

COLD TOLERANCE EVALUATION OF FOUR ANNUAL RYEGRASS VARIETIES GROWN IN OREGON USING A THERMOGRADIENT TABLE

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Introduction

The use of annual ryegrass (*Lolium multiflorum* L.) as a winter cover crop by Midwest corn and soybean farmers has opened a market for Oregon ryegrass seed growers. The advantage of annual ryegrass (ARG) over other cover crops is its ability to grow on poorly drained soil under no-till farming systems (Hart et al., 2011). In addition, ARG is generally not hard to kill in the spring after it fulfills its function as a cover crop in the fall and winter, provided recommended management practices are followed (Plumer et al., 2016).

One of the main challenges of using ARG as a cover crop in the Midwest is selecting appropriate varieties that tolerate low temperatures (approximately 5–10°C; 41–50°F) and produce good stand establishment in a cold environment. Although ARG is a cool-season grass, some varieties have better cold tolerance than others, depending on the genetic makeup of each variety.

Asomaning et al. (2011) reported that using a thermogradient table is an effective tool for predicting seed germination under cold climatic conditions (5–15°C; 41–59°F). This technology is a practical device for screening Oregon ARG varieties to determine which ones have the best potential for quick germination under temperatures similar to those in the Midwest during autumn months. Although planting in September is suggested in the northern Corn Belt and by mid-October in the southern Corn Belt, above-normal rainfall in some years may delay planting. In such cases, seeds have to germinate under suboptimal soil temperatures. Consequently, the ARG varieties that can tolerate cold have a better chance of quick, uniform emergence. This study was designed to use thermogradient technology to screen four ARG varieties for germination cold tolerance.

Materials and Methods

Approximately 500 grams of seed from Oregon-grown varieties, including ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’, were used in this study. Tetrazolium tests were conducted on the four varieties to determine the initial viability level. A total of 240 seeds of each variety were planted on the thermogradient table. The temperature range at which seeds were planted was 5–25°C

(41–77°F). Sections were divided into four increments: 5–10°C (41–50°F), 11–15°C (52–59°F), 16–20°C (61–68°F), and 21–25°C (70–77°F). The number of germinating seeds (both root and shoot emergence 0.5 cm or longer) was counted and reported at day 5, 9, and 14. Average seedling height was measured and recorded on day 14, which was the last day of the study.

Speed of germination indices (SGI) were calculated at the end of the trial using an established protocol to measure seed vigor. The higher the SGI, the faster the germination and the higher the seed quality.

Varieties with higher and faster germination index scores at lower temperatures indicate better potential emergence success in the Midwest environment. Mean SGI and standard deviation (SD) were used to identify and rank varieties for cold tolerance.

Results and Discussion

Two factors are considered when testing for cold tolerance of ARG. The first is the speed of germination (i.e., how fast the seeds germinate) under cold temperatures (especially the 5–10°C range) before colder weather arrives in late fall in the Midwest. The second is seedling height before temperatures drop to the freezing point. Reasonable seedling size (5–6 inches) is needed for the plant to survive through the winter. Smaller seedlings are more susceptible to winter kill.

Initial viability of seed samples

The initial viability by tetrazolium (TZ) tests of ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’ was 98%, 98%, 97%, and 97%, respectively. This indicates that high and similar quality seeds were used in the study. Thus, most of the variation among varieties for cold tolerance would be due to genetic factors rather than variation in seed quality.

Germination at 5–10°C (41–50°F) range

Five days after planting, none of the seeds from any of the varieties had germinated at the temperature range of 5–10°C (41–50°F) (Figure 1). This temperature range is critical to determine the extent of cold tolerance of an annual ryegrass variety because the soil temperature in the Midwest during late fall planting is within this

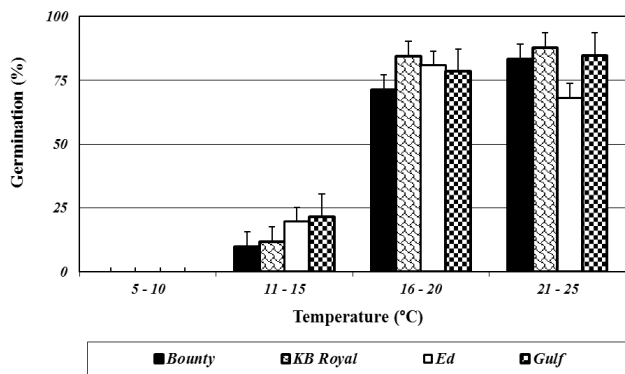


Figure 1. Germination rates of four annual ryegrass varieties after 5 days in a thermogradient table at four temperature ranges (5–10°C, 11–15°C, 16–20°C, and 21–25°C).

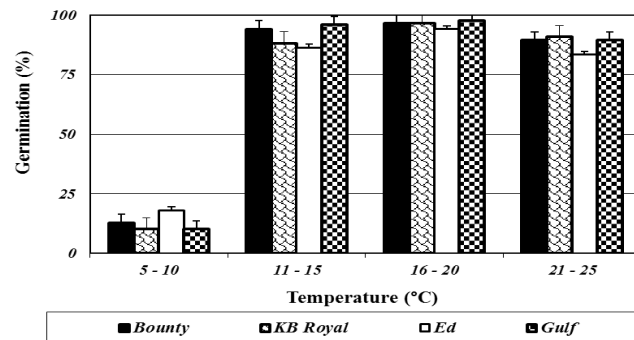


Figure 2. Germination rates of four annual ryegrass varieties after 9 days in a thermogradient table at four temperature ranges (5–10°C, 11–15°C, 16–20°C, and 21–25°C).

Table 1. Speed of germination index (SGI) and average seedling height of four annual ryegrass varieties grown at four temperature ranges in a thermogradient table.

Temperature range (°C)	Speed of germination index (SGI) over 14-day test period ¹				Average seedling height on day 14 ² (inches)
	Bounty	KB Royal	Ed	Gulf	
5–10	2	2	2	2	1.2
11–15	6	6	6	7	2.5
16–20	14	15	15	15	4.3
21–25	11	12	10	12	6.0

¹Gradual increase in the speed of germination occurred as the temperature increased. The level of seed vigor of each variety affects the SGI.

²As the germination temperature increased, seedling height increased. At a temperature range of 5–7°C, seedling height was about 0.5 inch; at 8–10°C, it was about 1.4 inches.

range. After 9 days, ‘Ed’ had the highest germination rate at 18%, while ‘KB Royal’ and ‘Gulf’ had the lowest at 10% (Figure 2). The SD of germination among the four varieties was 3.6. After 14 days, ‘KB Royal’ and ‘Bounty’ had the highest germination rates of 82% and 79%, respectively, whereas Gulf and Ed had the lowest at 67% and 64%, respectively (Figure 3). The large difference in germination rate was reflected by a SD of 9.0.

The SGI is an indication of speed of germination and seed vigor. The higher the index, the better the quality of the seed. At the temperature range of 5–10°C, the SGI was 2 for all varieties (Table 1), which provides evidence that the four varieties had a similar, low speed of

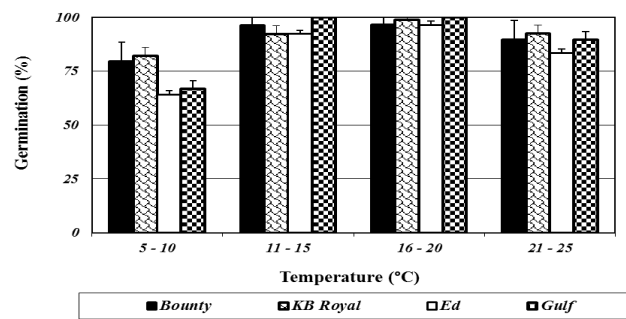


Figure 3. Germination rates of four annual ryegrass varieties after 14 days in a thermogradient table at four temperature ranges (5–10°C, 11–15°C, 16–20°C, and 21–25°C).

germination and cold tolerance. There was no superiority of one variety tested over another.

The average seedling height of the plants germinated at 5–10°C on day 14 was 1.2 inches (Table 1). As temperatures get closer to 5°C, the seedling size got smaller. At a temperature range of 5–7°C, the seedling height was approximately 0.5 inch, and at 8–10°C, it was approximately 1.4 inch. In general, as germination temperature increased, seedling height increased. Planting earlier in the fall when soil temperatures are higher than 5–10°C could increase the chance for better and faster stand establishment.

Germination at 11–15°C (52–59°F) range

Five days after planting, the germination rates of ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’ at the temperature range of 11–15°C were 10%, 12%, 20%, and 22%, respectively (Figure 1). After 9 days, ‘Gulf’ and ‘Bounty’ had the highest germination rates at 96% and 94%, respectively, followed by ‘KB Royal’ and ‘Ed’ with germination rates of 88% and 86% (Figure 2). After 14 days, ‘Gulf’ and ‘Bounty’ also had the highest germination rates at 100% and 96%, respectively, followed by ‘KB Royal’ and ‘Ed’ with a germination rate of 92% for both varieties (Figure 3).

At a temperature range of 11–15°C, the SGI was 6, 6, 6, and 7 for ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’, respectively. It is evident that varieties had similar SGI and cold tolerance.

The average seedling height of the plants germinated at 11–15°C on day 14 was 2.5 inches. This seedling size is too small for overwinter conditions in the Midwest. Planting earlier in the fall, when soil temperatures are above 15°C (59°F), is recommended to obtain larger seedlings.

Germination at 16–20°C (61–68°F) range

Five days after planting, the germination rates of ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’ at the temperature range of 16–20°C were 71%, 85%, 81%, and 79%, respectively (Figure 1). ‘Bounty’ had the lowest germination rate at this temperature range. After 9 days, the germination rates of ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’ at the same temperature range were 96%, 96%, 94%, and 98%, respectively (Figure 2). The final germination rates at this temperature range after 14 days were 96%, 99%, 96%, and 100% for ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’, respectively (Figure 3). Obviously, at the temperature range of 16–20°C, the

germination rates of all varieties reached near maximum by day 14. At this temperature range, the SGI was 14, 15, 15, and 15 for ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’, respectively. It is evident that at this temperature range all varieties had a similar high SGI. This is not unusual because this range of temperatures is optimum for growing cool-season grasses. The average seedling height of the plants germinated at 16–20°C after 14 days was 4.3 inches (Table 1). As the temperature range of germination increased, seedling size increased.

Germination at 21–25°C (70–77°F) range

Five days after planting, the germination rates of ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’ at the temperature range of 21–25°C were 83%, 88%, 68%, and 85%, respectively (Figure 1). ‘Ed’ had the lowest germination rate at this temperature range. After 9 days, the germination rates of ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’ were 89%, 91%, 83%, and 89%, respectively (Figure 2). The final germination percentages at the temperature range of 21–25°C after 14 days were 89%, 92%, 83%, and 89% for ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’, respectively (Figure 3). The germination of ‘Ed’ did not improve between 9 and 14 days. This might be due to a seed vigor issue rather than cold tolerance trait.

At the temperature range of 21–25°C, the SGI was 11, 12, 10, and 12 for ‘Bounty’, ‘KB Royal’, ‘Ed’, and ‘Gulf’, respectively (Table 1). It is evident that all varieties had a similar speed of germination. The average seedling height of the plants germinated at 21–25°C after 14 days was 6 inches (Table 1). Again, as the temperature range for germination increased, seedling size increased. Seedling size of 6 inches is a reasonable size for winter survival.

Conclusion

There was no consistent pattern of superiority of one variety tested over another in terms of cold tolerance over the four germination temperature ranges used in the study. Planting earlier in the fall, when soil temperatures are approximately 15°C (59°F) or above is recommended for better and faster stand establishment. As the temperature range of germination increases, so does seedling height, which is important to maintain good stand establishment throughout the winter and reduce the rate of winter kill. The thermogradient table proved to be an effective tool to screen annual ryegrass varieties for cold tolerance. Finally, cold tolerance, quick emergence, and reasonable seedling size are keys for successful stand establishment of annual ryegrass as a cover crop in cold climates such as the Midwest.

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