J. Agric. Sci. Mansoura Univ., 30 (3): 1391 - 1409, 2005

EFFECT OF TWO GROWTH RETARDANTS ON TUBER STORAGE ABILITY AND ANATOMY OF POTATO PLANTS TO CONTROL POTATO TUBER MOTH

Gharib A.A.[*]; M.M. Shahin[*] and M.U. El-Sgai[**]

*** Vegetable Crops Dept. Faculty of Agric., Cairo Univ., Giza, Egypt**

**** Dept. of Agric.Botany, Faculty of Agric, Cairo Univ., Giza, Egypt.**

ABSTRACT

Two field experiments were conducted in 2002 and 2003 to study the effect of two triazole compounds; namely paclobutrazol and uniconazole on growth, yield, storage ability of potato (*Solanum tubersom* L., cvs Nicola and Spunta) seed tubers and controlling of potato tuber moth (*Phterimaea operculella*). In addition, the anatomical study has been used to confirm the morphological data. Potato plants were sprayed twice, 60 and 70 days after planting with 500,1000 and 2000 ppm from each of paclobutrazol and uniconazole. Plant height, fresh weight of haulm and number of branches/plant were depressed proportionately to the concentration applied. Using the previous compounds significantly increased chlorophyll content in leaves, especially in Spunta cv at 2000 ppm of uniconazole. A significant increase in number and fresh weight of tubers/plant (three weeks after the second application), dry matter in tubers at harvest and total yield/feddan occurred following the application of either uniconazole or paclobutrazol at 1000 and 2000 ppm. Spraying potato plants with 2000 ppm of paclobutrazol significantly improved storage ability of harvested tubers especially with Nicola cv

Generally, paclobutrazol was more superior than uniconazole in decreasing percentage of decayed tubers due to infestation with potato tuber moth as well as percentage of sprouted tubers after four months from harvesting under the room conditions.

The anatomical study indicated that spraying potato plants with 2000 ppm of paclobutrazol or uniconazole caused considerable thickness of airial stem diameter due to the increase in thickness of the epidermis, cortex, vascular cylinder and number of cortical layers. Also, this treatment stimulated the thickness of lamina and midrib comparing with the control, which was attributed to the increase in the thickness of mesophyll and the size of middle bundle. In addition, the previous treatment increased thickness of the tuber cork, which led to an increase in the tolerance of the tubers against potato tuber moth infestation.

Keywords: Potato, growth retardance, paclobutrazol, uniconazole, storage ability, anatomical studies, potato tuber moth.

INTRODUCTION

Potato is one of the most important vegetable crops in the world. In Egypt, potato is reproductive vegetatively by tubers in widely areas for local consumption and industry or exporting. It is cultivated either in January and February as a summer crop or in September and October as a fall crop, while it is planted in November as "between seasons" crop. However, the summer planting is considered the main production season for local consumption, exporting and for potato seed tubers production for the further plantings. Late summer planting of seed tubers leads to many problems such as promoting foliage development in later stages of growth, which is undesirable for tuber formation, formation of secondary tubers and infection the tubers with potato

tuber moth (*Phtorimaea operculella*), which severely reduces tuber yield and quality.

In recent years, the biological activities of number of triazole derivatives have been studied in details. Some triazoles, in particular paclobutrazol and uniconazole, have been shown to inhibit extension of growth in a wide range of species including strawberry (Stang and Wies, 1984 and McArthur and Eaton, 1987), potato (Balamani and Poovaiah, 1985, Deng and Prange, 1988 and El-Sayed and Shehata, 1996a), pepper (Aloni and Pachkar, 1987), onion (El-Sayed *et al*., 1989), watermelon (Huang *et al*., 1989), tomato (Wang and Gregg, 1990), snap bean (El-Sayed, 1991), artichoke (El-Sayed and Shehata, 1996b) and okra (El-Sgai and El-Sayed, 1999).

Also, triazole compounds have been found to reduce shoot and respiratory activities (Steffens and Wang, 1984) and increase chlorophyll content in leaves (Wang *et al*., 1985 and Balamani and Poovaiah, 1985) which may lead to increasing photosynthetic activity and enhancing carbohydrate translocation (Deng and Prange, 1988).

Potato yield depends entirely on carbohydrate synthesis in leaves and its translocation to tubers. Meanwhile, foliar application of triazole may inhibit foliage development in later stages of growth, which occurs in late summer plantings in Egypt. Consequently, triazole application may enhance translocation of carbohydrates to tubers, and lead to producing large tubers, great yield and may improve storage ability of seed tubers which are required for the fall planting, by increasing thickness of the tuber cork.

In an attempt to control potato tuber moth without using pesticides, this study was, therefore, undertaken using different concentrations of two triazole compounds; namely uniconazole and paclobutrazol to increase yield and storage ability of potato seed tubers, in addition to decrease percentage of decayed tubers due to infestation with potato tuber moth.

MATERIALS AND METHODS

Two field experiments were conducted at the Agricultural Experimental Station, Faculty of Agriculture, Cairo Univeristy, Giza, Egypt, during the summer seasons of 2002 and 2003 to study the influence of foliar spray with some growth retardants; i.e., paclobutrazol and uniconazole, on plant growth, yield, tuber quality, controlling of potato tuber moth and storage ability of potato seed tubers. The soil type at the experimental site was clay loam with pH 7.2 and 1.6% organic matter content. Seed tubers of the two cultivars, i.e. Nicola and Spunta were cultivated in February 20th in both years at 20 cm spacing between plants. The area of each experimental plot was 10.5m^2 and consists of three rows. Each row was 5m long with 0.7m between rows. A guard row was left between each two experimental units to avoid drift spray. Irrigation, fertilization and pest control were applied as commonly practiced in the region. The experimental design used was Split-plot design where the cultivars assigned to the main plots while the growth retardant treatments were assigned to sub-plots.

Potato plants were sprayed twice using paclobutrazol and uniconazole each at 500, 1000 and 2000 ppm, in addition to water as a control treatment. Spraying was carried out at 60 and 70 days after planting using a knapsasck sprayer having a conical nozzle delivering 100ml water/m^2. Three plants in a sample was taken from each plot 20 days after the second application of the growth retardants, i.e. 3 months after planting. The following characters were recorded in such samples:

Plant height, fresh weight of haulm, number of branches per plant and the plant yield (weight and number of tubers/plant) were recorded. Also, chlorophyll content of leaves was recorded by A Minolta SPDAD Chlorophyll-Meter, model SPAD 502 (Yadava, 1986).

Harvesting was conducted on June 20th in both seasons of the study and the total yield of tubers per feddan was recorded. Five tubers from each plot were taken and thoroughly washed with running water. A sample of 100 g of tubers was weighted and dried at 70°C to constant weight to determine dry matter percentage. A sample of 5 kg of healthy tubers was taken from each plot and stored in jute bags for 4 months under room conditions. All sprouted and decayed tubers were separated monthly and the weight of marketable seed tubers was determined. All data were processed by analysis of variance according to the method described by Steel and Torrie (1960).

Three weeks after the second treatment, the anatomical study was carried out when plants were three months old, specimens; 1cm long, from the median portion of the middle internode of the airial stem, 1cm^2 from the median portion of the median leaflet blade of the compound leaf on the same node of airial stem and 1cm^2 from potato tuber were taken from control and treated plants that achieved maxium morphological variations from the controls; being 2000 ppm for Nicola and Spunta cultivars. All specimens were killed and fixed for at least 48h. in F.A.A. (10 ml Formalin, 5ml Galcial acetic acid and 85 ml. Ethyl alcohol 70%). The selected materials were washed in 50% ethanol, dehydrated in a normal butyl alcohol series embeded in paraffin wax (m.p. 56°C). Sections, were cut to thickness of 20μ by using rotary microtome and stained with crystal viott/erythrosin combinations, cleared in xyleme and maunted in Canada balsam (Willey, 1971). Slides were microscopically examined and the measurements were taken and averages of 10 readings from 3 slides were calculated.

RESULTS

Haulm characteristics:

The effects of growth retardants on some haulm characters 20 days after the second application were summarized in Table 1. Generally, spunta cv exceeded Nicola cv in haulm fresh weight and leaf content of chlorophyll while the reverse was true regarding number of branches per plant. On the other hand, all plant growth regulators treatments increased chlorophyll content and decreased plant height, haulm fresh weight, number of branches per plant, except uniconazole at 500 ppm which had unaffect effect on number of branches per plant.

Table 1: Effect of spraying potato plants with different concentrations of triazole compounds on vegetative growth.

Cultivars			Plant height (cm)		Haulm Fresh Weight (g.)		No. of branches per plant		Leaf content of chlorophyll	
			2002	2003	2002	2003	2002	2003	2002	2003
Nicola			60.94	61.17	176.4	181.2	5.9	6.5	47.97	47.28
Spunta			61.49	60.40	192.2	202.7	5.1	5.0	50.44	52.36
L.S.D. at 0.05			N.S.	N.S.	8.6	7.4	0.6	0.5	1.07	2.26
Treatments										
Uniconazole (ppm)		500	61.82	61.47	182.6	191.5	5.7	6.2	49.80	51.20
		1000	60.38	60.70	175.4	185.1	5.2	5.4	53.85	53.55
		2000	56.37	56.47	153.5	165.3	4.4	4.8	55.70	57.50
Paclobutrazol (ppm)		500	58.95	57.28	159.3	159.2	5.4	5.2	46.80	47.90
		1000	57.17	56.52	151.3	154.8	4.5	4.8	49.30	48.90
		2000	54.27	53.27	131.9	135.5	4.0	4.5	51.30	50.45
Control		0.0	67.33	67.12	234.8	236.6	6.9	7.0	45.40	46.25
L.S.D. at 0.05			5.02	5.41	18.2	15.8	1.3	1.0	2.27	4.19
Interaction										
Nicola	Uniconazole (ppm)	500	62.27	62.73	174.5	183.6	6.3	7.0	46.23	47.43
		1000	61.43	61.72	169.6	177.2	5.7	6.0	53.37	48.27
		2000	57.03	57.93	150.7	164.8	4.7	5.3	55.77	51.70
	Paclobutrazol (ppm)	500	57.10	55.50	142.8	138.3	6.0	5.7	45.20	46.33
		1000	55.90	54.57	130.3	134.1	5.0	5.3	47.67	47.20
		2000	54.13	52.97	116.9	121.4	4.3	5.0	50.30	48.27
	Control	0.0	66.87	68.37	234.1	237.2	7.0	8.0	44.40	45.42
Spunta	Uniconazole (ppm)	500	61.37	60.20	190.6	199.4	5.0	5.4	53.40	54.97
		1000	59.33	59.67	181.2	193.0	4.7	4.7	54.30	58.83
		2000	55.70	55.00	156.3	165.7	4.0	4.3	55.63	63.33
	Paclobutrazol (ppm)	500	60.80	59.07	175.7	180.0	4.7	4.7	48.40	49.53
		1000	58.43	58.47	172.3	175.5	4.0	4.3	50.87	50.60
		2000	54.40	53.57	147.0	149.6	3.7	4.0	52.30	52.60
	Control	0.0	67.80	65.87	235.4	236.0	6.7	6.0	46.37	47.13
L.S.D. at 0.05			7.10	7.54	25.7	22.3	1.8	1.5	3.21	6.18

As shown in the some Table, all the interactions between cultivars and plant growth regulators treatments had a significant effect on haulm characters. It is obvious that treating potato plants (cv, Nicola) with paclobutrazol at any dose or spunta cv with the high dose of paclobutrazole or using the high dose of uniconazole for the two cultivars caused significant retardation in plant height comparing with the control.

Also, a reduction in fresh weight of haulm was recorded due to using any of the two growth retardants at any concentration for the two cultivars in both seasons. Regarding the number of branches per plant, a significant reduction, comparing with control, was recorded at concentrations of 2000 ppm of uniconazole and 1000 or 2000 ppm paclobutrazol for the two cultivars in both seasons. It was also evident from Table 1 that leaf content of chlorophyll increased significantly with most concentrations of growth retardants in the two seasons. The highest values for the leaf content of chlorophyll were obtained by using uniconazole and paclobutrazol each at 2000 ppm. for the two cultivars in both seasons.

Seed tuber yield and its characteristics:

As shown in Table 2 fresh weight of tubers per plant was higher in cv Spunta than in Nicola cv, whereas contra results were recorded regarding number of tubers per plant and tuber dry matter percentage. Meanwhile all treatments of plant growth regulators led to a significant increment in seed tuber yield and its characters as compared with untreated control, except paclobutrazole at 500 ppm which had no influence of tuber dry matter percentage.

Regarding the interaction between cultivars and plant growth regulator treatments, a significant increase in the number and fresh weight of tubers per plant occurred following the application of either uniconazole at any dose or paclobutrazol at 1000 and 2000 ppm for both cultivars in the two seasons (Table 2). The same results were recorded for the total yield of seed tubers/fed. The maximum total yield of tubers was obtained after using 2000 ppm. from the previous compounds of retardants. Dry matter percentage of tubers was significantly increased by using uniconazole at any concentration or paclobutrazol at 1000 and 2000 ppm for the two cvs. in both seasons (Table 2).

Table 2: Effect of spraying potato plants with different concentrations of triazole compounds on yield and dry matter of tubers.

Cultivars			Tubers/plant				Total yield Ton/fed.		Dry matter of tubers (%)	
			Weight (g.)		Number					
			2002	2003	2002	2003	2002	2003	2002	2003
Nicola			321.8	317.8	7.1	6.7	11.522	11.534	18.29	18.19
Spunta			387.2	368.2	6.1	6.1	11.792	12.137	16.09	16.34
L.S.D. at 0.05			29.5	25.5	0.6	N.S	0.216	0.436	0.33	0.69
Treatments										
Uniconazole (ppm)		500	375.2	345.6	7.1	6.7	11.210	11.513	17.50	17.35
		1000	380.2	376.5	7.2	7.0	11.992	11.842	17.55	17.70
		2000	391.8	370.8	7.1	6.8	13.985	13.885	17.80	18.30
Paclobutrazol (ppm)		500	333.5	324.5	6.0	6.2	10.537	10.640	16.25	16.30
		1000	374.5	362.0	7.1	6.8	11.371	11.743	17.55	17.50
		2000	373.3	367.6	7.2	6.7	13.345	13.544	17.50	17.55
Control		0.0	252.9	253.7	4.8	4.8	9.499	9.681	16.15	16.15
L.S.D. at 0.05			62.6	54.1	1.3	1.7	0.457	0.925	0.70	0.94
Interaction										
Nicola	Uniconazole (ppm)	500	335.8	306.1	7.5	6.9	10.962	11.230	18.73	18.32
		1000	357.1	352.6	7.7	7.4	11.910	11.543	18.60	18.61
		2000	372.3	351.4	7.8	7.1	14.126	14.022	18.52	19.00
	Paclobutrazol (ppm)	500	300.0	297.4	6.7	6.5	10.445	10.115	17.51	17.33
		1000	328.2	342.7	7.3	7.3	11.570	11.609	18.53	18.44
		2000	333.9	350.2	7.6	7.0	13.020	13.205	18.81	18.60
	Control	0.0	225.0	223.9	5.3	4.1	9.324	9.011	17.40	17.10
Spunta	Uniconazole (ppm)	500	414.5	385.1	6.7	6.4	11.458	11.796	16.32	16.41
		1000	403.3	400.4	6.6	6.6	12.074	12.141	16.51	16.82
		2000	411.3	390.2	6.3	6.5	13.843	13.748	17.10	17.60
	Paclobutrazol (ppm)	500	367.0	351.6	5.3	5.9	10.629	11.165	15.03	15.33
		1000	420.7	381.3	6.8	6.3	11172	11.877	16.61	16.64
		2000	412.7	385.0	6.7	6.4	13.669	13.883	16.24	16.50
	Control	0.0	280.7	283.5	4.3	4.0	9.674	10.350	14.90	15.21
L.S.D. at 0.05			88.6	76.6	1.9	2.1	0.647	1.308	0.99	1.02

Storage ability:

Tuber storage ability was affected by cultivars and triazole concentrations and their interaction Table 3. Nicola cv was significantly superior in storage ability than Spunta cv. On the other hand, triazole concentrations significantly increased storage ability as compared with untreated control, except uniconazole at 500 ppm which similar to the control in its effect on storage ability.

Table 3: Effect of spraying potato plants with different concentrations of traizole compounds on marketable stored seed tubers (%)

Treatments		Marketable Stored Seed Tubers %											
		Season of 2002						Season of 2003					
		Three months			Four months			Three months			Four months		
		Nicola	Spunta	Mean	Nicola	Spunta	Mean	Nicola	Spunta	Mean	Nicola	Spunta	Mean
Uniconazole	500	71.3	54.6	62.95	66.2	50.5	58.35	73.5	58.8	66.15	69.7	52.1	60.90
	1000	73.9	59.7	66.80	68.9	57.9	63.40	74.2	60.4	67.30	71.0	56.6	63.80
	2000	74.6	66.8	70.70	71.4	64.7	68.05	74.1	63.8	68.95	71.9	64.6	68.25
Paclobutrazol	500	77.0	67.4	72.20	73.4	60.8	67.10	75.8	65.8	70.80	73.0	58.7	65.85
	1000	78.3	69.0	73.65	74.8	64.8	69.80	76.4	68.9	72.65	75.2	61.9	68.55
	2000	82.4	71.2	76.80	80.8	67.3	74.05	81.7	71.6	76.65	78.5	68.1	73.30
Control	0.0	65.1	51.3	58.20	63.4	49.0	56.20	64.5	52.8	58.65	62.7	48.6	55.65
Mean		74.66	62.86		71.27	59.29		74.31	63.16		71.71	58.66	
L.S.D. at 0.05 Cultivars			3.67			3.24			3.43			3.25	
Treatments			7.79			6.88			7.29			6.89	
Cultivars x treatments			11.01			9.73			10.30			9.74	

Also, data presented in Table 3 indicated that after four months from harvesting paclobutrazol at any concentration for the two cvs, in addition to uniconazole at 2000 ppm only for Spunta cv in both seasons caused a significant improvement in the percentage of marketable potato seed tubers. It was noticed also that percentage of decayed tubers due to infestation with potato tuber moth as well as percentage of sprouted tubers was decreased by using paclobutrazol at 1000 and 2000 ppm which reflected a significant increasing in storage ability of potato seed tubers especially with Nicola cv.

Anatomical studies :

Both paclobutrazol and uniconazole at 2000 ppm concentration were chosen for the anatomical investigation in the two cultivars as it gave the most distinguishable morphological results. Counts and measurements (μ) of tissues of airial stem are given in Table 4 an Figs. 1 and 2.

Results indicated that, in Nicola cv., paclobutrazol or uniconazole treatments at 2000 ppm increased stem diameter, being 7360 and 6890 μ, respectively, as compared with control (5840 μ). Epidermis was thicker with both treatments, being 24 and 22μ, than the control (20μ). Cortex thickness showed appreciated amounts of increments as they were, 940μ in paclobutrazol, 870μ in uniconazole, while it was 800μ in control. These increments were accompanied by an increase in number of cortical layers from 10 in control to 12 in both treatments.

Another increased was obtained in thickness of vascular cylinder that amounted from 1000μ in control plants to 1560 and 1400μ for paclobutrazol and uniconazole, respectively. Pith diameter in both treatments was also increased as compared with control, as it was 2360μ with paclobetrazol and 2300μ with uniconazole, while it was 2160μ in control.

F1

F 2

In Spunta cv, using 2000 ppm paclobutrazol and uniconazole increased stem diameter as compared with the control, being; 6990, 6288 and 5445µ, respectively. This was accompanied by increaments in thickness of cortex, vascular cylinder and pith diameter, being 882, 1550 and 2100µ with paclobutrazol and 800, 1300 and 2000µ with uniconazole compared with 751, 1030 and 1900µ in untreated plants, respectively.

Histological measurements of different leaflet blade tissues of the untreated and treated plants (2000 ppm paclobutrazol and uniconazole) are presented in Table 5 and Figs. 3 and 4.

Results indicated that treatments of 2000 ppm. paclobutazol and uniconazole for Nicola cv. generally gave thicker lamina comparing with the control, being 410, 392 and 380µ, respectively. Thicker palisade and spongy tissues were also observed with the same treatments. The corresponding increased amounts were, 250 and 120µ with paclobutrazol and 238 and 112µ with uniconazole, respectively, compard with 230 and 110µ for the control. The midrib thickness was also increased, being 1600 and 1500µ for paclobutrazol and uniconazole, respectively, while it was 1300µ for the control. Length and width of leaflet vascular bundle showed increments to be 1120 and 490µ for 2000 ppm paclobutrazol and from 940 and 470µ for uniconazole treatments instead of compared to 850 and 400µ which were recorded in the untreated plants.

In Spunta cv., using 2000 ppm paclobutrazol or uniconazole increased lamina thickness than the control, being 450, 416 and 390µ for the three treatments, respectively. This was accompined by increments in thickness of palisade and spongy tissues, being 262 and 138µ for paclobutrazol and 256 and 126µ for uniconazole compared with 235 and 121µ for the untreated plants, respectively. The thickness was 1565 and 1490µ in paclobutrazol and uniconazole respectively, while it was 1294µ in the control. Length and width of leaflet vascular bundle also increased; being 800 and 451µ by using 2000 ppm paclobutrazol, 850 and 455µ by using uniconazole and 600 and 391µ in the untreated plants.

It is obvious from Table 6 and Figurs 5 and 6 that 2000 ppm of paclobutrazol or uniconezole extremely altered the structure of outer cortex of tuber of the two cultivars under investigation.

Relative to the control, the outer cortex showed a distinctive decrease in thickness. This decrease accompanied by remarkable decrease in number of cell layers shared in periderm as well as decreased cell size. In Nicola cv., total periderm thicknesses were 375, 360 and 340µ for control, paclobutrazole and uniconazole (2000 ppm), respectively. The corresponding outer thickness values for "Spunta" cv. were 400, 350 and 330µ for the same treatments in the same order.

Data presented in Table 6 proved that, in Nicola cv, the anounced increases in cork thickness were 210, 185 and 125µ with paclobutrazole and unconazole compared with control, respectively. In Sponta cv, the same trend was observed, since these thicknesses were 180, 162 and 110µ with same order.The number of cork layers were greatly increased by both treatments.

T4.5.6

F3

f4

These thicknesses were 150, 135 and 250µ in Nicola cv and 170, 168 and 300µ in Spunta cv .

DISCUSSION

The foregoing results showed a retardation effect of paclobutrazol and uniconazole on plant height, haulm fresh weight and the number of branches/plant in the to cultivars in both seasons. The retardation effect in these characters increased with increasing the concentration of both triazole compounds.

Furthermore, at each concentration, uniconazole showed a high retardation effect on vegetative growth in the two cultivars in both seasons (Table 1). These results confirm those obtained by using paclobutrazol (Khurana and Mclareh, 1983; Balamani and Poovaiah, 1985; Deng and Pronge, 1988; El-Sayed and Shehata, 1996b) and using uniconazole by Wang and Gregg, 1990. Also the inhibiton effect of the two triazole compounds on the vegetative growth was previously recorded on many vegetable crops, e.g. strawberry (Stang and Wies, 1984 and McArthur and Eaton, 1987), Pepper (Aloni and Pashkar, 1987), onion (El-Sayed *et al*., 1989), tomato (Wang and Gregg, 1990), snap bean (El-Sayed, 1991), artichoke (El-Sayed and Shehata, 1996a) and okra (El-Sgai and El-Syed, 1999). The primary mode by which triazoles reduce shoot elongation in generally considered to be by inhibition of gibberellin biosynthesis (Hedden and Graebe, 1985).

A significant increase in the chlorophyll content in leaves was recorded with increasing uniconazle or paclobutrazol doses especially with Spunta cv in the two seasons (Table 1). An increase in chlorophyll content per unit leaf area was, likewise, recorded after treating potato plants with paclobutrazol under greenhouse conditions (Balamani and Poovaiah, 1985). Similar results were noticed after treating plants of strawberry with paclobutrazol (Sankhla *et al*, 1985**)** and potato plants with paclobutrazol or uniconazole (El-Sayed and Shehata, 1996b). In the same trend, a significant increase in the plant productivity (number and fresh weight of tubers/plant) as well as total yield of potato seed tubers/feddan occurred following the application of either uniconazole at any doses or paclobutrazol at 1000 or 2000 ppm for the two cultivars in both seasons (Table 2). Similarly, an increase in potato yield was recorded after using paclobutrazol under greenhouse conditions by Balamani and Poovaiah (1985**)**.

In another study, Kapur and Upadhya (1991**)** reported that treating sprouted seed tubes with uniconazole (1 ppm) yielded 21.4 t/ha., as compared with 16.3 t/ha., for he control.

On the other hand, an increase in Okra yield was recorded by El-Sgai and El-Sayed (1999**)** after using triazol compounds. As shown in Table 2 dry matter percentage in tubers was significantly increased by using uniconazole or paclobutrazol at 1000 or 2000 ppm in the two cultivars in both seasons.

F5

F6

Concerning storage ability, data in Table 3 indicated that paclobutrazol at any concentration in the two cultivars, in addition to uniconazole at 2000 ppm especially with Spunta cv in both seasons caused a significant improvement in the percentage of marketable potato seed tubers after four months harvesting. Also, it was noticed that paclobutrazol was more superior than uniconazole in decreasing percentage of decayed tubers due to infestation with potato tuber moth as well as percentage of sprouted tubers after four months from harvesting under room conditions. These results, may be, due to significant increase in the thickness of tuber cork that occurred after treated potato plants with the two triazole compounds. These results confirm those obtained by El-Sgai an El-Sayed (1999**)** who found that, spraying okra plants with paclobutrazol or uniconazole caused increase in thickness of the epidermis and cortex as compared with the control plants.

Finally, data in this investigation indicated that in Egypt under summer season conditions, the foliar application of growth retardants could be used to increase the storage ability of potato seed tubers and controlling potato tuber moth. It is known that this season (summer) in Egypt is characterized with a short photoperiod and low temperature from planting date until tuber initiation and a long photoperiod and high temperature until the maturity of tubers especially in late planting. The effect of triazoles on yielding ability of potato plants depends on the compound and concentrations used.

Generally, the present results indicated that using paclobutrazol or uniconazole at 2000 ppm led to increase in the plant productivity of potato and the total seed tubers/fed. This increment was due to increasing photosynthesis activity and the carbohydrate synthesis resulting from increasing chlorophyll contents per unit leaf area. All these activities direct the built assimilates to produce and enlarge new tubers by storing the carbohydrates and increasing by the dry matter of tubers, instead of consumption of the assimilates in the haulm enlargement. The previous studies revealed that growth retardants led to a reduction in shoot respiratory activity (Steffens and Wang, 1984) and an increase in photosynthetic activity of potato shoots during tuber formation (Ashour and El-Fouly, 1969). This may be responsible for increasing dry matter accumulation after using the triazole compounds.

Results and photomicrographs of anatomical studies reveald that using paclobutrazol and uniconazole at 2000 ppm for Nicola and Spunta cultivas had a stimulative effect in all measurements for airial stem, compared with the control. The increase in cortex thickness was due to the increase in number of cortical layers (20%) in both triazols for Nicola cv. and paclobutrazol (30%) and uniconazole (20%) for Spunta cv . The major increment, over the control was in the vascular cylinder thickness due to the increase in number and diameter of vessels; 56 and 40% for Nicola cv and 50.49 and 26.21% for Spunta cv, respectively. The wider vascular tissue observed in treated plant was due to the increasing in thickness of phloem and xylem tissues. The cambil activity obviously stimulated since more xylem vessels were produced. Moreover, xylem vessels had wider cavities which amounted to more total active conducting area to cope with vigorous growth resulting from the tested treatment. An increase was observed also, in pith diameter by using both

triazols as it was 9.26 and 6.48% for Nicola cv and 10.53 and 5.26% for Spunta cv, in the same order.

Treatment of 2000 ppm paclobutrazol gave slight higher increments than that of uniconazole, specially thickness of vascular cylinder (56 and 50.49% in paclobutrazol and 40 and 26.21% in uniconazole). Wang and Dunlap (1994) reported that the thicker vascular and cortical tissues than the untreated plants were observed in hibiscus by using uniconazole treatment. Also El-Sgai and El-Sayed (1999**)** found that spraying okra plants with paclobutrazol or uniconazole caused considerable thickness of stem internode diameter due to the increase in thickness of the epidermis, cortex, vascular cylinder and number of cortical layers.

Anatomical features of both leaflets and airial stem give a good horizon for defeuse against moth attach as the increase occurred in mesophyll layer of leaflet. Also, the increase in collenchyma layer benath to stem epiderm showed more mechanical resistance for such pest.

Concerning the leaflet anatomy, the same trend of the airial stem was apparent as both treatments of 2000 ppm paclobutrazol or uniconazole for the two cultivars, where thus increased all measurements than the control. In Nicola cv., the increments of palisade and spongy tissues were 8.70 and 9.09% with paclobutrazola and 3.48 and 1.82% with uniconazole, while in Spunta these increaments were 11.49 and 14.05% with paclobutrazol and 8.94 and 4.13% with uniconazole. The previous increments increased blade thickness by 7.89 and 15.38% with paclobutrazol and 3.16 and 5.32 with uniconazole in cvs Nicola and Spunta, respectively.

Due to the increase in aerial stem diameter with the two treatments, the thickness of midrib, length and width of bundle were higher than the control by 23.08, 31.76 and 22.50% with paclobutrazol and 15.38, 10.59 and 17.5% with uniconazole for Nicola cv. and 20.94, 33.3 and 15.64% with paclobutrazol and 15.15, 41.67 and 15.37% with uniconazole for Spunta cv.

It is obvious that paclobutrazol treatment give more significant results than uniconazole especially in thickness of blade, palisade and spongy tissues, while uniconazole was more significant than paclobutrazol in the measurements of midrib and bundle. This matching with the high increase in airial stem thickness caused by paclobutrazol treatment. El-Sgai and El-Sayed (1999) disclosed that both triazole treatments have a simulated effect on the thickness of lamina and midrib comparing with the control. The anatomical features of tuber outer cortex revealed and support the morphological data mentioned and support the morphological data mentioned before. Both studied cultivars; Nicola and Spunta showed the same response to paclobutrazol and uniconazole treatments specially at 2000 ppm.

It is obvious that, in Nicola cv, tubers periderm tissue thickness was reduced by 4.0 and 9.3% with paclobutrazol and uniconazole treatments, respectively. The corresponding decrease percentages for "Spunta" were 12.5 and 11.25% with both triazoles, respectively. Although there was an decrease in periderm tissue thickness, it was an increase in cork layers thickness, with both triazole treatments comparing with control by 65 and 48% in Nicola cv., 63.64 and 47.27% in Spunta cv.

The above mentioned results may be have an economical value as the increase in cork layer may give a mechanical defense for potato tuber against moth attacks.

REFERENCES

Aloni, B. and T. Pashkar, 1987. Antagonistic effects of paclobutrazol and gibberellic acid on growth and some biochemical characteristics of pepper (*Capsicum annum*) transplants. Scientia Hort., 33: 167-177.

Ashour, N.I. and M.M. El-Fouly 1969. Effect of (2-chloroethyl) trimethyl chloride (CCC) on photosynthetic pigments of cotton leaves. Acta Bot. Sci. Hung. Tomus 15:211-216.

Balamani, V. and B.W. Poovaiah 1985. Retardation of shoot growth and promotion of tuber growth of potato plants by paclobutrazol. Amer. Potato. J. 62: 363-369.

Deng, R. and R.K. Prange 1988. Effects of paclobutrazol (PP333) on ^{14}C-assimilate patitioning in potato (*Solanum tuberosum* L.). Hort. Science 23:811 (Abstract).

El-Sayed, S.F 1991. Growth and yield of snap beans under cold conditions as affected by growth regulators and pinolene. Sci. Hort., 47:193-200.

El-Sayed, S.F. and S.A. Shehata 1996a. Yield and yield component of globe artichoke (*Cynara scolymus* L.) as affected by plant density and spraying with two triazole compounds. J. Agric. Res. Tanta Univ., 22:166-178.

El-Sayed, S.F. and S.A. Shehata 1996b. A comparison between two triazole compounds and chlormequate chloride (CCC) on growth, yield and storage ability of potato seed tubers. Zagazig J. Agric. Res. 23:269-278.

El-Sayed S.F.; S.A. Shehata and E.A. Abou El-Hassan 1989. Seed production of onion (*Allium cepa* L.) as affected by application of some growth regulators and zinc. Bull. Fac. Agric. Univ. Cairo 40:595-604.

El-Sgai, M.U. and S.F. El-Sayed 1999. Effect of two triazole compounds on growth, fruiting and plant anatomy of Okra. Egypt. J. Appl. Sci., 14(7) 387-402.

Hedden, P. and J.E. Graebe 1985. Inhibition of gibberellin biosynthesis by paclobutrazol in cell-free-homogenate of *Cucurbita maxima* endosperm and Malus punile embryos. J. Plant Growth Regul. 4:111-122.

Huang, H.; W.S. Yin and C.F. Zheng 1989. The effect of paclobutrazol on watermelon growth. Sci. Hort., 39:9-14.

Kapur, K.K., Suman and M.D. Upadhya 1991. Effect of growth retardants on yield and tuber quality of potato. Amer. Potato. J. 68:619-620 (Abstract).

Khurana, S.C. and J.S. McLaren 1983. Some effects of the growth regulator, PP 333, on the growth and yield of potatoes in the field. J. Indian Potato Association 10:95-103.

McArthur, D.A.J. and G.W. Eaton 1987. Effect of fertilizer, paclobutrazol and chlormequat on strawberry. J. Soc. Hort. Sci. 112:241-246.

Sankhla, N.; P. Tcnutti and T. Tosi 1985. The effect of paclobutrazol on strawberry growth and fruiting. J. Hort. Sci. 60:501-506.

Stang, E.J. and G.G. Wies 1984. Influence of paclobutrazol plant growth regulators on strawberry plant growth, fruiting and runner suppression. Hort. Sci. 19:643-645.

Steel, K.G.D. and J.H. Torrie 1960. Principles and procedure of statistics. McGaw Hill New York, Toronto, London. Pp 481.

Steffens, G.L. and S.Y. Wang 1984. Physiological changes induced by paclobutrazol (PP333) in apple. Acta Hort. Sci. 19: 643-645.

Wang, S.Y., J.K. Byun and G.L. Steffens 1985. Controlling plant growth via the gibberellin biosynthesis system. II. Biochemical and physiological alterations in apple seedlings. Physiol. Plant 63:169-175.

Wang, Y.T. and J.R. Dunlap 1994. Effect of GA_{4+7} on growth and cellular change in uniconazole treated hibiscus. J. of plant Growth Regulation. 13(1) 33-38.

Wang, Y.T. and L.I. Gregg 1990. Uniconazole control growth and yield of greenhouse tomato. Sci. Hort., 43:55-62.

Willey, R.L. 1971. Microtechniques, A laboratory Guide. Macmillan Publishing Co., Inc., New York. pp. 99.

Yadava,U.L.1986.A rapid and non-destructure method to determine chlorophyll in intact leaves. Hort. Sci., 21:1449-1450.[[

تـأثير بعـض مـؤخرات النمـو علـى قابليـة تخـزين الـدرنات والصـفات التشـريحية لنبـات البطاطس لمقاومة فراشة درنات البطاطس

أحمد على غريب*، محمد محمد شاهين*، محمد أسامة السجاعى**

*** قسم الخضر – كلية الزراعة – جامعة القاهرة - جيزة**

**** قسم النبات الزراعى – كلية الزراعة – جامعة القاهرة - جيزة**

أجريت تجربة حقلية لمدة موسمين متتالين (٢٠٠٢، ٢٠٠٣) لدراسة تأثير المعاملة بمركبين من التريازول وهما البالكوبيوترازول واليونيكونازول على النمو والمحصول والقدرة التخزينية لدرنات البطاطس صنفى نيفولا وإسبونتا وذلك لمقاومة فراشة درنات البطاطس بالإضافة إلى إجراء الدراسة التشريحية لتأكيد البيانات المورفولوجية. ولقد رشت النباتات مرتين بتركيزات ٥٠٠، ١٠٠٠، ٢٠٠٠ جزء فى المليون من أى من مركبى التريازول السابق ذكرهما وذلك بعد ٦٠، ٧٠ يوم من الزراعة فى العروه الصيفية وكانت أهم النتائج انخفاض طول النبات والوزن الطازج للنبات وكذلك عدد الأفرع للنبات مع زيادة التركيزات المستعملة، حدثت زيادة معنوية فى محتوى أوراق الصنف إسبونتا من الكلورفيل نتيجة رش نباتات البطاطس باليونيكونازول بتركيز ٢٠٠٠ جزء/مليون. أيضا أدت معاملة النباتات بأى من مركبى التريازول عند تركيز ١٠٠٠ أو ٢٠٠٠ جزء/مليون إلى حدوث زيادة معنوية فى محصول النبات الواحد سواء من ناحية عدد أو وزن الدرنات/النبات (بعد ٣ أسابيع من الرشة الثانية) وكذلك زادت نسبة المادة الجافة فى الدرنات عند الحصاد كما أدت هذه المعاملات أيضا إلى زيادة المحصول الكلى للفدان من الدرنات. كما لوحظ أن رش نباتات البطاطس بمركب البالكوبيوترازول بتركيز ٢٠٠٠ جزء/مليون أدى إلى تحسين القدرة التخزينية للدرنات بصورة معنوية خصوصاً مع الصنف نيفولا. وعموماً فإن البالكوبيوترازول كان أكثر تفوقاً عن اليونيكونازول فى تقليل نسبة الدرنات المصابة بفراشة درنات البطاطس وكذلك تقليل نسبة الدرنات المزرعة وذلك بعد تخزينها لمدة ٤ أشهر من الحصاد تحت ظروف الغرفة العادية وربما يرجع السبب فى ذلك إلى الزيادة الملحوظة فى سمك قشرة الدرنات نتيجة لزيادة طبقة الفلين والتى أحدثتها المعاملة بهذه المركبات.

أتضح من الدراسة التشريحية أن رش نباتات البطاطس بالباكلوبيوترازول أو اليونيكونازول بتركيز ٢٠٠٠ جزء فى المليون سبب زيادة ملحوظة فى سمك قطر سلاميات السيقان الهوائية وذلك نتيجة لزيادة سمك البشرة والقشرة والأسطوانة الوعائية والنخاع وزيادة عدد خلايا القشرة. كما أدت هذه المعاملة إلى زيادة سمك نصل الورقة والعرق الوسطى مقارنة بالكنترول ويجرع ذلك لزيادة سمك الميزوفيل وحجم الحزمة الوعائية. أيضا أدت نفس المعاملة إلى زيادة سمك طبقة الفلين فى درنات البطاطس مقارنة بالكنترول مما قد يؤدى إلى زيادة حماية الدرنات من الإصابة بفراشة درنات البطاطس وتقليل نسبة الدرنات المصابة والتالفة خلال فترة تخزين التقاوى.

Table 4: Counts and measurements (μ) of certain histological features in transverse sections through the middle part of the internode of airial stem of potato plant "Nicola and Spunta cultivars as effected by paclobutrazol and uniconazole (2000 ppm).

Cultivars / Characters	Nicola			Spunta		
	Control	Paclobutezol 2000 ppm	Uniconazole 2000 ppm	Control	Paclobutezol 2000 ppm	Uniconazole 2000 ppm
Diameter of stem	5840	7360	6890	5445	6990	6288
Thickness of epidermis	20	24	22	20	25	23
Thickness of cortex	800	940	870	751	882	800
No. of cortical layers	10	12	12	10	13	12
Thickness of vascular cylinder	1000	1560	1400	1030	1550	1300
Diameter of pith	2160	2260	2300	1900	2100	2000

Table 5: Measurements (μ) of certain histological features in transverse sections through leaf blade on airial stem of potato plants "Nicola and Spunta cultivars" as affected by paclobutrozal and uniconazole (2000 ppm).

Cultivars / Characters	Nicola			Spunta		
	Control	Paclobutezol 2000 ppm	Uniconazole 2000 ppm	Control	Paclobutezol 2000 ppm	Uniconazole 2000 ppm
Thickness of lamina	380	410	392	390	450	416
Thickness of palisade tissue	230	250	238	235	262	256
Thickness of spongy tissue	110	120	112	121	138	126
Thickness of midrib	1300	1600	1500	1294	1565	1490
Dimensions of midrib Length	850	1120	940	600	800	850
Width	400	490	470	391	451	455

Table 6: Counts and measurements (μ) of certain histological featuses in tranverse sections through tuber of potato plant (Nicola and Spunta cvs.) as affected by paclobutrazol and uniconazole (2000 ppm).

Cultivars / Characters	Nicola			Spunta		
	Control	Paclobutezol 2000 ppm	Uniconazole 2000 ppm	Control	Paclobutezol 2000 ppm	Uniconazole 2000 ppm
Periderm thickness	375	360	340	400	350	330
Cork thickness	125	210	185	110	180	162
No. of cork layers	8	14	11	8	12	10
Phelloderm thickness	250	150	135	300	170	168