Some factors affecting seed quality during the mechanical threshing of dwarf French bean (*Phaseolus vulgaris* L.)

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Abstract

Recently, many Canterbury grown seed lots of dwarf French bean (*Phaseolus vulgaris* L.) have been rejected because of poor seed quality. Mechanical damage is considered the most common reason for poor seed quality in large seeded legumes. This occurs when seeds are threshed at unsuitable seed moisture content (SMC) at a high drum speed. In this experiment, three sowing dates, desiccation and three harvest times (800, 860 and 920°C days) were used to create seed lots whereby conditions at harvest maturity which may affect seed quality following mechanical threshing could be evaluated. Germination was highest when SMC at threshing was between 17 – 20%. Threshing seed when SMC was ≥30% reduced germination and vigour. Desiccation 9 days prior to harvest allowed seeds to reach 18 – 19% SMC at threshing, but seeds from plots sown in late October or mid-November and threshed after 860 or 920 °C days also reached this SMC without desiccation. Seed quality of Canterbury sown bean crops is therefore likely to be improved by threshing the crop at 17 – 20% SMC provided that the drum speed is no more than 10m/s, and importantly that threshed seeds are then immediately dried to a SMC (10 – 12%) safe for storage.

Additional key words: *germination, vigour, seed moisture content, desiccation, degree-days, sowing time, mechanical damage.*

Introduction

Dwarf French beans (*Phaseolus vulgaris* L.) have been grown for seed in Marlborough for many years, but more latterly have been introduced into Canterbury as a seed crop. Despite good yields, there have been problems with rejection of seed lots because of poor seed quality (David Harrison, pers. comm., 1997). Seed quality deterioration can be caused by both the physiological ageing of seed and mechanical damage. The latter is considered a common reason for poor seed quality in many large seeded legumes. This particularly occurs when seeds at 10 – 12% seed moisture content (SMC) are harvested at high drum speeds and moved through and out of the harvester by augers.

There is always something of a balancing act required when harvesting seeds. Seeds must be dry enough to have completed development and reached a high germination percentage (Ellis *et al.*, 1987), but still moist enough to survive the harvesting process without significant damage. The objective of this experiment was to evaluate conditions at harvest maturity, which may affect the seed quality of dwarf French beans.

Materials and Methods

During the 1997/98 season, a field experiment with the French dwarf bean cv. Prosperity was sown at Lincoln University as a confounded factorial design. The treatments were: three sowing dates (S1 on 29 October, S2 on 12 November and S3 on 26 November); desiccation nine days before harvest (300 g/ha Diquat) and no desiccation; and three harvests per sowing date (after 800 (H1), 860 (H2) or 920 (H3) °C days). Crop management was as described by Greven *et al.* (1997).

At each harvest all plants from within a 3 m^2 area of each plot were hand removed and threshed in a Kurt-Peltz stationary thresher with rubber beater bars and a 12 mm round wire concave, at 450 rpm (10 m/s circumference speed). After threshing, each seed lot was cleaned in a Westrup air cleaner with an 8 mm round hole top screen and a 3.25 mm slotted bottom screen. Seeds were then air-dried to 13% (± 1%) SMC as measured by moisture tester (Sinar AP 6060 Moisture Analyser) and stored in sealed plastic bags at 5°C until quality testing. Seed germination was tested using internationally standardised methodology (ISTA, 1999). Seed vigour was measured by means of accelerated ageing (AA) and electroconductivity (EC) (ISTA, 1995).

Mechanical damage and seed colour were assessed after soaking 2 x 100 seeds in water for 4 minutes (Silbernagel and Burke, 1973). Seeds were scored for the symptoms described in Table 1, the numbers in each category recorded and data were analysed both as part of the whole seed lot and separately for each category.

Statistical analysis was done by ANOVA, using the Genstat statistical package. Differences discussed were significant at $P < 0.05$ unless specifically mentioned, with means of separation by standard error of the difference (SED).

Results

Seed moisture content (SMC) at harvest, and therefore threshing depended on desiccation and harvest time (Table 2), particularly for H1 where non-desiccated seeds had SMC 10 – 15% higher than desiccated seeds. SMC was significantly lower for desiccated seeds, fell as harvest was delayed, and increased as sowing was delayed (Table 3). There was a significant interaction between sowing and harvest, and desiccation and harvest (Table 3); for the former SMC at H1 was higher than for H2 and H3, while for the latter, desiccated seed had a lower SMC at H1 than the other harvest times (Table 2).

There was a significant interaction for TSW between desiccation and harvest (Table 3) because at the time of desiccation, seeds at H1 were still filling and could not reach the size that non-desiccated seeds were able to reach in the further 9 days they had until harvest. Desiccated seeds from H1 had a TSW of 203g cf. over 245g for all other treatment combinations.

A significant three-way interaction for both damaged and sound seed occurred among sowing time, desiccation and harvest time (Fig. 1). Overall, desic-

Table 1. Mechanical damage assessment in mechanically threshed and cleaned dwarf French bean seed, harvested in 1997/98.

Symptom	Cause	Category
Testa damaged at top/bottom	Threshing damage, low moisture	Damaged
Testa cracked between cotyledons	Drying damage	Split
Green seed, whole and damaged	Harvested too early	Green
Smooth undamaged testa, not green		Sound

Table 2. Seed moisture content (%) at threshing

	S1 (29 Oct)[1]		S2 (12 Nov)		S3 (26 Nov)	
Harvest time	des[2]	non-des[3]	des	non-des	des	non-des
H1 (800 °C days)[4]	19	29	26	39	24	39
H2 (860 °C days)	18	22	19	22	19	30
H3 (920 °C days)	19	19	19	19	19	23

[1] sowing date; [2] desiccated 9 days before harvest; [3] not desiccated before harvest; [4] harvest time.

Table 3. Effect of sowing date, desiccation and harvest time on bean seed properties and quality parameters.

	SMC [1] (%)	Damaged seed (%)	TSW [2] (g)	Germination (%)	AA [3] (%)	Conductivity (µs/cm/g)
Sowing (S)						
29 Oct (S1)	20.6	21	252	81	63	26.9
12 Nov (S2)	23.0	14	240	78	59	26.3
26 Nov (S3)	24.6	11	236	82	57	29.2
Significant	xx	xxx	xxx	ns	ns	xxx
SED	1.14	2.2	3.1	29.	3.8	0.79
Desiccation (D)						
Yes	19.3	20	235	81	62	25.3
No	26.2	10	250	80	57	29.7
Significant	xxx	xxx	xxx	ns	ns	xxx
SED	0.93	1.8	2.5	2.3	3.1	0.6
Harvest (H)						
800 °C days (H1)	28.7	12	224	74	56	28.4
860 °C days (H2)	20.9	20	249	82	60	27.6
920 °C days (H3)	18.6	13	255	85	63	26.5
Significant	xxx	xx	xxx	xx	ns	ns
SED	1.14	2.2	3.1	2.9	3.0	0.79
CV (%)	21.3	63.7	5.4	15.1	27.2	12.2
Significant interactions	SxH, DxH	SxH, SxDxH	D x H	S x D x H	nil	S x H

[1] seed moisture content; [2] thousand seed weight; [3] accelerated ageing vigour test

cation increased the percentage of damaged seed (from around 10% to just over 20%). While there were inconsistencies, damage tended to be less where SMC was higher at harvest (Fig. 1A), and conversely the percentage of sound seed increased (Fig. 1B).

Germination was not affected by sowing date or desiccation, but increased as harvest was delayed (Table 3). There was a significant three-way interaction among sowing time, desiccation and harvest time (Fig. 2A) because germination of non-desiccated seed increased as harvest was delayed for the second and third sowings, but did not differ markedly for the first sowing or for desiccated seed. Vigour as assessed by accelerated ageing did not differ for sowing date, desiccation or harvest time, and there were no interactions (Table 3). However conductivity was significantly higher for the last sowing and in non-desiccated seeds (Table 3), and there was also an interaction between sowing and harvest dates where in non-desiccated seeds, conductivity was highest for the last sowing date at the first two harvests (Fig. 2B).

Germination data for all seed lots were plotted against SMC and a line fitted by means of an iterative asymmetrically weighted regression (Fig. 3). This suggests that for hand harvested but mechanically threshed seed, maximum germination is likely to occur at a SMC of around 20% (Fig. 3), but that this germination response will also depend on factors other than SMC.

Discussion

When mechanically harvesting seed, the two main factors influencing the extent of any mechanical damage are seed moisture content (Bay *et al.*, 1995b) and the speed of the drum and other moving parts in the harvester that are in contact with the seed (Smith, 1998). According to Pickett (1973), bean seeds should be harvested when SMC is between 17 – 20%, using a

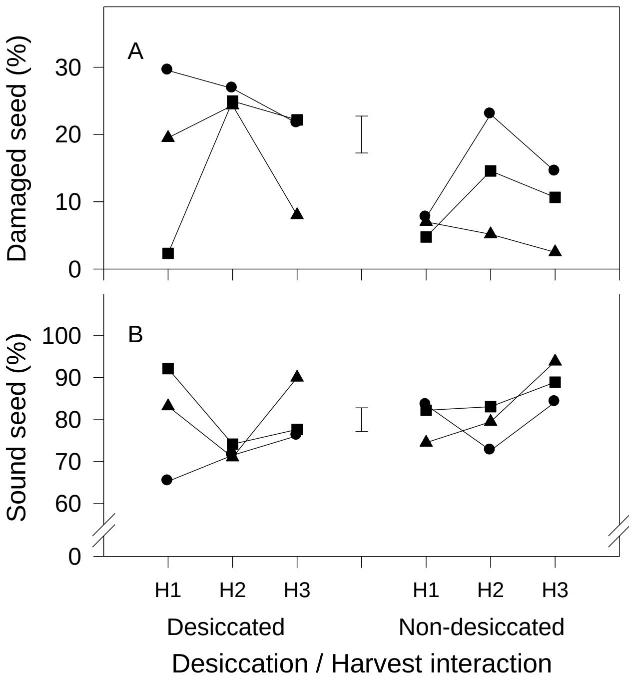

Figure 1. Three-way interactions for damaged seed and sound seed, among time of sowing (S), desiccation and time of harvest (H) for dwarf French beans. (● = 29/10/97 (S1), ■ = 12/11/97 (S2) and ▲ = 26/11/97 (S3); H1 = 800 °C days, H2 = 860 °C days, H3 = 920 °C days). The vertical error bar represents the pooled SED.

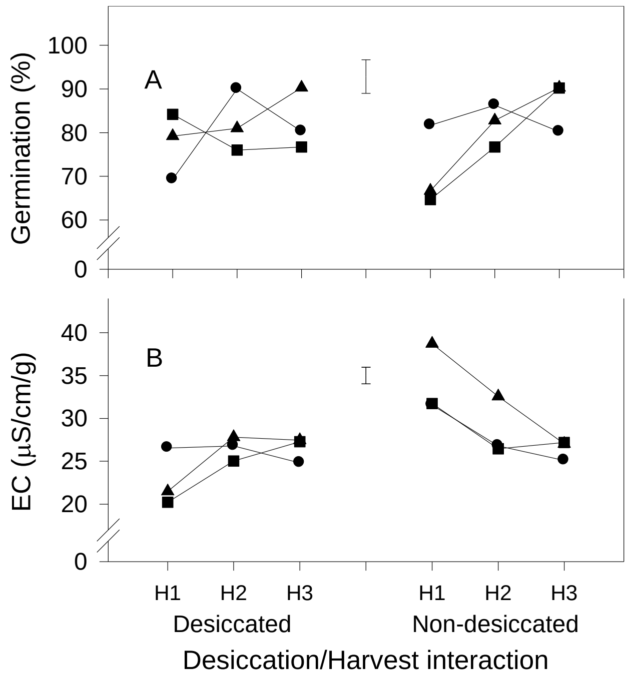

Figure 2. Interactions between time of sowing (S), harvest time (H) and desiccation for (A) germination % and (B) electroconductivity (EC) of dwarf French bean seed. (● = S1 (29/10/97), ■ = S2 (12/11/97), ▲ = S3; (26/11/97); H1 = 800 °C days, H2 = 860 °C days, H3 = 920 °C days). The error bars represent the pooled SED.

drum speed of around 10 m/s. Harvesting at SMC below 16% is likely to increase mechanical damage (Bay et al., 1995a;b), as is increasing the drum speed to >10 m/s (Evans *et al.*, 1990).

Because the drum speed in this experiment was kept at a constant 10 m/s, the factor influencing mechanical damage, and presumable therefore seed quality, was SMC. The percentage of damaged seed and SMC were significantly but negatively related ($r = -0.65^{xxx}$), as there tended to be less damaged seed where SMC was higher at harvest. For this reason, desiccation increased the percentage of damaged seed. The percentage of damaged seed was also strongly correlated ($r = 0.66^{xxx}$) with the percentage of abnormal seedlings recorded in the germination test.

A germination of ≥90% was achieved with four treatments: at S1H2 for desiccated plants; at S2H3 for non-desiccated plants; and at S3H3 for both desiccated and non-desiccated plants. For these treatments SMC at threshing ranged from 18 – 23%. When SMC at threshing was ≥ 30%, germination was below 80% (e.g., for S1H1, S2H1, S3H1 for non-desiccated plants), because of the production of abnormal seedlings (data not presented). Bean seed above 30% SMC is still soft and can be easily bruised, resulting in membrane damage. Non-desiccated seeds at H1 had higher conductivities than desiccated seeds at the same harvest, and also had a higher SMC at threshing.

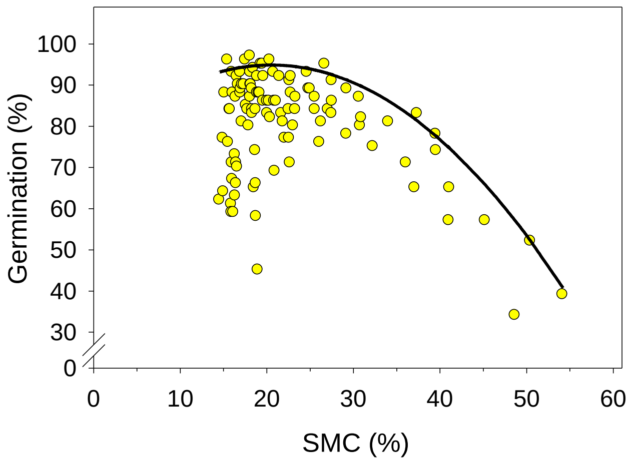

Figure 3. The influence of seed moisture on germination, for all seed-lots, with a line fitted by means of an iterative asymmetrically weighted regression (Sedcole, pers. comm., 2000).

The fitting of an iterative asymmetrically weighted regression to determine the relationship between SMC and germination supports the recommendation of Pickett (1973) that bean seed should be harvested at around 17 – 20% SMC. However, as SMC at threshing was never lower than 16%, the effects of lower SMC on bean seed quality could not be determined. It is also obvious from the data set that SMC alone was not the only factor influencing germination, but what other factor(s) is/are involved is not clear from these results. For example, seed size as measured by thousand seed weight was not correlated with germination (r = 0.12) or SMC (r = -0.14).

As a management tool, desiccation 9 days before harvest allowed SMC to reduce to 18 – 19% at harvest irrespective of sowing date for the H2 and H3, and to range from 19 – 26% for H1. Overall, desiccation had no effect on germination and decreased conductivity cf. no desiccation. However a similar response was achieved by sowing seeds in either late October or mid-November, and delaying harvesting to 920 °C days (H3), by which time they had dried down naturally to 19% SMC. Whether this will be possible every season in Canterbury will need further investigation.

Conclusions

- Bean seed germination fell when SMC at threshing was >25%.
- Threshing bean seeds at 17 – 20% SMC will increase the likelihood of obtaining a quality product, provided seed is subsequently dried to a SMC safe for storage.
- Irrespective of sowing date, desiccation 9 days prior to harvest allowed bean seeds to reach around the desired harvest SMC provided harvest was after 860 or 920 °C days.
- The same SMC was achieved without desiccation following sowing in late October and mid-November provided harvest was after 806 or 920 °C days.

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