Phenotyping Summer Dormancy in Tall Fescue: A Surrogate Approach

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Abstract

Tall fescue [Lolium arundinaceum (Schreb.) Darbysh] is a widely used forage. There are two major types of germplasm, continental and Mediterranean. Most Mediterranean germplasm, sought after for heat tolerance and other important traits, exhibit summer dormancy even if the growing conditions are favorable. There is a large variation in the degree of dormancy and phenotyping the trait in the field is lengthy and costly. Understanding the mechanisms and genetic factors underlying summer dormancy in tall fescue can aid in a faster transfer of favorable traits across germplasm pools and speed up the process of cultivar development. The objectives of this study are to develop a fast and low-cost surrogate phenotyping approach for summer dormancy. The environmental cues that trigger dormancy in the mother plant would act similarly on seed dormancy/germination and thus may be used as a surrogate phenotype. Germination tests were conducted under various combinations of photoperiod and temperature extremes with 3 non-dormant and 2 dormant check varieties in growth chamber conditions that simulate summer/fall natural conditions. Six different temperatures: 18°C, 20°C, 22°C, 28°C, 30°C, 32°C, and 34°C and 5 different photoperiods: 0/24, 12/12 14/8, 16/8 and 24/0 hours of light /dark were tested for each temperature and photoperiod combination. A complete dark treatment was used with each combinations. The data indicates that temperature had a larger effect on germination compared to photoperiod with higher temperatures reducing the germination of the dormant but not the non-dormant checks. 168 accessions were phenotyped for dormancy in field conditions using a combined score of regrowth height and senescence percentage based on Digital Image Analysis. Twenty seven putative dormant and 24 putative non-dormant accessions were selected for seed germination testing and to establish a correlation between the seed germination phenotype and field dormancy. The data showed that seed germination at 20°C and 30°C correlates well with field dormancy phenotypes and has potential to be used as proxy for phenotyping summer dormancy in tall fescue.

Material & Methods

- Pre-test on 4 check varieties for the best condition-combination differentiates dormant from the non-dormant
- Checks are: dormant (AFRAFA 126 and T0706-1) non-dormant (GA186 and Max-Q)
- Temperature and light conditions
  - High temperature: 30, 32, 34 ºC
- Low temperature: 18, 20, 22 ºC
- 0h (day); 24h (night)
- 12h (day); 12h (night)
- 14h (day); 10h (night)
- 16h (day); 8h (night)
- 24h (day); 0h (night)
- Field phenotypic method
  - Percentage of leaf senescence digital image analysis (DIA)
  - Regrowth height after cutting in June
- Putative dormant and non-dormant accessions were selected based on the field phenotypic data
- Germination ratio at 30/20 under 24 hr photperiod of putative dormant and non-dormant accessions.

Results

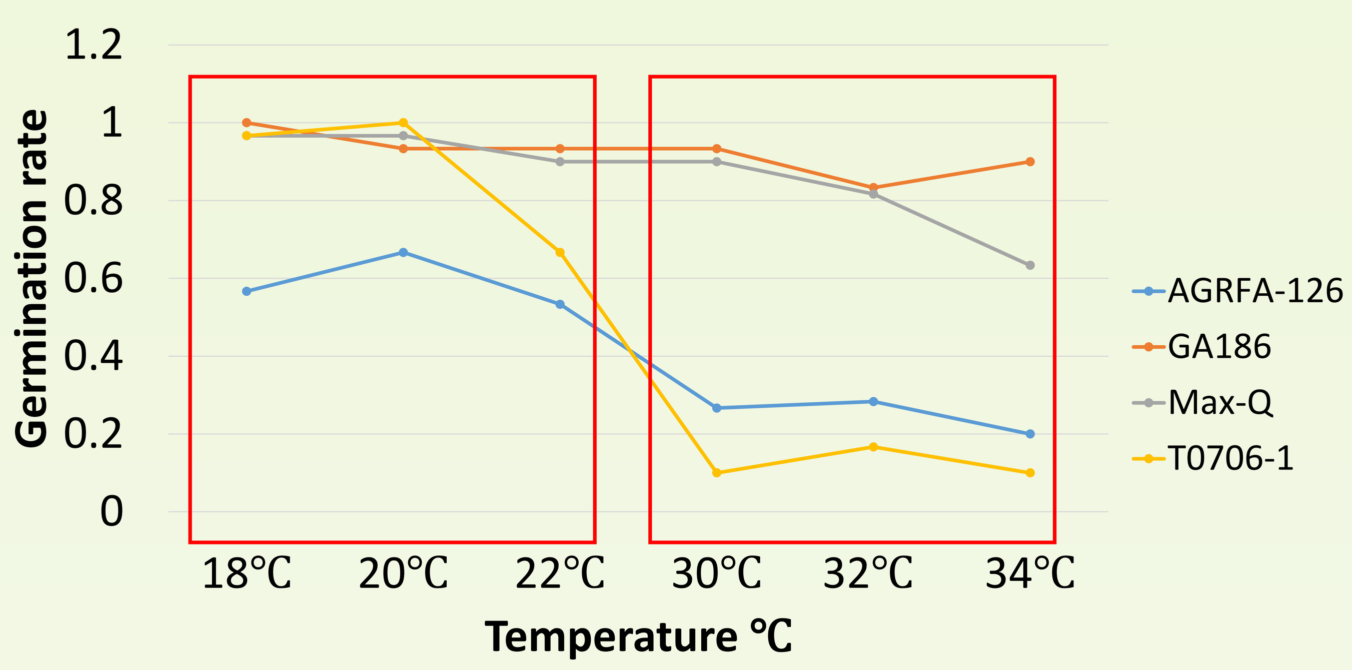

Figure 1. Germination rate under 24 hours of light and different temperatures for the 4 checks varieties. 30 ºC seems to be the break point in germination between the non-dormant (MaxQ, and GA186) and the dormant checks (T706-1 and AFRAFA).

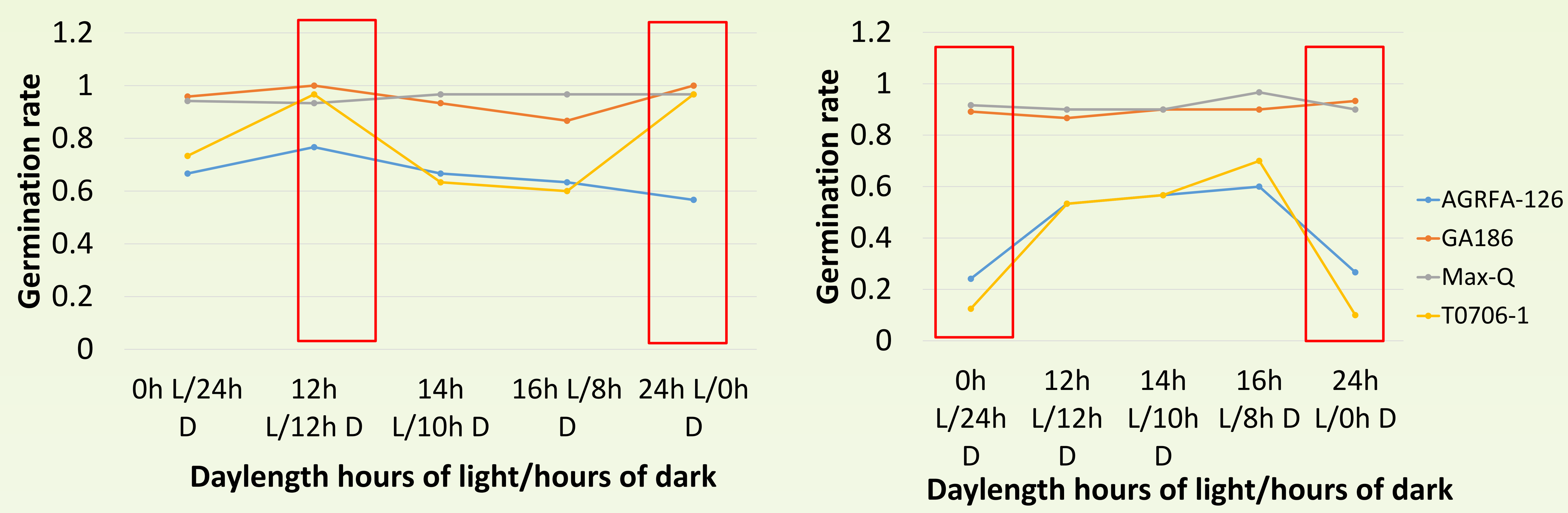

Figure 2. Germination rate at 18 ºC (left) and 30 ºC (right) under different photoperiods for 4 check varieties. 12h of light and 24h of light shows the least significant different germination rate between dormant and non-dormant checks under 18 ºC, 0h of light and 24h of light shows the most significant different germination rate under 30 ºC.

	Reps	Ave. germination rate difference (%) between dormant and non dormant accessions under different environment conditions					
		18 ℃	20 ℃	22 ℃	30 ℃	32 ℃	34 ℃
24 h of light	6	20.0 *	10.6	32.8***	71.7***	70.6***	62.8***
16 h of light	6	28.9***	24.4**	12.2*	28.9***	56.7***	42.8***
14 h of light	6	28.9***	17.2*	20.6*	32.2***	39.4***	53.9***
12 h of light	6	9.4	10.0**	12.8 **	33.9 ***	48.9 ***	60.6 ***
0 h of light	6	28.9 ***	18.9 ***	22.8 **	77.2 ***	67.2 ***	37.8 ***

Table 1. The best temperature-photoperiod combination that differentiate the dormant from non-dormant is 20 ºC and 30 ºC under 24h of light.

Figure 3. Digital image analysis of field non-dormant (left) and dormant (right) putative accessions. The red color indicates the green area of the plants, the senescence percentage of the plant is calculated as 1-green percentage.

	Senescence	GR Light
Regrowth Height	-0.7**	0.5**
Senescence		-0.5**

Table 2. Spearman Correlation coefficients between field phenotypic data and germination ratio under 24h of light for putative accessions. There is a significantly strong correlation between regorwth height, senescence, and germination ratio under 24h of light.

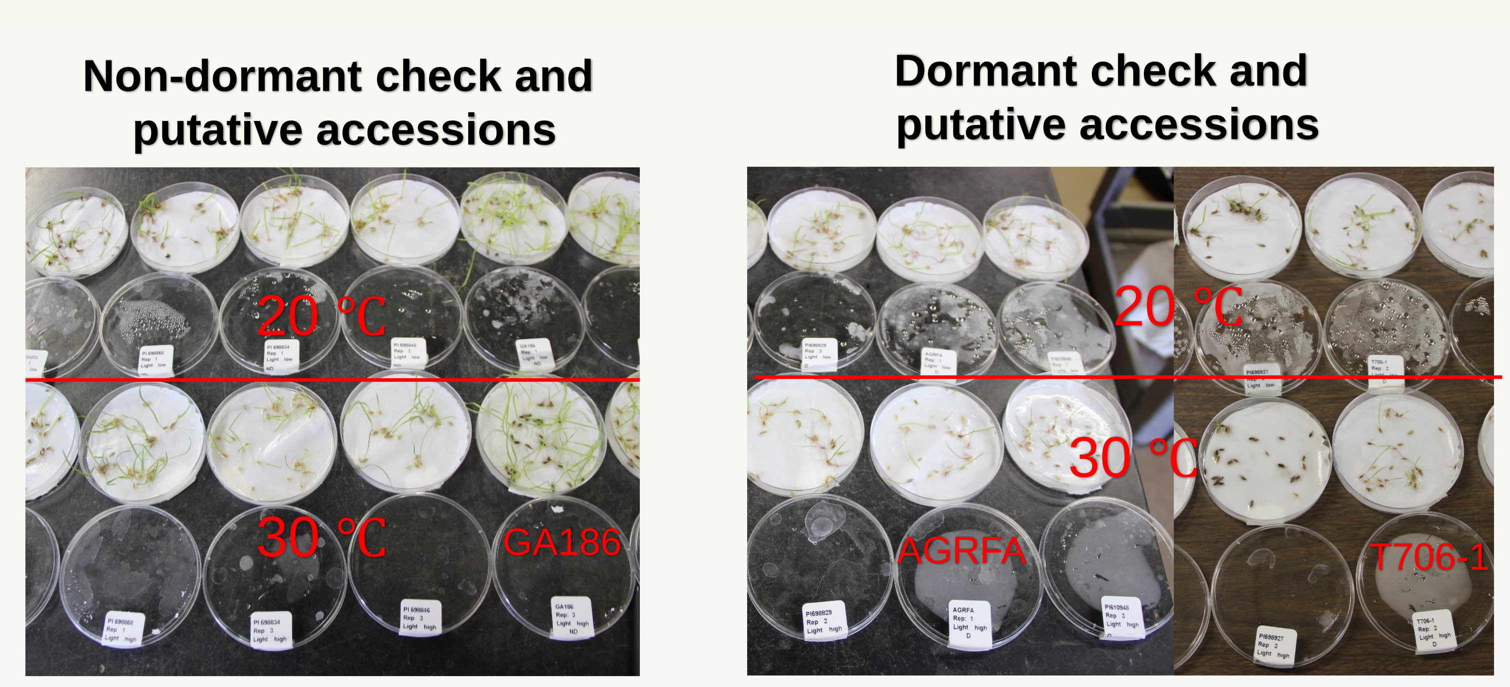

Figure 4. Germination test under 20 ºC and 30 ºC, 24h of light for dormant and non dormant checks and putative accessions. Under 30 ºC, the germination of dormant accessions is reduced compared to non-dormant.

Conclusion

- Temperature had a higher effect on germination than photoperiod, with higher temperatures reducing the germination of the dormant checks significantly but not the non-dormant checks.
- The data showed that the ratio of seed germination at 20°C and 30°C correlates well with field dormancy phenotypes and has potential to be used as proxy for phenotyping summer dormancy in tall fescue.

References

1. Hopkins, A.A., M.C. Saha and Z.Y. Wang. 2009. Breeding, Genetics, and Cultivars. In: H. A. Fribourg, D. B. Hannaway and C. P. West, editors, Tall Fescue for the Twenty-first Century. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America. p. 339-366.

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