

# Effects of plant growth regulation in seed crops of Italian ryegrass (*Lolium multiflorum* L.)

G.A. Rijckaert

Institute for Agricultural and Fisheries Research (ILVO) – Plant Sciences Unit,  
Burg. Van Gansberghelaan, 109-box 1, B-9820 Merelbeke, Belgium  
E-mail: georges.rijckaert@ilvo.vlaanderen.be

## Abstract

Despite the official registration of Moddus (trinexapac-ethyl) for growth regulation in C1-seed crops of all ryegrass species in Belgium since 2002, seed growers of Italian ryegrass have not adopted this new management practice. The main reasons for this non-adoption were the limited number of trials (2), the less pesticide-minded cattle farmers and the critical profitability due to very low growers' seed prices during 2002-2006.

A new series of trials was conducted for Italian ryegrass seed crops in three consecutive years, i.e., 2007-09. In all trials, eight PGR treatments and an untreated control were evaluated on a tetraploid variety 'Meroa'. The respective rates of Moddus (250 g a.i. l<sup>-1</sup>) were 0.4 – 0.4+0.4 – 0.8 – 1.2 l ha<sup>-1</sup>, either with or without methylated seed oil surfactant (Actirob B). Moddus was applied at the 2-3 node growth stage and again 10-20 days later for the split treatment.

Across years, the optimal seed yield response ranged from 7.3 to 32.6% over the untreated checks, and also the optimal application rates were different between years, i.e., 1.2 – 0.4 – 0.4 l ha<sup>-1</sup> for 2007-08-09, respectively. This could be attributed to a wet or dry season. The mean optimal seed yield over the years increased by about 17% (347 kg ha<sup>-1</sup>).

The addition of the surfactant was not always profitable, except for 2007 (very wet). The split treatment (0.4+0.4) rarely resulted in a higher seed yield when compared with the full rate (0.8). Seed yield responses are discussed in relation to seed yield components, thousand seed weight, straw yield, lodging, stem shortening and seasonal meteorological conditions.

## Introduction

Italian ryegrass (*L. multiflorum*) is the most commonly grown grass species for seed production in Belgium (51°N); i.e., on average 3,232 ha for the period 2006-09 in comparison with 1,257 ha in the period 1982-86. Currently, it represents 57% of the total grass seed area. Belgium is one of the better agro-climatic production sites for seed production of Italian ryegrass. The growing interest in Italian ryegrass seed crops over the years fits very well in the favourable region of Flanders with its moderate, humid climate, mild winters and long growing season. This crop is fully integrated on cattle farms (dairy) and mixed farms as a combined forage-seed production system. The very intensive, but sustainable production system consists of subsequent productions: i.e., a forage cut (prewilted) in May, a seed cut + grass seed straw in July-August, possibly followed by a forage cut or grazing during autumn, and finally a forage cut in the spring of next year. The latter is directly followed by silage maize. In other words, the

by-products of this grass seed crop are fully exploited in dairy and mixed farms. The combined forage-seed production system is a profitable speculation for Belgian seed growers. On the other hand, the more globalised market for grass seeds and very fluctuating market prices necessitate higher and more stable seed yields for Italian ryegrass over the years.

While the use of plant growth regulators (PGR) has become common practice in seed production of most grasses, preliminary seed production research has been somewhat neglected for Italian ryegrass worldwide. Some research is known on annual ryegrass-Westerwold type. Oregon studies (Melbye *et al.*, 2007) with trinexapac-ethyl (Palisade, Moddus) and prohexadione-calcium (Apogee, Regalis) reported an average seed yield increase of about 10% (250 kg ha<sup>-1</sup>) in annual ryegrass over seven site-years (1999-2006). In New Zealand, seed yield increases from the use of Moddus in annual ryegrass were even higher; over 75% (Pyke, 2007). In Belgium, the first PGR research (2 trials) on Italian ryegrass (biannual type) was conducted in 2000 and 2001, and this finally led to the Belgian registration of Moddus for use in all ryegrass species. The mean optimal seed yield increased by 17% (192 kg ha<sup>-1</sup>) for a diploid cultivar and the optimal rate of Moddus ranged from 100 to 200 g a.i. ha<sup>-1</sup> depending on growing conditions (Rijckaert, 2007).

However, seed growers of Italian ryegrass did not pick up this new management practice. Therefore, a new series of trials was started in order to ameliorate the economical return of Italian ryegrass seed crops over the years. In this article, we summarise the main effects of Moddus applied alone or in combination with a surfactant, on seed yield and related characters.

## Materials and Methods

Three growth regulation experiments (2007-08-09) were conducted at ILVO, Plant Sciences Unit, Merelbeke, on a sandy-loam soil in first year seed crops of Italian ryegrass cv. Meroa (tetraploid). All trials were sown using a precision drill (Øyord system) against 800 germinable seeds per m<sup>2</sup>, during late September to early October.

Eight PGR treatments and an untreated control were compared in a randomized complete block design with four replications. Namely Moddus (250 g l<sup>-1</sup> trinexapac-ethyl) was applied at 4 rates: i.e., 0.4 – 0.4 + 0.4 – 0.8 – 1.2 l ha<sup>-1</sup>, respectively without and with addition of methylated canola oil (Actirob B) at 0.25% by spray volume. The first application stage (T1) was GS 32-33 (Table 1) and this was followed by a second spray for the split application, 10-20 days later (T2). Treatments were applied using a 2.5 m wide boom sprayer (compressed air) with 5 flat nozzles; spray volume; 250 l ha<sup>-1</sup> and pressure: 181 kPa.

Gross plot size was 2.5 x 11 m where only the central part was harvested i.e., 1.5 x 10 m = 15 m<sup>2</sup> in order to avoid border effects and possible drift from the applied chemicals.

The total mineral nitrogen fertilisation was 200 kg ha<sup>-1</sup> which was divided in 120 units for the forage cut and 80 units for the seed cut. After the preceding forage cut in May (Table 1), plots were subjected to the experimental treatments.

**Table 1.** Some details of three PGR experiments on Italian ryegrass trials 2007-08-09

	Trial n° 1 harvest 2007		Trial n° 2 harvest 2008		Trial n° 3 harvest 2009	
<b>Time of defoliation</b>	03/05/07		15/05/08		20/05/09	
Harvest date	25/07/07		31/07/08		29/07/09	
Moisture content	30.7%		40.7%		27.4%	
Treatments	T1	T2	T1	T2	T1	T2
- planned GS	32-33	+ 10-20D	32-33	+ 10-20D	32-33	+ 10-20D
- application date	25/05/07	14/06/07	04/06/08	17/06/08	02/06/09	12/06/09
- average n° of nodes	1.8	3.6	2.8	4.0	2.0	3.5
Rainfall <sup>1</sup> - (temp. <sup>2</sup> ) <sup>3</sup>						
- May – 61,0 (13.8)	96.7 (14.1)		30.8 (16.0)		66.4 (14.2)	
- June – 77,9 (16.1)	91.6 (17.3)		79.1 (15.8)		69.5 (16.0)	
- July – 82,5 (18.1)	154.5 (17.1)		51.7 (17.8)		67.7 (18.2)	

<sup>1</sup> rainfall in mm<sup>2</sup> mean temperature in °C<sup>3</sup> average figures for period 1992-2009 in first column

When appropriate (except in 2007), the following parameters were evaluated: lodging, plant height, culm and ear length, fertile tiller density and secondary regrowth at harvest time. Finally, seed was harvested by cutting with a forage plot harvester designed for efficient bagging. The harvested swath was air dried in jute bags to a moisture content of 12% before threshing and seed cleaning. Cleaned seed, thousand seed weight (TSW), germination, straw yield, cleaning efficiency, harvest index and number of seed per unit area were determined.

## Results and discussion

Very high clean seed yields of Italian ryegrass were obtained in both dry seasons of 2008 and 2009; the untreated controls yielded 2,358 and 2,150 kg ha<sup>-1</sup>, respectively. In both years, the seed crop was preventively protected by one fungicide application. In 2007 on the other hand, the control only achieved 1,441 kg ha<sup>-1</sup>. This could be attributed to the very wet season and a late crown rust attack without any fungicide protection. Seed yield responses to PGR treatments were distinctly different between years and results are presented per year.

Across years, the optimal seed yield response ranged from 7.3 to 32.6% over the untreated checks, and also the optimal application rate of Moddus was different between years i.e., 1.2 – 0.4 – 0.4 l ha<sup>-1</sup> for 2007-08-09, respectively. Only in 2008, seed yield increases were not significantly different from the control, but the optimal rate tended to 0.4 l ha<sup>-1</sup>. In 2007, PGR treatments with surfactant Actirob B tended to enhance the effect on seed yield when compared to the respective doses without surfactant, but it was only significant at the rate of 0.8 l ha<sup>-1</sup>. In 2008 and 2009, this positive effect from the surfactant could not be observed.

**Table 2.** Effect of PGR on seed yield and related parameters in Italian ryegrass – 2007

Treatments <sup>1</sup>	Seed yield (rel. %)	Straw yield (rel. %)	Harvest index (%)	Seeds m <sup>-2</sup> calculated (x 1000)	TSW (dg)
	(=1,441 kg ha <sup>-1</sup> )	(=5.15 ton ha <sup>-1</sup> )			
1. 0 = control	100.0 b	100.0 ab	21.9 c	38.1 b	<b>378 c</b>
2. 100	105.5 b	101.2 a	22.5 bc	40.5 ab	<b>375 c</b>
3. 100 + 100 <sup>2</sup>	108.2 b	97.1 abcd	23.8 bc	40.8 ab	<b>382 c</b>
4. 200	109.6 b	96.7 abcd	24.1 bc	41.1 ab	<b>384 c</b>
5. 300	132.4 a	94.1 cd	28.2 a	46.1 a	<b>414 b</b>
6. 100 S <sup>3</sup>	110.5 b	98.3 abc	23.9 bc	42.5 ab	374 c
7. 100 + 100 <sup>2</sup> S	112.3 b	94.6 bcd	24.9 b	42.3 ab	384 c
8. 200 S	126.6 a	92.1 de	27.8 a	44.5 ab	410 b
9. 300 S	132.8 a	89.4 e	29.4 a	43.8 ab	438 a
P-value	<0.001	<0.001	<0.001	<0.05	<0.001
LSD (P<0.05)	12.6	3.9	1.8	4.3	21

<sup>1</sup> rate in g a.i./ha of Moddus (trinexapac-ethyl)<sup>2</sup> split application<sup>3</sup> S = surfactant methylated canola oil (Actirob B)

The split application of Moddus (treatment n°3 - n°7) was mainly introduced in order to be able to apply in practice the optimal dose, varying in accordance to soil moisture content and expected weather conditions. In this way the second spray should be carried out or not. A possible detrimental effect on seed yield from the split application could only be confirmed in one out of six cases in above trials (Table 2). Therefore, this approach of split application could be recommended when economical return will coming up; e.g. low grass seed prices, high product costs.

Seed yield increases in the wet season of 2007 were associated with lower straw yields, especially for treatments n° 5, 8 and 9 and higher thousand seed weights for the same treatments, both on a significant level. Harvest index and seed number per unit area responded accordingly. This indicated that these PGR treatments resulted in a less vegetative seed crop or a more favourable micro-environment for good pollination, seed setting, seed filling, ripening and harvesting during the extremely wet season of 2007.

The seasons 2008 and 2009 on the other hand, were quite dry when compared to the normal weather conditions in Belgium (Table 1). Because the optimal conditions for flowering and seed ripening were also present in the untreated controls – i.e., an upright seed crop, PGR treatments were less responsive to seed yield increases. So during dry growing seasons, plant growth regulation could not really offer an advantage against the controls.

**Table 3.** Effect of PGR on seed yield and related parameters in Italian ryegrass – 2008

Treatments	Seed yield	Straw yield	Seeds m <sup>-2</sup>	Lodging <sup>1</sup> (flowering)	Culm length	Lodging (near harvest)
	(rel. %)	(rel. %)	(x 1000)	04/07/08 (0 – 10)	24/07/08 (cm)	22/07/08 (0 – 10)
	= 2,358 kg ha <sup>-1</sup>	= 7.15 ton ha <sup>-1</sup>				
1. 0 = control	100.0	100.0 a	48.9	<b>4.3 a</b>	<b>80.4 a</b>	<b>7.3 a</b>
2. 100	106.5	96.1 ab	52.8	<b>2.1 b</b>	76.7 ab	5.9 b
3. 100 + 100 <sup>2</sup>	99.8	89.2 b	48.8	<b>1.1 bc</b>	72.9 ab	5.6 b
4. 200	105.3	94.8 ab	52.3	<b>1.6 b</b>	75.8 ab	4.8 c
5. 300	99.5	94.4 ab	49.4	<b>1.0 bc</b>	76.1 ab	4.1 c
6. 100 S <sup>3</sup>	108.1	92.1 ab	54.3	1.6 b	75.0 ab	5.9 b
7. 100 + 100 S	104.7	93.7 ab	51.8	1.9 b	73.8 ab	4.5 c
8. 200 S	103.3	89.7 b	51.4	1.0 bc	71.4 b	3.5 d
9. 300 S	104.0	92.6 ab	52.2	0.4 c	70.6 b	2.8 e
P-value	0.39	<0.05	0.17	<0.001	<0.05	<0.001
LSD (P<0.05)	-	5.9	-	0.7	5.1	0.6

<sup>1</sup> lodging score: 0 = erect; 10 = completely lodged<sup>3</sup> S = surfactant methylated canola oil (Actirob B)**Table 4.** Effect of PGR on seed yield and related parameters in Italian ryegrass – 2009

Treatments	Seed yield	Straw yield	Seeds m <sup>-2</sup>	Lodging (flower.)	Culm length	Lodging (near harvest)
	(rel. %)	(rel. %)	(x 1000)	06/07/09 (0 – 10)	22/07/09 (cm)	24/07/09 (0 – 10)
	= 2,150 kg ha <sup>-1</sup>	= 7,07 ton ha <sup>-1</sup>				
1. 0 = control	100.0 b	100.0 a	45,9 b	<b>3.8 a</b>	<b>83,2 a</b>	<b>8,0 a</b>
2. 100	117,9 a	95,2 b	55,2 a	<b>2.6 b</b>	<b>78,7 ab</b>	<b>8,1 a</b>
3. 100 + 100 <sup>1</sup>	118,1 a	93,9 bc	53,2 a	<b>1.0 cd</b>	<b>68,1 cd</b>	<b>5,6 cd</b>
4. 200	121,4 a	92,1 bcd	57,7 a	<b>1.1 cd</b>	<b>78,1 ab</b>	<b>6,4 bc</b>
5. 300	118,7 a	89,0 cd	55,6 a	<b>0.3 cd</b>	<b>66,5 cd</b>	<b>4,4 de</b>
6. 100 S <sup>2</sup>	119,1 a	93,2 bcd	55,4 a	<b>1.6 bc</b>	<b>76,3 b</b>	<b>7,3 ab</b>
7. 100 + 100 S	117,1 a	92,1 bcd	53,2 a	0.6 cd	<b>69,6 cd</b>	4,4 de
8. 200 S	114,1 a	89,1 cd	52,8 a	0.0 d	72,4 bc	4,3 de
9. 300 S	117,1 a	86,0 d	54,9 a	0.0 d	<b>64,2 d</b>	3,5 e
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD (P<0.05)	7.6	3.5	4.2	1.0	5.1	1.1

<sup>1</sup> split application<sup>2</sup> S = surfactant methylated canola oil (Actirob B)

In both years, lodging differences at flowering were rather small between the PGR treatments, while the controls only lodged 4.3 and 3.8 respectively; this is caused by drought (Tables 3-4). The lodging scores before harvest showed a nearly upright seed crop following the higher rates of Moddus; namely 0.8 and 1.2 t ha<sup>-1</sup>. The reduced lodging effect was more pronounced when the surfactant was used, especially in 2008, but also in 2009.

Further culm length measurements gave a good evaluation of the effectiveness of the straw shortening. In 2008, only the higher rates of Moddus + surfactant (treatments n°8-9) provoked a significant reduction in culm length against the control. Other treatments only showed a tendency to shortening. In 2009, the reduction in culm length was more pronounced and the split application resulted in a significant reduction when compared to the same rate at one time (0.8). This phenomenon was partly translated to the lodging score before harvest.

Seed yield differences between PGR treatments were negligible in 2008 and did not need further explanation. The lack of seed yield response when compared to the untreated control, was probably due to the drought stress just after PGR applications.

In 2009, the similar seed yield increases from all PGR treatments were associated with lower straw yields and resulted in higher seed numbers per unit area. However, no further seed yield increase occurred with the increasing rate of Moddus. This could also be attributed to the very dry conditions from 15 th of June until harvest, where higher growth inhibition could not ameliorate any further the micro-environment for optimal seed production.

In both years, the thousand seed weight and the number of fertile tillers were not affected by treatments (data not shown).

### **Conclusion**

Based upon the extremely different testing years with different optimal rates of Moddus i.e., 1.2 – 0.4 – 0.4 t ha<sup>-1</sup> in 2007-08-09 respectively, we believe a split application of Moddus will more easily approach the optimal rate over several years. The addition of a surfactant like Actirob B is highly recommendable.

### **References**

- Melbye M.E., Gingrich G.A. & Silberstein T.B. (2007). Use of plant regulators on annual ryegrass: the Oregon experience. In: Proc. 6<sup>th</sup> Intern. Herbage Seed Conference, Gjøennestad, Norway, Bioforsk Fokus 2 (12), 236-238.
- Pycke N.B. (2003). Applied research and extension for New Zealand herbage seed producer's progress and problems. In: Proc. 5<sup>th</sup> Intern. Herbage Seed Conference, Gatton, Australia: 64-67.
- Rijckaert G.A. (2007). Effects of trinexapac-ethyl (Moddus) in seed crops of Italian ryegrass and timothy. In: Proc. 6<sup>th</sup> Intern. Herbage Seed Conference, Gjøennestad, Norway, Bioforsk Fokus 2 (12), 231-235.