Genotypic variation in soybean for weathering tolerance.

T.J. Grant and A.T. James, CSIRO Tropical Agriculture, Indooroopilly

Abstract

Soybean productivity in high-rainfall coastal environments is high. However, total loss of crop or severe damage may occur in some years due to excessive weathering of grain prior to harvest. Improvement in cultivars available to growers has meant that cultivars with higher weathering tolerance such as A6785 and Zeus are available. However weathering tolerant cultivars come from a narrow genetic base, having been sourced from a subset of the southern USA gene pool, which is already known to be quite narrow. We are concerned that the potential for further improvement in tolerance may be limited. As a step toward identifying new and stronger sources of weathering tolerance, we are developing an improved screen of tolerance. In particular we wish to develop a screen able to assess large numbers of accessions with minimum error. We have therefore developed an artificial weathering chamber with capacity to vary the duration and intensity of weathering and are testing different measures of weathering damage, including visual ranking of plant and grain appearance and germination of grain. This paper reports some insights gained from the first two iterations of development of the weathering screen.

Introduction

Many of the current and future soybean production areas in Australia are affected by weathering. Coastal regions are particularly vulnerable. Weathering involves rainfall prior to harvest and causes a decrease in the viability and cleanliness of seed (Rose and Desborough, 1999). Damage can range from wrinkling and discolouration to cracked, sprouted, and moldy seed (Williams et al. 1995). These effects are dependent on the degree of wetting, and the relative susceptibility of the variety.

Crop improvement has produced cultivars such as A6785 and Zeus, which have high levels of weathering tolerance. However, a variety of other desirable characters, both cultural and culinary are often lacking, and therefore limit the end-use options for producers. Furthermore, the ancestral basis for weathering tolerance in many of these varieties can be traced to the North American soybean gene pool, which is known to be narrow. Delannay et al. (1982) identifies seventeen introductions, which collectively make up more than 80 percent the North American gene pool. Thus, many breeding programs have started to broaden the variety of germplasm evaluated for crop
improvement. Such a broad program necessitates the use of efficient, yet accurate screening methods to characterise and evaluate this potential.

The aim of this study was to investigate and therefore develop a screening process for the wider CSIRO soybean improvement program. This program incorporates a broad range of germplasm from a variety of sources, including South East Asia, and is involved in improving Soybean varieties and cultivation in many production environments. This paper presents results from the first two iterations of development of the weathering screen.

Methodology

A chamber with space for up to 400 samples with capacity to vary duration and intensity of wetting was built. Whole plants were harvested from the field at maturity, and stored under ambient conditions for two months. Prior to the experiment each line was scored for pod and pod pubescence colour, pod length, hilum colour, 100 seed weight, hardseededness and viability using grain sub-sampled from the hand-harvested plants. Two replicates made up of two plants per replicate were placed in the misting chamber, arranged randomly and in an upright position (supported within a ‘chicken mesh’ frame). At the start of the wetting cycle, the plants were sprayed continuously for an hour, then wet for five minutes every 90 minutes for the next 200 hours. Daily average minimum and maximum temperatures were 5.5°C and 28.7°C respectively. Samples were then removed from the chamber and dried at 30°C in a fan-forced drying oven for 2 days. Samples were then gently threshed and cleaned to separate seed from other material.

Samples of seed were then assessed for 100 seed weight, visually separated into undamaged and damaged classes. Undamaged seed was classed as seed with less than 50 percent discolouration to the testa and damaged seed was assessed as greater than 50 percent. Weights of each class were recorded and expressed as percentage. Seed was then treated with the fungicide Thiram at five times the recommended rate, placed on germination test paper and watered. After four days a count of the number of germinated and hard seed was made.

Results and Discussion

Variation in response to weathering was found to be large. As expected, symptoms of high discolouration, cracking and sprouting are strongly associated with reductions in seed viability. Both seed viability and visual grading methods identified the varieties F291-2-1 and Jabiru, as possessing high levels of weathering tolerance. The cultivars A6785, Zeus, and Poseidon, which have known tolerance also ranked highly (Table 1).
Table 1. The percentage of undamaged (<50% discolouration) seed and % germination recorded in 6 lines, following the exposure of plants to 200 hours of

<table>
<thead>
<tr>
<th>Line</th>
<th>Viability</th>
<th>% Undamaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>F291-2-1</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Jabiru (E115-6)</td>
<td>88</td>
<td>87</td>
</tr>
<tr>
<td>Cawana</td>
<td>88</td>
<td>80</td>
</tr>
<tr>
<td>Zeus (DM 266)</td>
<td>78</td>
<td>84</td>
</tr>
<tr>
<td>A6785</td>
<td>74</td>
<td>81</td>
</tr>
<tr>
<td>Poseidon (DM 288)</td>
<td>61</td>
<td>84</td>
</tr>
<tr>
<td>Lsd (0.05)</td>
<td>l3</td>
<td></td>
</tr>
</tbody>
</table>

These data were compared with a previous screening and the comparison is presented in Figure 1. Germination results across the two years were found to be significantly different (P=0.23 >0.05). The cultivars Poseidon and A6785 performed consistently high over both experiments, 15.7 and 10.1 percent difference in germination respectively, between years. Varieties that displayed high levels of tolerance in 2000 (F291-2-1 and Jabiru) had lower germination in 1999.

Figure 1. Seed viability results for seed from plants of 30 lines exposed to weathering simulation in 1999 and 2000. (A6785 △, CNC 0115 ▲, F291-2-1 ●, Jabiru ■, Poseidon ○, Zeus □)
Weathering tolerance measured as seed viability generally increased with decreasing seed size (Figure 2). This negative correlation may be related to small seeded pods being capable of maintaining overall integrity and continuing to shed water throughout the weathering process. One outlier from this trend, line CLN 1132 had large seed and reasonably high levels of weathering tolerance. However, CLN 1132 is known to possess tolerance. Importantly the correlation between small seed and weathering tolerance could explain the variation that exists between the two studies cited. The material used in the 2000 experiment was harvested from a trial with terminal water stress. As a result many of the late maturing lines recorded smaller seed sizes than those grown with optimal irrigation. For example, cultivar Centaur recorded a 100 seed weight of 11.8g and was ranked relatively high in the 2000 study (79 percent germination), whilst in 1999 with a seed size of 16g/100 seeds its tolerance was poor (32 percent germination).

![Figure 2. Association between seed viability post weathering and seed weight for seed from plants of 30 lines. (CLN 1132 △, CNC 0115 ▲, F291-2-1 ●, Jabiru ■, Zeus □)](image)

Visual estimates of weathering damage were highly correlated with germination in the 2000 study ($r^2 = 0.62^{***}$), but only weakly in the 1999 study ($r^2 = 0.32^{ns}$). The 1999 weathering was relatively severe and resulted in most lines suffering from severe visual damage. However some of these lines, including the CSIRO line 96119-5-1-2 still germinated well. This suggested that germination may have been a better indicator of tolerance than appearance in more severely weathered samples.
Germination and visual inspection are labour intensive. We therefore also tested weight loss in the weathering process. Unfortunately, loss of weight was not well correlated with either visual \( r^2 = 0.01^{\text{ns}} \) or germination \( r^2 = 0.00^{\text{ns}} \) estimates of weathering tolerance and is therefore not likely to be a reliable estimate of tolerance.

**Conclusions**

A good range of expression of tolerance was expressed in the artificial rainfall chamber. Viability of weathered seed appeared to be a good estimator of weathering tolerance as did visual estimates for moderate levels of weathering. In the severe weathering test in 1999, viability appeared to be a better estimate of tolerance than visual rating.

Seed size appeared to be negatively correlated with weathering tolerance. This is potentially useful in that selection for small seed size may lead to advances in weathering tolerance, even in the current breeding populations.

**Acknowledgements.** Research reported here was funded in part by the Australian Centre for International Agricultural Research under the auspice of PN 95130 ‘Soybean Improvement in Vietnam’.

**References**

