Genetic variation of seed dormancy in tetraploid wheat species

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Summary

In western Canada, durum wheat cultivars (*Triticum* turgidum L. Var durum) have low to moderate levels of seed dormancy and are susceptible to pre-harvest sprouting. The objective of this study was to assess the level of seed dormancy and the length of afterripening in diverse tetraploid wheat species. The plants were grown under field conditions, spikes harvested at Zadok's Growth Stage 92 (ZGS92), dried for one week and stored in a freezer at -20 "C. In 1995 and 1996, length of afterripening was assessed in 17 durum cultivars and three common hexaploid wheats over a period of seven weeks. Most durum cultivars showed little or no dormancy at ZGS92. Kyle was the only cultivar that exhibited some seed dormancy. On average, all cultivars but the hexaploid line RL4137 lost dormancy in a markedly similar pattern. Four species, *Triticum turgidurn, T. turanicum, T. carthlicum* and *T. polonicum* obtained from the USDA wheat collection were screened for seed dormancy over a two year period. Averaged over years, accessions ranged from 2% to 100% in germination. The accessions in this experiment can be grouped into four classes: nondormant, slightly dormant, moderately dormant and highly dormant. With the exception of *T. turanicum, the* tetraploid species contained highly dormant genotypes. The 10 most dormant wheat accessions were evaluated for length of afterripening. A number of accessions with higher levels of seed dormancy than the durum cultivar Kyle was identified.

1. Introduction

Quality is the most important criterion considered at the time of purchase of wheat. Several characteristics are considered as quality criteria for milling including: soundness, shape, size and hardness of kernels. Pre-harvest rain on wheat along with warm temperatures Create the right conditions for the wheat kernels to germinate in the wheat head. In other words, the wheat starts to sprout before the farmer has a chance to get into the field to harvest the crop. Many products prepared or baked from flours milled from sprouted wheat will suffer in quality. Bread produced from sprouted wheat will have a decreased volume, compact interior, and crust considered too brown (Mansour, 1993).

It is generally accepted that the long-term solution to the pre-harvest sprouting problem lies in the development of cultivars which are able to tolerate or resist the damaging effects of rain during the period between maturity and the completion of harvest. In most cases, the major factor being utilized in breeding programs is grain dormancy. The objective of this study was to assess the variability of seed dormancy in commercial durum cultivars and tetraploid genotypes and to identify accessions that might be useful to durum breeders.

2. Materials and Methods

2.1 Measurement of seed dormancy and length of afterripening in durum cultivars

2.1.1 Field experiment

For this experiment, 17 durum cultivars and three common wheat (hexaploid) controls were used. This experiment was conducted at two locations, University of Saskatchewan's Seed Farm and Kemen Farm Research Farm near Saskatoon in 1995 and 1996. At each location an RCBD with four replications was used. The following traits were measured for all cultivars: days to 50% spike emergence and days to physiological maturity. At Zadoks Growth Stage (ZGS) 92, 50 spikes were harvested per plot. The spikes were held at room temperature for seven days then placed in a freezer at -20 "C.

2.1.2 Laboratory experiment

Germination tests were conducted in an RCBD with four replications of 50 hand-threshed kernels in pertri plates (9 cm diam.) lined with a double layer of filter paper (Whatman No.1) containing 5 ml of double distilled water for 7 days in an incubator at 20 °C under dark conditions. At least 15 intact spikes per plot were threshed by hand. Seeds stored at -20 °C were removed from the freezer at one week intervals for eight weeks and kept at room temperature. After four and seven days germinated seeds were counted and removed. After seven days, ungerminated seeds were treated with 0.1 mM of gibberellic acid (GA) solution (Hou and Simpson, 1993) to evaluate their viability. In order to evaluate seed dormancy, the final percent germination was divided into the number of seeds germinated prior to GA treatment.

2.2 Screening tetraploid wheat germplasm for seed dormancy

The aim of this experiment was to assess the genetic variation for seed dormancy and compare it to that available in commercial durum and common wheats.

2.2.1 Field experiment

Seventy-eight tetraploid wheat accessions from the species *Triticum turgidum, T. turanicum, T. carthlicum, and T. polonicum* from the USDA germplasm collection, five commercial dumm cultivars, and three hexaploid wheat cultivars were used. This experiment was conducted at the University of Saskatchewan's Seed Farm in Saskatoon in 1995 and 1996. An RCBD with four replications was used. 30 and 50 spikes were harvest at ZGS 92 in 1995 and 1996, respectively. The spikes were held at room temperature for 7 days and then placed in a freezer at -20 "C.

2.2.2 Laboratory experiment

The experimental method was the same as experiment 2.1.2.

2.3 Length of afterripening in selected tetrapioid accessions

In this experiment, 10 accessions with the highest level of seed dormancy were evaluated for length of after-ripening. Germination tests were conducted in an RCBD with three replications of 25 hand-threshed kernels. The experimental method was the same as for experiment 2.1.2.

Analyses of variance were conducted seperately for years and locations. Subsequently, combined analyses were used over years and locations. Years, locations and replications were considered random. Both untransformed and transformed (arcsin-square root transformation) data were analyzed. Since the resulting ANOVA were similar, untransformed data are presented.

3. Results and discussion

3.1 Length of afterripening in durum cultivars

Analysis of variance detected significant differences among cultivars and after-ripening intervals for both years and locations. Likewise, a significant interaction was observed for cultivar by time interval in both Seed Farm and Kemen experiments in 1995 and 1996. A combined ANOVA indicated that differences among cultivars and after-ripening intervals were statistically significant ($p \leq 0.05$). Significant interaction between cultivar and afterripening period in 1995 and 1996 indicates that cultivars did not perform consistently.

All cultivars but RL4137 exhibited different levels of seed dormancy at maturity but lost dormancy at markedly similar rates (Table 1). RL4137 was the only cultivar that exhibited little loss of dormancy after three weeks.

Table 1. Germination (%) of wheat cultivars up to seven weeks of after-ripening at room temperature.

	Length of after-ripening (week)								
Cultivar	0	1	2	3	4	5	6	7	Average
Durum									
Arcola	96	**96**	99	99	100	99	99	99	98
Coulter	94	**96**	98	98	99	99	99	100	98
Hercules	93	**95**	97	97	99	98	99	99	97
Kyle	53	**63**	72	77	87	91	92	96	79
Lakota	71	**80**	84	88	91	93	96	97	87
Macoun		**91**	94	97	98	99	98	99	95
Medora	87	**95**	97	99	99	100	100	100	97
Mindum	6 6	**79**	84	87	93	94	98	99	87
Pelissier	6 7	**79**	87	91	94	97	96	99	88
Plenty	83	**88**	90	96	97	99	98	99	94
Ramsey	87	**94**	97	99	99	99	100	100	97
Sceptre	93	**96**	97	98	98	98	98	100	97
Stewart	72	**87**	91	98	99	99	100	100	93
Stewart 63	77	**84**	92	96	97	99	99	100	93
Wakooma	76	82	86	91	93	95	97	98	90
Ward	85	93	95	97	98	98	99	100	96
Wascana	61	71	81	89	90	98	96	98	85
Common wheat									
Katepwa	95	100	100	99	100	100	100	99	99
RL4137	5	7	12	27	38	50	62	70	34
Fielder	96	98	99	99	100	100	100	100	99

Eleven cultivars exhibited no level of mature seed dormancy as characterized by rapid onset and completion of germination. The cultivars Arcola and Fielder were typical of this group. A second group of nine cultivars exhibited a somewhat higher level of mature seed dormancy and a more pronounced effect on dormancy reduction as a result of seven weeks of afterripening. Among durum cultivars, Kyle (53% germination) had the highest level of dormancy at maturity. Slight levels of dormancy were observed for the second group at maturity. Lakota (71% germination) and Stewart (72% germination) were typical cultivars of this group. Overall, however, a 7-week afterripening period produced a consistent and rapid germination in all cultivars but RL4137.

3.2 Screening tetraploid wheat germplasm for seed dormancy

In this experiment 78 accessions were evaluated for seed dormancy. Analysis of variance indicated significant differences among accessions in both 1995 and 1996. Likewise, combined analysis indicated significant interaction between year and accessions. The accessions exhibited a wide range of germination at 20 "C. On average, accessions ranged from 2% to 100% in germination. The accessions in this experiment can be grouped into four classes (Morris and DeMacon (1994): nondormant, slightly dormant, moderately dormant, and highly dormant (Table 2). Only a few genotypes were in the highly dormant class. RL4137 with 1% germination and hexaploid accessions 93-634 (8%) and 93-480 (2%) were typical of this group. Accessions 93-22 and 93-37 with 100% germination were typical of the nondormant group. The results of this experiment indicate that ***T. polonicum and T. turgidum*** contained highly dormant genotypes. Of the durum checks, the highest level of seed dormancy was observed for 'Kyle'. Clarke et al. (1994) reported that 'Stewart 63' was the most dormant durum cultivar tetsted in their study.

Table 2. Different dormancy classes based on average % germination of genotypes in 1995/1996.

Class	Germination (%)	Number of genotypes
Highly-dormant	o-19	6
Dormant	2049	19
Moderately-dormant	50-69	17
Non-dormant	70-100	44

A number of accessions had higher levels of dormancy than the durum cultivar Kyle. Accessions 93-369 and 93-95 1 were typical of this group.

3.3 **Length of afterripening in selected tetraploid accessions**

Ten accessions with the highest level of dormancy were selected from experiment 2.2 in 1995. Two commercial durum cultivars, Kyle and Sceptre, and two common wheat cultivars, RL4137 and AUS 1408, were considered as controls in this experiment. The analysis of variance detected significant differences among genotypes and time intervals. Likewise, the interaction between genotype and interval was statistically significant. In this experiment, the accessions displayed a wide range of dormancy after seven weeks of afterripening. The result of this experiment (Table 3) suggest different patterns of afterripening. The first pattern, exhibited by 93480 and 93-634, showed no apparent changes in the level of dormancy after four weeks of afterripening and only a moderate change between four and seven weeks. The second pattern, characteristic of 93-95 1, 93-960, 93-580, 93-955, 93-369 and Kyle showed that four weeks of afterripening significantly reduced the level of dormancy. The last pattern, exhibited by 93-282, 93-581, RL4137 and AUS1408, showed a moderate reduction of dormancy after four weeks with a further significant decrease between four and seven weeks. Sceptre exhibited no level of seed dormancy as characterized by rapid onset and completion of germination.

Table 3. Germination (%) of tetraploid, durum and common wheat genotypes (averaged over replication) at harvest ripeness (no afterripening) and up to seven weeks of afterripening at room temperature.

	Length of afterripening (week)								
Genotype	0	1	2	3	4	5	6	7	Average
Tetraploid									
93-282	9	12	28	33	60	64	75	87	46
93-369	9	23	36	75	80	89	100	99	64
93-580	28	47	63	80	93	99	99	100	76
93-951	5	47	84	89	100	96	100	100	78
93-955	29	41	63	87	83	97	97	100	75
93-960	4	28	44	79	92	93	100	96	67
Kyle	43	49	67	79	91	93	96	95	77
Sceptre	91	95	93	99	99	99	100	100	97
Hexaploid									
93-480	1	4	9	16	19	28	35	51	20
93-581	7	13	31	49	56	73	69	81	48
93-619	12	25	47	43	64	80	88	91	56
93-634	1	1	11	5	18	32	31	34	17
RL4137	9	15	24	36	43	56	65	69	40
Aus1408	8	19	20	23	29	32	37	52	48	30

4. Discussion

In previous experiments studying the effects of wheat genotype and environment on the expression of dormancy it was concluded that the rate of dormancy loss during afterripening and the level of dormancy at maturity were more or less associated with each other (Hare et ***al.,*** 1988). However, these studies used only percentage germination at harvest maturity to characterized the level of seed dormancy and did not include the rate of afterripening. In this study, we were able to characterize the length of after ripening in different accessions. With respect to the results shown in Table 1., most cultivars show little or no dormancy at harvest maturity (no afterripening). Investigations have shown that temperature is one of the most influential environmental factors affecting the induction of seed dormancy during seed formation and expression of dormancy during germination (Reddy et al., 1985). Our results indicate that on average, the level of dormancy was higher in 1996 as compared to 1995. In a sharp contrast, 1996 was cooler with more precipitation during the period of crop growth. In general, low temperature during seed development induces deep and prolonged dormancy while high temperature induces a relative low level of dormancy.

The results of this study showed that commercial durum cultivars were non-dormant and a number of tetraploid accessions in the USDA collection were more dormant than the commercial durum cultivars. The accessions selected in this experiment can provide breeding material for the improvement of pre-harvest sprouting tolerance in durum wheat. We were also able to characterize the length of afterripening in different genotypes. The results indicated that a high level of seed dormancy could be maintained in genotypes to protect against pre-harvest sprouting.

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5. References

Clarke, J.M., R.M. Depauw, J. G. McLeod, T.N. McCaig. 1994. Variation of pre-harvest sprouting resistance in durum wheat. Crop Sci. 34:1632-1635.

Hare, R.A., B.E. Koth, and W.C. Barnes. 1988 Pre-harvest sprouting resistance in *Triticum turgidum* sp. durum. pp.951-956. In: Miller, T.E. and R.M.D. Koebner (eds). Proc 7th Int. Wheat Genet. Symp. Inst. Plant Sci. Res. Cambridge.

Mansour, K. 1993. Sprou tdamage **in** wheat and its effect on wheat flour products. pp. 8-9 In: Walker-Simmons, M.K. and J.L. Ried (eds). Pre-harvest sprouting in cereals 1992. American Association of Cereal Chemists.

Morris, **C.F. and V.L. DeMacon. 1994. See** dormancy and tissue culture response in wheat. Crop Sci. 34: 1324- 1329.

Reddy, L.V. R.J. Metzger, and T.M. Ching. 1985. Effect of temperature on seed dormancy of wheat. Crop Sci. 25:456-458.