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PHYSIOCHEMIACL STUDIES ON TUBERS SPROUTING OF POTATO PLANT UNDER THE INFLUENCE OF JASMONIC ACID, EUCALYPTUS ExTRACT AND DIFFERENT STORAGE TEMPERATURES

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ABSTRACT: *Two storage experiments were conducted in the Agriculture Botany Dep., Faculty of Agriculture, Minufiya University, Shibin El-kom Egypt, during the summer seasons of 2011 and 2012, as an attempt to investigate the effect of growth regulator (jasmonic acid), aromatic plant extract (eucalyptus extract) and their interaction on the behavior of potato seed tubers (Solanum tuberosum, L.) cultivar Spunta as well as the sprouting parameters represented by: sprouting percentage, number of sprouted eyes/tuber, number of total buds/ tuber as well as fresh and dry weight of sprout during their storage period at room and cold temperatures (30°C and 4°C). The obtained results revealed that the storage of potato seed tubers at (4°C and 30°C) with increasing storage period significantly affected tuber length, width and fresh weight loss. The usage of cold temperature significantly reduced tuber length, width and fresh weight loss as well as sprouting percentage, number of sprouted eyes/tuber, number of total buds/tuber and the fresh and dry weight of sprout. On the other hand, the storage at room temperature significantly reduced sprout length. It could be noticed that JA levels significantly decreased sprouting parameters compared with untreated tubers. In this regard, JA_1 treatment produced a significant decrease in these parameters higher than JA_2 treatment. Eu treatment caused the highest significant decrease in the loss of tuber length, width and fresh weight it also significantly reduced sprouting parameters. As for the interaction between jasmonic acid and eucalyptus extract, Eu+JA_2 treatment was the best treatment in decreasing the loss of tuber length, width and fresh weight. Moreover, Eu+JA_1 treatment significantly reduced sprouting parameters followed by Eu+JA_2 treatment under both room and cold storage temperatures.*

Key words: *Potato (Solanum tuberosum, L.), sprouting, storage temperature, jasmonic acid, eucalyptus extract.*

INTRODUCTION

Potato (*Solanum tuberosum*, L.) is one of the most important and popular vegetable crops grown in Egypt for local consumption and export (El-Ghinbihi and Ali, 2001). In 2013 Egypt produced 4,800,000.00 tonnes of potato. The total area of potato harvested in Egypt reached 178,000.00 Ha in 2013 (F. A. O., 2015).

Potatoes contain high nutritional values, which make them important for local consumption, industrial use and export to the Arabian and European countries (El-Shewy, 2009).

During the first and second months of harvesting, the tubers remain in dormant state and exhibit few sprouts. After this period, the tubers must be chemically treated to inhibit sprouting which if not inhibited causes loss of weight, conversion of starch to sugars, reduction in tuber quality and deterioration of their appearance (El-Shewy, 2009). The sprouts contain high

levels of toxic glycoalkaloids which are not destroyed during cooking (Sardo, 2006).

Anti-sprouting treatments employ chemical agents, essential oils, volatile organic compounds and some growth regulators. They are carried out at low level of storage temperature or even at room temperature. The ideal sprout inhibitor must effectively suppress sprouting at low dosage rates. The inhibitional action should be reversible, it should inhibit fresh loss and rotted tuber parts over a long storage period. It should also breakdown rapidly in the environment and be available and cost-effective (Vaughn and Spencer, 1991 as well as Vokou *et al.*, 1993). Hebeisen *et al.* (2007) found that storage temperature strongly affected sugar content which in turn affected the sprouting of potato tubers.

Growth regulators such as jasmonic acid, play an important role in regulating tuber formation and in sprouting inhibition (Lewis *et al.,* 1997).

Inhibiting sprouting of potato tubers and maintaining or improving their processing quality is done by exposing the tubers to jasmonates or jasmonate related compounds. The jasmonate may be applied singly or in a mixture, in a pure or substantially pure form or coplionally in a composition. The tuber sprouting and melanization which occurs during processing such as cooling or fryzing, may be controlled by exposure of the tubers to an effective amount of jasmonate (Lulai *et al*., 1996).

Jasmonates should be used at low concentrations to promote cell expansion and shoot elongation, while higher concentrations cause growth inhibition through root shortening and inhibition of tuber formation (Edison *et al.,* 2002). Wasternack (2007) mentioned that jasmonate alter gene expression in a regulatory network. In this respect, Nausicaä *et al*. (2007) revealed that jasmonic acid treatment affected the expression of carbohydrate binding proteins in plant cells of potatoes.

Recently, great attention has been focused on the possibility of using natural and safety substances such as eucalyptus extract in order to improve plant growth, flowering, fruit setting and total yield of different plant species and to overcome the negative effects of environmental stress conditions (El-Ghinbihi and Hassan, 2007).

Extracts obtained from aromatic and medicinal plants are used to inhibit the sprouting of potatoes. Their inhibitory effect confirmed together with lack of toxicological risks arising from their use (Hartmans *et al.*, 1995 as well as Oosterhaven *et al*., 1995 a).

The major constituent in eucalyptus leaves is a volatile oil, which is a rich source of antiseptic substance eucalyptol (1, 8-cineole), which use as antioxidant, antibacterial and antifungal agent.

Eucalyptus extract contains flavonoids such as quercetin, which has antioxidant properties. These substances may induce tolerance to treated plants against environmental stress conditions (El-Ghinbihi and Hassan, 2007).

Eucalyptus extract contains tannins, sterols, alkaloids flavonoids and saponins, which significantly increased growth characters, photosynthetic pigments, activity of enzymes of maize plants grown under unfavorable conditions (Selim *et al.,* 2002).

The positive effect of eucalyptus extracts as anti-sprouting agents was observed by GŐmez *et al*. (2010). Dorsaf *et al*. (2012) reported that eucalypts leaf extract exhibited high activation of antioxidants which promoted growth of potato tubers as well as the fresh and dry weight during storage period.

Therefore, the objective of the present study was to investigate the effect of jasmonic acid, eucalyptus extract and their interaction on the behavior of potato seed tubers and sprouting parameters during the storage period at room (30°C) and cold (4°C) temperatures.

MATERIALS AND METHODS

Two storage experiments were conducted in the Agriculture Botany Dept., Faculty of Agriculture, Minufiya University, Shibin El-Kom Egypt, during the summer seasons of 2011 and 2012 to investigate the effect of growth regulator (jasmonic acid), aromatic plant extract (eucalyptus extract) and their interaction on the behavior of potato seed tubers and the sprouting parameters during the storage period at room (30°C) and cold (4°C) temperatures.

Seed tubers of potato (*Solanum tuberosum,* L.) cultivar Spunta were obtained from the summer crop from Mapa comp. potato tubers were cured for 15 days at room temperature (30 °C). After that they were graded by size. Those of uniform size (60-65 mm) and weight (223-230 g) were chosen for storage treatments. Potato tubers were placed in cardboard boxes (30×25×20 cm). 5 Kg potato tubers were placed in each box in the laboratory room (30°C).or the refrigerator (4 °C). In total they were 36 boxes spread over 3 horizontal rows (3 replicates).

The storage experiment contained 12 treatments:

A- Room storage temperature (30 °C) treatments:

1- Control
2- JA_1 (Jasmonic acid at concentration of 0.1 mM)
3- JA_2 (Jasmonic acid at concentration of 0.05mM)
4- Eu (Eucalyptus extract at concentration of 5 %)
5- Eu+JA_1
6- Eu+JA_2

B- Cold storage temperature (4 °C) treatments:

1- Control
2- JA_1
3- JA_2
4- Eu
5- Eu+JA_1
6- Eu+JA_2

Potato seed tubers of each treatment were soaked in the corresponding solution for 45 minutes. Control tubers were treated with distilled water.

Tween 20 at rate of 0.5% was used as wetting agent. After treatment and air drying tubers were placed back into the boxes. 10 tubers from each box were measured, weighted and marked to determine the length, width and weight loss.

Preparation of jasmonic acid (JA):-

Jasmonic acid (JA) was obtained from Prof. B. Hause, Leibniz-Institut 1. Pflanzenbiochmie, Halle, Germany. The chemical structure of jasmonic acid shown in Fig. (1)**.** 1 ml jasmonic acid was dissolved in a small amount of methanol alcohol (2 ml), then adjusted with the distilled water to the desired volume of 1 liter. This mixture was considered stock solution. JA_1 treatment was prepared by adding 23.5 ml of stock solution to 976.5 ml distilled water according to Lulia *et al.* (1996)**.** JA_2 treatment was achieved by adding 11.75 ml of stock solution to 988.25 ml distilled water.

Preparation of eucalyptus extract (Eu):

Air dried eucalyptus leaves were ground in grinder to obtain a fine powder. A known amount of eucalyptus powder was extracted with chloroform solvent to obtain an extract with a concentration of 5 % as described by Selim *et al.* (2002).

Experimental design:

The randomized complete block design with three replicates was adopted (12 treatments × 3 replicates).

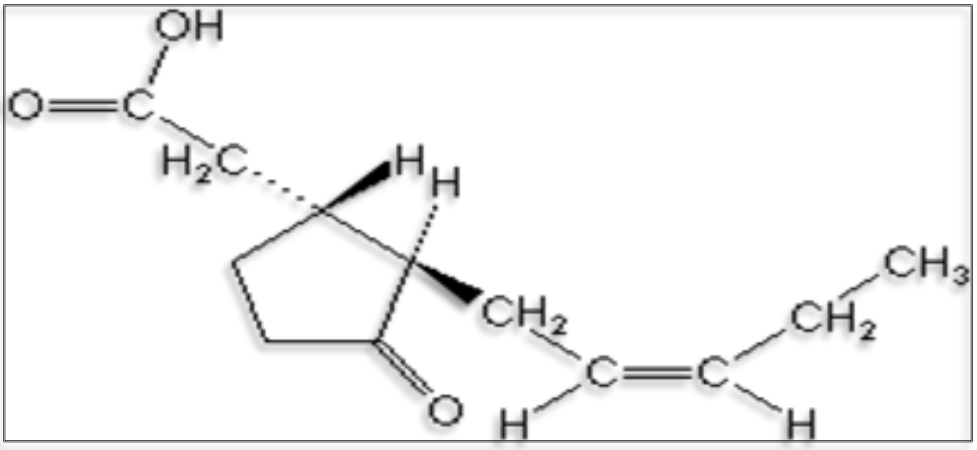

Fig. (1): Structure of jasmonic acid (JA)

After storage period about 42 days from the beginning storage, the following parameters were determined:-

1- Seed tuber length, width and fresh weight as well as the loss of seed tuber length, width and fresh weight:

10 tubers of each box were used. Each tuber was marked, measured and weighted at the beginning and the end of storage.

2-Number of sprouted eyes/tuber:

10 potato seed tubers were chosen and the number of eyes which contained sprout/tuber was recorded.

3- Sprouting percentage%:

The previously chosen tubers were used.

$$\text{Sprouting\%} = \frac{\text{Number of sprouted eyes}}{\text{Number of total eyes}} \times 100$$

4- Number of total buds/tuber:

10 seed tubers were used and the number of total buds/tuber was recorded.

5- Sprout length (cm):

All sprouts on the surfaces of all 10 tubers were removed and recorded for length.

6- Sprout fresh and dry weight (g):

All sprouts on the surfaces of all 10 tubers were weighted and dried at 70°C for 72 hours, then their dry weight was recorded.

Statistical analysis:

Data collected from both seasons were statistically analyzed using Costat Software (1985). Treatment means were compared with the revised L.S.D. test at 0.05 level (Snedecor and Cochran, 1981).

RESULTS AND DISCUSSION

The behavior of potato seed tubers:

1-Seed tuber length and the loss of tuber length

Effect of storage temperatures:

Data recorded in Table (1) show that the storage of potato seed tubers at different temperatures up to 42 days significantly decreased potato tuber length compared with the starting storage length. In this respect, the highest decrease recorded at room temperature.

Results in Table (1) and Fig. (2) demonstrate that the storage of potato seed tubers at (4°C and 30°C) with increasing storage period significantly affected tuber length loss. The usage of cold temperature significantly decreased tuber length loss compared to room temperature. In this connection, the differences between the two storage conditions were highly significant during the first season and non-significant in the second season.

Table (1): Effect of different storage temperatures, jasmonic acid, eucalyptus extract treatments and their interaction on potato seed tuber length and the loss of tuber length during the 2011 and 2012 seasons.

Characters / Treatments		2011 season			2012 season		
		Tuber length (cm)		Loss of tuber length	Tuber length (cm)		Loss of tuber length
Storage temperature	JA or Eu	Starting storage	After42 days of storage		Starting storage	After 42 days of storage	
Room temperature		14.08 a	13.39 b	0.69 a	12.81 a	12.35 a	0.58 a
Cold temperature		14.04 a	13.59 a	0.45 b	12.99 a	12.41 a	0.46 a
	Cont.	14.18 a	13.41 bc	0.77 a	13.17 a	12.21 ab	0.96 a
	JA_1	13.66 a	13.02 ab	0.64 ab	13.03 a	12.54 ab	0.49 ab
	JA_2	14.40 a	13.82 ab	0.58 abc	12.61 a	12.17 b	0.44 ab
	Eu	13.37 b	12.94 c	0.43 c	13.17 a	12.78 a	0.39 b
	$Eu+JA_1$	14.21 a	13.69 a	0.52 abc	12.77 a	12.34 ab	0.43 ab
	$Eu+JA_2$	14.56 a	14.07 a	0.49 c	12.65 a	12.24 b	0.41 ab
Room temperature	Cont.	14.38 abc	13.48abcd	0.90 a	12.31 b	11.73 bc	1.33 a
	JA_1	13.26 d	12.46 e	0.80 ab	13.35 a	12.88 a	0.50 b
	JA_2	14.08 bcd	13.38abcde	0.70 abc	12.03 b	11.58 c	0.43 b
	Eu	13.35 d	12.80 de	0.55bcde	12.80 ab	12.41 abc	0.38 b
	$Eu+JA_1$	14.55 abc	13.95 abc	0.60 abc	12.88 ab	12.45 abc	0.42 b
	$Eu+JA_2$	14.86 a	14.28 a	0.58bcde	13.44 a	13.03 a	0.40 b
Cold temperature	Cont.	13.96 bcd	13.33bcde	0.63abcd	14.01 a	12.68 ab	0.58 b
	JA_1	14.06 bcd	13.58abcd	0.48 cde	12.70 b	12.20 abc	0.47 b
	JA_2	14.70 ab	14.25ab	0.45 cde	13.19 ab	12.76 a	0.45 b
	Eu	13.38 d	13.08 cde	0.30 e	13.53 ab	13.15 a	0.39 b
	$Eu+JA_1$	13.86 cd	13.43abcd	0.43 cde	12.65 b	12.23 abc	0.43 b
	$Eu+JA_2$	14.25 abc	13.85 abc	0.40 de	11.85 c	11.45 c	0.41 b
L.S.D. at 5% for : A		0.32	0.34	0.12	0.33	0.31	0.07

B	0.56	0.58	0.21	0.58	0.53	0.12
A*B	0.79	0.82	0.30	0.82	0.75	0.17

Values marked with same alphabetical letter(s), within a comparable group of means, do not significantly differ using revised L.S.D. test at 0.05 level.

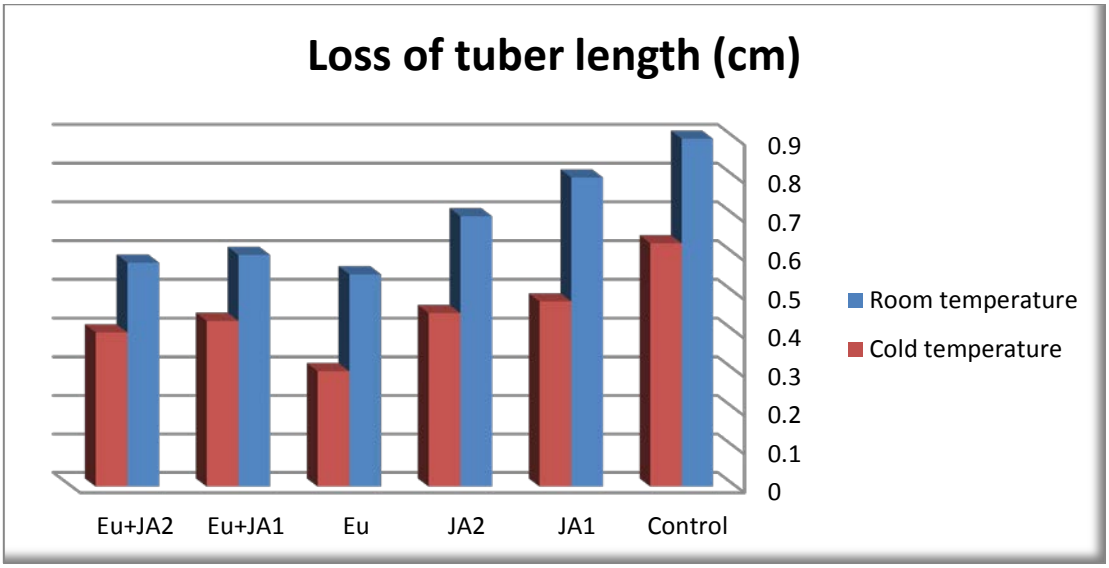

Fig. (2): Effect of jasmonic acid, eucalyptus extract and storage temperatures (4 °C and 30°C) on the loss of tuber length (cm) during the 2011growing season.

These results are in agreement with those observed by El-Shewy (2009) who demonstrated that storage potato seed tubers at 4°C reduced the loss of tuber length% compared with the control. Furthermore, Sergio *et al.* (2012) revealed that storage at 4°C and 8°C was more effective in reducing respiration rates which increased at higher temperatures, when respiration increase so does the loss of tuber length.

Effect of jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Results in Table (1) and Fig. (2) explain the effect of jasmonic acid, eucalyptus extract and their interaction on tuber length. After 42 days from starting storage the tuber length of potato tubers significantly decreased under all tested treatments.

Concerning the effect of JA levels, eucalyptus extract application and their interaction on the loss of tuber length, Results in Table (1) show that JA levels significantly decreased tuber length loss compared with the control. In this regard, JA_2 treatment was more effective than JA_1 treatment.

Data presented in Table (1) and Fig. (2) clear that the application of eucalyptus extract exhibited the highest significant reduction in the loss of tuber length This decrease reached to 44.16% and 59.38% in the first and second seasons, respectively, compared with the control. The obtained results are in harmony with Lorber and Muller (1976) who stated that the toxic substances isolated from essential oils may strongly affect tuber length. El-Shewy (2009)

attributed the reduction in tuber length loss to the reduction in tuber weight loss under the same treatments.

Regarding the effect of the interaction between JA levels and Eu application on the loss of tuber length, data in the same Table indicate that Eu+JA_2 treatment led to higher reduction in the loss of tuber length compared with Eu+JA_1 treatment.

Effect of storage temperatures, jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Data presented in Table (1) mention that the interaction between storage temperatures, JA, Eu and their interaction treatments had a significant effect on tuber length by increasing storage period up to 42 days under both room and cold temperatures. In this respect, JA_1 treatment showed the highest significant reduction in tuber length at room temperature, meanwhile Eu treatment was the most effective treatment at cold temperature in reducing the length of tuber in the first season.

Concerning the effect of JA levels, Eu application and their interaction under both room and cold temperatures on the loss of tuber length, the results illustrated in Table (1) and Fig. (2) indicate that the highest loss of tuber length was observed at JA_1 followed by JA_2 compared to the control in the first and second seasons. These findings are supported by Rohwer and Erwin (2008) who postulated that jasmonates can inhibit the rate of cell division and elongation which can affect the loss of tuber length.

Data recorded in Table (1) and Fig. (2) reveal that the application of eucalyptus extract significantly reduced the loss of tuber length under both storage temperatures. This reduction reached to 38.89% and 32.76% at room temperature as well as 52.38% and 71.43% at cold temperature in the first and second seasons, respectively, compared with the control. These results are in accordance with those obtained by Fathy *et al*. (2005) who suggested that natural extracts containing anise, fennel and mint oils greatly suppressed the incidence of length loss of potato tubers.

Results in Table (1) and Fig. (2) demonstrate that the interaction between JA and Eu under both room and cold temperatures alleviated the negative effect of jasmonic acid on the loss of tuber length. In this regard, Eu+JA_2 treatment markedly decreased the loss of tuber length. This decrease reached to 35.56% and 29.31% at room temperature as well as 36.51% and 69.92% at cold temperature in the first and second seasons, respectively, compared with owing controls.

Seed tuber width and the loss of tuber width

Effect of storage temperatures:

Data presented in Table (2) mention the effect of the storage temperatures (4°C and 30°C) on the width of potato seed tubers. Increasing storage period up to 42 days negatively affected tuber width.

Results recorded in Table (2) reveal that the storage of potato seed tubers at different temperatures up to 42 days decreased potato tuber width compared with the starting storage width. In this respect, the highest decrease recorded at room temperature.

Concerning the effect of different storage temperatures on the loss of potato seed tuber width, results in the same Table and Fig. (3) show that the usage of cold temperature significantly decreased tuber width loss compared to room temperature. In this connection, the differences between the two storage conditions were significant during 2011 and 2012 seasons. These results are in accordance with those

obtained by El-Shewy (2009) who mentioned that storage potato seed tubers at 4°C reduced tuber diameter and the loss of tuber diameter compared with the control.

Effect of jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Data in Table (2) clear the effect of jasmonic acid, eucalyptus extract and their interaction on tuber width. After 42 days from starting the storage period the tuber width of potato tubers decreased under all tested treatments. The highest reduction in tuber width was observed by the application of JA_1 level.

Table (2): Effect of different storage temperatures, jasmonic acid levels, application of eucalyptus extract and their interaction on Potato seed tuber width and the loss of tuber width during the two seasons of 2011 and 2012.

Characters / Treatments		2011 season			2012 season		
		Tuber width (cm)		Loss of tuber width	Tuber width (cm)		Loss of tuber width
Storage temperature	JA or Eu	Starting storage	After 42 days of storage		Starting storage	After 42 days of storage	
Room temperature		10.43 a	9.50 a	0.93 a	9.08 a	8.65 a	0.43 a
Cold temperature		10.09 a	9.57 a	0.52 b	9.00 a	8.68 a	0.32 b
	Cont.	10.39 a	9.46 ab	0.93 a	9.13 b	8.59 a	0.54 a
	JA_1	10.05 a	9.15 b	0.90 a	8.92 b	8.46 a	0.46 ab
	JA_2	10.26 a	9.54 ab	0.72 ab	9.40 a	9.00 a	0.40 bc
	Eu	10.08 a	9.54 ab	0.54 b	9.07 b	8.84 a	0.23 e
	$Eu+JA_1$	10.46 a	9.79 a	0.67 ab	8.89 b	8.54 a	0.35 cd
	$Eu+JA_2$	10.32 a	9.74 a	0.58 b	8.87 b	8.59 a	0.28 de
Room temperature	Cont.	10.57 a	9.44 ab	1.13 a	9.22 a	8.57 ab	0.65 a
	JA_1	10.28 a	9.18 b	1.10 ab	9.07 c	8.56 ab	0.51 ab
	JA_2	10.41 a	9.43 ab	0.98 abc	9.20 ab	8.75 ab	0.45 bc
	Eu	10.25 a	9.55 ab	0.70 cd	9.00 c	8.75 ab	0.25 de
	$Eu+JA_1$	10.55 a	9.65 ab	0.90 abc	8.95 c	8.55 ab	0.40 bcd
	$Eu+JA_2$	10.50 a	9.75 ab	0.75abcd	9.03 c	8.73 ab	0.30 cde

Cold temperature	Cont.	10.20 a	9.48 ab	0.72 bcd	9.03 c	8.60 ab	0.43 bc
	JA_1	9.82 a	9.12 b	0.70 cd	8.75 bc	8.35 b	0.40 bcd
	JA_2	10.10 a	9.65 ab	0.45 d	9.60 bc	9.25 a	0.35bcde
	Eu	9.91 a	9.53 ab	0.38 d	9.12 bc	8.92 ab	0.20 e
	$Eu+JA_1$	10.36 a	9.93 a	0.43 d	8.83 c	8.53 ab	0.30 cde
	$Eu+JA_2$	10.14 a	9.73 ab	0.41 d	8.70 c	8.44 ab	0.26 de
L.S.D at 5% for :							
	A	0.27	3.34	0.16	0.42	2.99	0.05
	B	0.46	5.79	0.27	0.73	5.18	0.08
	A*B	0.65	8.16	0.38	1.03	7.30	0.11

Values marked with same alphabetical letter(s), within a comparable group of means, do not significantly differ using revised L.S.D. test at 0.05 level

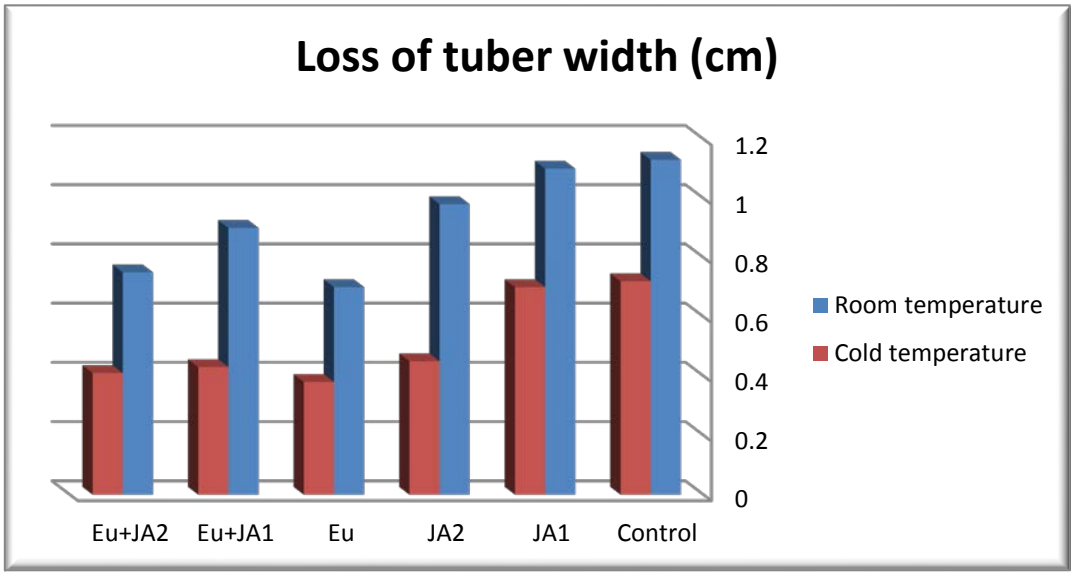

Fig. (3): Effect of jasmonic acid, eucalyptus extract and storage temperatures (4 °C and 30 °C) on the loss of tuber width (cm) during the 2011/2012 growing season.

Concerning the effect of jasmonic acid on the loss of seed tuber width, data in Table (2) and Fig. (3) indicate that all JA levels significantly decreased tuber width loss compared with the control.

Results in the same Table reveal that the treatment with Eu exhibited the highest significant decrease in tuber width loss. This decrease reached to 41.93% and 57.41% in the first and second seasons, respectively, compared with the control.

Concerning the effect of the interaction between Eu and JA treatments, data in Table (2) and Fig. (3) show that $Eu+JA_2$ treatment was the most significant interaction in reducing tuber width loss. This decrease reached to 37.63% and 48.15% in the first and second seasons, respectively, compared to the control.

Effect of storage temperatures, jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Results presented in Table (2) and Fig. (3) reveal the effect of the interaction between storage temperatures, JA levels, Eu treatment and their interaction on seed tuber width. Increasing storage period up to 42 days reduced tuber width under both room and cold temperatures. The highest decrease in tuber width recorded at JA_1 treatment in both temperatures.

Concerning the effect of the interaction between storage temperatures, JA, Eu and their interaction on the loss of tuber width, data recorded in Table (2) and Fig. (3) demonstrate that by increasing storage period under both room and cold temperatures the highest values of tuber width loss were observed by JA_1 followed by JA_2 compared to the control at both temperatures in the first and second seasons.Furthermore, Eu treatment was the best treatment in reducing tuber width loss which gave the lowest significant tuber width loss. This decrease reached to 38.05% and 61.54% at room temperature as well as 47.22% and 53.49% at cold temperature in the first and second seasons, respectively, compared with the control.

Data in Table (2) and Fig. (3) show that the interaction between JA and Eu treatments under both room and cold temperatures decreased the tuber width loss. In this regard, Eu+JA_2 treatment led to the maximum decrease in tuber width loss. This decrease reached to 33.63% and 53.85% at room temperature as well as 43.06% and 39.53% at cold temperature in the first and second seasons, respectively, compared with the control.

Seed tuber fresh weight and the loss of fresh weight

Effect of storage temperatures:

Data presented in Table (3) indicate that the storage of potato seed tubers at different temperatures up to 42 days decreased potato tuber fresh weight compared with the starting storage fresh weight. The highest reduction recorded at room temperature.

As seen in Table (3) and Fig. (4) the effect of storage potato seed tubers at different temperatures (room and cold temperatures) significantly affected tuber fresh weight loss.

The usage of cold temperature significantly decreased tuber fresh weight loss compared to room temperature. In this connection, the differences between the two storage conditions were highly significant during the first and second seasons. The obtained results are in harmony with those obtained by Gachango (2006) on potato who stated that high weight loss was observed in tubers stored under ambient conditions. The ware potato results indicated that low weight losses were recorded from tubers stored in the low temperature condition. Also, Wustman and Struik (2007) stated that under storage conditions potato will to a lesser or greater extent respire and transpire and thus lose fresh weight. Tubers therefore always show a weight loss due to transpiration (water loss) and respiration (dry matter loss). Furthermore, El-Shewy (2009) demonstrated that storage potato seed tubers at 4°C reduced tuber fresh weight and the loss of tuber fresh weight compared with the control. Ghazavi and Houshmand (2010) pointed out that the lowest weight was observed at the lowest tested temperature (5°C) and increasing temperature caused an increase of weight loss during storage of potato tubers.

Effect of jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Data recorded in Table (3) point out the effect of jasmonic acid, eucalyptus extract and their interaction on tuber fresh weight. After 42 days from starting storage period the tuber fresh weight of potato decreased under all JA levels in the first season only.

The highest decrease in this respect was recorded at JA_1 treatment.

The usage of Eu treatment led to the highest significant increment in tuber fresh weight compared with the control.

Concerning the effect of jasmonic acid, eucalyptus extract and their interaction on tuber fresh weight loss, Results in Table (3) and Fig. (4) reveal that all tested treatments decreased the loss of tuber fresh weight. It was observed that JA levels decreased tuber fresh weight loss compared with the control plants. The obtained results are in agreement with those observed by Barakat (1996) who found that soaking potato tubers in the growth inhibitor pp333 induced loss in fresh weight of tubers. Moreover, Wasternack (2007) observed that jasmonate alter gene expression positively leading to promoting of potato tuber formation and decreasing its loss in fresh weight.

Table (3): Effect of different storage temperatures, jasmonic acid, eucalypt extract treatments and their interaction on potato seed tuber fresh weight and the loss of tuber fresh weight in the 2011 and 2012 seasons.

Characters / Treatments		2011 season			2012 season		
		Tuber fresh weight (gm)		Loss of tuber fresh weight	Tuber fresh weight (gm)		Loss of tuber fresh weight
Storage temperature	JA or Eu	Starting storage	After 42 days of storage		Starting storage	After 42 days of storage	
Room temperature		258.38 a	225.13 a	33.25 a	186.55 a	164.17 a	22.38 a
Cold temperature		249.15 a	235.80 a	13.35 b	180.67 a	174.74 a	5.93 b
	Cont.	263.55 ab	233.90 bc	29.65 a	173.84 a	149.44 b	24.40 a
	JA_1	241.96 ab	215.30 bc	26.66 ab	177.11 a	160.88 a	16.23 ab
	JA_2	254.08 ab	230.72abc	23.36 abc	180.08 a	166.44 a	13.64 b
	Eu	265.82 a	247.59 a	18.23 c	189.44 a	181.26 a	8.18 b
	$Eu+JA_1$	259.69 c	238.10 ab	21.59 bc	191.75 a	178.43 a	13.32 b
	$Eu+JA_2$	237.49 b	217.16 c	20.33 bc	189.47 a	180.30 a	9.17 b
Room temperature	Cont.	262.54 bcd	222.28 bcd	40.26 a	196.88 a	158.59 bcd	38.29 a
	JA_1	231.74 cd	195.65 d	36.09 ab	160.41 ab	134.71 d	25.70 b
	JA_2	263.33 abc	231.38 abc	31.95 ab	186.70 a	165.29 abc	21.41 bc
	Eu	267.20 a	237.43 abc	29.77 b	189.35 a	176.08 ab	13.27 cd
	$Eu+JA_1$	271.70 a	240.62 abc	31.08 ab	201.26 a	180.03 ab	21.23 bc

Cold temperature	Eu+JA_2	253.76 bcd	223.39 bcd	30.37 ab	184.73 a	170.34 ab	14.39bcd
	Cont.	264.56 ab	245.52 ab	19.04 c	150.79 b	140.28 cd	10.51 cd
	JA_1	252.18 abc	234.95 abc	17.23 c	193.81 a	187.05 a	6.76 d
	JA_2	244.83 abcd	230.06 abc	14.77 cd	173.44 ab	167.58 abc	5.86 d
	Eu	264.44 ab	257.75 a	6.69 d	189.53 a	186.44 ab	3.09 d
	Eu+JA_1	247.66 abcd	235.57abc	12.09 cd	182.22 a	176.82 ab	5.40 d
	Eu+JA_2	221.21 d	210.93 cd	10.28 cd	194.20 a	190.25 a	3.95 d
L.S.D. at 5% for :							
	A	11.96	12.25	4.20	33.68	8.91	6.13
	B	20.72	21.22	7.27	58.33	15.43	10.61
	A*B	29.22	29.92	10.25	82.25	21.76	14.96

Values marked with same alphabetical letter(s), within comparable group of means, do not significantly differ using revised L.S.D. test at 0.05 level.

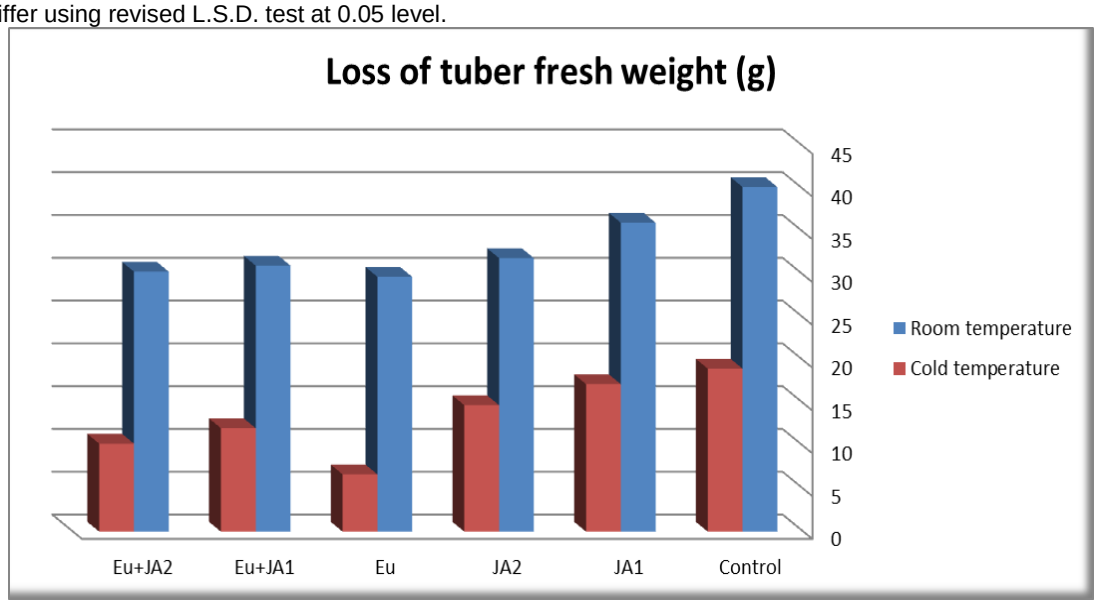

Fig. (4): Effect of jasmonic acid, eucalyptus extract and storage temperatures (4 °C and 30 °C) on the loss of tuber fresh weight (g) during the 2011/2012 growing season.

Data presented in Table (3) and Fig. (4) mention that the treatment with Eu caused the highest significant decrease in tuber fresh weight loss. This reduction reached to 38.52% and 66.48% in the first and second seasons, respectively, compared with the control. These results were confirmed by the findings obtained by Lorber and Muller (1976); Koedam (1982); Bouwmeester (1991); Poster *et al.* (1993); as well as Gorris *et al* (1994) who indicated that substrates isolated from essential oil have a

possitive effect on weight of potato tubers. Moreover, Abad *et al.* (2001 a) reported that extracts of aromatic plants decreased the loss of tuber fresh weight. Fathy *et al*. (2005) reported that natural extracts containing anise, fennel and mint oils greatly suppressed the incidence of fresh weight loss of potatoes. Furthermore, Dorsaf *et al*. (2012) postulated that eucalyptus leaves extract exhibited high activities of antioxidants which the best treatment in reducing the fresh weight of potato tubers leading to lowing the loss in fresh weight at the end of storage period.

Concerning the interaction between Eu and JA treatments, data in Table (3) and Fig. (4) demonstrate that Eu+JA_2 treatment was the most significant treatment in reducing tuber fresh weight loss. This decrease reached to 31.43% and 62.42% in the first and second seasons, respectively, compared with the control.

Effect of storage temperatures, jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Results recorded in Table (3) show the effect of the interaction between storage temperatures, JA, Eu and their interaction on seed tuber fresh weight. Increasing storage period up to 42 days reduced tuber fresh weight at both room and cold temperatures. The highest reduction in tuber fresh weight recorded by JA_1 at room temperature followed by Eu+JA_2 at cold temperature.

Data recorded in Table (3) and Fig. (4) demonstrate the effect of the storage temperatures, JA levels, eucalyptus extract application and their interaction on tuber fresh weight loss. In this concern, Eu treatment gave the lowest significant decrease in the fresh weight loss. This decrease reached to 26.06% and 30.69% at room temperature as well as 64.86% and 70.50% at cold temperature in the first and second seasons, respectively, compared with the control. These results are parallel to that achieved by El- Awady, (2002) who indicated that treating potato tubers with dill, thyme and caraway essential oils influenced their carbohydrates, sugars, minerals and T.S.S. This could in turn affect the loss of tuber weight specially, when tubers were stored at higher temperatures. He added that the loss in tuber weight was associated with minimum enzymatic and respiratory activities, the contents of T.S.S., Sugar, minerals, carbohydrates, and their change may be substrates and indicator for weight loss in the tubers. Also, Elbashir *et al.* (2014) recorded that the application of the aromatic spearmint oil in cold store demonstrated a significantly lower fresh weight loss than all other applications.

Results in Table (3) and Fig. (4) indicate that the interaction between JA and Eu treatments under room and cold temperatures decreased the tuber fresh weight loss. The Eu+JA_2 interaction was the best treatment in reducing the loss of tuber weight. This decrease reached to 24.57% and 62.42% at room temperature as well as 46.01% and 62.42% at cold temperature in the first and second seasons, respectively, comparing to owing controls.

The effect of the above mentioned treatments on the loss of length, width and fresh weight of potato seed tubers may be related to the effect of internal hormonal status (GA/ABA) which affects the metabolism, cell division and elongation within the tuber tissues (Fellenberg, 1978). In this connection, Hess (1981) reported that to decrease the loss of tuber fresh weight it must be regulate the biochemical changes and its states in tuber cells, while the changes in cell division and elongation are responsible for regulating the length and width of tuber.

Sprouting parameters:

Sprouting percentage%

Effect of storage temperatures:

Data recorded in Tables (4 and 5) and Fig. (5) indicate that the storage of potato seed tubers at different temperatures (4°C and 30°C) significantly affected tuber sprouting percentage. The usage of cold temperature caused the highest significant reduction in sprouting percentage compared to room temperature. In this connection, Hartmans and Vanloon (1987) found that the maximum sprouting capacity was reached about 80 to 100 days earlier when tubers were stored at 12°C and it reached about 50 days earlier at 4°C in potato tubers of two cultivars. Moreover, Mary *et al.* (2004) demonstrated that the cold storage of potato tubers was effective in inhibiting of tubers sprouting by interfering with cell division. Furthermore, Gachango (2006) pointed out that no sprout growth and development was recorded in potato tubers stored in the low temperatures. However, at ambient temperatures, all tubers were sprouted by the end of the storage period. El-Shewy (2009) revealed that the storage of potato tubers at 4°C decreased sprouting% compared with tubers stored at room temperature. .

Effect of jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

The obtained results as shown in Tables (4 and 5) and Fig. (5) mention that the application of JA levels significantly decreased sprouting% compared with untreated plants. The JA_1 level gave the highest significant decrease in sprouting% of potato tubers followed by JA_2 level. The highest reduction reached to 46.76% and 49.89% in the first and second seasons, respectively, compared with the control.

Table (4): Effect of different storage temperatures, jasmonic acid levels, application of eucalyptus extract and their interaction on sprouting characters of potato seed tubers during the 2011 season.

Characters / Treatments		Sprouting percentage %	Number of sprouted eyes/ tuber	Number of total buds/ tuber	Length of sprout (cm)	Fresh weight of sprout (g)	Dry weight of sprout (g)
Storage temperature	JA or Eu						
Room temperature		60.63 a	5.52 a	13.68 a	1.52 a	0.16 a	0.08 a
Cold temperature		49.47 b	2.65 b	9.20 b	1.03 b	0.11 b	0.03 b
	Cont.	72.52 a	5.95 a	17.40 a	1.84 a	0.20 a	0.12 a
	JA_1	38.61 c	2.10 e	5.50 d	0.72 c	0.09 e	0.02 d
	JA_2	47.98 b	3.35 d	9.80 c	1.16 b	0.11 d	0.04 cd
	Eu	49.22 b	3.70 cd	12.20 b	1.23 b	0.13 cd	0.05 c
	$Eu+JA_1$	51.32 b	4.25 c	12.80 b	1.29 b	0.15 bc	0.07 b
	$Eu+JA_2$	67.66 a	5.15 b	14.15 b	1.44 ab	0.17 ab	0.10 a

Room temperature	Cont.	78.73 a	7.80 a	23.30 a	2.38 a	0.21 a	0.13 a
	JA_1	44.00 cd	2.50 h	8.70 de	1.02 cd	0.11 e	0.03 cd
	JA_2	53.06 b	4.80 def	10.80 cd	1.26 bc	0.13 de	0.05 bcd
	Eu	56.88 b	5.40 cde	14.00 c	1.37 bc	0.15 cd	0.07 abcd
	$Eu+JA_1$	57.23 b	6.00 bc	14.80 bc	1.43 bc	0.17 bc	0.09 abcd
	$Eu+JA_2$	73.86 a	6.60 b	16.90 b	1.67 b	0.19 abc	0.11 abc
Cold temperature	Cont.	66.31 a	4.10 bc	11.50 c	1.29 bc	0.18 a	0.08 ab
	JA_1	33.22 e	1.70 g	2.30 f	0.42 d	0.06 e	0.01 d
	JA_2	42.90 d	1.90 fg	8.80 e	1.06 c	0.08 de	0.02 d
	Eu	41.55 d	2.00 fg	10.40 c	1.08 bc	0.10 cd	0.03 bcd
	$Eu+JA_1$	45.40 bc	2.50 efg	10.80 c	1.15 bc	0.12 bc	0.04 abcd
	$Eu+JA_2$	61.45 a	3.70 bcd	11.40 c	1.20 bc	0.14 ab	0.05 abcd
L.S.D. at 5% for :							
	A	3.03	0.46	0.94	0.25	0.01	0.01
	B	5.26	0.80	1.64	0.43	0.03	0.02
	A*B	7.41	1.13	2.31	0.60	0.04	0.03

Values marked with same alphabetical letter(s), within comparable group of means, do not significantly differ using revised L.S.D. test at 0.05 level.

Table (5): Effect of different storage temperatures, jasmonic acid, eucalyptus extract, treatments and their interaction on sprouting percentage, number of sprouted eyes per tuber, length, fresh and dry weight of sprout of potato seed tubers during the season 2012.

Characters / Treatments		Sprouting percentage %	Number of sprouted eyes/tuber	Number of total buds/ tuber	Length of sprout (cm)	Fresh weight of sprout (g)	Dry weight of sprout (g)
Storage temperature	JA or Eu						
Room temperature		40.19 a	2.78 a	6.09 a	1.69 a	0.27 a	0.08 a
Cold temperature		26.15 b	1.55 b	4.15 b	1.26 b	0.16 b	0.04 b
	Cont.	41.93 a	2.90 a	7.85 a	2.04 a	0.44 a	0.10 a
	JA_1	21.01 d	1.30 c	3.40 d	0.96 d	0.08 e	0.03 c
	JA_2	29.14 c	1.85 b	4.15 c	1.13 cd	0.13 de	0.04 c
	Eu	33.60 bc	2.15 ab	4.50 c	1.27 c	0.15 cd	0.05 c
	$Eu+JA_1$	35.86 abc	2.30 ab	6.25 b	1.51 b	0.22 bc	0.06 bc
	$Eu+JA_2$	37.50 ab	2.48 ab	7.00 ab	1.96 a	0.26 b	0.08 ab

Room temperature	Cont.	48.07 a	3.80 a	9.30 a	2.51 a	0.56 a	0.11 a
	JA_1	27.24 d	2.00 de	5.00 cd	0.95 f	0.10 e	0.04abcd
	JA_2	39.54 ab	2.20 cde	5.60 cd	1.14def	0.17 de	0.06 abc
	Eu	39.70 ab	2.70 bcd	6.60 bc	1.33 cde	0.18 cde	0.07 abc
	$Eu+JA_1$	42.22 ab	2.90 bc	6.90 bc	1.77 b	0.26 cd	0.08 abc
	$Eu+JA_2$	44.39 ab	3.06 ab	8.00 ab	2.46 a	0.32 bc	0.09 a
Cold temperature	Cont.	35.78 ab	2.00 b	6.40 abc	1.56 bc	0.31 b	0.08 a
	JA_1	14.77 d	0.60 e	1.80 e	0.97 f	0.05 e	0.01 e
	JA_2	18.73 cd	1.50 bcd	2.70 de	1.11 ef	0.08 de	0.02 de
	Eu	27.49 bc	1.60 bcd	2.40 de	1.20 def	0.12 cde	0.03 cde
	$Eu+JA_1$	29.49 ab	1.70 bcd	5.60 bc	1.24cdef	0.18 bcd	0.04bcde
	$Eu+JA_2$	30.61 ab	1.90 b	6.00 bc	1.46 bcd	0.20 bcd	0.06 ab
L.S.D. at 5% for :							
	A	3.92	0.30	0.82	0.12	0.06	0.02
	B	6.80	0.52	1.41	0.21	0.10	0.03
	A*B	9.59	0.73	1.99	0.30	0.14	0.04

Values marked with same alphabetical letter(s), within a comparable group of means, do not significantly differ using revised L.S.D. test at 0.05 level.

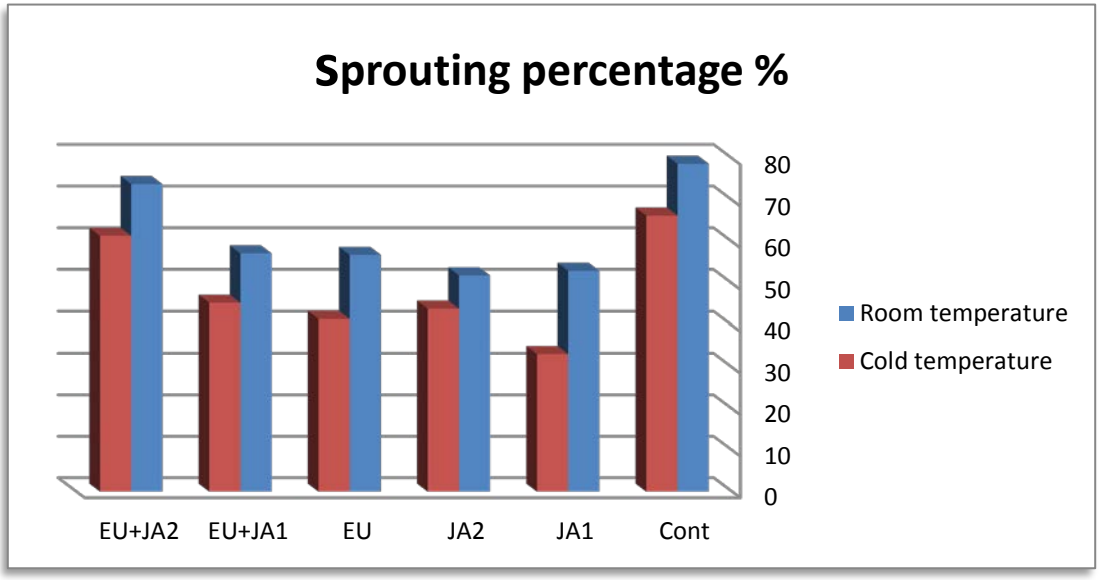

Fig. (5): Effect of jasmonic acid, eucalyptus extract and storage temperatures (4 °C and 30 °C) on sprouting percentage % at the first season.

The obtained results confirmed those reported by Meigh *et al.* (1969); Ravid *et al*. (1992) and Daniels *et al.* (1996) on potato who found that some growth inhibitors such as, salicyl-aldhyde, propham l chlor-propham and CIPC were effective in reducing the sprouting of potatoes during long term storage. Furthermore, Fellenberg (1978) found that jasmonates can interact with other hormones pathways especially

ethylene to affect potato sprouting. Moreover, Smid and Hiller (1981) suggested that treating with growth inhibitor glyphosate exhibits strong suppressive effect on sprouting of potatoes. Lulai *et al.* (1996) revealed that the absolute amount of jasmonates may provide an effective inhibition of tuber sprouting during processing. In addition, Rohwer and Erwin (2008) stated that jasmonates may affect sprouting of potatoes.

Data recorded in the same Tables show that the application of eucalyptus extract significantly decreased tuber sprouting%. This reduction reached to 32.13% and 19.87% in the first and second seasons, respectively, compared with owing controls. These results are in harmony with the finding of Coleman (2001) who demonstrated that essential oil of spearmint prevented sprouting in potatoes during storage. Also, El-Awady (2002) indicated that essential oils extracted from eucalyptus decreased potato tubers sprouting% compared with the control. He added that these oils have more beneficial effects on improving the storability of tubers during storage period.

Concerning the interaction between jasmonic acid (JA) and eucalyptus extract (Eu), data in the same Tables demonstrate that Eu+JA_1 treatment had a negative effect on sprouting%, this treatment significantly reduced the sprouting% of potato tubers compared with the control. It could be noticed that the effect of jasmonic acid was more pronounced in reducing sprouting% than eucalyptus extract.

Effect of storage temperatures, jasmonic acid, eucalyptus extract and their interaction:

Data recorded in Tables (4 and 5) and Fig. (5) state that under both storage temperatures (4°C and 30°C) all JA treatments (JA_1 and JA_2) significantly decreased sprouting% of potato seed tubers. In this connection, JA_1 treatment exhibited the highest significant decrease under both room and cold temperatures. This reduction reached to 44.11% and 43.33% at room temperature as well as 49.90% and 58.72% at cold temperature in the first and second seasons, respectively, compared to the control. Similar results obtained by Olorunda *et al*. (1974) who found that when treating tubers of the yam, *Dioscorea alata* L., stored at 10 and 15 ºC with some growth inhibitors such as isopropyl *N*-(3-chlorophenyl) carbamate (CIPC or chlorpropham) suppressed sprouting.

Furthermore, Paul *et al.* (2014) found that the usage of glyphosate as sprout suppressant was more effective when the treated tubers were stored at temperature lower than 18° C at 8–12°C. He added that sprout suppression by CIPC was more effective at temperatures below 15 °C.

Concerning the effect of eucalyptus extract application on sprouting% under room and cold storage temperatures, results in Tables (4 and 5) and Fig. (5) indicate that this treatment significantly decreased sprouting% in 2011 and 2012 seasons. This reduction reached to 27.75% and 17.41% at room temperature as well as 37.34% and 23.17% at cold temperature in the first and second seasons, respectively, compared with owing controls. The obtained results run with those published by Beveride *et al.* (1981a) who suggested that the evaporation of essential oils such as spearmint oil in cold store was reported earlier to suppress completely the emergence of sprouts in all treated tubers. Also, Frazier (2000) indicated that the aromatic spearmint oil evaporated in cold store controlled the sprouts throughout the storage in all tubers treated irrespective of potato variety. Furthermore, Elbashir *et al.* (2014) suggested that the treatment of spraying spearmint oil in cold store controlled the emergence of sprout during

the storage of potato varieties. No emergence of sprouts was observed on tubers treated with spearmint oil in cold store throughout the storage period.

Data recorded in Tables (4 and 5) and Fig. (5) mention that the interaction between jasmonic acid (JA) and eucalyptus extract negatively affected sprouting% compared with the control.

Number of sprouted eyes/tuber

Effect of storage temperatures:

The presented results in Tables (4 and 5) and Fig. (6) reveal that the storage of potato seed tubers at different temperatures (4°C and 30°C) significantly affected the number of sprouted eyes/tuber. The usage of cold temperature significantly decreased the number of sprouted eyes/tuber compared to the room temperature in both seasons.

In this regard, El-Shewy (2009) stated that the storage of potato tubers at 4°C decreased the number of sprouted eyes compared with tubers stored at room temperature.

Effect of jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

As seen in Tables (4 and 5) and Fig. (6) JA levels significantly decreased the number of sprouted eyes/tuber. The usage of JA_1 treatment caused the highest significant reduction in the number of sprouted eyes/tuber. This decrease reached to 64.71% at 2011 season and 55.17% at 2012 season compared with the control. These results are in agreement with those obtained by Hess (1981) who found that the inhibitory effect of some growth inhibitor is decreasing the number of sprouted eyes of potato tubers. This decrease might be due to the stimulation of cell elongation and differention epecially at low concentration.

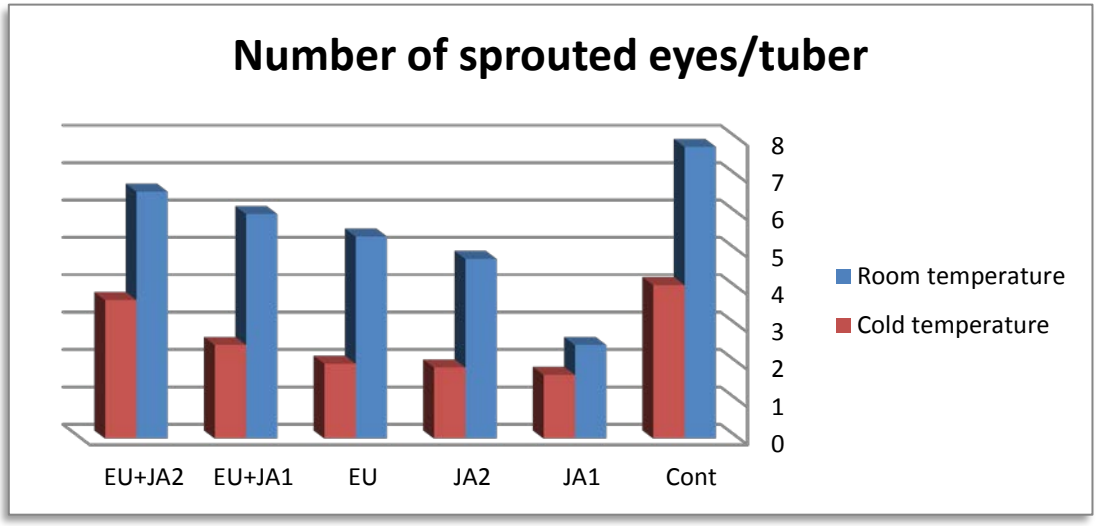

Fig. (6): Effect of jasmonic acid, eucalyptus extract and storage temperatures (4 °C and 30 °C) on the number of sprouted eyes/tuber in the first season.

Data in Tables (4 and 5) and Fig. (6) indicate that the treatment with Eu decreased number of sprouted eyes/tuber compared with the control during both seasons. This reduction reached to 37.82% and 25.86% in the first and second seasons, respectively, compared with the control. These data are parallel to those achieved by Daniels *et al.* (1996); Carol *et al.* (1997); El-Awady (2002) and El-Shewy (2009) on

potato who mentioned that different essential oils and extracts such as eucalyptus extract was the most potent treatment in suppressing the number of sprouted eyes of potato tubers. The reduction in the number of sprouted eyes may be due to that treating potato tubers with essential oils or growth inhibitors can lead to a suppression of the carbohydrate changes, mobilization or accumulation in tuber tissues (Koedam 1982; Poster *et al.* 1993; Bouwmeester *et al*. 1995; Arras *et al.* 1995 and Gurdip *et al*. 1997).

Results recorded in Tables (4 and 5) and Fig. (6) show the interaction between jasmonic acid and eucalyptus extract. In this regard, Eu+JA_1 treatment was the best treatment in decreasing the number of sprouted eyes followed by Eu+JA_2 treatment.

Effect of storage temperatures, jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Results listed in Tables (4 and 5) and Fig. (6) demonstrate the effect of storage temperatures, JA, Eu and their interaction on the number of sprouted eyes/tuber. Application of JA levels significantly decreased the number of sprouted eyes/tuber. The highest decrease was observed by using JA_1 treatment. This reduction reached to 67.95% and 47.37% at room temperature as well as 58.54% and 70% at cold temperature in the first and second seasons, respectively, compared with the control.

Data recorded in the same Tables indicate that Eu treatment decreased the number of sprouted eyes/tuber significantly as compared with the control plants at the two storage temperatures. These results are supported by the results obtained by Koedam (1982); Poster *et al.* (1993) and Arras *et al.* (1995) on potato who pointed out that using essential oils of aromatic plants decreased the number of sprouted eyes of potato tubers. Also**,** Bouwmeester *et al.* (1995) found that extracts from dill and carawy seeds inhibited the number of sprouted eyes of potato tubers. Gurdip *et al.* (1997) attributed that the essential oil of menthe spicata at higher temperature decreased the number of sprouted eyes of potato tubers.

Results presented in Tables (4 and 5) and Fig. (6) show the effect of the interaction between storage temperatures, JA, Eu and their interaction on the number of sprouted eyes/tuber. It could be noticed that Eu+JA_1 treatment led to a significant reduction in the number of sprouted eyes/tuber compared with Eu+JA_2 treatment under both room and cold temperatures in the first and second seasons.

Number of total buds/tuber

Effect of storage temperatures:

Data recorded in Tables (4 and 5) and Fig. (7) indicate that the storage of potato seed tubers at different temperatures (4°C and 30°C) differently affected the number of total buds/tuber. The usage of cold temperature significantly decreased the number of total buds/tuber compared to room temperature in both seasons.

Effect of jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Data presented in Tables (4 and 5) and Fig. (7) mention that JA levels significantly decreased number of total buds/tuber. The application of JA_1 gave the maximum significant decrease in this parameter. This decrease reached to 68.39% at 2011 season and 56.69% at 2012 season when compared with the control.

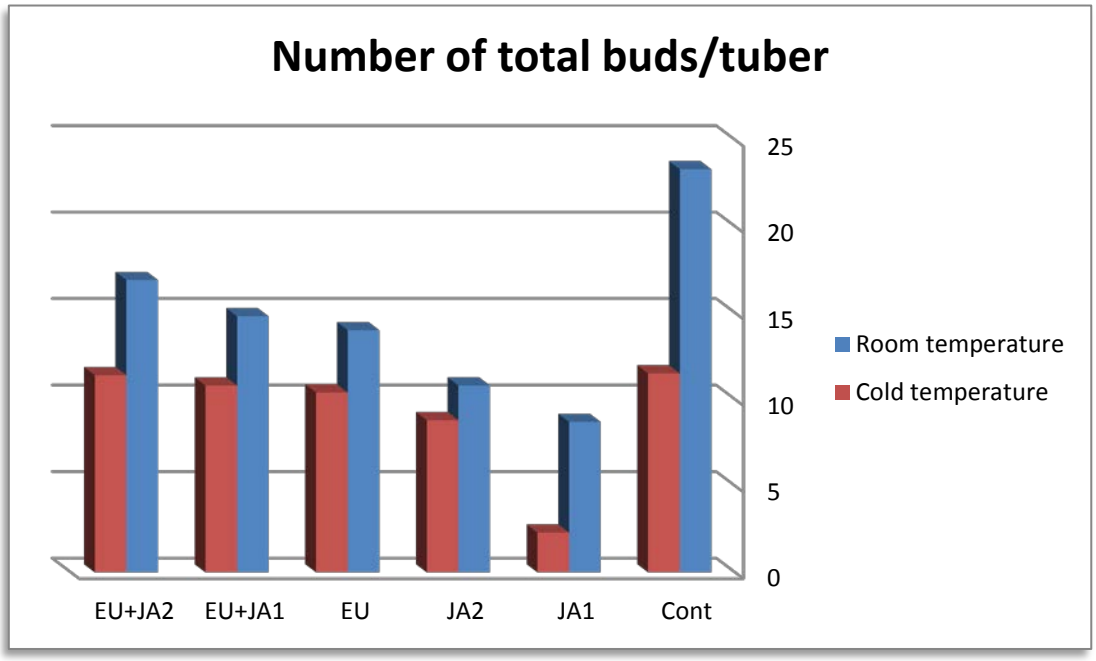

Fig. (7): Effect of jasmonic acid, eucalyptus extract and storage temperatures (4 °C and 30 °C) on number of total buds/ tuber at the first season.

Results in Tables (4 and 5) and Fig. (7) show the effect of Eu treatment on the number of total buds/tuber. It can be noticed that Eu treatment significantly decreased the number of total buds/tuber compared to the control. In both seasons.

With respect to the combination effect of JA and Eu treatments, data recorded in Tables (4 and 5) and Fig. (7) reveal that Eu+JA_1 treatment was more effective in decreasing the number of total buds/tuber. This treatment caused a decrease reached about 26.44% at 2011 season and 20.38% at 2012 season compared with the control.

Effect of storage temperatures, jasmonic acid, eucalyptus extract and their interaction:

As seen in Tables (4 and 5) and Fig. (7) all JA levels significantly decreased the number of total buds/tuber under both room and cold temperatures. The usage of JA_1 treatment caused the highest significant decrease in the number of total buds/tuber. This decrease reached to 62.66% and 46.24% at room temperature as well as 80% and 71.88% at cold temperature in 2011 and 2012 seasons, respectively, compared with the control.

Concerning the effect of eucalyptus extract application on the number of total buds/tuber under both room and cold temperatures. Results in Tables (4 and 5) and Fig. (7) indicate that this treatment significantly decreased the number of total buds/tuber in both seasons. This decrease reached to 39.91% and 29.03% at room temperature as well as 9.57% and 62.50% at cold temperature in the first and second seasons, respectively. Similar results were obtained by Carlo *et al.* (1997) who postulated that treating potato tubers with carvone vapour fully inhibit buds growth and development.

As for the interaction between jasmonic acid and eucalyptus extract application under room and cold temperatures, data recorded in Tables (4 and 5) and Fig. (7) reveal that the interaction treatments significantly decreased the number of total buds/tuber under both temperatures. In this regard, Eu+JA_1 treatment was the best treatment in decreasing the number of total buds/tuber. This treatment caused a decrease reached about 36.48% and 25.81% at room temperature as well as 6.09% and12.50% at cold temperature in the first and second seasons, respectively, compared with the control.

Sprout length

Effect of storage temperatures :

As seen in Tables (4 and 5) the storage of potato seed tubers at different temperatures (4°C and 30°C) significantly affected sprout length. The storage at room temperature significantly reduced sprout length compared to cold temperature, in both seasons. The contrary was noticed by the results obtained by El-Shewy (2009) who suggested that storage potato tubers at 4°C decreased sprout length compared with tubers stored at room temperature.

Effect of jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Concerning the effect of JA, Eu and their interaction on sprout length of potato tubers, data in Tables (4 and 5) indicate that both JA levels significantly decreased sprout length. In this concern, JA_1 treatment recorded the highest significant reduction in this parameter. This reduction reached to 60.87% in the first season and 52.94% in the second one when compared with the control. The inhibitory effect of growth inhibitors on tuber sprout length may be due to mineral and carbohydrates mobilization in tuber tissues, inhibition of respiratory pathway and inhibition of promoters synthesis pathways such as GA and cytokinins (Doerfflling, 1982). Similar results were observed by Kleinkopf *et al*. (2003 b) who stated that using of CIPC carbamate inhibited the sprout development of potato tubers by interfering with cell division.

Concerning the effect of eucalyptus extract application on sprout length of potato tuber, data in the same Tables show that the treatment with Eu significantly decreased sprout length compared with the control. This decrease reached to 33.15% and 37.75% in the first and second seasons, respectively, compared with the control. Similar results were obtained by Kleinkopf *et al.* (2003 a) who revealed that the utilization of caraway essential oils inhibited the elongation and the development of tuber sprouts of potato. Furthermore, Mehta and Kaul (2002) as well as El-Shewy (2009) on potato reported that some essential oils significantly reduced sprout length compared with the control.

The results illustrated in Tables (4 and 5) show the effect of the interaction between JA levels and Eu application on sprout length. In this respect, Eu+JA_1 treatment produced higher significant reduction in sprout length than Eu+JA_2 treatment in both seasons.

Effect of storage temperatures, jasmonic acid, eucalyptus extract and their interaction:

Regarding the interaction between storage temperatures, JA, Eu and their interaction, data in Tables (4 and 5) demonstrate that under both room and cold temperatures JA treatments gave the lowest significant sprout length compared with the other treatments. JA_1 treatment caused a reduction reached to 57.14% and 62.15% at room temperature as well as 67.44% and 37.82% at cold temperature in the first and second seasons, respectively, compared with the control. These results are in line

with those obtained by Barakat (1996) who postulated that the growth inhibitor PP 333 shortened sprout length of potato tuber after storage period of 3 months. Furthermore, Lewis *et al.* (1997) stated that the sprout length of potato tubers was reduced by treating with the growth inhibitors (DIPN and DMN). Daniel *et al*. (1996) found that treating potato tubers with the inhibitor CIPC reduced sprout length.

The obtained results as shown in Tables (4 and 5) reveal the effect of eucalyptus extract on the length of the sprout under both storage temperatures. In this respect, Eu treatment significantly decreased the length of the sprout under both room and cold temperatures in the first and second seasons compared to the control. These results were in agreement with those obtained by Vaughn and Spencer (1991); Oosterhaven *et al*. (1995 a & b) and Ali *et al.* (1997) who mentioned that several aromatic extract treatments were more effective in reducing the sprout initiation and sprout length of potato tubers. Furthermore, Fathy *et al.* (2005) reported that potato tubers treated with essential oils and marjoram extract exhibited marked reduction in the length of tuber sprout.

Concerning the effect of the interaction between JA and Eu on sprout length under both room and cold temperatures, results presented in Tables (4 and 5) indicate that the Eu+JA_1 treatment exhibited higher reduction in sprout length compared with Eu+JA_2 under both room and cold temperatures in both seasons. This decrease reached to 39.92% and 29.48% at room temperature as well as 10.85% and 20.51% at cold temperature in the first and second seasons, respectively, compared with the control.

It could be suggested that natural plant extracts and some plant growth inhibitors play an important role in cell division and elongation leading to activation or inhibition of tuber sprout growth, especially the single treatments of JA and Eu under cold storage condition, which were able to reduce the sprout length as compared with the control and other treatments (Hess, 1981).

Sprout fresh and dry weight

Effect of storage temperatures:

Data recorded in Tables (4 and 5) and Fig. (8) indicate that the storage of potato seed tubers at different temperatures (4°C and 30°C) differently affected the fresh and dry weight of sprout in the two growing seasons. The storage of potato seed tubers at cold temperature decreased the fresh and dry weight of sprout compared to room temperature in the first and second seasons. These results are partly in agreement with those obtained by El-Shewy (2009) who found that storage potato tubers at 4°C decreased sprout fresh weight. Meanwhile, sprout dry weight increased compared with tubers stored at room temperature.

Effect of jasmonic acid (JA), eucalyptus extract (Eu) and their interaction:

Concerning the effect of JA, Eu and their interaction on the fresh and dry weight of sprout, data in Tables (4 and 5) and Fig. (8) indicate that increasing JA levels significantly decreased sprout fresh and dry weight. It can be noticed that, JA_1 treatment caused the highest significant reduction in fresh and dry weight of sprout compared with the control and the other treatments. This decrease reached to 55 % for fresh weight and 83.33% for dry weight in 2011 season and 81.82% for fresh weight and 70% for dry weight in 2012 season when compared with the control. These results are in agreement with those achieved by Doerffling (1982) who stated that the inhibition of fresh and dry weight caused by the different JA treatments could be attributed to their effect on the enzymes

system involving in changes of carbohydrates accumulation, mobilization and reducing of water content in sprout tissues. Also, Daniels *et al*. (1996) mentioned that treating potato tubers with some growth inhibitors such as (CIPC) reduced sprout fresh and dry weight.

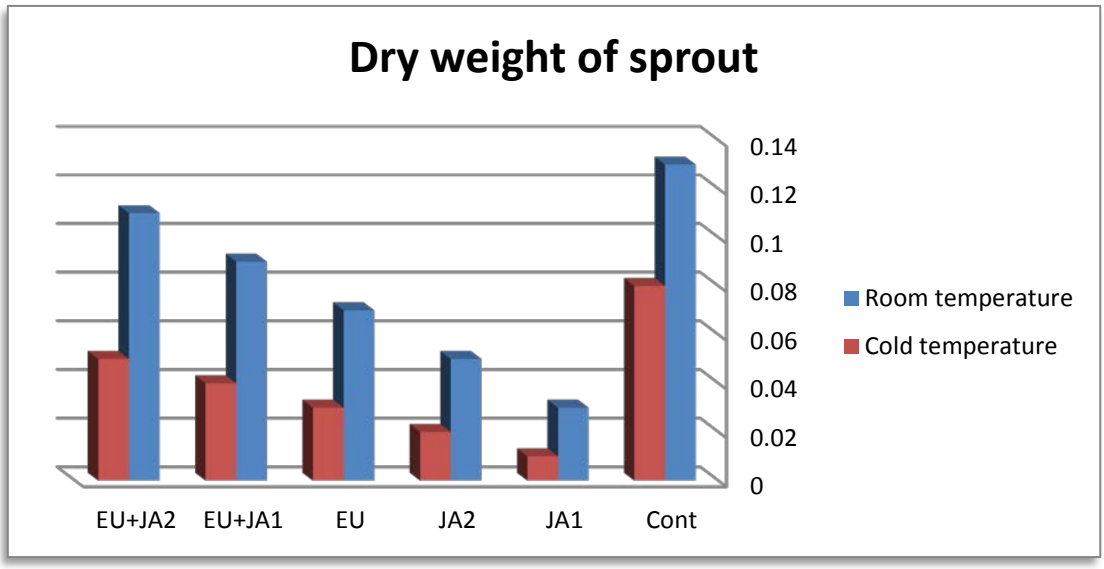

Fig. (8): Effect of jasmonic acid, eucalyptus extract and storage temperatures (4 °C and 30 °C) on dry weight of sprout (g) at the first season.

Data in the same Tables show that Eu treatment significantly decreased sprout fresh and dry weight compared with the control during the first and second seasons. This reduction reached to 35% and 65.91% for sprout fresh weight as well as 58.33% and 50% for sprout dry weight in the first and second seasons, respectively, compared to the control. In this concern, Arras *et al.* (1995) explained the relation between the loss of dry matter in tuber sprouts and their carbohydrates concentration and mobilization when tubers were treated with aromatic extracts. He indicated that such treatments might be considerably reduced and inhibited the responsible enzymatic system of carbohydrates and sugars changes and their mobilization in sprout tissues, leading to a decrease in its dry weight. In contrary these enzymatic systems will be promoted in the control treatment. Abad *et al.* (2001a) indicated that extracts of aromatic plants increased loss of sprout of potato tubers. In this concern, El-Awady (2002) and El-Shewy (2009) on potato observed that some essential oils such as anise, fennel, thyme and eucalyptus oils decreased the fresh weight of potato sprouts. This decrease due to the reduction in water content in sprout tissues and the low accumulation of carbohydrates and T.S.S% in sprout tissues. On contrary, Vokou *et al.* (1993) found that extracted essential oils of aromatic plants significantly increased sprout fresh and dry weight, but the sprout weight was decreased at low concentrations.

Data presented in Tables (4 and 5) and Fig. (8) explain the interaction between JA levels and eucalyptus extract application on sprout fresh and dry weight. The obtained results reveal that Eu+JA_1 treatment led to the maximum reduce in the fresh and dry

weight of sprout compared with the Eu+JA_2 treatment.

Effect of storage temperatures, jasmonic acid, eucalyptus extract and their interaction:

Regarding the effect of the interaction between storage temperatures, JA levels, Eu application and their interaction on the fresh and dry weight of sprout. Data recorded in Tables (4 and 5) and Fig. (8) demonstrate that under both room and cold temperatures it was found that JA_1 treatment was more effective in reducing the sprout fresh and dry weight significantly. This reduction reached to 47.62% for fresh weight and 76.92% for dry weight at room temperature and 66.67% for fresh weight as well as 87.50% for dry weight at cold temperature in the first season compared with the control. The second season showed the same trend.

From the above mentioned results Tables (4 and 5) and Fig. (8), it could be concluded that the most effective treatment was JA_1 at cold temperature, which recorded the lowest fresh and dry weight of sprout compared with the other treatments and the control in both seasons. In this regard, Barakat (1996) revealed that using some inhibitors such as PP_{333} reduced the loss of fresh and dry weight of potato tuber sprouts. Furthermore, Frazier *et al.* (2003) indicated that treating potato tubers with the growth inhibitor (IPC) inhibited the sprout development of tubers by interacting with cell division.

Concerning the effect of eucalyptus extract under both storage temperatures on fresh and dry weight of sprout of potato tubers as shown in Tables (4 and 5) and Fig. (8), results reveal that Eu treatment significantly reduced the fresh and dry weight of sprout under room and cold temperatures in the first and second seasons compared to the control. This decrease reached to 28.57% and 44.44% for sprout fresh weight as well as 46.15% and 62.50% for sprout dry weight at room and cold temperatures, respectively, in the first season compared with the control. The same trend recorded in the second season. The obtained results are partly in harmony with those obtained by Sayonara *et al.* (2011) who stated that eucalyptus leaves extract stimulated sprout fresh and dry weight of potato tubers at relatively higher temperature, but the weight was reduced at low storage temperature. Similar results were obtained by Hartmans *et al.* (1998) who reported that aromatic plant extracts inhibited sprout growth of potato tubers. Furthermore, Vaughn and Spencer (1991) indicated that several aromatic plant extracts suppressed the sprout mass and thickness of potato tubers during short or long term storage.

Results presented in Tables (4 and 5) and Fig. (8) indicate the effect of the interaction between storage temperatures, JA levels, Eu application on potato tubers fresh and dry weight. The obtained results demonstrate that Eu+JA_1 treatment led to the maximum decrease in fresh and dry weight of sprout under both room and cold temperatures compared with the control and Eu+JA_2 treatment in the first and second seasons.

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دراسات فسيوكيميائية على ظاهرة التزريع لدرنات البطاطس تحت تأثير معاملات حمض الجاسمونيك ومستخلص الكافور ودرجات حرارة تخزين مختلفة

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الملخص العربى

أجريت هذه الدراسة فى تجربتى تخزين بمعمل الفسيولوجى بقسم النبات الزراعى بكلية الزراعة – جامعة المنوفية – شبين الكوم – مصر خلال الموسمين الصيفيين ٢٠١١ و٢٠١٢ وذلك لدراسة تاثير منظم النمو (حامض الجاسمونيك) والمستخلص الطبيعى (مستخلص أوراق الكافور) وكذلك تأثير التفاعل بينهما على سلوك درنات البطاطس وصفات التزريع أثناء تخزينها على درجة حرارة الغرفة (٣٠°م) وكذلك تخزينها فى الثلاجة على درجة حرارة (٤°م) لنباتات البطاطس صنف سبونتا وكانت المعاملات المستخدمة كما يلى: مقارنة – حامض الجاسمونيك بتركيز ٠,١ مللى مول – حامض الجاسمونيك بتركيز ٠,٠٥ مللى مول – مستخلص الكافور بتركيز ٥ % – حامض الجاسمونيك بتركيز ٠,١ مللى مول + مستخلص الكافور – حامض الجاسمونيك بتركيز ٠,٠٥

مللى مول + مستخلص الكافور. بعد انقضاء فترة ٤٢ يوم من بداية التخزين تم اخذ العينات لقياس صفات التخزين والتزريع. وقد اوضحت النتائج المتحصل عليها مايلى:

- أدى إستخدام درجة حرارة الثلاجة إلى حدوث إنخفاض معنوى فى الفقد فى طول وعرض والوزن الطازج للدرنة وكذلك فى صفات التزريع المتمثلة فى نسبة التزريع وعدد العيون المنبتة/الدرنة وعدد البراعم الكلية/الدرنة والوزن الطازج والجاف للنبتة بينما أدى التخزين على درجة حرارة الغرفة إلى حدوث نقص معنوى فى طول النبتة.
- أظهرت الدراسة أن إستخدام تركيزات مختلفة من حامض الجاسمونيك أدت إلى حدوث إنخفاض معنوي فى نسبة الفقد فى طول وعرض والوزن الطازج للدرنات وكذلك فى صفات التزريع مقارنة بالدرنات الغير المعاملة. حيث أدى إستخدام حامض الجاسمونيك بتركيز ٠,١ مللى مول إلى حدوث أعلى إنخفاض معنوى فى هذه الصفات يليه حامض الجاسمونيك بتركيز ٠,٠٥ مللى مول.
- أدت المعاملة بمستخلص الكافور إلى حدوث أعلى إنخفاض معنوى فى الفقد فى طول وعرض والوزن الطازج للدرنة وقللت هذه المعاملة أيضا من صفات التزريع.
- أدى إستخدام التفاعل بين مستخلص الكافور وحامض الجاسمونيك بتركيز ٠.٠٥ مللى مول إلى تقليل الفقد فى طول وعرض والوزن الطازج للدرنة.
- أظهرت الدراسة أن إستخدام مستخلص الكافور و حامض الجاسمونيك بتركيز ٠,١ مللى مول أدى إلى حدوث إنخفاض معنوى فى صفات التزريع تبعت بمعاملة مستخلص الكافور و حامض الجاسمونيك بتركيز ٠,٠٥ مللى مول عند التخزين فى كلا من درجتى حرارة الغرفة والثلاجة.