Stress Induced Leakage of Sugars as an Estimator of Sweet Corn (Zea Mays) Seed Vigor

F.R. Lehle, N.F. Oebker and M. White

Abstract

The seed vigor of a super-sweet mutant of sweet corn (Sweetie 76) was compared to that of a traditional, non-mutant variety (Jubilee). The inherent seed vigor of a typical super-sweet corn mutant was considerably less than that of a traditional non-mutant variety. Leakage of reducing sugars from sweet corn seeds at a low temperature was not correlated with seed vigor.

Introduction

Despite the best efforts of seed producers, seed vigor varies considerably between sweet corn varieties. The newer super-sweet mutant varieties are notoriously low in seed vigor compared to some of the traditional varieties. The poor seed vigor of the super-sweet corn mutants has been related to several factors, including small endosperm size and leakage of soluble carbohydrates during imbibition and germination.

The leakage of soluble carbohydrates is thought to encourage the growth of seed pathogens, especially under cool soil conditions. Since fungicide seed coatings inhibit pathogen growth, some seed producers also believe seed vigor will be increased by such treatments.

An objective of this research was to demonstrate that the inherent seed vigor of a typical super-sweet corn mutant is less than that of a traditional non-mutant variety. A second objective of this research was to determine if leakage of reducing sugars from sweet corn seeds at a low temperature is correlated with seedling vigor under stressful soil conditions.

Materials and Methods

Sweet corn varieties 'Jubilee' and 'Sweetie 76' were generously donated by Roger Brothers Seed Co., P.O. Box 4727, Boise, ID 83711 and Agrigenetics, Eden Prairie, MN 55344, respectively. Jubilee is a traditional non-mutant variety and Sweetie 76 is a mutant, super sweet variety. The seeds of both varieties were treated with seed fungicides. Jubilee seeds were treated Vitavax (captan, thiram, and carboxin mixture) while Sweetie 76 seeds were treated with captan and thiram at recommended rates. To obtain untreated seeds to serve as controls, seed samples from both varieties were washed with three successive rinses in methanol followed by air drying.

For the warm germination and cold vigor tests, each variety was planted in small plastic containers (25 seeds per container) filled with a sandy loam soil obtained from the Maricopa Agricultural Center (MAC), Maricopa, AZ. Treatments consisted of the two varieties of sweet corn whose seeds were or were not rinsed with methanol. Each experiment was replicated eight times using a completely randomized design.

Warm germination test.

Containers were incubated at 25^{o}C in continuous light for 7 days. The number of emerged seedlings was recorded and the seedlings were rinsed free of soil with water. The endosperm was separated from each seedling and the fresh weight of each seedling (shoots and roots) recorded.

Cold vigor test.

Containers were incubated at 10°C in darkness for 7 days followed by incubation at 25°C in continuous light for 5 days. Emergence and seedling fresh weight were recorded as above in the warm germination test.

Reducing sugar leakage.

Forty seeds of each variety, rinsed or not-rinsed in methanol, were individually added to small test tubes containing 0.25 ml of distilled water chilled to 8°C. Seeds were incubated at this temperature for 4 hours. A small sample of the soak solution was removed and assayed for total reducing sugar using a microassay. Glucose served as a standard. The seeds were then planted in a sandy loam soil (from MAC) such that individual seedlings could be differentiated from one another. The planted seeds were then subjected to the cold vigor test conditions above, except that the incubation at 25°C lasted 7 days.

RESULTS AND DISCUSSION

Under warm soil conditions, the emergence of the traditional sweet corn variety 'Jubilee' was high and considerably better than the super-sweet mutant 'Sweetie 76' (Table 1). The emergence of the methanol-rinsed seeds of both varieties was considerably reduced; Sweetie 76 exhibited the largest inhibition. Surprisingly, the emergence of both varieties was not greatly inhibited by the more stressful conditions of the cold vigor test (Table 2). The emergence of the methanol-rinsed seed under the cold vigor test conditions was also similar to that obtained under warm germination conditions.

Like emergence, the growth of Jubilee seedlings was superior to that of Sweetie 76 under warm germination test conditions (Table 3). The growth of methanol-rinsed seeds was also reduced under warm germination conditions, but the inhibition of Sweetie 76 seedling growth was greater than that of Jubilee. The stressful conditions of the cold vigor test were more apparent in terms of seedling growth than emergence (Table 4). The seedling growth of Sweetie 76 was more greatly reduced by the conditions of the cold vigor test than was that of Jubilee. The trend for methanol-rinsed seeds was similar.

The results of these experiments clearly demonstrate that there are significant differences among sweet corn varieties in terms of seed vigor. Under both optimal and stressful soil conditions, Jubilee seeds are substantially more vigorous than those of Sweetie 76.

While methanol rinses are effective in removing the bulk of fungicide seed treatments from many seeds, this procedure is toxic to some seeds. Since the germination of the sweet corn seeds rinsed with methanol was not compared to that of the non-treated seeds in the absence of soil, the relative effectiveness of the fungicide can not be separated from the possible toxic effects of the methanol. We believe that the fungicide coating was removed from the corn seeds with the methanol rinses, but this was not verified with a specific assay.

The lack of a relationship between seedling growth and the leakage of reducing sugars at low imbibition temperatures is illustrated for unrinsed seeds of Jubilee and Sweetie 76 in Figures 5 and 6, respectively. Essentially identical relationships were obtained for methanol rinsed seeds. These surprising results suggest that the leakage of reducing sugars does not play a significant role in determining seedling vigor in sweet corn seeds. This contradicts the commonly held notion that leaky seeds are generally low in vigor because of their increased propensity to pathogen infection.

Table 1. Percent emergence of methanol-rinsed and unrinsed Jubilee and Sweetie 76 sweet corn seeds following incubation in a sandy loam soil for 7 days at 25°C in continuous light.

Variety	Unrinsed	MeOH rinsed
	emergence, % ± s.e.	
Jubilee	90.0 ± 2.5	46.5 ± 6.4
Sweetie 76	43.5 ± 5.9	6.0 ± 1.5

Table 2. Percent emergence of methanol-rinsed and unrinsed Jubilee and Sweetie 76 sweet corn seeds following incubation in a sandy loam soil for 7 days at 10°C in darkness and 5 days at 25°C in continuous light.

Variety	Unrinsed	MeOH rinsed
	emergence, % ± s.e.	
Jubilee	83.5 ± 8.0	49.5 ± 4.9
Sweetie 76	47.5 ± 7.2	8.0 ± 1.9

Table 3. Seedling fresh weights of methanol-rinsed and unrinsed Jubilee and Sweetie 76 sweet corn seeds following incubation in a sandy loam soil for 7 days at 25°C in continuous light.

Variety	Unrinsed	MeOH rinsed
	seedling fresh weight, gm ± s.e.	
Jubilee	10.6 ± 0.6	6.3 ± 0.8
Sweetie 76	6.6 ± 0.7	1.0 ± 0.3

Table 4. Seedling fresh weights of methanol-rinsed and unrinsed Jubilee and Sweetie 76 sweet corn seeds following incubation for 7 days at 10°C in darkness and 5 days at 25°C in continuous light.

Variety	Unrinsed	MeOH rinsed
	seedling fresh weight, gm ± s.e.	
Jubilee	9.5 ± 0.6	4.9 ± 0.5
Sweetie 76	3.9 ± 0.6	0.4 ± 0.1

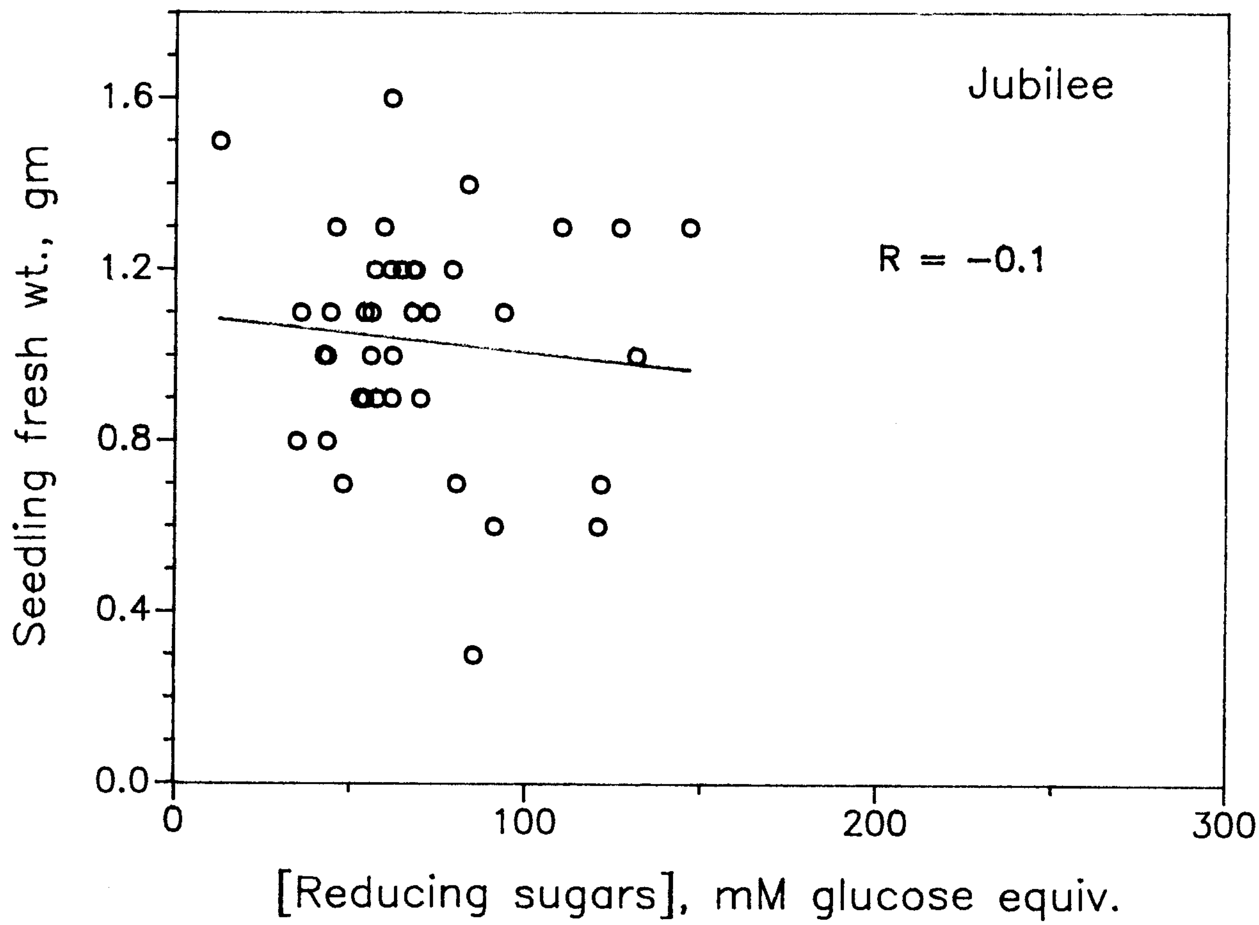

Figure 5. Relationship between leakage of reducing sugars from individual unrinsed Jubilee sweet corn seeds during early imbibition at 8°C and their subsequent seedling growth after incubation in a sandy loam soil for 7 days at 10°C in darkness and 7 days at 25°C in continuous light.

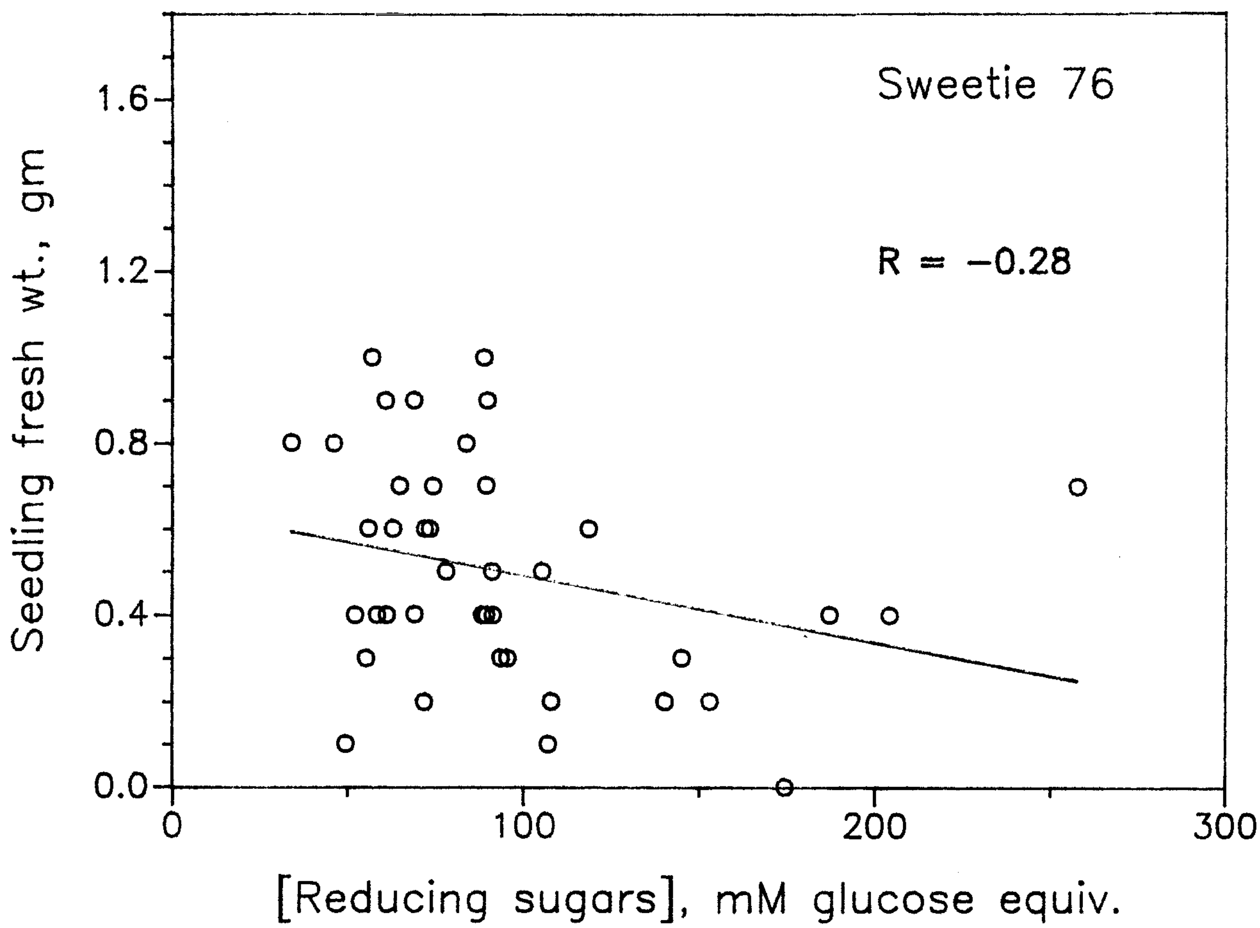

Figure 6. Relationship between leakage of reducing sugars from individual unrinsed Sweetie 76 sweet corn seeds during early imbibition at 8°C and their subsequent seedling growth after incubation in a sandy loam soil for 7 days at 10°C in darkness and 7 days at 25°C in continuous light.