

GROWTH CONTROL IN CUCUMBER SEEDLINGS BY GROWTH REGULATORS APPLICATION

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Abstract

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An investigation was carried out with paclobutrazol (Bonzi), daminozide (B-Nine) and chlormequat chloride (Cycocel) in order to study their effect on control of elongation in cucumber seedlings. The seeds of cucumber cv. 'Maraton F₁' were soaked into 500 and 1000 mg/L solutions of paclobutrazol, and 7500 and 15000 mg/L solutions of daminozide and chlormequat chloride, each for 12 and 24 hours. After soaking the seeds were sown into peat medium in which the plants were grown for 20 days in a greenhouse. Measurements of height and quality of seedlings were measured from control and treated seedlings. Paclobutrazol applications were effective on seedling height, whereas daminozide and chlormequat chloride had lower inhibition. Both concentrations of paclobutrazol caused shortening in hypocotyl and epycotyl lengths. The transplant heights were reduced as 63.4% at 500 mg/L and 74.9% at 1000 mg/L. The application of paclobutrazol for 24 h showed effective seedling height control than that of 12 h. Paclobutrazol applications had no significant effect on stem diameter, however, decreased the leaf area and dry weight of both leaves and stems. Applying daminozide and chlormequat chloride to seeds for 12 h was ineffective on plant height, while 24 h applications of 15000 mg/L daminozide and chlormequat chloride reduced the plant height.

Key words: cucumber, height control, paclobutrazol, daminozide, chlormequat chloride

Introduction

In the integrated plant growing growth regulators are widely applied for seed soaking. In case of vegetables, growth regulators are used mainly to improve seed germination power, increase yield, plants become resistant to diseases and unfavorable growth conditions (Kadiri et al., 1997; Saglam et al., 2002; Halter et al., 2005; Jankauskienė and Survilienė 2009; Mukhtar 2008; Turan et al., 2009).

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The control of seedling heights is a main problem in the greenhouses in which large-scale vegetable seedling production is carried out. The problem of elongation and quality losses in vegetable seedlings occur under high temperature and humidity with low light intensity in winter and spring periods or high temperature during summer period. Inhibition of seedling elongation and improved plant quality are possible in case of strict control of environmental conditions or application of growth regulators (Cutler and Sch-

neider 1990)

The effectiveness of plant growth regulators by reducing longitudinal shoot growth and improving functional and qualitative aspects of several plants is well known. The growth retardants used commercially to inhibit transplant heights are B-Nine, Cycocel, Bonzi, A-Rest, and Sumagic, which are applied for seed soaking, inflorescences spraying, shoot and plant watering or spraying through leaves. The plant growth regulating properties of these compounds are mediated by their ability to alter the balance of important plant hormones including gibberellic acid, ABA and cytokinins. They also inhibit gibberellin and ergosterol biosynthesis in plants and fungi, respectively (Cutler and Schneider, 1990; Rademacher, 2000; Mander, 2003; Boehme et al., 2005; Abdul Jaleel et al., 2007; Kishorekumar et al., 2007; Martinez et al., 2007; Banon et al., 2009). However, high concentrations of these substances applied by spraying to young seedling result in chlorosis and delay in growth and development, besides with an important environmental pollution problem.

There is little information available so far about the effects of growth regulators that are generally used as foliar application in cucumber seedlings. The objective of this study is to ascertain the effect of soaking seeds into paclobutrazol, daminozide, and chlormequat chloride solutions on growth and plant properties of cucumber seedlings, with specific emphasis on shoot height.

Material and Methods

Plant Material and Experimental Conditions

The seeds of partenocarp cucumber (*Cucumis sativus* L.) cv. Maraton F₁ were obtained from BIAR Seed Company, Istanbul, Turkey. The growth retardants paclobutrazol (Bonzi) and daminozide (B-Nine) were obtained from UNIROYAL Chemical Comp. Inc., Connecticut, USA and chlormequat chloride (Cycocel) was obtained from Olympic Horticultural Products

Co., Pennsylvania, USA. The plants were grown in a greenhouse (1000 m² area, 2.5 m height at the side and 3.5 m at the centre) located in Gorukle Campus, Uludag University, Bursa, Turkey. The temperature and relative humidity were recorded by a TESTO 175-T3 Data Logger. During the study, the temperature was 23±8°C, relative humidity (RH) varied between 65-80% and light intensity was 3500-7500 lux.

Cucumber seeds were soaked in distilled water (control) and in the solutions of growth regulators: 500 and 1000 mg/L paclobutrazol solutions and 7500 and 15000 mg/L daminozide and chlormequat chloride solutions, each for 12 and 24 h. At the end of these periods, seeds were sown into peat medium in 45 celled transplant trays. The transplant trays were watered daily and the soil was fertilized in order to ensure healthy growth of the seedlings.

Growth and Plant Analysis

20 days after the sowing linear dimensions of hypocotyl and epycotyl of length (mm) and diameter (mm) were measured using a vernier caliper (MITUTOYO 530-105 6", MITUTOYO Measuring Tools, USA). The leaf area (cm²) was measured with the aid of a KOIZUMI Placom KP-90N digital planimeter. Leaf and stem dry weights (mg) were determined after drying for 72 h at 70°C. The Hunter *L* (color lightness), *a* (position on the green-red axis) and *b* (position on the blue-yellow axis) values of leaf were read using a KONICA MINOLTA CR-300 colorimeter. A negative *a* value indicates a greenish hue while a positive *a* means reddish/magenta. On the *b* axis, negative values stand for blue and positive for yellow. A value of 0 for *L* is equivalent to black and *L* = 100 describe white.

Statistical Analysis of Data

The experiment was conducted by randomized plots design (RBD) with 3 replicates of 15 plants. Statistical analysis was performed using two-way ANOVA followed by Duncan's multiple range

test (DMRT). A significance level of $P < 5\%$ was accepted. In figures the least statistical difference (LSD 5%) was calculated to indicate differences between treatments. All analyses were performed using the Minitab for Windows (Ver. 14) Statistical Software Package (Minitab Inc., State College, PA, USA).

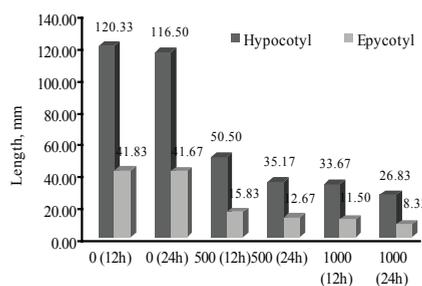
Results and Discussion

A significant height reduction in both hypocotyl and epicotyl over untreated control seedlings was apparent with 12 and 24 hours of treatment at all dosages of paclobutrazol.

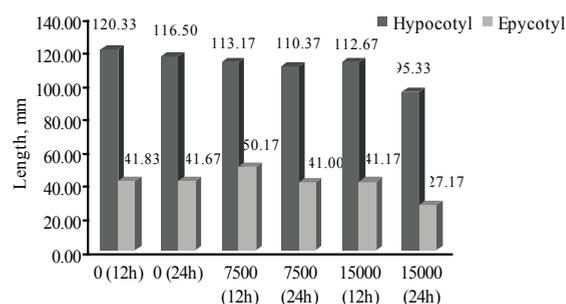
The degree of height control was generally greater the higher application rate of paclobutra-

zol. The inhibition ratio of height in seedlings was 63.4% with 500 mg/L paclobutrazol concentration and 74.9% with 1000 mg/L. However, under the conditions of present work the effects of daminozide and chlormequat chloride treatments were not that significant as paclobutrazol (Figure 1).

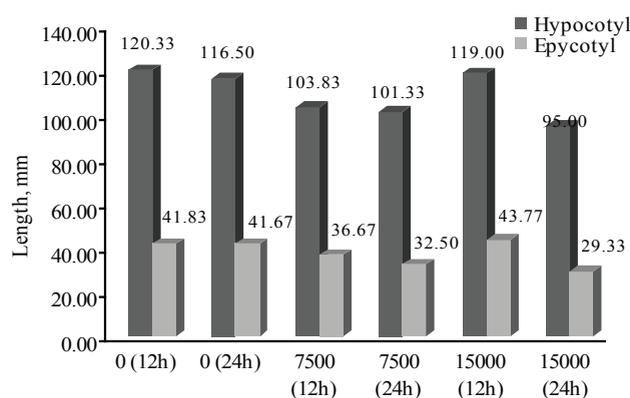
There was no significant loss in hypocotyl diameters between paclobutrazol treated and untreated seedlings, however, paclobutrazol treatment decreased epicotyl diameters, leaf area, leaf and stem dry weights when compared to control. Soaking seedlings in 1000 mg/L paclobutrazol for 24 hours resulted in highest reduction in all four parameters (Table 1). Pasian (2000) applied paclobutrazol to tomato seeds, reported that the height control in plants was dependent on treat-



(a) Paclobutrazol, mg/L



(b) Daminozide, mg/L



(c) Chlormequat chloride, mg/L

Fig. 1. The effect of growth retardants applications [a) paclobutrazol, b) daminozide and c) chlormequat chloride] on the hypocotyl and epicotyl lengths of cucumber seedlings

ment period and concentration.

Paclobutrazol has proved as a plant growth retardant in many of the previous works counteracting gibberellin or cytokinin biosynthesis (Hunter et al., 1992; Asao et al., 1996; Xu et al., 1998; Berova and Zlatev, 2000; Fletcher et al., 2000; Nie et al., 2001; Sebastian et al., 2002). It has been reported that paclobutrazol treated barley seedlings (Sarkar et al., 2004) and tomato (Still and Pill, 2004) retained two times more chlorophyll than control. Tekalign et al. (2005) stated that paclobutrazol treated leaves were dark green due to high chlorophyll *a* and *b* in potato in accordance with the stimulation effect of paclobutrazol on cytokinin synthesis that enhances chloroplast differentiation, chlorophyll biosynthesis and prevents chlorophyll degradation. The present findings on color attributes (*L*, *a* and *b* values) of 1000 mg/L paclobutrazol treated seedlings were in accordance with these earlier findings.

Daminozide was used by most bedding plant

producers for height control of vegetable transplants for many years (Cantliffe, 2009). It is highly effective in controlling growth of seedlings in plug flats, and it is more effective in cooler climates. The use of daminozide is restricted to non-food crops due to toxicological concerns (dermal and carcinogenicity). Therefore, the producers are seeking viable alternatives to the use of daminozide such as moisture stress, Prohexadione Calcium (Pro-Ca) (Brown et al., 1992; Ilias and Rajapakse, 2005; Ergun, 2007; Kahar, 2008; Mukhtar, 2008; Palonen et al., 2009). Kim et al. (2010) reported that Pro-Ca suppressed the plant length up to 30.7% while daminozide inhibited up to 27.12% at optimum concentration in *Chrysanthemum morifolium* R. cv Monalisa White. Karlovic et al. (2004) applied different concentrations of daminozide and chlormequat chloride and concluded that daminozide is more effective as a growth retardant.

In present study, the hypocotyl diameters were affected by neither by concentration nor period of

Table 1

The effect of paclobutrazol applications on the elongation and quality criteria in cucumber seedlings

Concentration, mg/L	Time, h	Diameter of hypocotyl, mm	Diameter of epycotyl, mm	Leaf area, cm ²	Leaf dry weight, mg	Stem dry weight, mg	Leaf color		
							<i>L</i>	<i>a</i>	<i>b</i>
0	12	3.83	3.13aA	50.34aB	87.81aB	115.12aB	29.19aA	-9.38cB	10.57aA
	24	3.9	3.31aA	50.90aA	91.38aA	117.29aA	28.29aB	-8.87cA	9.82aB
500	12	3.8	3.01aA	37.45bA	44.20cB	49.60cB	24.82bB	-7.13bA	7.53bA
	24	3.99	2.99bA	29.97bB	53.83bA	58.17bA	25.32bA	-7.10bA	7.58bA
1 000	12	3.73	3.09aA	31.18cA	75.60bA	69.34bA	24.88bB	-5.70aA	6.33cB
	24	3.78	2.84bB	24.79cB	52.91cB	43.55cB	25.62bA	-6.56aB	7.09cA

a,b For each treatment, within a column, different lowercase superscripts denote significant differences ($P < 0.01$) between different applied concentration A,B Within a column, different superscript capital letters denote significant differences ($P < 0.01$) between different treatment time

Table 2
The effect of daminozide applications on the elongation and quality criteria in cucumber seedlings

Concentration, mg/L	Time, h	Diameter of hypocotyl, mm	Diameter of epycotyl, mm	Leaf area, cm ²	Leaf dry weight, mg	Stem dry weight, mg	Leaf color		
							<i>L</i>	<i>a</i>	<i>b</i>
0	12	3.83	3.13bB	50.38bB	90.81bB	115.12bB	29.19cA	-9.38aB	10.57bA
	24	3.9	3.31aA	50.97aA	91.38aA	117.29bA	28.29cB	-8.87bA	9.82bB
7 500	12	3.91	3.40aA	52.78aA	101.61aA	128.90aB	31.05aB	-10.26bA	12.01aA
	24	3.96	3.22aB	42.38bB	87.56bB	134.03aA	31.83aA	-10.29cA	12.06aA
15 000	12	3.87	3.12bB	48.51cA	70.41cA	113.94cA	30.32bA	-9.28aB	10.56bA
	24	3.98	3.30aA	37.73cB	69.10cB	103.17cB	29.30bB	-8.14aA	9.07cB

a,b For each treatment, within a column, different lowercase superscripts denote significant differences ($P<0.01$) between different applied concentration A,B Within a column, different superscript capital letters denote significant differences ($P<0.01$) between different treatment time

Table 3
The effect of chlormequat chloride applications on the elongation and quality criteria in cucumber seedlings

Concentration, mg/L	Time, h	Diameter of hypocotyl, mm	Diameter of epycotyl, mm	Leaf area, cm ²	Leaf dry weight, mg	Stem dry weight, mg	Leaf color		
							<i>L</i>	<i>a</i>	<i>b</i>
0	12	3.83	3.13bB	50.38bB	87.81bB	115.12cA	29.19bA	-9.38	10.57
	24	3.9	3.31aA	50.97aA	91.38bA	117.29bB	28.29bB	-8.87	9.82
7 500	12	3.94	3.32aA	50.88aA	92.13aB	120.90bB	28.45cA	-9.5	10.8
	24	3.8	3.31aA	45.87bB	96.04aA	125.92aA	27.35cB	-9.37	10.52
15 000	12	3.97	3.27aA	46.58cA	80.22cA	128.63aA	29.61aA	-9.48	11.19
	24	3.95	3.17bA	44.69cB	77.73cB	110.14cB	29.51aA	-9.36	10.58

a,b For each treatment, within a column, different lowercase superscripts denote significant differences ($P<0.01$) between different applied concentration A,B Within a column, different superscript capital letters denote significant differences ($P<0.01$) between different treatment time

daminozide treatments. However, epycotyl diameters, leaf area, leaf and stem dry weights and leaf color were significantly different with daminozide treatments; the effect of daminozide was significant at 7500 mg/L than control and 15000 mg/L on these parameters. Leaf area, which was 50.97 cm² in control plants, was reduced to 37.73 cm² with 15000 mg/L treatment after 24 h soaking. Mean leaf dry weight declined to 69.77 mg from 89.59 mg for the same treatment (Table 2).

The growth retardant chlormequat chloride, applied as soaking the cucumber seeds in, was effective in reducing the leaf area of the plants, epicotyl diameters and leaf and stem dry weights, whereas was not effective on hypocotyl diameters and leaf color *a* and *b* values (Table 3.). Leaf area, which was 50.67 cm² in average in control plants, reduced to 46.63 cm² with 15 000 mg/L treatment. The results obtained from chlormequat chloride treatments were similar to daminozide activity; however had no comparable effect as paclobutrazol applications. In certain crops, the use of chlormequat chloride with daminozide or ethephon (at reduced rates) is proposed in order to provide better height control and reduction in the potential for phytotoxicity/chlorosis (Passam et al., 1983; McKee and Morris, 1986; Koutri, 2005; Smith et al., 2008).

Conclusion

The growth retardant, paclobutrazol, which is applied to cucumber seeds, significantly reduced length of the hypocotyl and epycotyl of cucumber seedlings. Reductions up to 74.9% were obtained in transplant heights. The height reduction in transplants increased with the increased concentrations (500 and 1000 mg/L) and prolonged soaking periods (12 and 24 hours). The activities of daminozide and chlormequat chloride were of no effect in comparison to paclobutrazol. The effects of these growth retardants were significant only after 24 h of soaking the seeds and at 15 000 mg/L concentrations.

Growth retardants used in the study resulted in reductions in leaf area, leaf and stem dry weight. There was no significant effect on hypocotyl and epycotyl diameters. However, paclobutrazol treated seeds were dark green, possibly due to high chlorophyll *a* and *b* contents, in comparison to daminozide or chlormequat chloride treated seedling leaves.

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