THE EFFECT OF SEED AGE ON THE GERMINATION, DORMANCY, AND FIELD EMERGENCE OF ANNUAL RYEGRASS USED AS A COVER CROP

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Introduction

Annual ryegrass is an accepted cover crop in parts of the midwestern United States for corn and soybean production. Cover crops help prevent soil erosion, improve soil tilth, increase soil organic matter, and capture nutrients subject to leaching or runoff losses. Annual ryegrass used as a cover crop is characterized by quick establishment in overseeding, drilling, and broadcast applications if temperature and moisture conditions are favorable. In addition, annual ryegrass is especially noteworthy for developing a deep root system that helps improve the rooting depth of subsequent corn or soybean crops (Plumer et al., 2017).

When used as a cover crop in the Midwest, annual ryegrass is occasionally observed growing in fields a year or more after the original seeds were planted. Midwestern farmers have questioned whether this is due to the presence of dormant or "latent" seed in a newly harvested crop, which is a form of primary dormancy referred to as "postharvest dormancy." Primary dormancy is the condition wherein newly harvested, viable seeds fail to germinate in the presence of suitable conditions. In contrast, secondary dormancy occurs when viable seed fails to germinate because of unsuitable conditions such as drought or extreme high or low temperatures. When the environment becomes favorable again, seeds resume germination. This phenomenon is not unique to annual ryegrass; it occurs in many types of seeds as a survival mechanism under adverse conditions.

In the Midwest, farmers have asked whether storing seed would affect dormancy and stand establishment. The objectives of this study were to: (1) determine whether there is a difference in seed dormancy between newly harvested annual ryegrass seed and seed that has been stored for 1 year, and (2) evaluate whether the age of seed has an effect on emergence under field conditions in Oregon and in the Midwest.

Materials and Methods

Two trials were conducted in this study, one under growth chamber conditions in the OSU Seed Laboratory and the other under field conditions in Oregon and Indiana. In both experiments, seed from the same four annual ryegrass varieties ('Bounty', 'KB Royal', 'Ed', and 'Gulf') were used. Varieties were from different seed companies and were selected to represent a range of annual ryegrass varieties produced in Oregon. The variety 'Gulf' is the oldest and one of the most commonly grown annual ryegrass varieties in Oregon, but it lacks sufficient cold tolerance for use in the Midwest. 'Bounty', 'KB Royal', and 'Ed' are among varieties with improved cold tolerance that have been developed for use in the Midwest (Mellbye, 2017).

A total of eight seed lots were sampled in Oregon, four from 2017 (new crop) and four of the same varieties from 2016 (1-year-old seed stored in Oregon). Samples were collected from seed lots that had gone through commercial seed conditioning in approved Oregon seed cleaning warehouses. Seed samples were obtained using standard sampling procedures used in the seed industry and by the OSU Seed Certification Service, which are designed to obtain representative and unbiased samples. A minimum of 30 bags were probed (or 1 bag/1,000 lb seed) with a sampling tier to obtain a sample size of approximately 2 lb of seed.

Seed germination tests

In the first experiment, seed germination was measured on new-crop (2017) and 1-year-old seed (2016) for each variety. Germination tests were carried out by the OSU Seed Laboratory according to AOSA rules for testing seeds (AOSA, 2017). All germination tests were conducted with and without a 7-day prechilling treatment at 10°C. The prechilling treatment is a common method for breaking postharvest dormancy in grass seed crops.

To evaluate the effect of storage time on dormancy and seed viability, especially of new-crop seed, the germination tests were conducted over a period of time. The first testing date was in early postharvest of the new crop (August 1, 2017). The second test was conducted 2 months postharvest of the new crop (October 1, 2017), and the final testing date was approximately 8 months postharvest (April 20, 2018). For the 1-year-old crop, the testing dates corresponded to 12, 14, and 20 months postharvest.

Field emergence

In the second experiment, the same four varieties (eight seed lots) were planted in small plots in Oregon and Indiana to evaluate emergence under field conditions. Seeds used in these plots were taken from the same samples used in the seed laboratory germination tests, but they did not receive a prechilling treatment. For each field site, 100 seeds of each variety were counted and placed in sealed envelopes. Samples were replicated three times for each site and included a check plot with no seed planted. The plot areas were defined by a 2-inch x 4-inch wooden frame anchored to the ground and laid out in an 8-foot x 5-foot grid in a completely randomized block design with three replications. Individual plots within each replication were separated by 1-inch x 2-inch lumber and were 1 ft^2 in size. The wooden grid was used to ensure plot separation and to aid in later evaluations.

Three locations were used in the field emergence experiment: one in Oregon and two in Indiana. The Oregon location (Lebanon, OR) was managed to represent optimal seed bed conditions. The site was cultivated, raked, and packed to prepare a smooth, firm, sod-free seedbed. It was watered three times in late August and early September with overhead irrigation (0.5 inch per set) to allow volunteer ryegrass and weeds to be controlled with glyphosate prior to planting on September 20, 2017. Seed was raked in and packed to ensure good seed–soil contact, then irrigated five times (0.4 inch per set) over a 2-week period to ensure that moisture was not a limiting factor for germination.

Two fields were selected in Indiana (one near Lafayette, IN and one near Brook, IN) that were in no-till corn and soybean rotations. These sites represented typical or "real-world" conditions found in Midwest agriculture, where seeds are often broadcast and fall cover crop plantings rely on rain for establishment. The annual ryegrass seed plots near Lafayette were broadcast on September 23, 2017 into a silt loam soil with 3% organic matter in dry soil conditions. The first rain occurred approximately 2 weeks later. The Brook site was a level silt loam soil with 4% organic matter. Annual ryegrass seed was broadcast, then lightly raked in and watered with overhead irrigation (0.5 inch per set) every 7 days until emergence. On both the Oregon and Indiana sites, soil temperatures were in the range considered ideal for annual ryegrass germination (65–80°F).

After the annual ryegrass seed germinated in the field plots, seedling emergence was counted at the one- to three-leaf stage in mid-October. In the spring, the ryegrass was controlled with glyphosate in Oregon (2 lb ai/acre applied twice in May). In Indiana, plots were sprayed during farming operations using glyphosate (1.25 lb ai/acre) consistent with Purdue University Extension Service recommendations (Legleiter et al., 2015). A second count of seedling emergence was conducted in the spring and early summer of 2018, followed by a final count in the fall of 2018 to determine whether seed remained viable 1 year after planting.

Results and Discussion

Seed germination

The germination in the seed laboratory of the four annual ryegrass varieties used in the study exceeded 95% when the 7-day prechilling treatment was applied (Table 1). This was true for both years of production and was well above the minimum germination standard of 85% for certified annual ryegrass in the OSU Seed Certification Standards. Even without the prechilling treatment, newly harvested seeds tested 2 and 8 months after harvest and all 1-year-old crop seeds had germination levels that exceeded the OSU certification standard. The germination rates for these lots ranged from 96% to 98%. This was an indication of excellent seed viability and minimal primary dormancy levels for all varieties across both years of production and is typical of seed quality of annual ryegrass grown in Oregon.

Statistical analysis of germination data from the OSU Seed Laboratory indicated that the prechilling treatment and date of the germination test significantly affected germination, while year of production and variety were not significant. Only the new crop seed tested early postharvest (Aug. 1, 2017) showed a benefit to the 7-day prechilling treatment (Table 1). Without prechilling, the newly harvested seed averaged 86% germination. The interaction between varieties and prechilling treatment was not significant, indicating that varieties responded similarly to the prechilling treatment. Likewise, the interaction between varieties and germination dates was not significant, indicating that the response of varieties to the three germination dates was similar.

While not significant, varieties showed some variation in germination, ranging from 78% to 92% (Figure 1). After the early postharvest testing date, however, the four varieties averaged over both years had similar germination levels (Figure 2). The 7-day

Table 1. Mean germination of four annual ryegrass seed varieties ('Bounty', 'KB Royal', 'Ed', and 'Gulf') as a function of time after harvest and year of production (new crop versus 1-year-old seed).

Treatment	Year harvested	Prechill (7 days)	Germination[1,2]		
			Aug. 1, 2017	Oct. 1, 2017	Apr. 20, 2018
			(%)		
			(Postharvest)	(2 months postharvest)	(8 months postharvest)
New crop seed	2017	Yes	96	98	97
		No	86	97	97
			(12 months postharvest)	(14 months postharvest)	(20 months postharvest)
1-year-old crop seed	2016	Yes	97	97	97
		No	96	97	96
LSD (0.05)			5	NS	NS

[1]Seed germination tests were conducted at the Oregon State University Seed Laboratory according to AOSA rules.
[2]NS = not statistically significant

prechilling treatment is the standard procedure used by the OSU Seed Lab to break postharvest dormancy (primary dormancy). Previous research documented that this type of dormancy in annual ryegrass is short lived (Elias and Garay, 2012). Approximately 2 months after harvest, dormancy naturally disappears, and the OSU Seed Lab stops prechilling annual ryegrass in early September.

The results of the germination tests confirm that postharvest dormancy is short lived in the annual ryegrass varieties used in this study, which includes varieties that have been used successfully as cover crops in the Midwest. The results also show that there is some dormant seed in newly harvested annual ryegrass; however, the fraction of seed actually dormant was small, as indicated by the comparatively high germination levels present without a prechilling treatment. If planting in the Midwest in September, most of the primary seed dormancy would be broken.

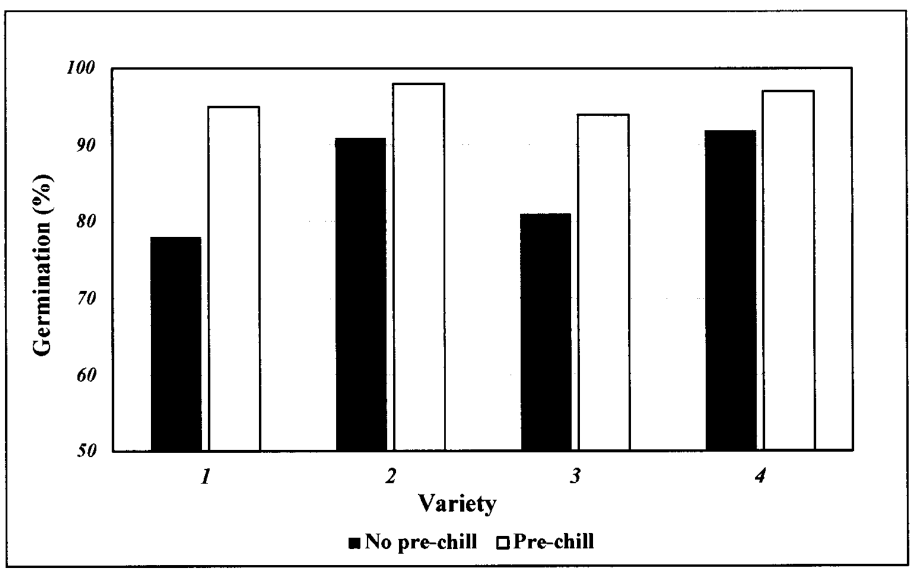

Figure 1. Standard germination test results of four ryegrass varieties tested immediately after harvest with and without prechilling treatment at 10°C for 7 days (2017). Data represent means of four replications; replication data are not available.

Field emergence

Under field conditions, the germination and emergence of annual ryegrass in the Indiana and Oregon field plots was not affected by the year seed was produced (Table 2). At the time of planting in September, seeds of all eight lots had laboratory germination counts at or above 95%. There was no advantage to using seed that had been stored for 1 year before planting.

All four varieties had similar field emergence levels within each site (Table 2). As expected, emergence in the irrigated Oregon plots was greater than on the two Indiana sites that were broadcast and rain-fed or received less water. Mean seedling stand counts per plot in Indiana, averaged across varieties, were 24 in the rain-fed broadcast site and 46 at the site that was irrigated, compared to 84 under optimal conditions in Oregon. Average emergence in Indiana was less than half that observed in Oregon. In Indiana, seed was broadcast over plant residue, resulting in a larger proportion of the seed lacking good seed–soil contact. Thus, there was potential for ungerminated seed to persist into the following year.

The annual ryegrass plantings in both states were allowed to overwinter and then were either sprayed out in early spring with glyphosate following recommended practices (Oregon) or during normal cropping practices for corn production (Indiana) (Plumer et al., 2017). In the Indiana plots, no ryegrass seedlings or established plants were observed in the spring postspray (May–June 2018) or in the fall 1 year after the original seed was planted (October–November 2018). In Oregon, some ryegrass seedlings

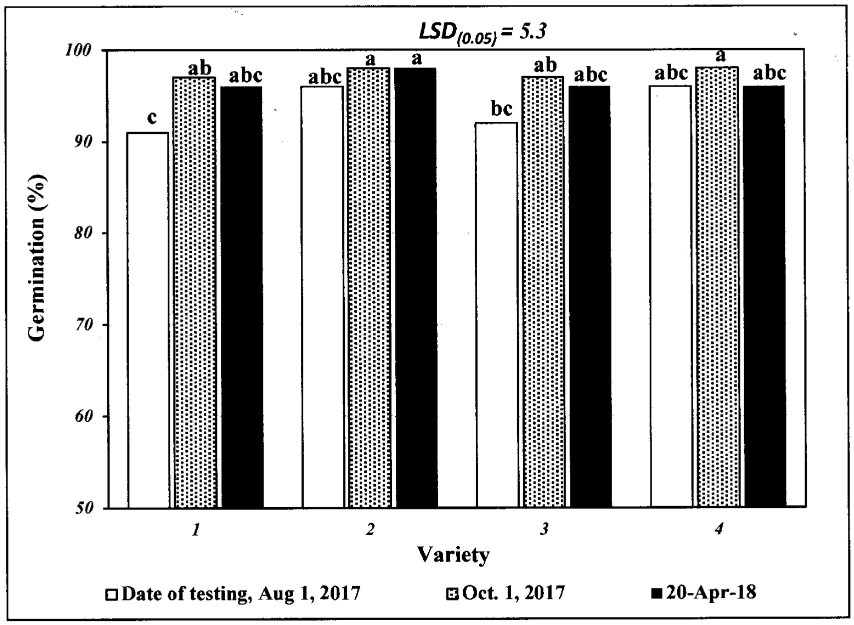

Figure 2. Standard germination test results of four ryegrass varieties tested three times: August 1, 2017, October 1, 2017, and April 20, 2018 (2-year average). Means sharing the same letter do not differ significantly at $P \leq 0.05$.

Table 2. Mean emergence of four annual ryegrass seed varieties (‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’) from two different years of seed production, planted in Oregon and Indiana in the fall of 2017.

Treatment	Year harvested	Seedling emergence in field plots after planting in 2017[1,2]		
		Lebanon, OR Seeded Sep. 20 Cultivated Seed raked in Sprinkle irrigated (Oct. 18, 2017)	Lafayette, IN Seeded Sep. 23 Dry soil No-till broadcast Rain-fed site (Oct. 13, 2017)	NW of Lafayette, IN Seeded Sep. 23 No-till broadcast Overhead irrigated (Oct. 13, 2017)
		--------------------------- (no./plot) ---------------------------		
New crop seed	2017	84	26	46
1-year-old crop seed	2016	84	24	39
LSD (0.05)		NS	NS	NS

[1]One hundred seeds were planted in each plot. The Indiana location received 1.1 inch of rain in September, 0.11 inch on October 4, and 0.22 inch on October 6.

[2]NS = not statistically significant

were observed 1 year after planting, but the grass counts were low and were not significantly different from unseeded check plots.

Field conditions and weather patterns in Midwest agriculture vary greatly from year to year, and rainfall patterns in the fall can vary significantly from site to site. In addition, dormant seed that germinated later on the Midwest sites could have been controlled in the normal crop rotation. Predation by animals and winter kill of later-germinated seed could also be a factor. All of these factors may have contributed to the lack of ryegrass seedlings observed 1 year after planting in Indiana.

Conclusion

The observation in the Midwest that annual ryegrass persists in some fields is due to secondary dormancy rather than postharvest (primary) dormancy. Storage of annual ryegrass seed prior to planting is not necessary to achieve good germination in the field. There was no difference in stand counts between newly harvested and 1-year-old seed in Oregon or Indiana. Local environmental conditions and seeding method had more impact on germination and stand establishment of annual ryegrass than age of the seed.

The four varieties used in this study and most other annual ryegrass varieties grown in Oregon have high seed quality, due to the favorable climate for seed development, harvest, and storage. However, not all annual ryegrass varieties are acceptable for use as a cover crop for corn and soybean production in the Midwest. Characteristics such as cold tolerance, enhanced rooting depth, uniform growth in the spring to aid in termination, and ability to control with labeled herbicides are important. We recommend that farmers in the Midwest use annual ryegrass varieties that have been selected for cold tolerance and tested successfully in the region of use.

References

AOSA. 2017. *Rules for Testing Seeds*, vol. 1. Washington, DC: Association of Official Seed Analysts.

Elias, S.G. and A.E. Garay. 2012. Expression of germination and fluorescence in annual ryegrass samples after seven and fourteen-day germination periods. In A.G. Hulting, N.P. Anderson, D.L. Walenta, and M.D. Flowers (eds.). *2012 Seed Production Research Report*. Oregon State University, Ext/CrS 143.

Legleiter, T., B. Johnson, and B. Young, 2015. *Successful Annual Ryegrass Termination with Herbicides*. Purdue University Extension Service, WS-52-W.

Mellbye, M.E. 2017. Buying annual ryegrass seed for cover crops. http://ryegrasscovercrop.com/wp-content/uploads/2018/05/ryegrass-source.pdf

Plumer, M., M.E. Mellbye, D. Towery, and A.G. Hulting. 2017. Annual ryegrass as a cover crop in Midwest corn and soybean production: Management recommendations. http://ryegrasscovercrop.com/wp-content/uploads/2017/07/ryegrass-recommendations.pdf