

Changes in seed yield and quality resulting from lodging in Italian ryegrass crop

Promjene u prinosu i kvaliteti sjemena uslijed polijeganja usjeva talijanskog ljulja

Zlatko SVEČNJAK¹ (✉), Dario JAREŠ¹, Martina KOVAČEVIĆ¹, Klara BARIĆ², Tomislav IVANUŠIĆ³, Dubravko MAČEŠIĆ¹, Dubravka DUJMOVIĆ PURGAR⁴

¹ Department of Field Crops, Forage and Grassland, University of Zagreb, Faculty of Agriculture, Svetošimunska cesta 25, 10000 Zagreb, Croatia

² Department of Herbology, University of Zagreb, Faculty of Agriculture, Svetošimunska cesta 25, 10000 Zagreb, Croatia

³ Bc Institute for breeding and production of field crops, Dugoselska 7, 10370 Rugvica, Dugo Selo, Croatia

⁴ Department of Agricultural Botany, University of Zagreb, Faculty of Agriculture, Svetošimunska 25, 10000 Zagreb, Croatia

✉ Corresponding author: svecnjak@agr.hr

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ABSTRACT

Rainfall accompanied with winds favour lodging of Italian ryegrass (*Lolium multiflorum* Lam.). Thus, the main objective was to determine the changes in seed yield and quality resulting from lodging of Italian ryegrass crop grown under various nitrogen (N) fertilization rates. Nitrogen fertilization consistently increased lodging score and seed moisture content at harvest. The onset of considerable lodging (>50%) was observed before crop heading at the highest N fertilization, while delayed lodging occurred at lower N fertilization rates. Seed yield decreased at the highest N rate. In spite of increased lodging score, the 1000-seed weight tended to increase with higher N fertilization rates, which was not found for seed germination.

Keywords: 1000-seed weight, moisture content, nitrogen, seed germination

SAŽETAK

Vremenske nepogode (kiše praćene vjetro) redovito dovode do polijeganja sjemenskog usjeva talijanskog ljulja (*Lolium multiflorum* Lam.). Stoga je glavni cilj istraživanja bio utvrditi promjene u prinosu i kvaliteti sjemena uzrokovane polijeganjem usjeva talijanskog ljulja uzgojenog na različitom intenzitetu gnojidbe dušikom (N). Više doze N gnojidbe konzistentno su povećale polijeganje usjeva i sadržaj vode u sjemenu u žetvi. Osjetno polijeganje (> 50%) utvrđeno je već početkom klasanja pri najvišoj dozi gnojidbe, dok je sličan intenzitet polijeganja na nižim razinama N gnojidbe opažen u kasnim fenofazama usjeva. Posljedično je u parcelama gdje je primijenjena najveća doza N gnojidbe došlo do smanjenja prinosa sjemena. Unatoč povećanom polijeganju usjeva, primjena viših doza N gnojidbe je rezultirala u povećanoj masa 1000 sjemenki, a što nije utjecalo na klijavost sjemena.

Ključne riječi: masa 1000 sjemenki, sadržaj vode, dušik, klijavost sjemena

INTRODUCTION

Inability to retain seed until the time of harvest is one of the undesirable features of Italian ryegrass crop grown for seed production and therefore, it is generally direct combined at higher moisture content than perennial ryegrass (*Lolium perenne* L). Direct combining is not usually advisable at seed moisture concentrations above 40%. However, Roberts (1971) stated that seed crop of tetraploid Italian ryegrass may be successfully combined directly starting at around 45% seed moisture content as long as combine drum speeds are adjusted correctly. The effect of N fertilization on the seed production of perennial ryegrass is well documented (e.g. Griffith et al. 1997), whereas information for Italian ryegrass crop is scarce. Rolston et al. (2012) reported that in two field trials in New Zealand, seed yields were greater than 3500 kg/ha under N fertilization rate of 180 kg/ha for Italian ryegrass crop. Increasing N fertilization increases growth and prolongation of stems that are more inclinable to lodging and Griffith (2000) found that lodging reduced seed yield in perennial ryegrass crop. Furthermore, lodging combined with favourable weather conditions supports the growth of new vegetative tillers, which may lead to difficulties in harvesting. Previous research indicated that the application of plant growth regulator (PGR) has great potential of improving Italian ryegrass seed yields. On-farm experimentation carried out by Rolston et al. (2012) showed that after applying PGR seed yields increased by 29 to 64% compared to untreated control. The seed yield response was associated with stem shortening, and reduction in lodging, resulting in more saleable seeds per unit area and increased number of saleable seeds produced from the number of florets counted post anthesis. The main objective was to determine the changes in seed yield and quality resulting from lodging of Italian ryegrass crop grown under various N fertilization.

MATERIALS AND METHODS

A two-factorial experiment (nitrogen fertilization and PGR application) was conducted in biannual Italian

ryegrass crop for seed during one growing season at the Maksimir experimental field. The PGR Moddus 250 EC was sprayed during shooting (ZCK 21-23, Zadoks et al. 1974) at the rate of 1.0 L/ha and compared to unsprayed plots. The spray volume used in the PGR application was 200 l/ha. Nitrogen fertilization was applied at the total rates of 60, 120 and 180 kg/ha. Granular N fertilization, as calcium ammonium nitrate (27% N) was top broadcast in split applications. Plots were free of weeds, diseases and pests throughout experimentation.

Crop lodging severity was assessed visually and scored as a percentage of plot lodged where 0 is not lodged (plants are fully upright) and 100% is most severe lodging (plants are lying flat on the ground). Lodging was observed daily until harvest. The crop was harvested by direct combining when seed moisture content reached approximately 40-45%. Mature grain was harvested with a small plot combine with drum speed and concave settings to simulate commercial farm practice. After harvest, samples were taken for determination of seed moisture content for harvested seed. The harvested seed yield was dried at room temperature for several weeks, and then cleaned of impurities to determine clean seed weight (yield), which is expressed with 14% moisture content. Thousand seeds weight was determined by twice counting 200 seeds and weighed. Germination was determined approximately 90 days after harvest in accordance with the ISTA Rules (ISTA, 2008) by placing 100 seeds to imbibe on a moist germination paper. After a chilling treatment for five days at 5°C, the seeds were germinated at 20°C. The final seedling count was made after 14 days.

Field trial was arranged in a split-plot design with four replicates. Data were analysed using Mixed Model procedures (SAS Institute, 1997). Analysis of variance was computed with crop management (with or without PGR application) and N fertilization considered fixed. Means separation was calculated using the LSD values if the F-test was significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

The crop was harvested within the optimum window for seed moisture content, which averaged 44.6%. Seed moisture content consistently increased with higher N fertilization (Figure 1) and the highest seed moisture content was measured at the highest N rate in both untreated plots and plots treated with PGR. A seed moisture concentration of approximately 40% is quoted by Silberstein et al. (2005) as suitable for cutting Italian ryegrass for later picking up by combine when seed moisture drops to about 12%. Plants treated with PGR had higher seed moisture content than the untreated crop at all fertilization levels (Figure 1).

Seed yields ranged from 1251 kg/ha for the unsprayed plots at the highest N rate to 2373 kg/ha for the sprayed plots at the N rate of 120 kg/ha. Seed yield averaged 1371 kg/ha in the unsprayed plots at the basal N fertilization of 60 kg/ha. The application of N fertilization rate of 120 kg/ha in unsprayed plots produced higher yields that averaged 1631 kg/ha despite an associate increase in lodging (Figure 1). In Serbia, maximum seed yield (1095 kg/ha) of the Italian ryegrass crop was produced at relatively low N fertilization of 50 kg/ha (Simić et al., 2012). In Belgium (Vleugels et al. 2017), seed yields averaged over years increased between 0, 60 and 90 kg N/ha, but no differences were found between 90, 120 and 150 kg N/ha.

In comparison to the N rate of 120 kg/ha, the highest N fertilization brought about significant yield reduction by a 26% in the unsprayed plots. This yield reduction in the unsprayed plots at the highest N rate was attributed to severe (Figure 1) and early occurring lodging. The onset of lodging in the both sprayed and unsprayed crops was observed in early May (data not shown). However, at the highest N rate of 180 kg N/ha considerable crop lodging (>50%) was observed on 13 May in the unsprayed plots and on 18 May in crop sprayed with PGR. At the N rate of 120 kg/ha, the unsprayed crop also lodged >50% on 13 May, but similar lodging rate was not observed before 12 June in the crop treated with PGR; thus, the onset of considerable lodging was delayed for more than 4 weeks following PGR application. Seed yield responses to lodging in grass crops are sometimes difficult to interpret because lodging may often occur on several occasions with varying degree of severity during growing season. Moreover, the effects of lodging depend on the growth stage of the crop at the time of lodging, and on subsequent weather conditions. Following couple of rainy days with strong winds, the onset of lodging in our experiment was also just before heading, when plots fertilized with 180 kg N/ha completely lodged (97.3%). This early-season lodging resulted in shading and it was suggested that the physiological explanation of lodging effects on yield lie in its effects on crop growth rate because less-favourable

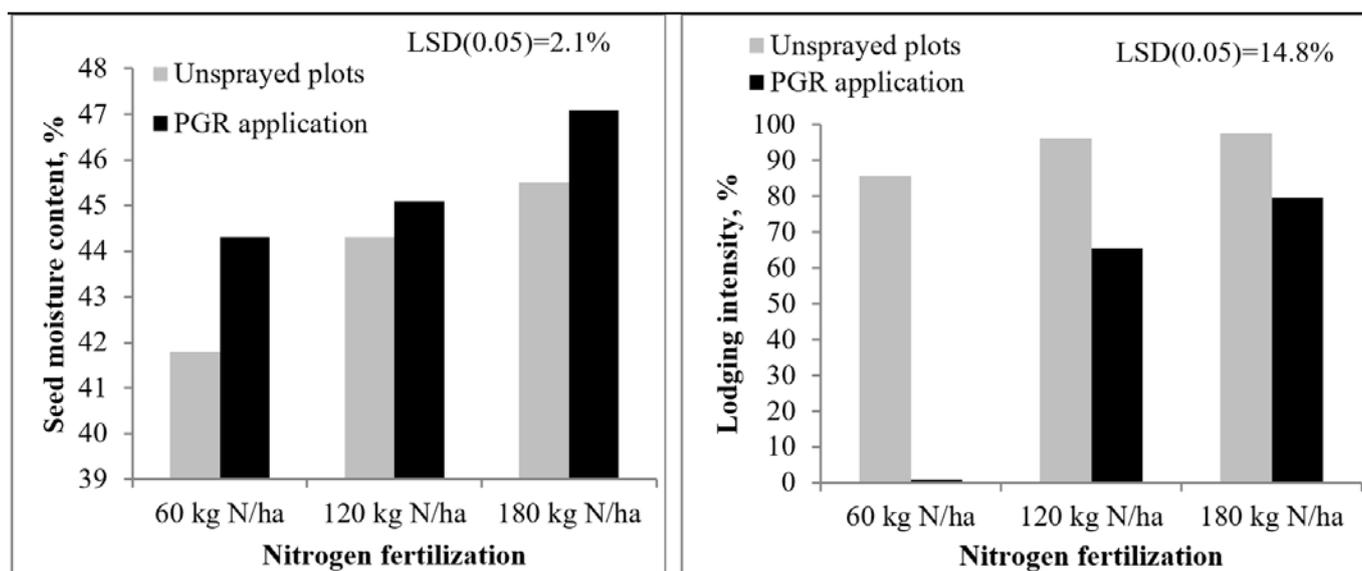


Figure 1. Seed moisture content (left) and lodging intensity (right) of Italian ryegrass as affected by nitrogen and plant growth regulator (PGR) applications

distribution of light reduce post-lodging crop growth rate. For example, the decrease in final total dry weight resulting from lodging was found on wheat (*Triticum aestivum* L.) by Fisher and Stapler (1987) with these reductions being equal to or more than the reductions in grain yield. Similarly to responses in unsprayed plots, seed yields improved with N rate of 120 kg/ha in the plots sprayed with PGR, and then slightly reduced at the highest N fertilization. Consequently, plots treated with PGR produced larger seed yields than the unsprayed plots at all fertilization levels (data not shown).

Compared with N rate of 120 kg/ha, earlier and more severe lodging in the unsprayed plots occurring at the highest N fertilization had no effect on the 1000-seed weight (Figure 2), which indicated that differences in seed yields were associated with seed number per unit area. In wheat crop, Fischer and Stapper (1987) found that kernel-number reductions were greater with lodging commencing at or before anthesis, while kernel-weight reductions were greater with later lodging. This pattern supports the idea that the reductions in seed number with early-occurring lodging were mainly due to reductions

in photoassimilate supply. Interestingly, higher lodging severity brought about by more intensive N fertilization had no negative effect on seed weights (Figure 1 and 2). Seed weight increases in lodged perennial ryegrass crop reported Griffith (2000), which is similar to our findings.

Crop sprayed with PGR produced the highest seed yield of 2373 kg/ha at the N rate of 120 kg/ha, which was by 45% larger than the unsprayed crop at the same N fertilization. This highest yielding crop sprayed with PGR had relatively high lodging severity at harvest (Figure 1), but the onset of lodging occurred almost a month later (on June 7) in comparison to the unsprayed crop at the same fertilization level. These results suggested that delayed lodging was the main reason for enhanced yield in the crop sprayed with PGR. The highest germination rates were found at the N fertilization of 120 kg/ha, which averaged 94.0% in the unsprayed crop and 95.5% in the crop sprayed with PGR (Figure 2). Young III et al. (1996) found that seed germination of annual ryegrass in Oregon ranged from 86 to 97%. Seed germination was slightly affected by N fertilization and PGR application (Figure 2).

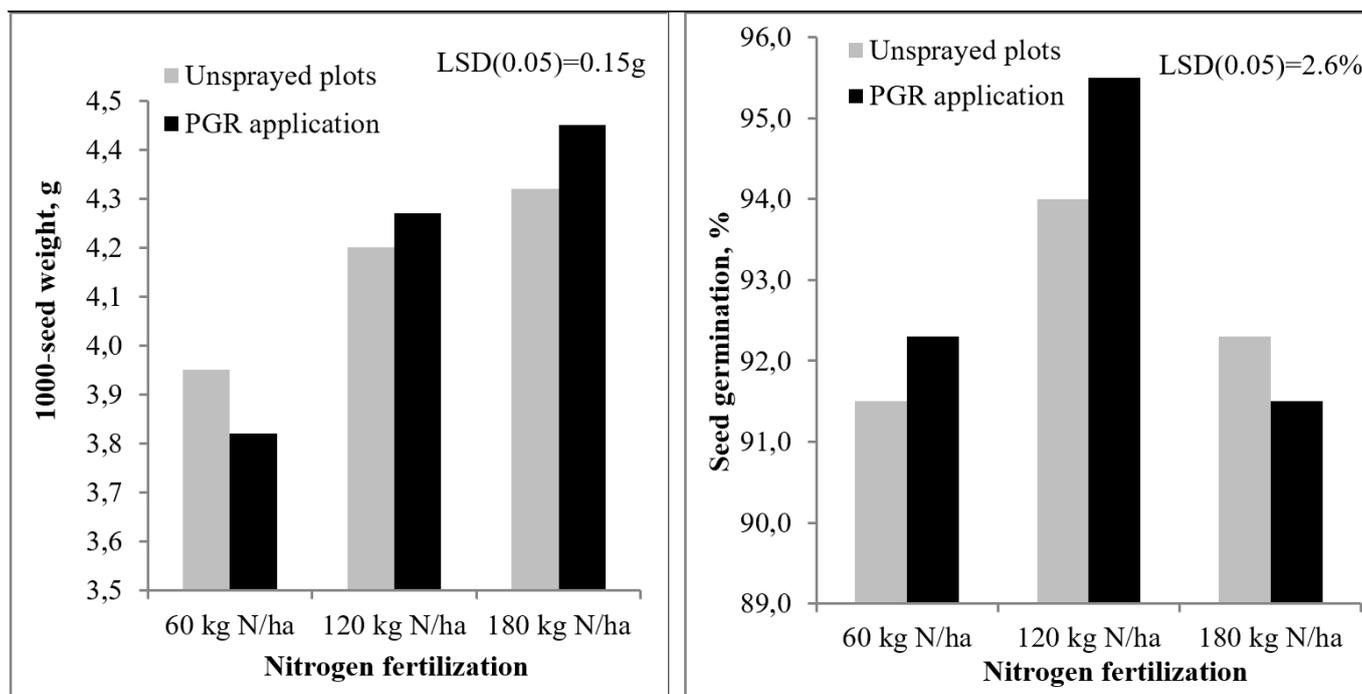


Figure 2. The 1000-seed weight (left) and seed germination (right) of Italian ryegrass as affected by nitrogen and plant growth regulator (PGR) applications

CONCLUSIONS

In spite of increased lodging score at harvest, seed yields and the 1000-seed weight tended to increase with higher N fertilization rates in crops sprayed with PGR. In contrast, lodging resulted in decreased seed yield for the unsprayed crop at the highest N fertilization. Seed germination could not be related to lodging intensity in our research.

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