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Relationship Between Germination Tests and Field Emergence of Wheat

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Abstract: The suitability of various laboratory germination parameters to predict field emergence of eight wheat (*Triticum aestivum* L. cv. Ghods) seed lots in late fall, early Spring and late Spring plantings were evaluated in 2005 at the Isfahan University of Technology, Isfahan, Iran, using correlation coefficients. Electrical conductivity of seed leachate, final germination percentage and velocity of germination coefficient in both cold (10°C) and standard (20°C) germination tests were unable to satisfactorily predict field emergence. Germination rate in both laboratory conditions was a good estimator of field emergence. Although, it showed slightly lower consistency than percent of germination (radicle emergence>2 mm) measured after 24 h at 20°C (G20-D1). The G20-D1 is a simple and rapid test and was the best predictor of field emergence under the conditions of the present experiment.

Key words: Wheat, germination, EC, GR, ER

INTRODUCTION

Time and rate of seedling emergence are controlled by an array of interacting factors including genetic constitution, seed dormancy, seed vigor, depth of planting, soil impedance and aeration, temperature and water supply (Forcella *et al*., 2000; Samarah and Al-Kofahi, 2008). Consequently, although many seeds germinate satisfactorily under ideal laboratory conditions, they may fail to emerge successfully in the field (Kolasinska *et al*., 2000; Kulik and Yaklich, 1982; Wang *et al*., 2004). Many researchers have examined various laboratory tests such as speed of germination (Khan *et al.,* 2007; Kolasinska *et al*., 2000; Kulik and Yaklich, 1982; Maguire, 1962; Samarah and Al-Kofahi, 2008; Wang *et al*., 2004), cold germination (Kolasinska *et al*., 2000; Kulik and Yaklich, 1982; Samarah and Al-Kofahi, 2008; Seefeldt *et al*., 2002), biochemical tests (Kolasinska *et al*., 2000; Steiner *et al*., 1989), controlled deterioration test (Khan *et al.,* 2007; Kulik and Yaklich, 1982; Modarresi and van Damme, 2003; Samarah and Al-Kofahi, 2008; Wang *et al*., 2004) and Electrical Conductivity (EC) of seed leachate (Khan *et al*., 2007; Samarah and Al-Kofahi, 2008; Steiner *et al*., 1989; Wang *et al*., 2004) to evaluate seed vigor or to predict field emergence.

In the experiments of Seefeldt *et al*. (2002) cold test successfully differentiated the emergence ability of wheat cultivars in growth chamber. This is consistent with the results of Samarah and Al-Kofahi (2008) with barley that used a modified cold test (seeds kept at 5°C for 7 days in soil at 70% field capacity then transferred to 20°C for 7 days). Khan *et al.* (2007)

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found that accelerated aging and EC were very sensitive tests in ranking wheat seed lots quality. While a combination of laboratory tests were found suitable for estimation of final emergence count in the experiments of Steiner *et al.* (1989) and Kolasinska *et al.* (2000). However, Kulik and Yaklich (1982) and Wang *et al.* (2004) were unable to predict field emergence using laboratory tests. Brown and Mayer (1986) argued that GR of Maguire (1962) was weighted in favor of early germination and did not reflect germination rate. They proposed measuring germination after a given time and total germination at the end of the experiment as a simple, direct and unambiguous practical alternative to the use of GR. Seefeldt *et al.* (2002) showed that the percent of emergence in 4 DAP differentiated Spring wheat genotypes for seed vigor very well. The objectives of this research were to predict field emergence of eight wheat seed lots using several laboratory seed germination parameters at 20 and 10°C temperatures using correlation coefficients.

MATERIALS AND METHODS

Eight seed lots were generated by grading (into two weight groups) and accelerated aging (aged and check) of wheat seeds harvested by hand in late June, 2004 from randomly selected 10 m^2 of two commercial fields. The fields are located approximately 2 km apart in the Southern part of Isfahan, Iran (approximately 32°13' N, 51°46' E, elevation 1700 m). The heads were hand threshed and the seeds with diameters smaller than 2 mm were discarded using an adjustable sieve with longitudinal slots. The remaining seeds were graded in two weight groups (heavy and medium) by a seed blower. The 1000-kernel weights of graded seeds differed for each field, but ranged between 36.3 to 40.5 g. Seeds were kept in refrigerator (4±1°C) until tested.

For accelerated aging, approximately 60 g of each field-weight group were disinfected with 0.5% sodium hypo chloride for 10 min. Seeds were then rinsed with distilled water for approximately 10 min. The seeds were placed in a 0.25×0.25×0.8 m plastic pan on a stainless steel wire mesh lined with bandage (made from cotton fiber and supplied by a local drugstore) and 0.025 m above distilled water level (0.025 m deep). The pan was covered tightly with aluminum foil and kept at room temperature for 2 h in order to attain humidity equilibrium, after which it was transferred to 45±1°C for 24 h (Modarresi and Van Damme, 2003). Longer periods of accelerated aging resulted in very low germination ability (data not reported). The seeds used as check were also surface disinfected by the same procedure used for aged seeds.

Seed lots were tested for cumulative daily germination percentage (D1, D2,….Dn), Final Germination Percentage (FGP), Germination Rate (GR) of Maguire (1962) and Velocity of Germination Coefficient (VGC) of as described by Kolasinska *et al.* (2000). Germination studies were conducted in the dark at constant temperature regimes of 10°C (as cold germination test) and at 20°C (as standard germination test) replicated four times. Fifty seeds of each seed lot were placed in 0.09 m Petri dishes on two sheets of filter paper with 10 mL of distilled water as experimental unit. The number of germinated seeds (radicle emergence>2 mm) was recorded at 24±1 h intervals and continued until no further germination occurred. Electrical Conductivity (EC) of seed leachates was determined on four weighed replicates of seed (2 g) soaked in 50 mL of distilled water at 25°C for 16 h using a digital conductivity meter.

Field emergence evaluation studies using the same seed lots used in laboratory experiments were conducted at the Isfahan University Campus (31° 32' N, 51° 33' E, elevation 1610 m) field station. The soil is a sandy clay loam. Three field plantings including early

Spring (7 Mar. 2005), late Spring (20 Apr. 2005) and late fall planting (7 Nov. 2005) with three replications were conducted using a randomized complete block design. The field was fallow during the previous year and no plant residues were present. The field was tilled by shovel and seed bed was well prepared before planting. No chemical fertilizer was applied because only seedling emergence was under consideration. The field was surface irrigated lightly whenever the soil surface dried out. Each plot consisted of a single row of 45 seeds, planted 0.02 m apart and 0.03 m deep. Emergence (when green leaf could be seen inside coleoptiles) was recorded at 24±1 h intervals and continued until no further emergence occurred. The same variables measured in the germination studies were considered in the field. In the notations used for field studies, G (germination) was replaced by E (emergence).

Correlations among measured laboratory germination parameters and emergence variables of each planting were calculated using PROC CORR procedure of SAS. The daily minimum and maximum temperatures were obtained from the meteorological station located near the field.

RESULTS

The correlations among laboratory and field emergence vigor tests are presented in Table 1. The correlations between EC and germination parameters in both cold and standard tests were non-significant. The correlation between FGP in standard and cold laboratory tests was not significant, but D1 of the standard test was significantly correlated ($p \geq 0.01$) with D2, GR and VGC of the cold test. The GR of the standard and cold tests were strongly ($p \geq 0.01$) correlated. In addition, D1 and GR of the standard laboratory test had correlation coefficient close to 1.00.

Table 1: Correlation coefficientsx ‡ between variables measured on eight seed lots germinated at 10 and 20°C and field emergence in three planting dates

	G10				G20				
Variables	D2	FGP	GR	VGC	D1	D2	FGP	GR	VGC
EC	0.33	-0.29	0.23	0.27	0.08	-0.34	-0.37	0.01	-0.16
G20-D1	0.88	0.67	0.89	0.84	1.00	0.65	0.49	0.99	0.72
G20-D2	0.58	0.77	0.62	0.69	0.65	1.00	0.93	0.75	0.92
G20-FGP	0.44	0.65	0.50	0.46	0.49	0.93	1.00	0.60	0.88
G20-GR	0.87	0.72	0.90	0.85	0.99	0.75	0.60	1.00	0.79
20-VGC	0.62	0.61	0.65	0.65	0.72	0.92	0.88	0.79	1.00
LSP-D5	0.46	0.73	0.49	0.37	0.24	0.32	0.20	0.26	0.22
LSP-D6	0.83	0.53	0.79	0.71	0.53	0.50	0.48	0.56	0.58
LSP-FEP	-0.08	-0.44	-0.13	-0.16	0.09	-0.62	-0.73	-0.03	-0.41
LSP-ER	0.52	0.03	0.43	0.35	0.47	-0.22	-0.38	0.37	0.02
LSP-VEC	0.04	0.25	0.07	0.05	-0.17	0.25	0.28	-0.11	0.06
ESP-D8	0.89	0.63	0.90	0.94	0.92	0.65	0.43	0.92	0.72
ESP-D9	0.80	0.75	0.84	0.85	0.90	0.65	0.39	0.89	0.66
ESP-FEP	0.22	0.18	0.22	0.18	0.33	0.18	0.07	0.32	0.39
ESP-ER	-0.07	-0.43	-0.15	-0.28	-0.06	-0.58	-0.57	-0.15	-0.26
ESP-VEC	0.83	0.54	0.87	0.83	0.82	0.21	-0.01	0.75	0.26
LFP-D11	0.80	0.53	0.81	0.77	0.86	0.48	0.31	0.83	0.52
LFP-D12	0.81	0.63	0.84	0.81	0.82	0.69	0.53	0.84	0.68
LFP-FEP	0.43	0.27	0.44	0.46	0.47	0.03	-0.22	0.41	-0.01
LFP-ER	0.61	0.53	0.64	0.59	0.62	0.40	0.24	0.61	0.33
LFP-VEC	0.61	0.76	0.65	0.51	0.55	0.72	0.67	0.61	0.67

‡ Values $\geq +0.83$ or ≤ -0.83 are significant at 1% level of probability and values $\geq +0.71$ or ≤ -071 are significant at 5% level of probability. G10 and G20 = Germination at 10 and 20°C, respectively; EC: Electric conductivity of seed leachates, D: Cumulative germination percentage at days after initiation of germination or cumulative emergence percentage after initiation of planting, FGP: Final germination percentage, GR: Germination rate, VGC: Velocity of germination coefficient, LSP: Late spring planting, ESP: Early spring planting, LFP: Late fall planting, FEP : Final emergence percentage, ER: Emergence rate, VEC: Velocity of emergence coefficient

The mean air temperature during the period between planting to full emergence was 17.6°C in late Spring, 12.2°C in early Spring and 8.7°C in late fall. In these three plantings, emergence was started and completed between 5-10, 8-13 and 10-16 Days After Planting (DAP), respectively. In late Spring planting, only aged seed lots showed significant differences with control seed lots for ER ($p \geq 0.05$) and for the percent of emergence in the second (6 DAP) count ($p \geq 0.01$). In addition, all seed lots had similar FEP (data not reported).

In early Spring planting, all seed lots showed significant differences for the percent of emergence in the first and second counts (8 and 9 DAP, respectively). Later counts showed no differences between seed lots (data not reported). In late fall planting, all seed lots showed significant differences ($p \geq 0.01$) for the percent of emergence in the first and second counts (11 and 12 DAP, respectively). Only seed size lots showed significant differences ($p \geq 0.01$) in the 13 DAP and no significant differences between seed lots thereafter (data not reported). Although, the differences were small, ER and VEC showed significant differences ($p \geq 0.05$) for seed size lots (data not reported). Like early Spring planting, D1 and GR of the standard germination test were the best estimators of LFP-D11 and LFP-D12 percent of emergence with low correlations with LFP-FEP.

DISCUSSION

The observation that EC did not correlate with other germination indices is in agreement with the conclusion of Wang *et al*. (2004), who found that EC may not be a good predictor of seed vigor in grasses. While Khan *et al.* (2007) found that EC was very sensitive tests in ranking wheat seed lots quality. This contradiction might be due to inclusion of severely aged seed lots in the experiments of Khan *et al.* (2007). The GR of Maguire (1962) has been criticized by Brown and Mayer (1986) that it is weighted in favor of early germination. Our results indicate that GR is more affected by higher early germination percentage than VGC. At 20°C, germination of majority of seed lots was completed in 2 days and of the remainder in 3 days (data not reported). Thus early germination count as suggested by Brown and Mayer (1986) may have the same merit as GR of Maguire (1962) for evaluating vigor of seed lots of wheat that germinate quickly in standard germination test. As individual seeds with high vigor are expected to germinate sooner (Brown and Mayer, 1986; Ranal and Santana, 2006), it might be concluded that high D1 of the standard laboratory test (radicle length>2 mm) might be strongly associated with high wheat seed lots vigor.

In this experiment, no laboratory vigor test consistently and/or significantly predicted the planting value of seed lots in late Spring planting. Air temperatures at this planting date were suitable for emergence (17.6°C). Thus, the emergence of wheat seed lots may not be affected by differences in vigor under optimum temperatures and good seed bed conditions, if they have suitable quality.

The early counts of emerged seeds in early Spring planting (when the mean temperature during emergence was 12.2°C), well defined the differences among seed lots. This may also explain that why D1 and GR of the standard germination test had the highest correlation with ESP-D8 and ESP-D9 and low correlation with ESP-FEP. Seefeldt *et al.* (2002) showed that the percent of emergence in 4 DAP differentiated Spring wheat genotypes for seed vigor very well. Kolasinska *et al.* (2000) found that high first count of the standard germination test is associated with high field emergence percentage of bean. It might be implied that a large portion of differences in vigor of seed lots tested in the present experiment might be mainly due to the differences in the percentage of vigorous seeds. This is consistent with the statement of Brown and Mayer (1986) and Ranal and Santana (2006) that vigorous seeds germinate sooner.

In late fall planting, like early Spring planting, D1 and GR of the standard germination test were the best estimators of LFP-D11 and LFP-D12 percent of emergence with low correlations with LFP-FEP. However, both D1 and GR showed slightly lower predicting value of seed lots for late fall planting than for early Spring planting, implying that quality differences between seed lots might become less distinct under harsh environmental conditions. This is in agreement with the conclusion of Kolasinska *et al.* (2000) that soil temperature during emergence is an important environmental factor influencing field emergence potential of a seed lot.

The data evaluated by Brown and Mayer (1986) showed that seed germination continues at a slow rate after a fast period of germination. Apparently, these slow germinating seeds have low vigor (Brown and Mayer, 1986; Ranal and Santana, 2006). Rice and Dyer (2001) working with *Bromus tectorum* showed that late emerging seeds have lower competitive ability than early emerging seeds. In the experiments of Samarah and Al-Kofahi (2008) with barley, smaller seedlings were obtained as quality of seed lots decreased.

CONCLUSION

Although, no experimental results are available on cultivated crops, this assumption might be logical that low vigor seeds may not significantly contribute to the final plant stand at harvest. If our assumption is correct, then final percent of emergence might be ignored and percent of seeds emerging during the first 2-4 days of emergence might be used to evaluate wheat seed vigor and D1 of the standard germination test is a valuable laboratory index for this purpose under conditions similar to this experiment.

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