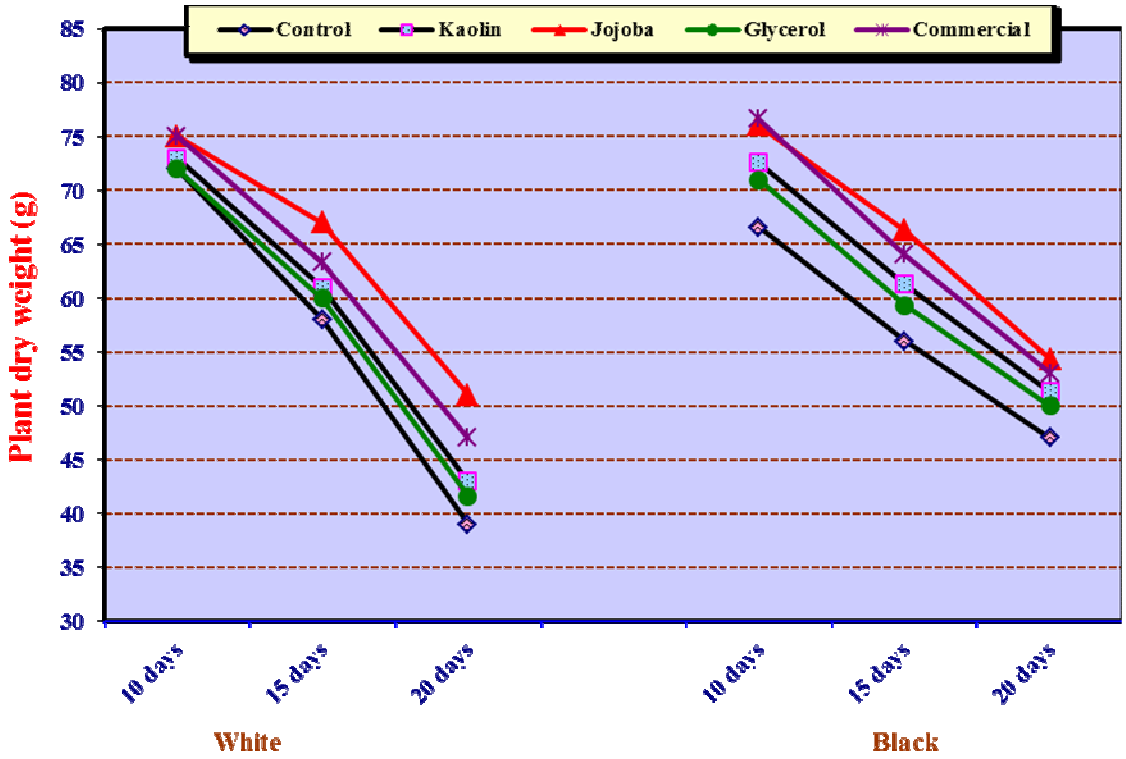

Fig. 2. Plant dry weight (g) as affected by the interaction among eggplant cultivars, irrigation intervals and antitranspirants treatments during 2015 season.

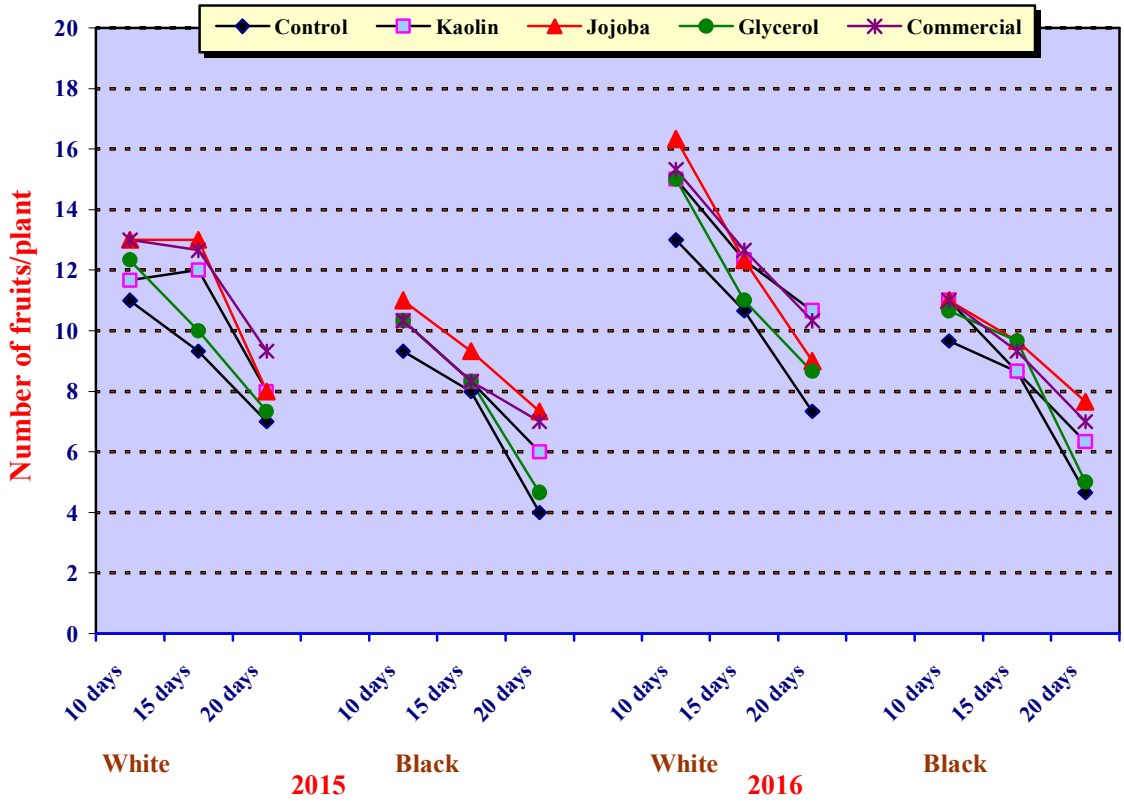

Fig. 3. Number of fruits/plant as affected by the interaction among eggplant cultivars, irrigation intervals and antitranspirants treatments during 2015 and 2016 seasons.

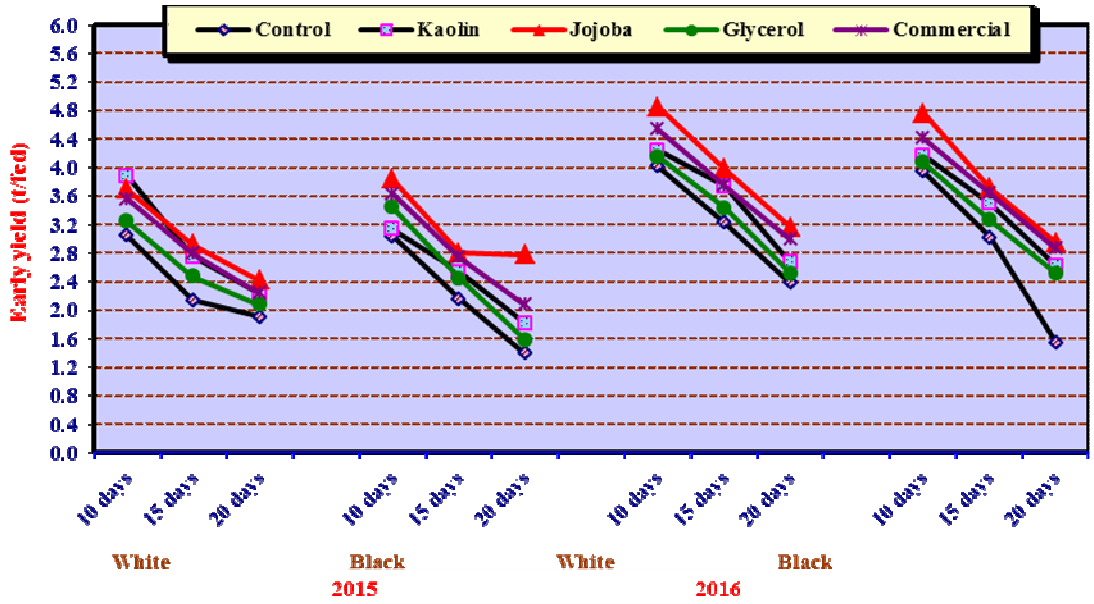

Fig. 4. Early yield (ton/fed) as affected by the interaction among eggplant cultivars, irrigation intervals and antitranspirants treatments during 2015 and 2016 seasons.

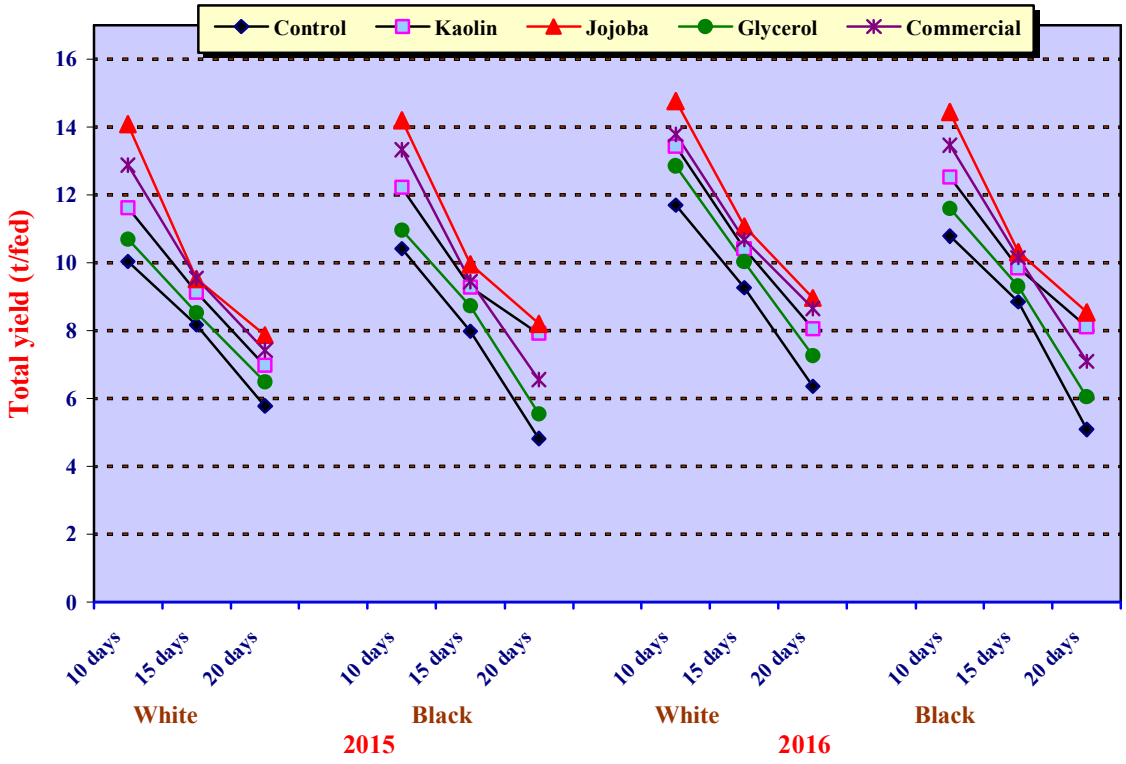

Fig. 5. Total yield (ton/fed) as affected by the interaction among eggplant cultivars, irrigation intervals and antitranspirants treatments during 2015 and 2016 seasons.

CONCLUSION

Application of antitranspirants such as kaolin, jojoba oil, green miracle and glycerol with irrigation intervals every 15 days decrease the harmful effects of long irrigation intervals on eggplant cultivars and increase vegetative growth, yield and quality moreover decrease total amount of water used under the similar circumstances at Dakahlia governorate conditions, Egypt during summer seasons.

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استجابة صنفين من الباذنجان لفترات الرى والرش ببعض مضادات النتح

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نفذت تجربتان حقليتان بمزرعة كلية الزراعة جامعة المنصورة خلال الموسمين الصيفيين لعامى 2015- 2016 لدراسة تأثير ثلاث فترات رى كل (10-15-20 يوم) وخمس مضادات نتح رشا على الاوراق (كنترول - كاؤولين - زيت الجوجوبا – الجليسرول – جرين ميركل) على صنفين من الباذنجان (الابيض الطويل – الاسود الطويل) وكذلك التفاعلات بينهما على النمو والمحصول وصفات الجودة. اظهرت النتائج المتحصل عليها أن صنف الباذنجان الاسود الطويل اعطى زياده معنوية فى قياسات النمو الخضرى،وعلى النقيض وبخصوص عدد الثمار للنبات و المحصول المبكر والكلي وصفات الجودة (البروتين الخام فى الموسم الاول والالياف الخام فى كلا الموسمين) كانت الافضلية لصنف الابيض الطويل بفروق معنوية. علاوة علي ذلك الري كل 10 ايام اعطى زيادة معنوية فى قياسات النمو الخضرى والمحصول ومكوناته بينما صفات الجودة :(البروتين والكربوهيدرات الكلية والالياف وفيتامين C) زادت زيادة معنوية عند الري كل 15 يوم. فيما يتعلق بمعاملات الرش وجد ان الرش بزيت الجوجوبا اعطي تفوقا معنويا مقارنة بباقي معاملات الرش فى قياسات النمو الخضرى والمحصول ومكوناته بينما أعلى جودة لثمار الباذنجان كانت عند رش النباتات بالمركب التجارى جرين ميركل .يمكن التوصية باستخدام ايا من مضادات النتح المستخدمة فى الدراسة مع الرى كل 15 يوم لتحسين نمو وإنتاجية أصناف الباذنجان وجودة الثمار تحت ظروف زيادة فترات الرى وخاصة أثناء الزراعات الصيفية حيث الجو الحار الجاف.