

EFFECTS OF MEFLUIDIDE AND PACLOBUTRAZOL ON GROWTH AND QUALITY OF "TIFWAY" BERMUDAGRASS PLANTS

Abdel-Kader, H. H. and M. Y. A. Abdalla

Veget. and Flor. Dept., Fac. of Agric., Mansoura Univ.

ABSTRACT

"Tifway" hybrid bermudagrass [*Cynodon transvaalensis* Burtt-Davy x *C. dactylon* (L.) Pers.] is a popular turfgrass used in Egypt on a large scale. When this grass is managed as a medium- to high- quality turf, frequent mowings are needed to limit vegetative growth and seedhead emergence. Plant growth retardants offer the potential to reduce the number of mowings needed by turfgrasses and accordingly reduce the cost of turf maintenance. Therefore, a field experiment was conducted during spring of the two successive seasons of 2002 and 2003 to study the effects of two different growth retardants on growth and quality of "Tifway" bermudagrass under the Egyptian conditions. Three weeks after planting the turf plugs, the treated grasses received once either mefluidide at a rate of 14 mg/block (1x1m), paclobutrazol at a rate of 110 mg/block, or mefluidide plus paclobutrazol at the previously mentioned rates. Each treated block was sprayed individually with 5 liters distilled water containing the designated amount of growth retardants using a 5 liter semi-automated hand sprinkler. Control blocks (untreated grasses) were sprayed with distilled water only.

Measurements on grass height, coverage percentage, clipping weight, quality and color of the turfgrass were conducted at the end of 3, 6 and 9 weeks after application with the plant growth retardants in addition to shoot and root weight at the end of experiment to determine the effects of mefluidide and paclobutrazol on growth and quality of the used turfgrass.

The obtained results showed that three weeks after application, mefluidide alone provided fast suppressive effects on grass height and shoot growth, but reduced quality, color, and the coverage percentage. Paclobutrazol alone, on the other hand was more effective than mefluidide in suppressing height and reducing clipping dry weight with little effect on grass quality, color, and coverage percentage after six weeks from application. Mefluidide plus paclobutrazol treatment gave fast and best suppressive effect on grass height and shoot growth throughout the experiment. This treatment reduced quality and color of "Tifway" bermudagrass during the first three weeks after application, but grasses recovered their quality and color six weeks after application until the end of the experiment. The results also showed that the effects of both growth retardants were minimized after nine weeks of application. At the end of experiment, mefluidide alone produced the highest shoot and root dry weights and the highest root/shoot ratio among the three growth retardant treatments.

These results were obtained from using a single application, and future experiments are needed to study the effect of these growth retardants using multiple applications on a well established turfgrass stand.

INTRODUCTION

"Tifway" bermudagrass [*Cynodon transvaalensis* Burtt-Davy x *C. dactylon* (L.) Pers.] is a warm-season, aggressive, dark green turf hybrid with fine texture and high shoot density that does best in full sun and mowing height of ½ - ¾ inch. (Beard, 1983). It is used as recreational and landscape

turf in areas of moderate maintenance, such as fairways and sport fields and higher maintained lawns (Johnson, 1994).

The degree of management for this warm-season grasses depends on whether the turfgrass is maintained at a low, medium, or high quality level. Johnson (1992) and (1994) reported that when "Tifway" hybrid bermudagrass and common bermudagrass are managed as a medium-to high-quality turf, frequent mowings are needed to limit vegetative growth and seedhead emergence.

Nowadays, "Tifway" bermudagrass is used in Egypt on a large scale as a medium- to high quality turf. However, as water resources decline, drought stress becomes a major limiting factor in turf management in many parts of the world (Kenna and Horst, 1993). Mowing costs comprise a large part of the overall budget in maintaining a medium to high quality "Tifway" bermudagrass turf.

The utilization of plant growth retardants (PGRs) or inhibitors has become an accepted practices in some turfgrass management system (Beard, 1985; Kaufmann, 1986; Yan *et al.*, 1993) for their potential to reduce the cost of turf maintenance by suppressing shoot growth and thus reduce mowing frequency (Schott and Walter, 1991). Batten (1983) reported that the number of mowings was reduced up to 50% for 5 to 8 weeks after application of PGRs.

The use of PGRs is important especially on hazardous slopes (Batten, 1983), ditches and difficult to mow areas (Watschke *et al.*, 1992), and during periods of rapid growth (Kaufmann, 1985). Plant growth retardants (PGRs) were originally categorized as Type I or Type II compounds (Watschke *et al.*, 1992). A Type I PGR can inhibit or suppress the vegetative growth and seedhead development of susceptible grass species through the inhibiting of cell division and differentiation in meristematic regions while Type II PGRs suppress grass growth through the interference of gibberellin biosynthesis, thus reducing cell elongation and subsequent plant organ expansion.

Researches had shown that PGRs have activity in common (DiPaola *et al.*, 1985; Johnson, 1989, 1990a and 1992; Watschke and DiPaola 1995) and Tifway (Fagerness and Penner ,1998; Fagerness and Yelverton 2000; Johnson, 1989, 1990b, 1992 and 1994; Wiecko, 1997) bermudagrasses. Johnson (1992) and (1994) reported plant growth retardants had potential to inhibit vegetative growth and seedheads of "Tifway" bermudagrasses, and to reduce the number of required mowings..

Mefluidide is a Type I foliar absorbed PGR and paclobutrazol is Type II PGR that it is taken up by plant roots (Watschke *et al.*, 1992). Both could be used on low (roadsides, airports, hard-to-mow areas), medium (industrial grounds, parks, cemeteries, golf course roughs, home lawns) and high (putting greens, tees, fairways, high quality home lawns) maintenance areas of Bermudagrass.

The aim of this investigation was to study the effects of Type I (mefluidide) and Type II (paclobutrazol) growth retardants alone or in

combination on growth, development and quality of "Tifway" bermudagrass under the Egyptian conditions.

MATERIALS AND METHODS

The present research was conducted during spring (first of April) of the two successive seasons of 2002 and 2003 to study the effects of two different growth retardants on growth and development of "Tifway" bermudagrass. The experiment was carried out as follows:

Location: A commercial farm in El-Tahrir area, Behera Governorate, Egypt.

Soil: The texture of the soil was loamy sand (51.85% sand, 4.4% silt and 44.75% clay). The main analytical data of the soil were: pH (1 : 2.5 soil : water suspension) = 8.0 ; EC = 0.9 dSm⁻¹; CaCO₃ = 7.3 % and available nutrients (mg kg⁻¹): N = 12.9, P = 11.49, K = 93.5, Zn = 0.6, Mn = 1.4, Fe = 6.8 and Cu = 0.7. The soluble anions of the soil (meq / 100 g soil) were: HCO₃⁻ = 2.6, Cl⁻ = 2.01 and SO₄⁼ = 4.3. The soluble cations (meq / 100 g soil) were: Ca⁺⁺ = 4.1, Mg⁺⁺ = 1.7, Na⁺ = 2.37 and K⁺ = 0.56.

Analytical methods of soil were done as described by Jackson (1973), Page (1982) and Klute (1986). Zn and Fe were determined using diethylene triamine pentaacetic acid (DTPA)- extractable method as described by Lindsay and Norvell (1978), then measured by the atomic absorption spectrophotometer.

Studied grass: "Tifway" bermudagrass [*Cynodon transvaalensis* Burt-Davy x *C. dactylon* (L.) Pers.], Fam. Poaceae.

Studied plant growth retardants: Two plant growth retardants (PGRs) were used individually and in combination. The tested PGRs were mefluidide as a Type I foliar absorbed suppressor and paclobutrazol as a Type II roots absorbed suppressor.

Experimental design: Randomized Complete Block design with 5 replicates (blocks).

Preparation the experimental area for planting: Calcium super phosphate (15.5% P₂O₅) was added to the soil at a rate of 150 kg/fedd. during land preparation. The experimental area was tilled, leveled, and divided to 20 square blocks or replicates (1x1 m) with a 50 cm distance between blocks.

Planting: On the first of April in both seasons, small square plugs (5x5 cm.) of "Tifway" bermudagrass were planted in the blocks in a properly sized holes spaced at 20 cm. Each block contained 25 plugs, and after planting, plugs were rolled over and watered. During the initial establishment of plugs which continued for 3 weeks after planting, tips of all grasses were slightly cut when they turned yellow, and blocks were watered regularly.

Fertilization: Ammonium sulphate (50g) and potassium sulphate (10g) were added to each block at three weeks intervals starting from the planting date.

Water application: During the whole experiment, turfgrass was irrigated as needed using overhead sprinklers to maintain optimum growth (Johnson, 1994). Underground water was used to irrigate this experiment. The main analytical data of this water were: pH = 7.5; EC = 1.3 dSm⁻¹ ; P = 0.56 ppm; K = 0.4 ppm; Ca = 12.7 ppm and Mg = 5.3 ppm.

Application of plant growth retardants: Three weeks after planting (at the end of the initial establishment), grasses were cut to 2 cm above soil level, additional soil was added to level the soil between plugs; then grasses received the tested growth retardants once. There were four treatments; mefluidide, paclobutrazol, mefluidide plus paclobutrazol, and untreated control. Mefluidide at the rate of 14 mg/block was sprayed as Embark compound (28% mefluidide) early in the morning and blocks were watered late in the afternoon. Johnson and Murphy (1996) reported that mefluidide requires 8 hours rain-free period after application for optimum activity. Paclobutrazol at the rate of 110 mg/block was sprayed as TGR compound (50% paclobutrazol) late in the afternoon and blocks were watered immediately after application according to Johnson and Murphy (1996). The combination treatment (mefluidide plus paclobutrazol) was sprayed early in the morning with mefluidide (14 mg/block) and at the same day was sprayed with paclobutrazol (110 mg/block) late in the afternoon. After paclobutrazol application, plants were watered immediately as recommended. Each treated block was sprayed individually with 5 liters distilled water containing the designated amount of growth retardants using a 5 liter semi-automated hand sprinkler. Control blocks were sprayed with distilled water only.

Examined parameters: In order to study the effect of the tested plant growth retardants on "Tifway" bermudagrass, data on growth and quality of treated and untreated grass were collected after 3, 6 and 9 weeks from application with PGRs. After measurements, grasses were cut to 2 cm above soil level at each date. The following measurements were recorded:

* **Grass height:** Grass heights of Tifway were taken from soil surface to tip of leaves. Five grass height measurements were made within each block.

* **Percentage of suppression:** The differences in height between the treated and untreated grass were recorded as percent suppression compared with untreated grass.

* **Percentage of coverage:** The coverage of treated and untreated grass in percentage was measured using wooden frame (1x1 m) internally divided by wire to 100 small squares (10x10 cm). The frame was put on each block and the covering green area was calculated for each small square. The calculations for all small squares were added to each other to represent the total percentage of green area/block (Kaiser, 1981).

* **Turf quality:** The quality was estimated visually judged by three persons on a scale of 1 to 5 based on overall appearance and freedom of injury (1=dead, 2=poor, 3=good, 4=very good, and 5=excellent).

* **Turf color:** The color of the used grass was also rated visually using a color scale from 1 to 5 (1=brown, 2=yellow, 3=pale green, 4=green, and 5=dark green).

* **Clipping dry weight (g/m²):** After previous data were collected, grasses were cut to 2 cm above soil level. Clippings were dried in an oven at 70° C for 72 hours until constant weight and their dry weight in g/m² was recorded.

In addition, on the 9th week after application of PGRs (the end of the experiment), the following measurements were carried out:

* **Shoot and root dry weight (g/m^2):** The dry weight of the above ground parts and of the roots were recorded by taking three random plug samples from each block using metal plug 15 cm in diameter and 15 cm in depth. The soil was washed away, the roots and rhizomes were separated, dried in an oven at 70° C for 72 hours until constant weight, and their dry weight was recorded. The vegetative parts were dried and weight. Shoot dry weight was recalculated by adding the dry weight of clippings to the dry weight of the vegetative parts separated from the roots.

* **Root/shoot ratio:** This ratio was calculated using the root and shoot dry weight of treated and untreated grass.

Statistical analysis: All data were analyzed statistically using ANOVA to determine the significant magnitude of variability among various treatments using SAS computer software program (SAS Institute, 1985).

RESULTS AND DISCUSSION

Height suppression

Figure (1) and (2) represented the height suppression in percentage of "Tifway" bermudagrass 3, 6 and 9 weeks after application with PGRs in both seasons 2002 and 2003 respectively.

Three weeks after application, mefluidide alone resulted in 19.2 and 17% suppression, while paclobutrazol alone suppressed grass height by 15.6 and 14.9% in the first and second seasons respectively compared with the control. On the other hand, the combination of mefluidide plus paclobutrazol suppressed grass height by 21.9 and 22% in the first and second seasons respectively compared with the untreated grasses (control). Our results agreed with previous researches. Mefluidide and paclobutrazol were used to reduce number of mowings of common and Tifway bermudagrass (Johnson, 1990, 1992 and 1994). Mefluidide was commercially introduced in 1978 as a seedhead and foliar suppressant for use in rough turf areas (Elkins, 1983; Johnston and Faulkner, 1985). Penetration of leaf tissue occurs most readily at basal leaf sheaths and leaf axils where cell division and elongation occur. It may act to inhibit gibberillic acid (GA) biosynthesis and subsequent cell elongation and/or to inhibit cell division and meristematic activity of responsive plant areas that come into contact with this compound (Watschke *et al.*, 1992). However, Elkins (1983) emphasized that lower concentrations of mefluidide that inhibit cell elongation will not inhibit cell division. On the other hand, paclobutrazol was reported to reduce leaf and culm elongation of treated grasses since it acts to inhibit gibberillin biosynthesis by blocking the oxidation of kaurene to kaurenoic acid (Watschke *et al.*, 1992). The results showed that, three weeks after application, the combination of both mefluidide and paclobutrazol induced more height suppression than when each of them was used individually. Similarly, Johnson (1989) reported that the combination of paclobutrazol plus mefluidide provided good seedhead suppression of tall fescue.

Three weeks later, (six weeks after application), effect of mefluidide alone was decreased to 11 and 14% in the first and second seasons

respectively. To the contrary, the effect of paclobutrazol alone increased to reach 18.4 and 17.9% suppression in the same respective order. Johnson (1992) found that multiple applications of paclobutrazol suppressed vegetative growth of "Tifway" bermudagrass from 16 to 27% for 7 weeks after the initial treatment.

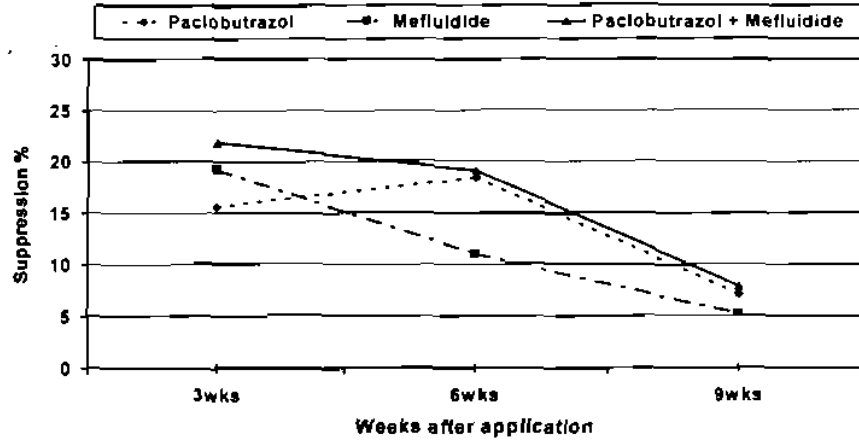


Fig. 1: Suppression effect of plant growth regulators on "Tifway" bermudagrass during the first season 2002.

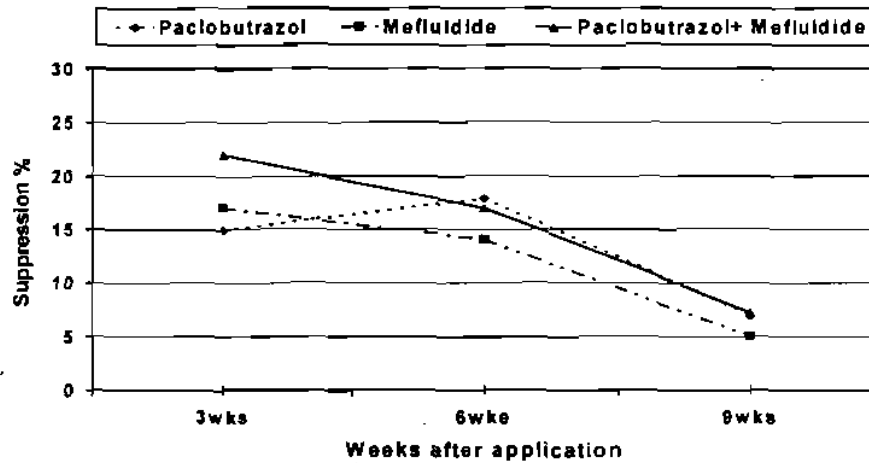


Fig. 2: Suppression effect of plant growth regulators on "Tifway" bermudagrass during the second season 2003.

The results also showed that mefluidide plus paclobutrazol effect on height suppression was very close to that of paclobutrazol alone. These results suggest that the effect of mefluidide plus paclobutrazol treatment six weeks after application was mainly due to the effect of paclobutrazol. This agreed with (Watschke *et al.*, 1992) who reported that Type I PGRs (such as mefluidide) are primarily absorbed foliarly and can be rapidly taken up. Their growth inhibition occurs within 4 to 10 days, and lasts 3 to 4 weeks, depending on application rate. On the other hand, Type II PGRs (such as paclobutrazol) are slower in growth suppression response, but their duration is usually from 4 to 7 weeks (Watschke and DiPaola, 1995) depending on application rate. Noticeable retardation was slow but lasts for a greater period of time than many foliar absorbed growth retardants (Shearing and Batch 1979 and 1982).

By week nine after application, the suppression effects of all treatments was decreased to less than 8%. At this time, mefluidide alone had the lowest suppression effect which was about 5% in both seasons. These results are in accordance with the previously mentioned reports.

Grass coverage

It is obvious from Table (1) that the percentage of area covered with "Tifway" bermudagrass planted using plugs was slightly affected by mefluidide and paclobutrazol treatments. However, mefluidide alone showed a retarding effect on grass coverage compared with the control throughout the experiment. In addition, by the end of the experiment (nine weeks after application) both treatments containing mefluidide had the least coverage percentage. In this concern, Fry and Dernoeden (1986) found that the rate of zoysiagrass coverage was increased in perennial ryegrass, but not in Kentucky bluegrass with mefluidide treatment. It worth to mention that the percentage of coverage in this experiment exceeded 95% which is very good coverage for "Tifway" bermudagrass.

Table 1: Influence of plant growth retardants on vegetative covering of "Tifway" bermudagrass during 2002 and 2003

Treatment	Covering (%) ¹					
	2002, WAT [*]			2003, WAT [*]		
	3	6	9	3	6	9
Paclobutrazol (110mg/m ²)	90.1ab ²	94.2a	99.2a	91.3ab	94.8b	99.7a
Mefliudide (14 mg/m ²)	87.2b	89.3b	95.8b	88.5b	90.5b	95.9b
Paclobutrazol (110 mg/m ²) + Mefliudide (14 mg/m ²)	89.1ab	96.2a	96.0b	90.7b	98.2a	95.3b
Control (untreated turf)	91.2a	96.9a	100.0a	94.6a	100.0a	100.0a

^{*} WAT = Weeks after treatment

¹ In case of % values the original data were firstly arcsine transferred.

² Means followed by the same letter(s) within column are not significantly different at P = 0.05 according to Duncan's multiple range test.

³ All grasses were recut after taking measurements after 3, 6, and 9 weeks from applications.

Grass quality

Table (2) represented the quality of "Tifway" bermudagrass 3, 6 and 9 weeks after application with PGRs in both seasons 2002 and 2003 respectively.

Three weeks after treatment, grasses treated with mefluidide alone or in combination with paclobutrazol had lower quality than those treated with paclobutrazol alone. The quality of grasses treated with paclobutrazol alone was similar to that of the control and both were estimated as very good appearance. This clearly indicated that mefluidide caused a reduction in grass quality in the first three weeks following application. In this concern, Watschke *et al.* (1992) reported that more injury has been generally noted when the treated turf with mefluidide was environmentally stressed. By the weeks six and nine after application, grass quality of all treated grasses was indifferent from the control. The effect of treatments on grass quality had similar trend in both seasons. This supports the previously mentioned view that the effect of mefluidide was restricted to the first three weeks following application. In addition, the work of DiPaola *et al.* (1985) and Johnson (1997) showed improved foliar quality when N-containing fertilizers were used with the growth retardants program and the grasses in this experiment received continuous N and K fertilizers.

Table 2: Influence of plant growth retardants on quality of "Tifway" bermudagrass during 2002 and 2003

Treatment	Turf quality*					
	2002, WAT*			2003, WAT*		
	3	6	9	3	6	9
Paclobutrazol (110mg/m ²)	4.2a [†]	4.2a	4.9a	4.3a	4.4a	5.0a
Mefluidide (14 mg/m ²)	3.1b	4.0a	4.8a	3.0b	4.1a	4.7a
Paclobutrazol (110 mg/m ²) + Mefluidide (14 mg/m ²)	3.2b	4.1a	4.8a	3.1b	4.3a	4.9a
Control (untreated turf)	4.2a	4.3a	4.7a	4.2a	4.4a	4.8a

* WAT = Weeks after treatment

† Quality was based on grass visual appearance and freedom of injury; scores ranged from 1-5 (1=dead, 2=poor, 3=good, 4=very good, and 5=excellent).

‡ Means followed by the same letter(s) within column are not significantly different at P = 0.05 according to Duncan's multiple range test.

• All grasses were recut after taking measurements after 3, 6, and 9 weeks from applications.

Grass color

Table (3) represented the color of "Tifway" bermudagrass 3, 6 and 9 weeks after application with PGRs in both seasons 2002 and 2003 respectively.

Three weeks after application the color of grasses treated with mefluidide alone or in combination with paclobutrazol was pale green and was estimated significantly lower than the green color of grasses treated with paclobutrazol alone or the control. These results were similar in both seasons. Although paclobutrazol was reported to induce initial discoloration of red fescue (Johnston and Faulkner 1985), our results showed that the

decrease in color values of "Tifway" bermudagrass was, mainly, a result of mefluidide not paclobutrazol. This view agreed with several researchers (Watschke, 1976, Chappell *et al.*, 1977; Schott *et al.*, 1977) who reported that mefluidide caused unacceptable phytotoxicity on fine-textured species and suggested that its use should be limited to rough turf areas. On the other hand, the results disagreed with Wakefield and Fales (1977) and Warmund *et al.* (1980) who reported no phytotoxicity on tall fescue.

Six weeks after application, in the first season, mefluidide alone treatment resulted in the lowest color value and was significantly lower than the control, while the color values of paclobutrazol alone or in combination with mefluidide treatments were intermediate and did not significantly differ from either mefluidide alone or the control. However, at the same time in the second season, the three treatments did not significantly differ in their color values from the control. These results indicated that the effects of mefluidide on reducing the color of "Tifway" bermudagrass was mainly during the first three weeks after application and did not extend for six weeks after application.

Table 3: Influence of plant growth retardants on color of "Tifway" bermudagrass during 2002 and 2003

Treatment	Turf color*					
	2002, WAT*			2003, WAT*		
	3	6	9	3	6	9
Paclobutrazol (110mg/m ²)	4.1a [†]	4.2ab	5.0a	4.0a	4.0a	5.0a
Mefliuidide (14 mg/m ²)	3.0b	3.7b	4.7a	3.0b	3.6a	4.8a
Paclobutrazol (110 mg/m ²) + Mefliuidide (14 mg/m ²)	3.2b	3.9ab	4.8a	3.1b	3.7a	4.9a
Control (untreated turf)	4.1a	4.1a	4.9a	4.0a	4.0a	4.9a

* WAT = Weeks after treatment

† Color was rated visually according to greenness on basis of 1-5 (1=brown, 2=yellow, 3=pale green, 4=green, and 5=dark green).

‡ Means followed by the same letter(s) within column are not significantly different at P = 0.05 according to Duncan's multiple range test.

• All grasses were recut after taking measurements after 3, 6, and 9 weeks from applications.

Clipping dry weight

Data in table (4) showed the clipping dry weight (g/m²) of "Tifway" bermudagrass 3, 6 and 9 weeks after application with PGRs in both seasons 2002 and 2003 respectively.

In the first season, the clipping dry weights of all treated grasses were significantly lower than the control after 3,6, and 9 weeks after treatment. Three weeks after application, the three treatments did not significantly differ in their clipping dry weight. Six weeks after application, grasses treated with paclobutrazol alone or paclobutrazol plus mefluidide had less clipping dry weight than those treated with mefluidide alone. These results showed that the retardation of clipping weight after six weeks of application was mainly a result of paclobutrazol not mefluidide. This was similar to the previous discussion of the effects of paclobutrazol on percentage of suppression. By week nine after application, there were no

significant differences among grasses treated with plant growth retardants, but all treatments resulted in significantly less clipping dry weight than the control. These differences could be attributed to the retardation effects of treatments took place early after 3 and 6 weeks from application. In the second season, results obtained at week 3 after application were similar to those obtained in the first season. However, by week six in the second season, the clipping dry weight of grasses treated with mefluidide alone were not significantly different from the control. By week nine after treatment, both mefluidide alone and paclobutrazol alone did not significantly differ from the control. The results of both seasons showed that mefluidide effect on vegetative growth retardation was greatly reduced after six weeks of application, while paclobutrazol effect continued to week six and was minimized by reaching week nine after application. However, the effect of paclobutrazol on clipping dry weight was inconsistent in the two seasons. Similarly, paclobutrazol was also reported that it could not provide consistent retardation on vegetative growth and seedhead suppression in some cases (Johnson 1989 and 1994).

Table 4: Influence of plant growth retardants on clipping dry weight of "Tifway" bermudagrass during 2002 and 2003

Treatment	Clipping dry weight (g/m ²)					
	2002, WAT*			2003, WAT*		
	3	6	9	3	6	9
Paclobutrazol (110mg/m ²)	42.4b ^x	55.4c	75.0b	44.1b	57.2b	78.9b
Mefluidide (14 mg/m ²)	40.7b	60.7b	77.1b	41.9b	63.1ab	80.5b
Paclobutrazol (110 mg/m ²) + Mefluidide (14 mg/m ²)	39.4b	55.3c	74.6b	40.2b	56.9b	76.0b
Control (untreated turf)	52.8a	68.2a	83.2a	54.6a	71.0a	86.1a

* WAT = Weeks after treatment

^x Means followed by the same letter(s) within column are not significantly different at P = 0.05 according to Duncan's multiple range test.

- All grasses were recut after taking measurements after 3, 6, and 9 weeks from applications.

Shoot and root dry weight

Data in table (5) presented the shoot and root dry weights (g/m²) of "Tifway" bermudagrass 9 weeks after application with PGRs (at the end of experiment) in both seasons 2002 and 2003 respectively.

At the end of the experiment, shoot dry weights of all treated grasses were significantly lower than that of the control. However, there was relative variations among treatments. Mefluidide alone resulted in the highest relative shoot dry weight.

In the first season, the root dry weights of all treated grasses were significantly less than that of the control. In this concern, many growth retardants tended to inhibit root and rhizome development of different turfgrasses (Elkins *et al.*, 1977; Schmidt and Bingham, 1977; Wakefield and Fales 1977). In the second season, the root dry weight of the control (untreated) grasses was highest, followed by that of grasses treated with mefluidide alone, while those of grasses treated with paclobutrazol either

alone or in combination with mefluidide were the lowest. This indicated that paclobutrazol had significant effect on reducing the root dry weight of "Tifway" bermudagrass. Paclobutrazol is root absorbed and it is very likely to affect root growth. Schmidt and Bingham (1977) suggested that prolonged root growth inhibition was due to chemical residual of the growth regulators in the soil. Unlike paclobutrazol, mefluidide is foliarly absorbed and exhibits little translocation to other leaf organs, roots, and lateral growth meristems (Field and Whitford, 1982; Watschke et al. 1992). Mefluidide was reported to have little or no suppressive effect on turfgrass roots (Marcum and Jiang, 1997; Nielson and Wakefield, 1975). Mefluidide in this experiment reduced root dry weight in comparison with the control which could be attributed to its effect on shoot growth and subsequently the root growth. However, Freeborg and Danial (1981) reported that research concerning the relationship of PGRs and their effect on rooting was inconsistent, even when identical experiments were performed two consecutive years.

Table 5: Influence of plant growth of retardants on shoot dry weight, root dry weight and root/shoot ratio of "Tifway" bermudagrass after 9 weeks from application during 2002 and 2003

Treatment	2002			2003		
	Shoot dry weight (g/m ²)	Root dry weight (g/m ²)	R/s ratio	Shoot dry weight (g/m ²)	Root dry weight (g/m ²)	R/s ratio
Paclobutrazol (110mg/m ²)	87.6b ^a	34.2b	0.39b	90.1b	36.3c	0.40c
Mefluidide (14 mg/m ²)	89.7b	42.6b	0.47a	92.0b	44.9b	0.49ab
Paclobutrazol (110 mg/m ²) + Mefluidide (14 mg/m ²)	86.3b	35.4b	0.41ab	88.5b	38.2bc	0.43bc
Control (untreated turf)	94.6a	50.6a	0.53a	97.2a	53.2a	0.55a

^aMeans followed by the same letter(s) within column are not significantly different at P = 0.05 according to Duncan's multiple range test.

Root/shoot ratio

The effect of the treatments on root/shoot ratio is a resultant of their effects on both shoot and root dry weights previously mentioned. The root/shoot ratio represented in table (5) showed that all treatments had significantly lower root/shoot ratio than the control. Among treatments, mefluidide alone treatment had the highest relative root/shoot ratio, while paclobutrazol alone was the lowest in both seasons.

Root renewal is essential for water and mineral uptake required for growth of the plant. Wakefield and Dore (1974), reported that duration of root suppression mirrored that of the foliage. By the end of this experiment, mefluidide alone treatment resulted in the highest shoot and root dry weights in addition to the highest root/shoot ratio among grasses treated with growth retardants. One could suggest that since mefluidide was fast in action and suppressed shoot growth of the turfgrass early, it resulted in earlier renewal of root growth and subsequently more shoot dry weight at the end of the experiment. In this concern, Wakefield and Fales (1977) noted post-suppression flushes in root growth of turfgrasses 7 weeks after treatment with

PGRs. The results of this experiment agreed with Cooper *et al.* (1987) and Watschke *et al.* (1992), who reported that mefluidide applied in spring improved the ability of annual bluegrass to tolerate summer drought stress through shoot suppression and subsequent enhanced rooting.

In conclusion, it is known that mefluidide is foliar absorbed while paclobutrazol is root absorbed plant growth retardant. Mefluidide provided faster effect on suppressing vegetative growth of "Tifway" bermudagrass which is of great importance to inhibit seedhead formation, but reduced grass quality and color within three weeks period after treatment. On the other hand, paclobutrazol was slower and suppressed growth of "Tifway" bermudagrass after three weeks of application and continued to six weeks after application without affecting the turfgrass quality and color. Thus the combination of both could induce good suppression of "Tifway" bermudagrass under field conditions faster and for a longer period than when each of them was used alone. This would result in reducing the mowing requirements for six weeks, and subsequently reduce the cost of maintenance of "Tifway" bermudagrass. However, these results were obtained from using a single application, and future experiment is needed to study the effect of these PGRs using multiple applications on a well established turfgrass stand.

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تأثير Mefluidide و Paclobutrazol على نمو وجودة نباتات المسطحات
الخضراء "Tifway" bermudagrass
هشام هاشم عبد القادر - محمد يونس على عبد الله
قسم الخضار والزينة - كلية الزراعة - جامعة المنصورة

نبات [*Cynodon transvaalensis* Burt-Davy x *C. dactylon* (L.) Pers] هجين البرمودا صنف "Tifway" من حشائش المسطحات الخضراء المشهورة ويستخدم على نطاق واسع في مصر. عندما يتم صيانة مسطحات هذا النبات كمسطحات متوسطة إلى عالية الجودة، فإن تكرار عملية القص تكون مهمة للحد من نموه الخضري وتكوين الرؤوس البذرية. مؤخرات أو مثبطات النمو لها القدرة على تقليل عدد مرات القص التي يحتاجها المسطح وبالتالي تقليل تكاليف الصيانة. ولهذا فقد أجريت تجربة حقلية خلال الربيع (أول أبريل) في عامي ٢٠٠٢ و ٢٠٠٣ لدراسة تأثير نوعين مختلفين من مثبطات النمو على نمو وجودة نباتات "Tifway" bermudagrass وذلك تحت الظروف المصرية. بعد ثلاثة أسابيع من زراعة الأجزاء الخضرية عوملت نباتات المسطح إما بمشط النمو Mefluidide بمعدل ١٤ ملليجرام/قطعة تجريبية أو ملليجرام/قطعة تجريبية (١×١ م)، أو بمشط النمو Paclobutrazol بمعدل ١١٠ ملليجرام/قطعة تجريبية أو بإضافة المثبطين السابقين معا بنفس المعدلات المذكورة. إضافة المثبطات المستخدمة تمت عن طريق رش النباتات بها حيث أذيت كمية المثبط المخصصة لكل مكررة على حدة في ٥ لتر ماء مقطر ثم رشتها بها نباتات المكررة الواحدة بتوزيع منتظم وذلك باستخدام رشاش يدوي نصف أوتوماتيكي سعة ٥ لتر. أما نباتات المسطح غير المعاملة (الكنترول) فقد رشت بماء مقطر فقط.

هذا ولقد أجريت عدة قياسات لتحديد تأثير هذه المثبطات على نمو وتطور حشيشة المسطح. هذه القياسات شملت ارتفاع النبات، النسبة المئوية للتغطية، وزن نواتج القص، جودة ولون المسطح وذلك بعد مرور ٣، ٦ و ٩ أسابيع من المعاملة بهذه المثبطات. في نهاية التجربة تم اقتلاع أجزاء من المسطح المعامل بالمثبطات المختلفة وغير المعامل (الكنترول) بواسطة اسطوانة حديدية قطرها ١٥ سم وبعمق ٥ سم في التربة حيث فصل المجموع الخضري عن المجموع الجذري وتم تجفيفهما وذلك لقياس الوزن الجاف لكل منهما على حدة وتحديد نسبة المجموع الجذري إلى المجموع الخضري لنباتات المسطح المستخدم.

ولقد بينت النتائج المتحصل عليها أنه بعد مرور ثلاثة أسابيع من المعاملة كان مثبط النمو Mefluidide عند استخدامه بمفرده سريع التأثير في تثبيط ارتفاع النباتات والنمو الخضري، إلا أنه أدى إلى تقليل جودة المسطح ولونه وكذلك نسبة التغطية. أما مثبط النمو Paclobutrazol المستخدم بمفرده كان أكثر فاعلية من مثبط النمو Mefluidide في تثبيط ارتفاع النباتات، وتقليل الوزن الجاف لنواتج القص وذلك بعد ٦ أسابيع من المعاملة في حين أن استخدامه كان له تأثير محدود على تقليل جودة ولون المسطح وكذلك نسبة التغطية. أما المعاملة باستخدام المثبطين السابقين مجتمعين فقد أعطت تقريبا أسرع وأفضل النتائج على مدار التجربة من حيث تثبيط ارتفاع النباتات والنمو الخضري. بالرغم من أن هذه المعاملة أدت إلى تقليل جودة ولون المسطح خلال الثلاث أسابيع الأولى بعد إضافة مثبطات النمو، إلا أن المسطح استعاد جودته ورونقه عند الأسبوع السادس بعد الإضافة وحتى نهاية التجربة. ولقد بينت أيضا نتائج التجربة أن تأثيرات مثبطات النمو المستخدمة قد قلت إلى أدنى حد وذلك بعد تسعة أسابيع من المعاملة. في نهاية التجربة (بعد تسعة أسابيع من المعاملة) أعطت المعاملة بمثبط النمو Mefluidide المستخدم بمفرده أعلى وزن للمجموع الخضري الجاف والمجموع الجذري الجاف وكذلك أعلى نسبة للمجموع الجذري الجاف/المجموع الخضري الجاف وذلك عند مقارنتها بنتائج النباتات المعاملة الأخرى.

نتائج هذه التجربة تم الحصول عليها من معاملة نباتات المسطح مرة واحدة بواسطة مثبطات النمو. هذا وينصح مستقبلا بإجراء دراسات على تأثير هذه المثبطات باستعمالها أكثر من مرة خلال موسم نمو المسطحات الخضراء.