The influence of climatic factors and crop nutrition on seed vigour in wheat

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Abstract

Seed vigour is the first important factor that influences plant growth and yield. Time of sowing, frost, nutrition and falling numbers are the major environmental/management factors in Western Australia that can influence seed vigour. We collected seed lots from field experiments, or fields where these factors had differentially affected the treatments, and conducted seed vigour tests in the field or in controlled environment rooms using a weed-free, sandy loam soil.

Time of sowing of the seed crop could affect germinability through seasonal finish conditions but speed of field emergence remained unaffected in our experiments. While light frost did not affect germinability, heavy frost significantly reduced percentage of germination. Germination speed was not influenced. Seeds contrasting for falling numbers (between about 200 and 400 seconds) had similar seed vigour and were influenced to the same extent by seeding depth. Crop nutrition (N, P, K and trace elements) influenced both the speed and percentage of field emergence.

We conclude that most of the prevalent climatic conditions influenced only germination percentage while nutrition affected germination speed as well. The appropriate strategy for quality seed production would be to sow at the optimum time for each cultivar and apply sufficient quantities of P, K and trace elements to avoid any deficiency (rates may need to be slightly higher than the economic optimum for a grain crop).

Key Words

Seed vigour, wheat, field emergence, germination speed, environmental influences, nutrition

Introduction

Farmers often produce grain that has some small defect, which reduces its value for sale. The germination percentage of this grain may not be markedly different from sound seed and they may decide to keep the seed for sowing. There are few data that indicate the likely reduction in germinability of such seed, or the possible reduction in early growth that may result from its use.

Seed vigour is a concept that embraces the idea that speed of germination, emergence and establishment are important for early growth, competition against weeds and tolerance to herbicides. Vigour includes the extent and rate of field emergence. High germination percentage and rapid field emergence are essential features of seed vigour (1). While high field emergence is important to ensure optimum plant density, germination speed is important for competitive advantage against weeds and rapid early growth.

Temperature and available moisture during grain development are the two main climatic factors influencing seed development. Crop nutrition influences seed composition, which can also affect embryo development and subsequently seed vigour. Germination percentage and speed of germination are often related to each other but speed of germination is probably a better indication of seedling vigour and early growth (2). To investigate the effects of these factors we compared emergence percentage and speed of emergence of seed lots where sowing time, frost damage, applied nutrition of the parent crop and wet weather during grain filling may have influenced seed quality.

Methods

Seed lots

Seeds from a range of sowing times (late May to early July) were collected from wheat agronomy field trials in 1998 and 1999 (unstressed grain filling periods) and 2000 (hot, dry grain filling period) in the Northern Agricultural Region of Western Australia. Seeds for frost contrasts came from the 1998 season in southern districts of WA where samples were taken from heavily affected through to relatively unaffected parts of farmers' paddocks. Seed for weather damage (falling number) contrasts were selected from a variety x time of sowing trial in 2001 season in the high rainfall area at Northampton. Nutrition contrasts were available in two factorial experiments (in 1998 and 1999) involving N, P, K and Trace elements (Cu plus Zn). All seeds were stored prior to testing in sealed, plastic containers in a cool room maintained at 4?C.

Tests

All tests except the falling number set were conducted on a weed free, sandy loam soil. Moisture level throughout the conduct of each experiment was sufficient to support unhampered emergence. Fifty seeds were evenly spaced in 5-mm wide, 3-cm deep and one-meter long furrows made in softened and levelled soil. Soil was gently pressed from both sides to ensure even depth of seeding. The fusion line was sealed using a small press wheel. All treatments were replicated six times and a control was planted after every five rows. The number of seedlings emerging each day was recorded.

The falling number contrasts were artificially aged at 42?C for 96 hours before sowing in tubs filled with sandy loam soil. The seeds were sown at two depths (3cm and 6cm). The number of seedlings emerging each day were recorded.

Statistical analysis

Seed viability expressed as percentage of germination and germination speed expressed as time for emergence of 80% of the germinated seeds were analysed separately using analysis of variance.

Results

Time of Sowing

Percent emergence of seed from the late sowing was not significantly less in either of the unstressed seasons (1998 and 1999, Table1). However, the seeds from year 2000, which was a tight finishing year, suffered a heavy decline in germinability with delayed seeding compared to their performance in 1999 (cultivar Brookton).

Table 1. Percent field emergence of wheat seed lots obtained from plots sown at different times in the previous season. [Bulk seeds used except for 1998 where seeds sorted using 3.1 & 3.4mm screens were also tested. lsd (0.05)= 7%]

Season	Cultivar	Early Sowing	Late Sowing
Unstressed Finish (Mingenew 1998)	Calingiri	63	60
	Calingiri (sorted seeds)	61	62

Unstressed Finish (Morawa 1999)	Brookton	80	80
	Westonia	75	78
Hot, dry Finish (Mullewa 2000)	Brookton	81	72
	Carnamah	77	77
	Wyalkatchem	83	68

The relatively more stressful conditions during grain filling in 2000 also resulted in reductions in germination percentage of the short season cultivar Wyalkatchem, but not of the mid-season cultivar Carnamah. Although Wyalkatchem suffered maximum seed quality decline over this period, it remained the highest yielder, which suggests that stability of grain yield could be different from seed quality (Table2). Examination of the yield components of the three cultivars in 2000 reveals that the larger reductions in germination percentages with seeds from later sowings were found in cultivars that did not reduce their kernel numbers markedly in response to delayed sowing.

Germination speed was not influenced by time of sowing of the seed source.

Table2. Grain yield and yield components for 2000 seed crop (field emergence data shown in table1)

Cultivar	Grain Yield (t/ha)		Grain Weight (mg)		Grains/m^2		Grains/spike		Tillers/m^2	
	26 June	05 July	26 June	05 July	26 June	05 July	26 June	05 July	26 June	05 July
Brookton	1.4	1.1	24	24	6658	6149	26	24	266	260
Carnamah	1.4	1.1	22	22	8578	4326	27	21	319	203
Wyalkatchem	1.9	1.4	23	22	10019	7927	28	25	356	314

Frost

The influence of frost damage on the emergence percentage of seed lots was variable. Within defined range of seed sizes, field emergence declined for the Perenjori cultivar, which experienced 20% stem and 80% head frost, while no difference was seen in Brookton, which experienced only 10% frost on each of the stem and head. The sample of Carnamah from a heavily frosted paddock clearly suggested deleterious effect of frost (Table3). Further, when seeds graded to the same size (2.8-3.1mm) from the frosted and unfrosted bulks were compared, the germination percentage trend with frost level was not significantly changed (Table 3). This suggests that small grains in the bulk sample did not markedly lower the average germination percentage of seed from these frosted crops.

Table 3. Percent field emergence of wheat seed lots obtained from less frosted and heavily frosted parts of the paddocks

Cultivar	Frost severity in the paddock	Seed size range (mm)	Emergence Percentage	
			Less Frost	High Frost
Brookton	10%Stem; 10%Head	Bulk	67	71
Perenjori	20%Stem; 80%Head	Bulk	73	70
Carnamah	Heavy	Bulk	70	63
Brookton	10%Stem; 10%Head	2.8-3.1	70	73
Perenjori	20%Stem; 80%Head	2.8-3.1	76	69
Carnamah	Heavy	2.8-3.1	71	58

lsd (0.05)= 6%

All seed lots that suffered seed viability decline with frost had similar germination speed.

Falling Number

Emergence percentage and days to 80% emergence were influenced by cultivar and seeding depth but not by falling number of the seed sample (Table 4). Interaction of falling number with cultivar (coleoptile length) and seeding depth were not significant for either of the two parameters.

Table 4. Germination percentage and germination speed of seed lots differing for falling number from different depths, after accelerated ageing

Cultivar	Falling Number	Emergence Percentage		Days to 80% Emergence	
		Seeding Depth		Seeding Depth	
		3cm	6cm	3cm	6cm
Amery (Short Coleoptile)	183	69	59	7.0	7.9
	433	67	61	6.7	8.0
Carnamah	227	73	63	6.5	7.5

(Medium Coleoptile)	416	69	70	6.9	7.8
Westonia (Long Coleoptile)	201	65	57	7.5	7.9
	429	70	58	7.2	7.8
	LSD (0.05)	*8.0*		*0.5*	

Nutrition

All of the nutrition (N, K, P and Cu + Zn) treatments applied to the grain crop influenced vigour of the seed. However, the response to some nutrients differed between sites and varieties. This is not unexpected given that the sites could differ for nutrient status while varieties are known to differ for nutrient uptake.

Application of N, K and trace elements improved field emergence of cultivar Brookton at one site, which had a lower average germinability than Carnamah. The data suggests that there was a genetic factor that resulted in reduced emergence vigour at both levels of applied nutrients. Data from a wider range of varieties and field conditions are needed to better understand this result. Grain yields at these sites were increased by the addition of 100kg/ha of N compared to nil, but not by the addition of either K or trace elements.

Germination speed was also affected by additions of N, K, P and trace elements Cu + Zn. Seed that came from high (K+TE) treatment emerged sooner when a high level of N was used (Fig1).

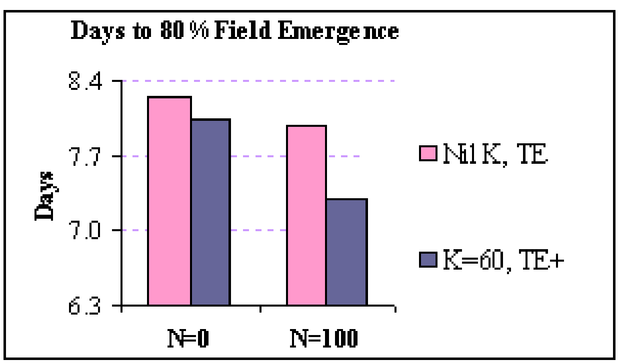

Figure1. Emergence speed of seed lots different for the levels of applied nitrogen, potassium and trace elements

Conclusion

In conclusion, crop management for seed production may need to be somewhat more specialised than for grain yield alone. These experiments have shown that seed vigour can benefit from sowing at the appropriate times, with nutrition that is slightly in excess of that required for maximum economic yield of grain crops, and from sowing in the appropriate part of the landscape to minimize the risk of frost damage. Considerably more research is required to fully understand the impact of climatic conditions on seed composition and seed vigour. However, within the limits of the seed lots tested, it appears that germination percentage and emergence speed were mostly in agreement as measures of seed vigour.

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