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THE INFLUENCE OF THE GROWTH REGULATOR TRINEXAPAC-ETHYL ON THE REGROWTH RATE OF LAWN GRASSES

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Abstract. One of the limitations to the plant regrowth rate is the application of different kinds of natural and synthetic growth regulators. These substances when used in small doses actively influence direct transformations in plants, causing considerable changes in their growth and development. The lawn experiment was conducted from 2002 to 2004. It was done on an experimental plot in the arrangement of randomized blocks in four replications. In the investigation the mixture of the grasses called Super Gazon was used. The mixture was cultivated in combination with four mineral multiple-nutrient fertilizers with a balanced dose of nitrogen. The growth regulator, Moddus 250 SC, produced on the basis of the active substance trinexapac – ethyl (TE) by the Swiss firm Syngenta Crop Protection AG, was also applied in the experiment as an investigation factor. It was used as a spray in the quantity 0.06 $cm^3 \cdot m^{-2}$. Some lawn plots were not sprayed. The measurement was done at three-day intervals when the grasses on the experimental plots where spraying was applied had 12 cm of height. The obtained results showed that trinexapac-ethyl effectively slowed down the regrowth of turfgrasses in the examined sward. The influence of the growth regulator depended also on the weather conditions during the vegetation period. The growth regulator, trinexapac–ethyl, effectively influenced the slow regrowth of turfgrasses in the sward of the Super Gazon mixture, regardless of the kind of fertilizer used or the weather conditions.

Key words: trinexapac-ethyl, lawns, regrowth, fertilization, weather conditions

INTRODUCTION

Lawns are one of the cheapest ways of land farming. Thanks to their numerous advantages, they are often used to fill up empty spaces for decorative or usable purposes. Lawn grasses are perfect and the simplest natural way used to cover empty areas on

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condition that they have good growth and development conditions as well as proper cultivation.

When lawn grasses are cultivated much attention is paid to the optimization of the cultivation measures connected with the maintenance of lawns in good shape, especially in the summer when their utilization is the highest. Then the most intensive in the whole vegetation period regrowth of grasses becomes a problem. It is connected both with the occurrence of various weather conditions in different months of the vegetation period as well as with the selection and efficiency of cultivation measures.

One of the limitations to the plant regrowth rate is the application of different kinds of natural and synthetic growth regulators. These substances when used in small doses actively influence direct transformations in plants, causing considerable changes in their growth and development [Kościk 1991, Ervin and Ok 2001].

According to Beam [2004] managing turfgrass height is vital to the turfgrass industry. Mowing turfgrass to a manageable height consumes a large amount of turfgrass professionals' time and resources. The use of plant growth regulators (PGR) on turfgrass can reduce mowing requirements.

In order to limit the plant regrowth rate in the lawn sward one of the growth regulators, trinexapac-ethyl, used in cereal cultivation [Syngenta 2001], was applied.

According to many authors [Johnson 1990, 1997, Wiecko and Couillard 1997, Fagerness and Penner 1998a, Jiang and Fry 1998, Qian et al. 1998, Fagerness and Yelverton 2000, Ervin and Ok 2001, Fresenburg and Durm 2002, McCann and Huang 2007]; trinexapac-ethyl suppresses bent grass bermudagrass, Kentucky bluegrass, perennial ryegrass, tall fescue and zoysiagrass growth.

As maintained by Fagerness and Penner [1998b], trinexapac-ethyl [4-(cyclopropyl-α-hydroxy-methylene)-3,5-diox-ocyclohexanecarboxylic acid ethyl ester is the foliar-absorbed, cyclohexanedione turfgrass growth regulator that can inhibit shoot growth in numerous turfgrass species. As stated by Beam [2004] trinexapac-ethyl blocks cell elongation and suppresses turfgrass growth.

Our objective was to determine the influence of trinexapac-ethyl on the mixture of turfgrasses and on interval elongation between successive mowings.

MATERIALS AND METHODS

The lawn experiment was carried out from 2002 to 2004. It was put on an experimental plot in the arrangement of randomized blocks in four replications at the Agricultural Farm of the University of Podlasie in Siedlce (52°16' N, 22°28' E). In the investigation the mixture of the grasses called Super Gazon was used. It is available in retail sale and has the following botanical composition: *Lolium perenne* 40%, *Festuca rubra* 35%, *Festuca ovina* 10%, *Poa pratensis* 10% *and Agrostis capillaris* 5%. The mixture was cultivated in combination with four mineral multiple-nutrient fertilizers with a balanced dose of nitrogen (tab. 1). Among the applied mineral fertilizers, three, i.e. Pokon – N1, Trawovit complit – N2, Azofoska – N3, are available in retail sale, while the fertilizer proposed by the authors, N4, consisted of one-component mineral fertilizers, e.g. ammonium saltpetre, potassic salt and superphosphate in the NPK ratio of

Table 1. Used in study multicomponental mineral fertilizers
Tabela 1. Użyte w badaniach wieloskładnikowe nawozy mineralne

Name of fertilizer Nazwa nawozu	Chemical composition Skład chemiczny	Fertilizer dose g · m^{-2} Dawka nawozu g · m^{-2}
N1 Pokon	N – 10% (NH_4) N – 10% (NO_3) P_2O_5 – 5% K_2O – 7% MgO – 3%	20
N2 Trawovit	N – 10% (NH_4) N – 10% (NO_3) P_2O_5 – 10% K_2O – 15% MgO – 4% SO_3 – 4% CaO – 8% Fe – 0.4% Cu – 4% Co, Zn, Mn, B	20
N3 Azofoska	N – 8.1% (NH_4) N – 5.5% (NO_3) P_2O_5 – 6.4% K_2O – 19.1% MgO – 4.5% Cu, Fe, Zn, Mn, B, Mo	100
N4 Proposed fertilizer – Nawóz zaproponowany Comopsition – skład Amonnium nitrate – Saletra amonowa Potassium salt – Sól potasowa Superphosphate – Superfosfat	N – 34% (MgO – 0.2%) K_2O – 60% P_2O_5 – 20%	69

Source: own elaboration. Źródło: opracowanie własne.

6:2:4. In this experiment, the growth regulator, Moddus 250 SC, produced on the basis of the active substance trinexapac-ethyl (TE) by the Swiss firm Syngenta Crop Protection AG, was also applied as the investigation factor. It was used as a spray in the quantity of 0.06 $cm^3 \cdot m^{-2}$. Some lawn plots were not sprayed. In the months from July to September and after mowing the grasses to a height of 6 cm, the regrowth of the grasses was measured with a stiff measure scaled in centimeters [Domański 1998]. The measurement was done at three-day intervals when the grasses on the experimental plots where spraying was applied had 12 cm of height. On the experimental plots where spraying was not applied and where grass height reached 12 cm quickly, the mowing at a height of 6 cm was done. Before each treatment the achieved values of individual regrowths were added up; as a result, all the values created the total value. The number of measurement cycles in individual years of the investigations depended on weather conditions, which limited the possibility of spraying and also influenced the length of the turfgrass measurement. In the year 2002 one cycle of measurements was done from 12th Aug. to 26th Sep., in the year 2003 two cycles, from 19th July to 10th Aug. and from 28th Aug. to 12th Sep. Finally, in 2004 three cycles of measurements were conducted

from 21st July to 5th Aug., from 24th Aug to 2nd Sep. and from 20th Sep to 11th Oct. The results of the investigations were subject to the statistical analysis via the computer programme Statistica.

RESULTS AND DISCUSSION

In all the years of investigations, the growth regulator TE caused significant limitation of the regrowth rate of the grasses in the sward in comparison with the regrowth of the plants without this spraying (tab. 2). Reducing turfgrass clipping production is often the goal of managers who recognize the need to save time, money, or landfill space. Lickfeldt et al. [2000] showed that turf treated with TE consistently displayed better visual quality than untreated turf regardless of the TE application rate. In our study the use of TE did not have any influence on the utilization of the applied mineral fertilizers by the plants. Only a significant interaction between the growth regulator and the applied fertilizers was found. In study of McCullougha et al. [2005] TE reduced clippings 67% from nontreated while clippings increased with N rate. The significant differences were also observed in the influence of the mineral fertilizers on the plants in individual years of the investigations.

Table 2. The rate of regrowth (in cm) of lawn grasses in years 2002–2004 with the applied growth regulator TE and fertilizers

Tabela 2. Odrastanie traw gazonowych (w cm) w latach 2002–2004 z zastosowanymi czynnikami badawczymi: TE – regulator wzrostu, zróżnicowane nawożenie

Year Rok	Fertilizer – Nawożenie								Mean for treatment TE Średnia dla czynnika TE		Mean Średnia
	N1		N2		N3		N4				
	I	II	I	II	I	II	I	II	I	II	
2002	6.6	40.3	6.8	42.9	6.5	43.1	5.8	39.0	5.6	33.5	19.5
2003	10.2	14.3	10.0	15.0	10.4	15.0	10.8	14.9	9.0	12.8	10.9
2004	6.4	8.3	6.7	8.2	6.8	8.3	6.4	8.3	5.9	7.2	6.6
Mean	7.7	21.2	7.8	22.0	7.9	22.1	7.4	20.8	6.8	17.9	12.3
Mean (B)	14.5		14.9		15.0		14.1				

$LSD_{0.05}$ for			$NIR_{0,05}$ dla			
TE	A	10.9			A × B	5.5
Fertilizer – Nawóz	B	10.8	interaction – interakcja		B × C	10.2
Year – Rok	C	8.5			A × B × C	4.1

I – with (z) TE
II – without (bez) TE

One of the reasons why there were significant differences in the utilization of the mineral fertilizers by the plants in the individual years of the investigations were different weather conditions in individual periods of measurements.

The highest average air temperature from July to September 2002 (tab. 3) with a low level of precipitations caused the weakest regrowth of the lawn grasses treated with TE

regardless of the mineral fertilizers applied (tab. 2). In Heckam et al. [2002] study Kentucky bluegrass plants treated with TE are less heat tolerant than untreated plants. They explain it that electrolyte leakage tests can determine cell membrane thermostability of several species and is related to relative heat tolerance.

Table 3. The meteorological conditions of the investigation area from the Synoptic Station in Siedlce

Tabela 3. Warunki meteorologiczne występujące w rejonie prowadzonego doświadczenia według stacji synoptycznej w Siedlcach

Factor Czynnik	Month Miesiąc	2002	2003	2004	Mean from many years Średnia z lat 1960–2003
Mean monthly air temperatures (ºC) Średnie miesięczne temperatury powietrza (ºC)	VI	16.9	16.9	15.2	16.2
	VII	20.8	19.8	17.4	17.8
	VIII	20.0	18.2	18.7	17.2
	IX	12.8	13.2	13.0	12.7
	X	7.1	5.1	9.9	7.8
Mean – Srednia VII–IX		17.9	17.1	16.4	15.9
Mean annual – Średnia roczna		9.1	7.7	7.9	7.4
Precipitations (mm) Opady (mm)	VI	75.1	61.7	45.2	72.7
	VII	58.6	44.5	53.5	68.6
	VIII	32.2	62.2	69.3	62.1
	IX	31.9	36.5	17.5	62.4
	X	59.2	44.0	32.2	37.7
Sum – Suma VII–IX		122.7	143.2	140.3	193.1
Sum annual – Suma roczna		465.5	423.5	517.5	529.0

In the year 2002 the highest regrowth of grasses was on the plots without the growth regulator in comparison to those where TE was applied. This showed a high index of impact on lawns, particularly in the period of high air temperatures with the simultaneous shortage of precipitations. However studies of Xu and Huang [2001] reported that plants treated with a growth inhibitor, TE had improved drought tolerance. They explain it that plants has been associated with reduction in water use rate due to shoot growth reduction and increases in osmotic adjustment due to the accumulation of inorganic solutes and soluble sugars [McCann and Huang 2007; Bian et al. 2009]. The highest decrease of the air temperature from July to September 2004 with the mean level of precipitations of 46.8 mm caused the equalization of the regrowth rate of the lawn grasses on the plots treated with TE and not treated with it.

The best effect of the TE reaction was reached in the year 2002 when the mean difference in the regrowth of the lawn grasses of the mixture Super Gazon sprayed with TE was 27.9 cm in comparison with the grasses without this spray application (tab. 2). The cause of such high differences in plant growth in the sward, except for the grasses with no growth regulator applied, could also have been the weather conditions (tab. 4). In this investigation year there was some lack of water in the soil, unfavorable for the regrowths of the grasses. This, in connection with the high air temperature, caused drought.

There were also differences, influenced by weather conditions, in the regrowth rate of the grasses in individual months of the investigations (fig. 1). It was connected with the existing weather conditions at that time (tab. 3). To a smaller or larger degree lower growth rate of the lawn mixture Super Gazon occurred after applying TE. It was observed every year and it showed that it was possible to apply it in various months of the vegetation period with a similar result.

Table 4. The weather conditions occurring in the area of the investigations in individual months of the vegetation periods from 2002 to 2004 expressed by the hydrometric coefficient by Sielianinow

Tabela 4. Warunki pogodowe występujące w rejonie badań w poszczególnych miesiącach sezonu wegetacyjnego wyrażone współczynnikiem hydrometrycznym Sielianinowa (2002–2004)

Year Rok	Strong drought Silna posucha						Drought Posucha						Weak drought Słaba posucha						Lack of drought Brak posuchy					
	V	VI	VII	VIII	IX	X	V	VI	VII	VIII	IX	X	V	VI	VII	VIII	IX	X	V	VI	VII	VIII	IX	X
2002	o	o								o					o		o							o
2003							o								o		o			o		o		o
2004					o									o	o				o			o		o

o – kind of drought – rodzaj posuchy

The occurrence of droughts from July to September 2002 made it impossible to carry out spraying with TE on the experimental plots. So, the measurements were started just in July when the weather conditions allowed to spray properly with the growth regulator. In that period, the highest regrowth rate of grasses in the sward was on all the experimental plots (fig. 1).

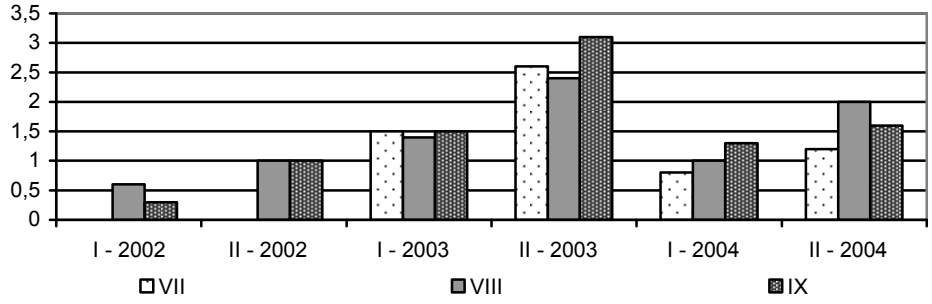

Fig. 1. The mean increase of the grass sward (in cm) between successive measurements (at a three-day interval) from July to September, depending on the applied growth regulator

Rys. 1. Średni przyrost runi (w cm) pomiędzy kolejnymi pomiarami (w odstępie trzech dni) od lipca do września, w zależności od zastosowanego regulatora wzrostu

The obtained results show that the longest time of the sward regrowth to the hight of 12 cm after TE application (45 days) was reached in 2002 and the shortest in 2004 (9 days) in the second study cycle.

However, according to Johnson [1993**,** 1994] trinexapac-ethyl is the foliar-absorbed turfgrass growth regulator that can cause growth inhibition, with a maximum efficiency on the 14th to 21st day after treatment in numerous turfgrass species.

As maintained by Beam [2004] the reduction percent of perennial ryegrass biomass in a greenhouse was higher in the first and fourth weeks after the initial treatment. Jiang and Fry [1998] reported that trinexapac-etyl suppressed perennial ryegrass growth in the greenhouse until the fourth week after initial treatment.

In Fagerness and Penner's [1998a] study the magnitude of growth inhibition by TE varied for different species. The maximum growth inhibition of TE occurred in either the second or third weeks after the treatment of all the species, following specifications given on a chemical label.

However in this study there was still a difference between the growth rate of the lawn grasses under the influence of TE applied to the plots and without this substance, giving the average difference of 3.8 cm. This testifies about the effectiveness of the applied growth regulator. In the year 2004 the air temperature in the months of investigations generally decreased by an average of about 1.5^{o}C against the year 2002 and 0.7^{o}C in comparison with 2003 (tab. 3). At that time there was an average level of precipitations. This stopped the regrowth of lawn grasses. There was also a decrease in differences of growth rates on the plots with applied spraying in comparison with the plots without TE applied. However, there was still a difference observed in grass regrowths, which testifies about the effectiveness of the TE impact. By Lickfeldt et al. [2000] applications of TE not only reduced Kentucky bluegrass clipping production but were also effective in managing turfgrass growth.

Table 5. Regrowth of lawn grasses (in cm) average from study years in depend on the trinexapac ethyl and fertilizers applied

Tabela 5. Odrastanie traw gazonowych (w cm) średnio z lat badań w zależności od zastosowanego regulatora wzrostu i nawozów

Fertilization Nawożenie	Trinexapac ethyl Trinexapac etyl		Mean Średnio
	I	II	
N1	9.07	16.55	12.81
N2	9.02	16.63	12.83
N3	9.16	16.61	12.88
N4	8.93	16.44	12.24
Mean – Średnio	9.05	16.56	12.80
$LSD_{0.05}$ for: A – 6.78, A × B – n.s., B × A – 7.23			

I – with (z) TE
II – without (bez) TE

The post suppression rebound effect can be utilized to manipulate turfgrass growth, allowing the turf to grow rapidly when it is beneficial to do so. But, in regard to the mean values of regrowth in study years (tab. 5) it can be stated that undepending on the type of fertilizers, applied trinexapac ethyl caused a significant reduction of lawn sward regrowth amounted 7.51 cm. This analysis also showed significant differences in regrowth of turf lawn, depending on the applied mineral fertilizers. Significant regrowth inhibition of the sward was found at all objects, where different types of fertilizers were used what confirm a significant interaction between fertilization × TE.

Obtained results show that reducing of shoot growth must be considered in total to fully understand TE effect on grasses growth. Father researcher are needed to elaborate this results and examine the effect of various TE rates and multiple applications on lawns growth.

CONCLUSIONS

1. The obtained results showed that trinexapac-ethyl effectively slowed down regrowths rate of turfgrasses in the studied sward especially the Super Gazon mixture, regardless of the kind of fertilizer applied or weather conditions.

2. Trinexapac-ethyl did not influence negatively the utilization of mineral fertilizers by the turfgrasses.

3. The influence of this growth regulator was depended also on the weather conditions during the vegetation period.

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WPŁYW REGULATORA WZROSTU TRINEKSAPAK-ETYL NA TEMPO ODROSTU MURAW TRAWNIKOWYCH

Streszczenie. Czynnikiem ograniczającym tempo odrostu roślin jest stosowanie różnego rodzaju naturalnych bądź syntetycznych regulatorów wzrostu. Substancje te, kiedy są stosowane w małych dawkach, pozytywnie wpływają na kierunek przemian w roślinach, powodując istotne zmiany w ich wzroście i rozwoju. W procesie użytkowania muraw trawnikowych wiele uwagi poświęca się optymalizacji zabiegów pielęgnacyjnych związanych z utrzymaniem trawników w dobrej kondycji, zwłaszcza w okresie letnim, gdy stopień ich wykorzystania jest najwyższy. Problemem staje się wówczas najbardziej intensywny w całym okresie wegetacyjnym odrost traw w runi. W celu ograniczenia tempa odrostu roślin w runi zastosowano regulator wzrostu trineksapak etyl, który w dotychczasowej praktyce rolniczej stosowany jest w uprawie zbóż. Doświadczenie trawnikowe

obejmujące 3-letni okres badań (2002–2004) założono na poletku doświadczalnym Akademii Podlaskiej w Siedlcach w układzie losowanych bloków w czterech powtórzeniach. Badaniami objęto dostępną w handlu mieszankę traw o nazwie Super Gazon, traktowaną regulatorem wzrostu w mieszance z jednym z czterech wieloskładnikowych nawozów mineralnych (Pokon, Trawovit Komplet, Azofoska) lub nawozem zaproponowanym przez autorów (F4), składającym się z jednoskładnikowych nawozów mineralnych w proporcji 6:2:4 NPK. Preparat wraz z odpowiednim nawozem stosowano w formie opryskiwania. Kontrolę stanowił trawnik nieopryskiwany. W okresie letnim w odstępach trzydniowych dokonywano pomiarów odrostu traw sztywną miarką do momentu aż trawy na poletkach doświadczalnych, gdzie zastosowano opryskiwanie, osiągnęły wysokość 12 cm. We wszystkich latach badań regulator wzrostu trineksapak etyl powodował istotne spowolnienie tempa odrostu traw w runi, w porównaniu z odrostem traw bez jego stosowania. Zastosowanie tego preparatu nie miało natomiast wpływu na wykorzystywanie przez rośliny zastosowanych nawozów mineralnych. W związku ze zróżnicowanymi warunkami atmosferycznymi w poszczególnych latach stwierdzono również istotne różnice w odroście traw. Trineksapak etyl skutecznie spowalnia odrost traw w runi. Zastosowany trineksapak etyl wykazuje korzystną interakcję z nawozami mineralnymi w aspekcie tempa odrostu runi.

Słowa kluczowe: odrastanie, trineksapak etyl, nawożenie, trawniki, warunki klimatyczne

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