INFLUENCE OF ETCHED SEEDCOATS ON THE DURABILITY OF SOYBEAN SEED DURING CONDITIONING, WEATHERABILITY IN THE FIELD, AND THE EFFECT OF CULTURAL PRACTICES ON THE INCIDENCE OF ETCHED SEEDCOATS IN A SEEDLOT

by

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CHAPTER I

INFLUENCE OF ETCHED SEEDCOATS ON THE DURABILITY OF SOYBEAN SEED DURING CONDITIONING

INTRODUCTION

High quality soybean (Glycine max (L.) Merr.) seeds are required for uniform stands under field conditions. Maturity, seed size, and disease resistance have all been identified as factors influencing seed quality (4,8,9). Another factor, seed coat etching, may substantially influence seed quality, emergence and handling durability of soybean seed (6,13).

Etched seed has been referred to as defective, cracked and physiologically cracked seed (12,14,13,6). Schlub and Schmitthenner (13) described the condition as an irregular crack in the hypodermal layer of the seedcoat thereby exposing the spongy parenchyma cells. The presence of etched seed in soybeans has been observed for a number of years (12,14). Several studies have been conducted to investigate the inheritance of this condition. Stewart and Wentz (14) reported that F_2 seed from a cross involving two non-etched parents exhibited the etched characteristic. They also found that seed which carried the gene I, the gene for inhibition of black and brown hilum color, lacked seedcoat etching. Therefore, they concluded that I prevents etching. The symbol, de, was suggested to designate the etched characteristic. This recessive gene, de, was found to be completely linked to t, the gene for grey pubescence. Later work by Woodworth (16) and Woodworth and Williams (17) confirmed this linkage.

Since the seedcoat of the etched seed does not offer optimum protection to the embryo, these seeds may be more vulnuerable to damage. Burris (6) concluded that etched seed are predisposed to splitting and damage during combining and handling. He stated that the overall, physical integrity of the seedcoat is effected and that increased stress forces are placed on the seed during conditioning.

Seed damage incurred during harvest and conditioning often alters field performance. Seed improperly harvested and conditioned exhibit an increased amount of cracked seedcoats and split seed. Cracked seed often produce abnormal seedlings which will not emerge well under field conditions. Seedlots with low warm germination scores also have low field emergence (8). Factors such as cylinder speed, seed moisture content and temperature during harvest and handling have all been identified as influencing seed damage (6,8).

The purpose of this study was to determine the effects of etched seed on soybean durability and performance following harvest.

MATERIALS AND METHODS

This experiment was conducted at the Ashland Agronomy Farm at Manhattan, Kansas and at the Cornbelt Experiment Field in Powhattan, Kansas. Plots at the Manhattan location in 1980 and 1981 were planted in a Eudora silt loam classified as a Fluventic Hapludoll, coarse-silty, mixed, mesic. In 1980, 2.4 l/ha trifluroline (a,a,a triflouro-2,6-dinitro-N,N-diproyl-s-toluidine) was applied in late April and 3.37 kg/ha chloramben (3-amino-2,5-dichlorobenzoic acid) was applied at planting time for weed control. In 1981, the chloramben was applied at planting time at a rate of 3.37 kg/ha. Plots at the Powhattan location in 1980 and 1981 were planted in a Grundy silty clay loam. Herbicides applied both years were 2.4 l/ha triflurolin and 3.37 kg/ha chloramben. Seeding rates for all plots were 25 seeds per meter in rows spaced 76 cm apart. Environmental conditions at Ashland in 1980 were dryer and warmer than normal (30-year average, 1951-1980). The average monthly temperatures for June, July, August and September were 2.1, 5.0, 3.0 and 1.8^{o}C above normal, respectively. Rainfall deficits in 1980, were 68.6 mm in May, 63.5 mm in June, 71.2 mm in July, 7.7 mm in August and 38.1 mm in September. The 1981 growing season was cooler and wetter than the 1980 season. Average monthly temperatures were near or below the 30-year normal. Rainfall in May, June and July was above normal by 65.0 mm, 31.5 mm and 40.6 mm, respectively. Powhattan environmental conditions in 1980 were warmer and dryer than normal. 1981 weather conditions were favorable early in the season. Rainfall was below normal except in May and late July. All plots at Manhattan were irrigated, those at Powhattan were dryland. Plot design was a randomized complete block design with three replications. Four genotypes adapted to Kansas were selected for evaluation. They were Calland (maturity group III), DeSoto, Pomona and Douglas (maturity group IV).

After harvest preliminary data was taken on the seedlots. Information gathered included seed quality, 100 seed weight, etching, wrinkling and smooth seed percent and warm germination (WG). Seed quality was a visual assessment evaluating the amount of wrinkling, etching, green, moldy or rotten seeds present in a sample. A scoring system of 1 to 5 with 1 being good and 5 being poor was used. WG was conducted using the rolled towel method outlined in the AOSA Rules for Testing Seeds (2). Two-hundred seventy-five gram samples of etched and non-etched seed were separated from each seedlot. These samples were subdivided into two equal subsamples which were conditioned to 8% and 13% moisture by exposing the seed to a relative humidity (RH) of 45% or 75% at 25°C for 72 hours. These moisture levels were verified using the oven dry moisture check method outlined by Christensen (7). After moisture conditioning each of the subsamples were divided into two equal parts and sealed in plastic bags for temperature conditioning. The two temperature levels were -18°C and 21°C. These were attained by exposing the seeds, sealed in plastic, to their respective temperatures for 12-hours. Each of these temperature samples was divided into thirds for the drop tests. The drop heights consisted of three levels; 0 m (control), 3 m and 6 m. The seeds were dropped from the appropriate height onto a 3.2 mm steele plate inclined at a 45° angle. The seeds struck the plate once and were deflected in a cloth barrier to be collected. A factorial arrangement using two classes of seed condition (etched, non-etched), two moisture levels (8%, 13%), two temperatures (-18, 21°C), three drop heights (0m, 3m, 6m) and four genotypes replicated three times was used. WG and accelerated aging (AA) were used to evaluate these treatments and their effects on soybean seed durability. Fifty seed samples were collected to conduct the WG and AA tests on seedlots from each replication. WG was conducted according to the AOSA Rules for Testing Seed using the rolled towel method (2). AA was run by exposing the seed to 100% RM at 40^{o}C for 72-hours followed by the standard WG test. Because of a shortage of seed in 1980, AA tests were not conducted at Powhattan. There was sufficient seed in 1981 to run the AA tests, but these data were deleted because of the two-year analysis. Analysis of variance were run on the data using WG and AA as dependent variables with variety, seedcoat conditions, drop height, temperature and moisture level as independent variables in a factorial arrangement with a split-plot design. Years were considered main plots, with genotype the subplots.

RESULTS AND DISCUSSION

Seeds harvested in 1981 were significantly higher in quality and viability than those harvested in 1980. Table 1.1 shows several characteristics of the seedlots harvested at Manhattan. In 1981, seed had higher overall quality, larger size, less etching, less wrinkling and better germination than seed produced in 1980. 1981 seed showed approximately a 50% decrease in the average etched and wrinkled seed percent. The average number of smooth, sound seed increased from 62% in 1980 to 80.3% in 1981. Warm germination increased more than 20% from 1980 to 1981.

Pomona had the best visual seed quality score in both years, but not significantly higher than the remaining 3 genotypes in 1981. Pomona also exhibited the lowest 100 seed weight in 1981. In 1980, there were no significant differences between any of the four genotypes for 100 seed weight. Douglas exhibited the lowest seed quality, highest seed weight and most etched seed although seed weight and seed quality were not significantly different among the entries in 1980 and 1981, respectively. Douglas had the lowest germination in 1980 and the highest in 1981. DeSoto had the highest germination in 1980, but was not significantly different from Calland and Pomona in 1981. Calland had a significantly higher percent of wrinkled seed in both 1980 and 1981.

Data in Table 1.2 show the effect of drop height, moisture levels and temperature on warm germination and accelerated aging at Manhattan and WG only at Powhattan, from the combined 1980 and 1981 data.

In order to discuss the effects of various drop heights, some of the aspects of the free-fall of seed must be examined. The seed accumulates momentum as it falls. This energy must be released at the time of impact, either through the resiliance of the impacted surface or back into the seed itself. If the seed is not sufficiently strong to absorb the energy, damage will occur. Several authors state that the velosity of the seed is directly related to the amount of damage (1,3,5). Seed velosity can be calculated from the equation, $V = \sqrt{(2GH)}$ where H is the height of the fall, and G is acceleration due to gravity. Table 1.3 shows the velosity that the beans reached upon impact when dropped from heights used in this study. Friction from air would influence the velosity but for these calculations it is assumed to be negligible.

There were significant decreases in WG as drop height increased at both Manhattan and Powhattan. The average germination at Manhattan was 6.5% and 14.3% less than the control at the 3 m and 6 m drop height, respectively. Seedlots from the Powhattan location dropped 3 m germinated 10.1% less than the controls, and those dropped 6 m germinated 16.5% less than the control. Vigor was reduced as drop height increased at the Manhattan location as reflected in the AA scores. Seed dropped 3 m displayed 5.8% less vigor than the control and those dropped 6 m displayed 11.6% less than those not dropped.

Moisture levels significantly influenced WG and AA at both locations. The 13% moisture level exhibited a 8% higher WG at Manhattan and a 10.4% higher WG at Powhattan than the 8% moisture level. There was a small, but significant difference in accelerated aging between the 8% and 13% levels of moisture. The warm temperature exhibited a small, but significantly higher WG than the freezing temperature at both Manhattan and Powhattan. There was no significant difference in AA for the two temperature levels at Manhattan.

Significant interactions between drop heights and moisture levels were detected at Manhattan for WG and AA and Powhattan for WG (Table 1.4). Manhattan WG and AA scores show significant decreases in both 8 and 13% moisture levels over the drop heights. The decrease in WG and AA from the 0 m to 3 m height at the 8% moisture level was four times that of the 13% level. The decrease in germination from the 3 m to 6 m drop height in both 8% and 13% moisture levels were similar. The Powhattan WG scores followed the same pattern. Germination decreased from 68 to 58% from the 0 m to 3 m drop height at the 8% moisture level. This is more than twice the decrease in the 13% moisture level. The drop in germination in both moisture levels from the 3 m to 6 m drop height differed by only 1 percentage point, 5% in the 8% level, 4% in the 13% level. These interactions seem to indicate that soybeans at low moisture content are damaged to a greater extent at small drop heights than soybeans at higher moisture levels. This could be explained by the low moisture seeds being more brittle and less able to absorb the energy from the fall. The higher moisture seeds may be a little more elastic and able to withstand the impact. As the drop height increased, the decrease in germination is not significantly different between moisture levels.

As drop height increased, seedlots from Powhattan at the low temperature germinated less than those dropped at room temperature (Table 1.5). Seedlots at 78°C dropped 3 m germinated 13% less than the control, compared to a 7.2% decrease in WG for the seedlots at room temperature. The seedlots at the low temperature dropped 6 m, germinated 8.3% less than those dropped 3 m. The seedlots dropped from 6 m at room temperature showed a decrease in WG of 4.6%. The larger decline in WG for seedlots dropped at freezing temperatures than those at 21^{0} may have been due to the increased rigidity of the seed. Since the seed lots at -18^{0}, had less resiliance than those at room temperature, they were less able to absorb the energy from the fall. The larger amount of damage at relatively low drop heights may be due to the velosity of the seed at impact. Although the drop height doubled from the 3 m to 6 m drop height, the velosity only increased 41%.

The influence of seedcoat condition on WG was not consistant between 1980 and 1981 at Manhattan and Powhattan (Table 1.6). At both locations the etched seedlots germinated significantly less than the non-etched seedlots. WG scores at Manhattan in 1981 were significantly higher for both seedcoat conditions than those in 1980. Non-etched seedlots from Powhattan in 1981 germinated better than those in 1980, however, etched seedlots in 1980 germinated better than those produced in 1981. The higher germination in 1981 could be attributed to the more favorable climatic conditions during the growing seasons. The higher WG score for the etched seed from Powhattan in 1980, may have been due to the reduced number of etched seeds produced because of the more favorable weather during the 1981 growing season. Because of the fewer number of etched seed in the 1981 seedlots, etched seeds that would have been discarded because of other quality defects, were included in order to have sufficient seed for the tests.

A significant interaction between seedcoat condition and drop height was found for WG in the combined 1980-81 analysis (Table 1.7). Etched seedlots dropped 3 m germinated 10.8% less than those not dropped, while germination of non-etched seedlots dropped 3 m, were reduced only 3.7% below the control. Both etched and non-etched seedlots dropped from the 3 m height, demonstrated the etched seeds' decreased ability to withstand damage, compared to sound seed.

Handling at the low moisture level caused significantly more damage to etched seedlots than non-etched seedlots from Powhattan (Table 1.7). Seedlots at 8% moisture germinated 25% less than non-etched seedlots at the same moisture level and exhibited 15% less viability than etched seedlots at 13% moisture. Non-etched seedlots at the 13% moisture level germinated 18.9% better than the etched seed at the same moisture level. This data indicated that handling of seed at low moisture levels caused increased damage, and that etched seed is damaged to a greater extent than non-etched seed.

The vigor of etched seed was reduced more than non-etched seed when handled at freezing temperatures. Table 1.7 shows the AA scores of etched and non-etched seedlots for the two temperature levels. Etched seedlots handled at room temperature exhibited a 14.3% decrease in vigor, while those handled at -18^{o} showed a 17% lower AA score, compared to non-etched seedlots. There was no significant difference in vigor between the two temperature levels for etched or non-etched seedlots. The difference in the amount of vigor lost shows that etched seed handled at freezing temperatures loses more vigor than non-etched seedlots when the two seed coat conditions are compared at the higher temperatures.

The effect of seedcoat condition on genotypes was not consistant between 1980 and 1981 for viability and vigor at Manhattan. Table 1.8 shows the data for WG and AA from Manhattan for the two years. In 1980, the difference in germination between etched and non-etched seedlots was smaller for Calland and Douglas than for DeSoto and Pomona. In 1981, Douglas exhibited the smallest difference in viability between etched and non-etched seedlots, with Pomona having the next larger difference. Calland had the third largest difference and DeSoto had largest difference in germination between etched and non-etched seedlots. The difference between the etched and non-etched catagories increased for Calland, DeSoto and Douglas in 1981 over 1980, while the difference between the etched and non-etched seedlots decreased for Pomona in 1981. The vigor data on Table 1.8 followed some of the same trends as the viability. DeSoto had the largest difference between etched and non-etched seedlots for AA in both years. Douglas had the smallest difference both years. In 1980, Douglas showed no significant difference for vigor between etched and non-etched seed.

The influence of the different growing seasons on the effect of seedcoat condition on genotypes was easily seen. Vigor and viability was significantly higher in 1981 than in 1980, for all except the WG score for the etched Calland seedlot. The inconsistency between the years showed the genotypic variations for the influence of the etched seedcoat characteristic and that the genotypes are effected differently in different years.

Table 1.9 shows the means for a genotype by seedcoat condition by year interaction for WG at Powhattan. These data did not follow the same trends as the Manhattan data for the same interaction. The etched seedlots from all four genotypes in 1981, exhibited a significantly lower to non-significantly higher germination than the respective etched seedlots in 1980. The non-etched 1981 germination scores were higher for each genotype but not significantly so for Calland.

All four genotypes showed larger differences in germination between etched and non-etched catagories in 1981 than in 1980. In 1980, DeSoto showed a significantly lower germination for non-etched than etched seedlots. The narrow range between the etched and non-etched seedlots in 1980 and the low germination of the etched seedlots in 1980 and the low germination of the etched seedlots in 1981, was attributed to the influence of the different climatic conditions prevelant during the two growing seasons. In 1980, the unfavorable weather caused poor visual seed quality. The seeds classified as non-etched suffered from other quality defects which also influence the seeds' ability to withstand damage, such as wrinkling and shriveling. In 1981, the more favorable weather caused fewer etched seeds. Consequently, etched seed with additional quality defects, which would otherwise have been discarded, were included in order to have sufficient seed to conduct the experiment.

Although the etched seedlots of all genotypes at Manhattan germinated significantly less than non-etched seedlots at both the 8% and 13% moisture levels, the magnitude of the differences were not consistant (Table 1.10). Calland and DeSoto showed a larger difference between etched and non-etched catagories at the 8% over the 13% moisture level. Pomona and Douglas exhibited a larger difference between the etched and non-etched seedlots at the 13% moisture level. These data indicated that although etched seed is damaged more than non-etched seed at higher moisture levels it may be damaged to a greater extent at lower moisture levels than sound seed, depending on the genotype. Data from Powhattan, also shown on Table 1.10, followed a similar trend. Calland, Pomona and Douglas showed 36%, 31% and 21%, respectively, lower germination of the etched than non-etched seed at the 13% moisture level. DeSoto did not follow the trend, as it exhibited a 5% lower germination for etched seed than non-etched at the 8% level, while it showed 25% less viability for etched seed at the 13% moisture level.

Table 1.11 shows the difference in the amount of viability lost as drop height increased for the four genotypes as influenced by seedcoat condition, from Powhattan. All four genotypes followed the expected trend of less viability as drop height increased. However, not all genotypes showed a similar magnitude of decline in germination as drop height increased for etched and non-etched seedlots. The reduction in germination for the etched seedlots at the 3 m drop height as compared to the control, was similar for Calland, Pomona and Douglas. DeSoto viability was reduced significantly less, only 3.6%. However, when comparing the reduction in WG from the 3 m to 6 m drop height, etched DeSoto seedlots had a significantly greater drop than did Calland, Pomona and Douglas. DeSoto also exhibited a significantly greater drop in WG from the control to 3 m drop height in the non-etched seedlots. The decrease in viability of Calland, Pomona and Douglas was not significantly different for the same interval. DeSoto and Pomona exhibited significantly lower decreases in WG than Calland and Douglas for the 3 m to 6 m interval. These data indicated that not all genotypes behaved in an identical manner concerning seed durability as influenced by the etched seed coat characteristic.

Etched seedlots at low moisture levels were damaged to a greater extent from small falls than those at higher moisture. Data in Table 1.12 showed that etched seedlots at higher moisture levels from Powhattan were also more susceptible to damage than non-etched seeds at low moisture levels. Etched seeds at 8% moisture, dropped from 3 m, decreased in germination significantly more than etched seed at 13% moisture dropped from the same height. Non-etched seedlots at 8% moisture decreased in viability more at the control to 3 m interval than at the 3 to 6 m interval. Non-etched seedlots at 13% moisture followed a similar trend although the decreases in WG were not as large as those at 8% moisture.

The influence of temperature on etched and non-etched seedlots from Powhattan was not consistent among genotypes (Table 1.13). Etched seedlots of DeSoto, Pomona and Douglas handled at -18^{o} exhibited significantly less viability than those handled at room temperature. There was no significant difference in WG for etched seedlots of Calland between temperature levels. Non-etched seedlots of Calland and Pomona had significantly less germination when handled at freezing temperatures as compared to room temperature. There was no significant difference in the germination of non-etched seedlots of DeSoto and Douglas between the two temperatures. These data indicated that handling of seedlots at low temperatures should be avoided, especially etched seedlots.

SUMMARY AND CONCLUSIONS

The effect of etched seedcoat on the durability of four soybean genotypes during conditioning, was examined at two locations, in 1980 and 1981. The influence of seed moisture level and seed temperature on durability, simulated by dropping from various heights was also examined.

The four genotypes differed in the amount of seedcoat etching present in the seedlots among themselves and between years. Seedlots of etched seeds were found to generally have lower germination and were less able to withstand damage from low drop heights than were non-etched seedlots.

Handling, as simulated by the drop heights, at low moisture levels and low temperatures caused greater amounts of damage in etched seedlots as compared to non-etched seedlots, as shown by WG and AA scores. Since the etched seed did not have a continuous protective layer around the embryo, anything that reduced the seeds ability to resist damage, such as low moisture or low temperature, caused a greater reduction in damage resistance in etched seed than in non-etched seed.

These results emphasized the need for careful handling of soybean seed, especially lots exhibiting the etched seedcoat condition. Handling of seedlots with etched seed present at moisture levels near 13% and at room temperature produced lesser amounts of damage and retained more viability, than handling at low moisture levels and freezing temperatures. Drops from even small distances should be avoided as etched seeds are easily damaged.

Table 1.1 Etched, smooth and wrinkled seed percent, seed quality, 100 seed weight and warm germination of four genotypes grown at Manhattan, Kansas in 1980 and 1981.

	Seed Quality	Seed Weight	Etched Seed	Smooth Seed	Wrinkled Seed	Warm Germination
	Score +	g/1000	%			
	1980					
Calland	2.3 b†	15.9 a	14.3 a	56.0 b	29.7 b	75 ab
DeSoto	2.8 c	16.2 a	27.7 b	59.3 b	13.0 a	87 a
Pomona	1.8 a	15.9 a	11.7 a	81.7 a	6.7 a	75 ab
Douglas	3.3 d	16.7 a	44.7 c	51.0 b	4.3 a	65 b
	1981					
Calland	2.0 a	16.2 bc	8.3 a	75.3 b	16.3 b	91 ab
DeSoto	1.7 a	17.0 b	10.3 a	82.7 ab	7.0 a	86 b
Pomona	1.6 a	15.2 c	6.0 a	89.7 a	4.3 a	91 ab
Douglas	2.2 a	18.6 a	25.7 b	73.3 b	1.0 a	95 a
$\bar{X}$ 1980	2.6 b	16.2 b	24.6 b	62.0 b	13.4 b	75 b
$\bar{X}$ 1981	1.8 a	16.7 a	12.6 a	80.3 a	7.2 a	91 a

+ Scale 1-5 (1 best - 5 poorest)

† Means followed by the same letter within a column are not significantly different according to the Duncan's Multiple Range Test. α=0.05.

Table 1.2 Effect of Drop Height, Seed Moisture Level and Temperature on Warm Germination and Accelerated Aging of Four Genotypes Grown at Manhattan and Powhattan, Kansas in 1980-1981.

Treatment		Manhattan Warm Germination	Manhattan Accelerated Aging	Powhattan Warm Germination
		%		
Drop Height (m)	0	77a+	69 a	69 a
	3	72 b	65 b	62 b
	6	65 c	61 c	58 c
Moisture Levels (%)	8	69 b	63 b	69 b
	13	75 a	64 a	67 a
Temperature (^{o}C)	-18	71 b	64 a	62 b
	21	73 a	65 a	65 a

+ Means followed by the same letter are not significantly different according to the Duncan's Multiple Range Test. α=0.05

Table 1.3 Calculated velosity of soybean seeds dropped from various heights, from Burris (5).

Drop Height (m)	Velosity (m/sec)
0	0 m/sec
3	7.67 m/sec
6	10.84 m/sec

Table 1.4 Influence of Seed Moisture Levels on Drop Height Damage Reflected by Warm Germination and Accelerated Aging at Manhattan and Powhattan, Kansas in 1980-1981.

		Seed Moisture Level			
		%			
		8	13	8	13
		Warm Germination		Aging Accelerated	
		%			
		Manhattan			
Drop Height	0	77	78	70	69
	3	68	76	61	67
	6	62	79	58	64
LSD .05		2			
		Powhattan			
	0	68	71		
	3	58	67		
	6	53	63		
LSD .05		2			

Table 1.5. Influence of Seed Temperature on Germination of Seed Lots Dropped from Different Heights, Powhattan, Kansas, 1980-1981.

		Seed Temperature (°C)	
		-18	21
		Warm Germination	
		%	
Drop Height (m)	0	69	69
	3	60	64
	6	55	61

LSD .05 = 2

Table 1.6. Influence of Etched Seedcoats on Warm Germinaton at Manhattan and Powhattan, Kansas in 1980-1981.

	Manhattan		Powhattan	
	1980	1981	1980	1981
	Warm Germination			
	%			
Etched Seedcoat	60	73	67	53
Non-Etched Seedcoat	69	85	65	78

	Manhattan	Powhattan
LSD .05 within years =	2	2
between years =	2	3

Table 1.7 Influence of Etched Seedcoats, Drop Height, Seed Moisture Level and Temperature on Warm Germination and Accelerated Aging of Four Genotypes, Manhattan and Powhattan, Kansas, 1980-1981.

Seed Condition		Manhattan				Powhattan	
		Etched	Non-Etched	Etched	Non-Etched	Etched	Non-Etched
		Warm Germination		Accelerated Aging		Warm Germination	
		%					
Drop Height (m)	0	74	81	65	74	60	78
	3	66	78	59	69	55	70
	6	60	71	54	67	50	66
	LSD .05	2	2	NS	NS	NS	NS
Seed Moisture Level (%)	8	70	80	61	71	51	68
	13	63	74	57	69	60	74
	LSD .05	NS	NS	NS	NS	2	2
Temperatures	-18	65	76	58	70	59	70
(^{o}C)	21	68	78	61	70	57	72
	LSD .05	NS	NS	3	3	NS	NS

Table 1.8. Influence of Year and Seedcoat Condition on Genotypes for Warm Germination and Accelerated Aging at Manhattan, Kansas in 1980 and 1981.

	Etched		Non-Etched	
	Warm Germination	Accelerated Aging	Warm Germination	Accelerated Aging
		%		
		1980		
Calland	66	53	70	67
DeSoto	54	48	69	63
Pomona	60	54	74	67
Douglas	60	34	64	32
		1981		
Calland	63	61	77	71
DeSoto	68	64	88	85
Pomona	78	78	85	88
Douglas	83	82	89	87
LSD .05 Within Years	3	4	3	4
Between Years	4	5	4	5

Table 1.9. Influence of Year and Seedcoat Condition on Warm Germination of Genotypes at Powhattan, Kansas in 1980 and 1981.

	Seedcoat Condition	
	Etched	Non-Etched
	Warm Germination	
	%	
	1980	
Calland	56	67
DeSoto	53	46
Pomona	60	74
Douglas	61	70
	1981	
Calland	44	70
DeSoto	46	77
Pomona	56	86
Douglas	64	78
LSD .05 Within Years	4	
Between Years	5	

Table 1.10. Influence of Seedcoat Condition and Seed Moisture Levels on Warm Germination of Different Genotypes from Manhattan and Powhattan, 1980-1981.

	Manhattan				Powhattan			
	Seed Moisture %							
	8		13		8		13	
	Etched	Non-Etched	Etched	Non-Etched	Etched	Non-Etched	Etched	Non-Etched
	Warm Germination							
	%							
Calland	59	71	70	75	44	69	56	70
DeSoto	57	76	65	81	49	54	51	68
Pomona	68	78	69	81	52	76	64	83
Douglas	68	72	75	81	58	73	68	75
LSD .05	3				5			

Table 1.11. Influence of Seedcoat Condition and Drop Height on Warm Germination of Different Genotypes, Powhattan, Kansas in 1980-1981.

	Seedcoat Condition					
	Etched			Non-Etched		
	Drop Height m					
	0	3	6	0	3	6
	Warm Germination %					
Calland	56	48	47	76	70	62
DeSoto	55	53	41	71	56	56
Pomona	63	57	55	84	79	78
Douglas	68	62	59	81	73	68

LSD .05 within and between columns and rows = 5.

Table 1.12. Influence of Seedcoat Condition and Moisture Level on Germination of Seedlots Dropped from Different Heights, Powhattan, Kansas 1980-1981.

		Seedcoat Condition			
		Etched		Non-Etched	
		Moisture Level %			
		8	13	8	13
		Warm Germination %			
Drop Height (m)	0	59	61	76	80
	3	49	61	67	73
	6	44	57	63	69

LSD .05 within and between columns and rows = 3.

Table 1.13. Influence of Seedcoat Condtion and Seed Temperature on Warm Germination of Different Genotypes from Powhattan, Kansas 1980-1981.

	Seedcoat Condition			
	Etched	Seed Temperature °C		Non-Etched
	-18	21	-18	21
	Warm Germination			
	%			
Calland	50	51	67	72
DeSoto	47	53	62	61
Pomona	56	60	78	82
Douglas	60	65	73	75

LSD .05 within and between columns = 4.

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CHAPTER II

THE INFLUENCE OF DELAYED HARVEST ON THE DURABILITY OF ETCHED SEEDCOATS DURING CONDITIONING

INTRODUCTION

High quality soybean (Glycine max (L.) Merr.) seeds are required for uniform stands under field conditions. Maturity, seed size, and disease resistance have all been identified as factors influencing seed quality (11,13,18). Another factor, seed coat etching, may substantially influence seed quality, emergence, and handling durability of soybean seed.

In Chapter I, the durability of etched seed was evaluated. Etched seed was found to be more easily damaged than sound seed, especially at low seed moisture levels and temperatures. Significant amounts of damage were found when etched seedlots were subjected to even low drop heights. Burris (6) believed that etched seed were predisposed to splitting and damage during conditioning and handling. He stated that overall, physical integrity of the seedcoat was effected and that increased stress forces were placed on the seed during conditioning.

Since quality soybean seed is needed for planting, the seeds should be harvested at their highest potential quality. Several researchers agree that soybean seed attain their highest seed quality at physiological maturity (PM) but because of their high moisture content, they cannot be effectively harvested. The length of time the seeds are left in the field after PM is critical with respect to final seed quality. The deterioration of seed left in the field after harvest maturity is well documented (12,15,18). High temperatures and low humidity after PM can cause a rapid decrease in the moisture content of seeds. Low moisture seeds are more susceptible to mechanical damage from combining and conditioning

(4,8). Moore (12) concluded that mature seeds left in the field and exposed to alternating relative humidity (RH) shrink and swell in order to be in equilibrium with atmospheric conditions. He stated that the seed size caused crushed tissue and the resulting, necrotic areas were more susceptible to disease invasion. Tekrony et al. (15) found that high temperatures and moisture levels decreased vigor in soybeans if harvest was delayed.

The purpose of this experiment was to investigate the influence of etched seed on the durability of seed left in the field after harvest. Since weathered seed is more susceptible to disease, the influence of etched seed and weathering on seedborne fungus was also examined.

MATERIALS AND METHODS

This experiment was conducted at the Ashland Agronomy Farm at Manhattan, Kansas in 1980 and 1981. Plots were planted in a Eudora silt loam classified as a Fluventic Hapludoll, coarse-silty, mixed, mesic. In 1980, 2.4 l/ha triflurolin (a,a,a,trifloro-2,6-dinitro-N, N-diproyl-s-toliudine) was applied in late April for weed control. In 1981, 3.37 kg/ha chloramben (3-amino-2,5-dichlorobenzoic acid) was applied at planting time. Seeding rates for all plots were 25 seeds per meter, in rows spaced 76 cm apart. Environmental conditions in 1980 were warmer and dryer than normal (30-year average 1951-1980). The average temperature in June was 2.1^{o}C above normal and the rainfall was 6.35 mm below the normal amount of 134.6 mm. In July, the average maximum temperature was 38.6^{o}C compared to the normal maximum temperature of 33.2^{o}C. July precipitation showed a deficit of 71 mm. August and September had 7.6 mm and 38.1 mm less precipitation than their respective 30-year averages of 81.3 mm and 101.6. August average temperature was 3^{o} warmer than normal and the September average temperature was 1.8^{o} warmer than normal. 1981 rainfall was above normal in May, June and July. Precipitation in May was 179.3 mm, June was 166.1 mm and July was 142.2 mm. Average temperatures in May, July and August and September were 10.0 mm and 66.4 mm below normal. Moderate average temperature of 21^{o} in September prevented serious moisture stress. All plots were furrow irrigated both years. Three genotypes adapted to Kansas; DeSoto, Pomona, and Douglas (maturity group IV) were selected for evaluation. 1980 harvest samples were obtained from foundation soybean fields. Harvest dates were 10/6, 10/20 and 10/31 for DeSoto and Pomona and 10/20, 10/31, 11/10 for Douglas. 1981 plots were in a randomized complete block design with two replications for each of the three harvest dates. 1981 harvest dates for all three genotypes were 10/7, 10/23 and 11/7. After harvest, preliminary data including seed quality, 100 seed wieght, etching, wrinkling and smooth seed percent were taken on the seed lots. Seed quality was a visual assessment evaluating the amount of wrinkling, etching, green, moldy or rotten seeds. A scale of 1 to 5 was used to grade seed quality, with 1 being good and 5 being poor. Two hundred seventy-five grain samples of etched and non-etched seed were separated from each seedlot. These samples were subdivided into two equal parts with one of the subsamples conditioned to 8% and the other to 13% moisture. This was accomplished by exposing the seed to a relative humidity (RH) of 45 or 75% at 25^{o}C for 72-hours to attain the 8% or 13% moisture level, respectively. These moisture levels were verified using the oven dry moisture check method as outlined by Christiensen (7). After moisture conditioning, each of the subsamples was divided into two equal parts and sealed in plastic bags for temperature conditioning. Two temperature levels, -18^{o} and 21^{o}C, were attained by exposing the seeds, sealed in plastic to their respective temperature for 12-hours. Each of the temperature samples was divided into thirds for the drop tests. The drop height consisted of three levels; 0 or control, 3 m, and 6 m. The seeds were dropped from their appropriate heights onto a 3.2 mm steel plate inclined at a 45^{o} angle. The seeds struck the plate once and were deflected into a cloth barrier to be collected.

A factorial arrangement consisting of two classes of seed condition, (etched, non-etched), three harvest dates, two moisture levels (8%, 13%), two temperatures (-18^{o}, 21^{o}C) three drop heights (0 m, 3 m, 6 m) and three genotypes replicated twice was used. Becuase of a shortage of seed in 1980, only one temperature level, 21^{o}C, and two drop heights, 0 m and 6 m, were examined. Consequently, the combined data for 1980 and 1981 only includes those treatments used both years. Warm germination (WG) and accelerated aging (AA) were used to evaluate these treatments and their effects on soybean seed durability as influenced by etched seedcoats and delayed harvest. Fifty seed samples were collected to conduct the WG and AA tests on seedlots from each replication. WG was conducted according to the AOSA Rules for Testing Seed using the rolled towel method (3). AA tests were run by exposing the seed to 100% RH at 40°C for 72-hours followed by the standard WG test. Analysis of variance were run on the data using WG and AA as dependent variables with harvest date, genotype, seedcoat condition, drop height and moisture level as independent variables in a factorial arrangement with a split plot design. Years were considered main plots, with genotypes as sub-plots.

In order to evaluate the influence of etched seed and weathering on fungal invasion of soybean seed, plots were grown at the University of Maryland at Beltsville, Maryland. Three replications of Douglas and Pomona were planted in four-row plots with a row spacing of 76 cm. The experimental design was a split-plot with variety being the whole plot and date of harvest as the sub-plot. Harvest dates were 10/14 and 10/31. Physiological maturity for both varieties was 10/10. Fifty gram samples of etched and non-etched seeds were obtained from each of the replications. Four, 50 seed subsamples from each replication of etched and non-etched seed were subsequently plated in a potato dextrose agar (PDA) media. The seeds were surface sterilized using a 2% sodium hypochlorite solution for one minute followed by a distilled, deionized water rinse. The dishes were incubated for 72-hours at 21°C to facilitate fungal growth. Percent fungal invasion as well as fungus species were determined on each subsample. Analysis of variance were run on the data using species of fungus and total percent seed infected with a fungus at the dependent variable, with genotype, seedcoat conditon, harvest date and their interactions as independent variables.

RESULTS AND DISCUSSION

Because of the more favorable weather conditions, the seedlots harvested in 1981 had better visual seed quality, higher seed weight, less etching, less wrinkling and more smooth seed. Table 2.1 shows the combined 1980 and 1981 preliminary data for the three harvest dates and the three genotypes. Seed quality was highest at the first harvest date and then began to decline with later harvest dates. Seed weight was also highest at the first harvest date. There was no significant difference for etched seed percent over the three harvest dates. This was expected since the etching characteristic is expressed before maturity (6). Smooth seed percents decline and wrinkled seed percent increases as the seed was weathered in the field. Significant genotypic differences were found for all preliminary observations except wrinkled seed. DeSoto exhibited the highest seed quality, lowest seed weight, fewest etched seed and most smooth seed. Douglas had the lowest seed quality, highest seed weight, most etched seed and fewest smooth seed. Pomona was intermediate for all observations.

Data in Table 2.2 show the effects of harvest date, drop height, etching, and moisture level on WG and AA. Before a discussion can be made concerning drop height, the aspects of the free fall of a seed must be examined. As a seed falls, it generates kinetic energy. Upon impact the energy is converted to work. This work must either be transferred to the object that was impacted by moving the object, or be absorbed by the seed. If the seed is not sufficiently strong, it cannot absorb the energy and damage occurs. The amount of damage to the seed is directly related to the velocity of the seed (2,4,5). DeSoto and Pomona had significantly better WG scores than did Douglas, although there was no significant difference between the three genotypes for AA. Harvest dates 2 and 3 exhibited significantly lower WG than harvest date 1 and there were significantly lower AA scores for succeeding harvest dates. Seeds dropped from 6 m had significantly lower WG and AA scores than those not dropped. Etched seedlots exhibited less viability and vigor as indicated by their WG and AA scores. Seedlots at 8% moisture had a small, but significantly higher WG score than did those at 13% moisture. AA scores followed the same trend with a significantly higher score for seedlots at 8% moisture as compared with those at 13% moisture.

A significant harvest date by seed moisture level interaction was found for WG in the 1980-1981 combined analysis (Table 2.3). There was no significant difference in germination between the two moisture levels at the first two harvest dates. Seedlots harvested at the third date and handled at the 8% moisture level showed a small, but significantly higher WG socre than those seedlots handled at 13% moisture. The first harvest date exhibited significantly higher viability at both moisture levels, than the second and third harvest date. There was no significant difference in germination between the second and third harvest dates for either moisture level.

The decline in vigor from handling damage, simulated by the drop tests, was not consistent between harvest dates (Table 2.3). Although there were significant decreases in vigor as harvest was delayed, the magnitude of the decreases differed. The vigor of the control treatment declined 9% at the second harvest date as compared to the first harvest date, while the third harvest date showd a 19% lower AA score than the second. The seedlots from the second harvest date dropped 6 m showed an 18% lower AA score than the second date. The difference in vigor between the control and 6 m drop height was greatest at the second and third harvest dates, with declines of 24% and 23%, respectively for seedlots dropped 6 m. Seedlots from the first harvest date showed a 14% decline in vigor when dropped 6 m. These data indicated that weathering reduced the vigor of soybean seeds and that weathered seed was less able to withstand mechanical damage.

WG scores in 1981 were significantly higher for the first and third harvest dates than those in 1980 (Table 2.3). There was no significant difference between the two years for germination at the second harvest date. Vigor of the seedlots was much higher in 1981 than in 1980 for all three harvest dates. AA scores in 1980 for the first two harvest dates were approximately 50% of the 1981 scores for the same dates. The AA score for the third harvest date in 1981 was nearly 3.5 times larger than the third harvest date in 1980. These differences in viability and vigor between the years, could be attributed to the more favorable climatic conditions in 1981 over those in 1980.

The influence of seedcoat condition and harvest date on WG was not consistent between genotypes (Table 2.4). Etched seedlots of DeSoto and Douglas exhibited significantly higher WG at the first harvest dates compared to the second and third harvest dates. Etched Pomona seedlots displayed a significantly lower germination in the second harvest date in comparison to the first harvest date. Etched Pomona seedlots from the third harvest date had a significantly higher WG score than the second. The apparent increase in germination can be explained by the atmospheric conditions at harvest in 1981. The weather was hot and dry during the second harvest date. The cool, humid weather during the third harvest caused the seeds to absorb moisture from the atmosphere and reduced the amount of mechanical damage from threshing. Non-etched seedlots of Douglas showed no significant difference for WG at the first two harvest dates but a significantly lower germination at the third harvest. Non-etched Pomona seed showed no significant difference between the second and third harvest dates although they were significantly lower than the first date. Non-etched DeSoto showed a significant decrease in the second harvest date over the first, but the third date was significantly higher than the second. This apparent increase in germination is also related to the cooler, more humid weather conditions at the third harvest. The fact that etched Pomona showed a significant increase in germination at the third harvest date, while non-etched seedlots did not, and the DeSoto acted in a reverse manner, is explained by the genotypic variability for the etched seed characteristic and the influence of weather upon it.

A significant harvest date by seedcoat condition interaction was found for WG, but the interaction was not consistent across years (Table 2.5). Seedlots in 1981 exhibited significantly better WG scores than 1980, except for the etched and non-etched seedlots from the second harvest date which were not significantly different. There was an unexpected significant increase in germination for the etched seedlots at the third harvest date in 1981. In 1980, there was no significant difference in WG between the second and third harvest dates for etched seed. The decrease in germination from the first to second harvest date was greater for etched seed than for non-etched seed in both years. This larger decrease in germination for etched seedlots at the second harvest date indicated that etched seeds were more rapidly weathered than non-etched seed and less able to withstand damage during conditioning.

The effect of seedcoat conditions on damage caused by dropping was non consistent between harvest dates as shown by WG scores in Table 2.6. Etched seedlots had significantly lower germination than non-etched seedlots in all cases. Etched seedlots exhibited a wider spread in germination between the control and 6 m drop height, than did the non-etched seedlots. Etched seeds from the first harvest dropped 6 m exhibited 26% less germination than the control, seeds from the second harvest, dropped 6 m had 42% less germination than the control and etched seed from the third harvest date displayed a 34% spread. The non-etched seed exhibited a 19.4%, 19.4% and 24.6% decrease between the 6 m drop height control and the first, second and third harvest date, respectively. This data indicated that etched seed was less able to withstand damage as well as non-etched seed. Etched and non-etched seed behaved in a similar manner at the control height for all three harvest dates. There were significant drops in germination at the second harvest date followed by a small, non-significant increase at the third harvest date. Etched and non-etched seedlots dropped from 6 m did not behave in a similar manner. Etched seeds dropped 6 m exhibited a 29.5% decrease in germination at the second harvest date followed by a 15.4% increase in WG scores at the third harvest date. Non-etched seed dropped from 6 m exhibited a significant decrease in germination at the second lowest date followed by a small, nonsignificant decrease at the third harvest date. This difference in response of the seedcoat condition to harvest date indicated that etched seeds deterioated faster than non-etched seeds, when left in the field. The increase in germination of the etched seedlot dropped 6 m for the third harvest date was related to the humid conditions during harvest and its increased influence on etched seed over non-etched seed in preventing thresher damage.

Significant differences were found for genotypes and seedcoat condition but not for harvest date concerning species and total amount of fungal invasion of seedborne diseases (Table 2.7). Douglas exhibited significantly higher levels of Diaporthe infestations, while Pomona exhibited significantly higher amounts of Cercospera. Overall, Douglas had a total infestation of fungus almost 28% higher than Pomona. Several other fungi were identified, but since they were in such a small amount or not significantly different for any of the treatments, they were not singled out for analysis. However, they were included in the total percent infestation for the different treatments.

Etched seedlots exhibited twice as many instances of Disporthe as non-etched seedlots. The appearance of Cercospera was found on etched seed 41% more than non-etched. Total infestation of etched seed was 27.2% compared to 15.5% for the sound seed.

Significant differences were found for Diaporthe between harvest dates, with the second date (10/31), exhibiting a larger amount of the fungus than the first (10/14). There was no significant difference for Cercospera between harvest dates or for the total infestation of fungus.

Non-etched Douglas seedlots showed a dramatic increase in the amount of fungus infested seed at the second harvest date (Table 2.8). Pomona seedlots exhibited no significant difference between harvest dates for either etched or non-etched seeds, while there were significant differences between etched and non-etched seedlots within a harvest date. Etched Douglas seedlots showed no significant difference between harvest dates, while non-etched seedlots exhibited a 50.2% increase in infestation at the second harvest date. This large increase in fungal infestation indicates that there may be variation in genotypes in their resistance to weathering and subsequent disease infestation. Douglas had a initial visual seed quality score of 3.5 at harvest while Pomona had a 3.0 quality score. This lower initial seed quality may have influenced Douglas' decreased ability to withstand disease invasion.

SUMMARY AND CONCLUSIONS

The data presented here show the great influence that climatic conditions have on seed quality, viability and vigor during harvest and conditioning. Even the positive effects of favorable growing conditions can be negated if soybean crops to be used as seed are left in the field to weather. Viability and vigor both decrease after physiological maturity, so the seed must be removed as soon as possible for the best quality seed. Damage to the seed during conditioning was increased as the seed was left in the field for longer periods of time, as it was less able to withstand mechanical damage.

Seedlots that exhibit a high degree of etching must be handled with care. Etched seeds are more susceptible to weathering in the field and damage from conditioning. Etched seeds show a greater degree of seedborne fungal diseases than non-etched seeds. If etched seedlots are to be used as seed, special care at harvest such as proper moisture level must be monitored. During conditioning, rough handling and free falls from even small heights must be avoided.

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Table 2.2. Effects of Cultivars, Harvest Date, Seedcoat Condition, Drop Height, and Seed Moisture Level on Germination and Viability.

		Warm Germination	Accelerated Aging
		%	%
Cultivar			
DeSoto		74 a+	51 a
Pomona		73 a	51 a
Douglas		71 b	50 a
Harvest dates	1	79 a	59 a
	2	70 b	51 b
	3	69 b	42 c
Drop Height (m)	0	84 a	56 a
	6	61 b	45 b
Seed Condition			
Etched		67 b	45 b
Non-etched		79 a	56 a
Moisture Level (%)	8	74 a	54 a
	13	72 b	48 b
Year			
1980		68 b	31 b
1981		77 a	71 a

+ Means followed by the same letter are not significantly different using Duncan's Multiple Range Test α=0.05.

Table 2.3 Effect of Seed Moisture Level, Drop Height and Year on Viability and Vigor for Three Dates of Harvest, 1980-1981.

		Harvest Date					
		1		2		3	
		WG	AA	WG	AA	WG	AA
		%					
Moisture Level (%)	8	81	63	69	53	72	46
	13	78	55	69	50	68	38
	LSD .05	3	NS	3	NS	3	NS
Drop Height m	0	90	64	81	58	82	47
	6	70	55	57	44	58	36
	LSD .05	NS	3	NS	3	NS	3
Year							
1980		74	40	68	35	63	19
1981		85	80	70	67	77	65
	LSD .05	3	3	3	3	3	3

Table 2.4 Influence of Seedcoat Condition and Delayed Harvest on Germination of Three Cultivars, 1980-1981.

	Harvest					
	1	2	3	1	2	3
	Etched			Non-Etched		
	Warm Germination					
	%					
DeSoto	72	63	67	85	76	84
Pomona	78	57	67	87	75	75
Douglas	75	63	61	80	79	68

LSD .05 = 5

Table 2.5. Influence of Seedcoat Condition on the Germination of Seedlots Harvested at Different Times, 1980 and 1981.

	Seedcoat Condition			
	Etched	Non-Etched	Etched	Non-Etched
	Warm Germination			
	%			
	1980		1981	
Harvest Date				
1	67	81	83	87
2	59	77	62	77
3	59	67	70	83

LSD .05 Within Years = 4

Between Years = 5

Table 2.6. Influence of Seedcoat Condition and Drop Height on the Germination of Seedlots Harvest at Different Times, 1980 and 1981.

		Drop Height m			
		0	6	0	6
		Etched		Non-Etched	
		Warm Germination			
		%			
Harvest Date					
	1	86	64	93	75
	2	77	45	85	69
	3	78	52	86	65
LSD .05 = 4					

Table 2.7. Effects of Seedcoat Condition, Harvest Date and Cultivar on the Presence of Seed-Borne Fungus from Beltsville, Maryland, 1980.

	Fungal Species Present		
	Diaporthe	Cercospera	Total
	%		
Seedcoat Condition			
Etched	11.9 b+	14.3 b	27.2 b
Non-Etched	5.9 a	8.5 a	15.5 a
Harvest Date			
1(10/14)	7.4 a	12.0 a	20.3 a
2(10/31)	10.4 b	10.9 a	22.3 a
Cultivar			
Pomona	2.5 a	14.2 b	17.9 a
Douglas	15.3 b	8.7 a	24.7 b

+ Means followed by the same letter are not significantly different using Duncan's Multiple Range Test. α=0.05.

Table 2.8. Influence of Seedcoat Condition and Delayed Harvest on the Presence of Seed-borne Fungus for Two Cultivars from Beltsville, Maryland, 1980.

	Total Seeds Infected with Fungus %			
	Seedcoat Condition			
	Etched	Non-Etched	Etched	Non-Etched
	Harvest Date 1 10/14		Harvest Date 2 10/31	
Douglas	33.5	11.8	29.8	23.7
Pomona	22.7	13.3	22.7	13.0

LSD .05 = 8

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CHAPTER III

DURABILITY OF CULTIVARS CONTAINING ETCHED SEEDCOATS DURING CONDITIONING

INTRODUCTION

High quality soybean (Glycine max (L.) Merr.) seed are needed for uniform stands under field conditions. Several factors govern seed quality, such as viability, vigor, purity and physical integrity (12). Low levels of physical integrity are evidenced by the amount of damage incurred during combining. Several factors such as seed size and moisture content influence the structural integrity of the seed and its resistance to damage (4,5,9). Broken and split seed can be removed by processing and conditioning, but even the act of cleaning has been shown to have a detrimental effect on some seedlots (11). Mechanical damage from both combining and conditioning lower seed quality and may even contribute to increased disease occurrence in seedlings (10).

Several possible solutions to the problem of mechanical damage have been investigated. These involved harvesting at higher moisture levels, delayed plantings, and selecting genotypes which are more resistant to damage (4,8,9). Harvesting at moisture levels above 10 to 12% has been shown to reduce the amount of seed damage during threshing (8). High quality seeds, often small seeds, have been shown to resist mechanical damage better than low quality seeds (8). Genotypic differences have been identified in navy beans (Phaseolus vulgaris L.) for resistance to mechanical damage (4).

Damage to seedlots after harvest and during conditioning are often the results of falls into bins and hoppers. Several researchers have concluded that the amount of damage inflicted on a seed is proportional to its velocity at the time of impact (1,3,5).

Asgrow Seed Company (1) found that damage from repeated drops may be cumulative. As the seed falls it generates energy that must be expended upon impact. The energy can be transferred to the object impacted, or the seed itself can absorb the energy. If the seed is not structurally capable to absorb the impact, damage may occur. Factors such as low moisture levels and low temperatures may reduce the seeds ability to resist damage (5).

In Chapter 1 and 2, the influence of etched seedcoats was examined concerning durability and weatherability, respectively. In this experiment, durability of eight different genotypes was examined without separating the seedlots into etched and non-etched catagories. Viability and vigor of these bulk seedlots was examined to identify genotypes that resist damage from handling under a range of environmental conditions.

MATERIALS AND METHODS

This experiment was conducted at the Ashland Agronomy Farm at Manhattan, Kansas in 1980 and 1981. Seedlots used in the 1980 evaluations were obtained from the Kansas State Agricultural Experiment Station. These seedlots were from the foundation class in a Limited Generation System of certification, using foundation, registered and certified as the three classes of seed. Seedlots used in 1981 were harvested from plots in a randomized complete block design replicated three times. 1981 plots were grown in a Eudora Silt loam, classified as a Fluventic Hapludoll, coarse-silty, mixted, mesic. All plots were irrigated in 1981. Approximately 3.4 kg/ha chloramben (3-amino-2,5-dichlorobenzoic acid) was applied at planting time for weed control. Seeding rates was 25 seeds per meter, in rows spaced 75 cm apart. Eight genotypes adapted to Kansas were selected for evaluation. They were Calland, Cumberland, Williams (maturity group III), DeSoto, Pomona, Douglas, Crawford (maturity group IV) and Essex (maturity group V).

Environmental conditions in 1980 were warmer and dryer than normal (30-year average 1951-1980). The average temperature in June was 2.1^{o}C above the normal of 23.7^{o} and the rainfall was 63.5 mm below the normal amount of 134.6 inches. In July, the average maximum temperature was 38.6^{o}C, compared to the normal maximum temperature of 33.2^{o}. July precipitation showed a deficit of 71 mm. August and September had 7.6 mm and 38.1 mm less precipitation than their respective 30-year averages of 81.3 and 101.6 mm. August average temperature was 3^{o} warmer than normal and the September average temperature was 1.8^{o} warmer than normal. 1981 rainfall was above normal in May, June and July. Precipitation in May was 179.3 mm, June received 166.1 mm and July 142.2 mm. Average temperatures in May, July and August were below the 30-year normal temperature. Rainfall in August and September was 10.0 and 66.4 mm below normal, respectively. Moderate temperatures in September prevented serious moisture stress during low rainfall periods.

After harvest, preliminary data including seed quality and 100 seed weight was taken on the seedlots. Seed quality was a visual assessment evaluating the amount of wrinkled, etched, moldy or rotten seeds. A rating of 1 to 5, with 1 being good and 5 being poor was assigned to each seedlot. Two hundred seventy-five gram samples from each seedlot were prepared to simulate mechanical damage incurred during conditioning. These samples were sub-divided into two equal parts with one subsample conditioned to 8% and the other to 13% moisture. This was accomplished by exposing the seed to a relative humidity (RH) of 45 or 75% at 25^{o}C for 72-hours to attain the 8 or 13% moisture level, respectively. These moisture levels were verified using the oven dry moisture check method as outlined by Christensen (6). After moisture conditioning, each of the two subsamples was divided into two equal parts and sealed in plastic bags for temperature conditioning. Two temperature levels, -18^{o} and 21^{o}C, were attained by exposing the seeds sealed in plastic, to their respective temperatures for 12-hours. Each of the temperature samples was divided into thirds for the drop tests. The drop heights consisted of three levels, 0 m or control, 3 m and 6 m. The seeds were dropped from their appropriate heights onto a 3.2 mm steel plate inclined at a 45^{o} angle. The seeds struck the plate once and were deflected into a cloth barrier to be collected.

A factorial arrangement consisting of varieties, two moisture levels (8%, 13%), two temperatures (-18^{o}, 21^{o}), three drop heights (0 m, 3 m, 6 m) replicated three times, was used. Warm germination (WG) and accelerated aging (AA) was used to evaluate viability and vigor of the seedlots as influenced by the treatments described. Fifty seed samples from each replication were used to conduct the WG and AA tests. WG was conducted using the rolled towel method outlined by the AOSA Rules for Testing Seed (2). AA tests were run by exposing the seeds to 100% RH at $40^{o}C$ for 72-hours followed by a standard WG test. Analysis of variance were run on the data using WG and AA as dependent variables with genotype, moisture level, temperature and drop height as independent variables in a factorial arrangement with a split plot design. Years were considered main plots with genotypes as subplots.

RESULTS AND DISCUSSION

Table 3.1 shows the preliminary data collected on the various seedlots. Essex, Pomona and Williams had significantly higher visual seed quality than the remaining five genotypes. Calland, Cumberland and Crawford exhibited a 2.2 seed quality score and were not significantly different from DeSoto with a score of 2.3, Douglas exhibited a significantly lower seed quality score of 2.8, and the highest 100 seed weight. Essex had the smallest seed weight with Crawford and Pomona the next smallest. Calland, Cumberland, Williams, and DeSoto were significantly different with respect to seed weight. Yearly averages showed 1981 had a significantly better visual seed quality rating of 1.7 as compared to 1980 with 2.3. Seed size was not significantly different between years.

Table 3.2 shows the genotypic difference and treatment effects on WG and AA. Essex exhibited significantly higher overall viability and vigor than the remaining genotypes. Pomona, Douglas and Crawford were also not significantly different for AA scores, but Douglas had the lowest vigor rating for all the genotypes. Cumberland, Williams and DeSoto were not significantly different for WG with Calland exhibiting the lowest viability. DeSoto vigor was not significantly different from Pomona and Crawford. AA scores for Cumberland were significantly better than Williams which was only higher than Douglas.

WG scores in 1981 were significantly higher than in 1980. There was no significant difference between years for AA. The difference in years for WG is explained by the more favorable growing conditions in 1981, with lower temperature and more rainfall than in 1980.

Burris (5) reports a slightly lower germination for seed handled at freezing temperatures. He attributes the decline in germination to the increased rigidity of the seed, which would not be able to absorb the impact from falls or blows. Several authors have concluded that damage to a seed from a fall is directly related to the velocity of the seed. Upon impact, the energy the seed has gained from the fall must be either transferred to the object impacted, or absorbed by the seed. If the seed is not sufficiently strong enough to absorb the energy, damage will occur. Seedlots handled at 21^{o} germinated significantly better than those at -18^{o} but there was no significant difference in vigor. There were significant decreases in both germination and vigor as drop height increased. Seedlots handled at 13% moisture were better able to resist damage as evidenced by a significantly better WG score than those at 8% moisture. There was no significant difference for vigor between moisture levels. Seeds at higher moisture levels are not as dry and brittle as those at lower moisture levels. Seeds that are brittle are less able to absorb the impact from a fall or blows from some mechanical object, such as a combine cylinder (8).

Table 3.3 shows the interaction of genotype with years for WG and AA. All genotypes, except Calland and Cumberland, had significantly higher germination in 1981 than in 1980. Calland and Cumberland exhibited significantly lower WG scores in 1981. AA scores in 1981 were significantly lower than those in 1980 for Calland, Cumberland, Williams and DeSoto, but Pomona and Crawford and Essex had significantly higher vigor with Douglas being not significantly different. The cause for the increase in viability and vigor for some of the genotypes, was the more favorable growing conditions in 1981. The genotypes in the table are listed according to maturity. The two earliest maturing genotypes in 1981 displayed the lowest germination and the four earliest genotypes displayed the lowest vigor. Since these earlier maturity genotypes reached harvest maturity sooner, they were all harvested before the late maturing types. Low seed moisture conditions at harvest would increase the amount of thresher damage and consequently cause a reduction in viability and vigor. Tekcroney et al. (14) states that vigor is reduced sooner than viability in seed in the field. This would explain Williams' and DeSotos' significantly lower vigor but significantly higher WG scores in 1981 than in 1980.

A significant genotype by drop height interaction was found for vigor in the combined 1980 and 1981 data (Table 3.4). Calland was the only genotype that displayed a significant decrease in vigor for each increase in drop height. DeSoto, Douglas, Crawford and Essex showed a significant difference in vigor between the control and 3 m drop height. Cumberland, Williams, DeSoto, Pomona and Crawford showed no significant difference between the 3 m and 6 m drop height. These data suggested that the genotypes may differ in their resistance to loss of vigor from mechanical damage. However, there are many factors that must be taken into account such as maturity, harvest time, climatic conditions at harvest, and storage conditions, before such assumptions could be verified. There appeared to be a trend of lower vigor as drop height increased.

The influence of temperature on the vigor of the eight genotypes was not consistent across years (Table 3.5). In 1981, there were no significant differences between the two temperature levels for any of the genotypes. In 1980, Calland, DeSoto and Crawford exhibited significantly higher vigor at room temperature than at the lower temp- perature levels. Generally, the 1980 vigor scores for Calland, Cumberland, Williams and DeSoto for both temperatures were higher than those in 1981. The opposite is true for the remaining genotypes. This difference may be related to low humidity and warm temperatures and consequently the lower seed moisture at harvest as discussed in the genotype by year interaction for AA.

Table 3.6 shows the data from a significant interaction between genotype, drop height and seed moisture level for WG. Calland and Pomona showed significant decreases in viability at each drop height increase at the 8% moisture level, while none of the genotypes at the 13% moisture level showed significant differences at both drop heights. Calland, Cumberland, DeSoto, Crawford and Essex show no significant difference between any of the drop heights at the 13% moisture level. Williams, Pomona and Douglas showed no significant decrease in germination between the 0 m and 3 m drop height at the 13% moisture level. Cumberland, DeSoto, Douglas and Crawford behaved in a similar manner at the 8% moisture level.

The large number of non-significant decreases in germination as drop height increased at the 13% moisture level can be explained by the assumption that seeds at a higher moisture level are more resistant to damage than those at lower moisture levels. Dry seeds are more brittle and may not be as resiliant and able to absorb the impact from falls or blows. Williams and Essex showed no significant difference for genotypes at the different drop heights at the 8% moisture level. This seemed to contradict the above assumption, but these two genotypes were of high visual seed quality, 1.5 and 1.4, respectively. High quality seeds maybe able to withstand damage at low moisture levels better than lower quality seeds at higher moisture levels. For example, Douglas, which exhibited the lowest visual seed quality, showed a significant drop in viability as the drop height was increased from 3 m to 6 m at the 13% moisture level. None of the genotypes at the 13% moisture level showed significant differences in germination between the control and 3 m drop height, while two of the genotypes at the 8% moisture level did. This indicates that seedlots at higher moisture levels are more resistant to low levels of mechanical damage, such as small falls, than those of low moisture levels.

SUMMARY AND CONCLUSIONS

There were genotypic differences for visual seed quality in soybeans. These differences were genetically controlled but heavily influenced by maturity and climate. All seeds were subject to damage from abuse and mishandling, but those of low quality and at low moisture levels generally were damaged to a greater extent. Temperature seemed to influence the amount of damage caused by handling, especially low temperatures. Seedlots that were of high visual quality were more resistant to damage, even at lower moisture levels and temperatures, than low quality seedlots.

Although there were genotypic differences for durability, making definite conclusions that one genotype was more durable than another was difficult. In order to be fairly compared, the genotypes needed to be of the same approximate maturity, and the same seed moisture level at harvest. Some genotypes were heavily influenced by environment, so comparing years did not always give a satisfactory estimate of the seedlot relative durablility.

Table 3.1. Seed Quality and Seed Weight for Eight Cultivars, 1980-1981.

	Seed Quality	Seed Weight
	Score +	g/1000
Calland	2.2 b†	16.1 bc
Cumberland	2.2 b	16.5 b
Williams	1.5 a	16.1 bc
DeSoto	2.3 b	16.6 b
Pomona	1.7 a	15.5 cd
Douglas	2.8 c	17.7 a
Crawford	2.2 b	15.1 d
Essex	1.4 a	12.4 e

+ 1-good, 5 poor

† Means followed by the same letter within a column are not significantly different using Duncan's Multiple Range Test $\alpha=0.05$

Table 3.2. Effects of Seed Temperature, Drop Height, and Seed Moisture Level on Viability and Vigor of Eight Cultivars, 1980-1981.

	Warm Germination	Accelerated Aging
	%	
Cultivars		
Calland	81 e[+]	74 cd
Cumberland	88 b	70 d
Williams	87 b	69 e
DeSoto	86 bc	76 bc
Pomona	84 cd	78 b
Douglas	84 cd	66 f
Crawford	83 d	76 bc
Essex	91 a	81 a
Temperature (°C)		
-18	83 b	74 a
21	88 a	74 a
Drop Height (m)		
0	89 a	79 a
3	86 b	73 b
6	82 c	70 c
Moisture Level (%)		
8	84 b	73 a
13	87 a	74 a
Year		
1980	83 b	74 a
1981	88 a	74 a

+ Means followed by the same letter are not significantly different using Duncan's Multiple Range Test α=0.05.

Table 3.3 Influence of Year on the Germination and Vigor of Eight Cultivars, 1980 and 1981.

	Warm Germination		Accelerated Aging	
	%			
	1980	1981	1980	1981
Calland	85	77	81	66
Cumberland	90	85	80	64
Williams	83	92	74	64
DeSoto	82	90	79	74
Pomona	80	89	72	83
Douglas	77	91	64	68
Crawford	79	87	74	78
Essex	87	95	70	92
LSD .05	3	3	4	4

LSD .05 within years = 3

between years =5

Table 3.4 Effect of Drop Height on the Vigor of Eight Cultivars, 1980-1981.

	Drop Height m		
	0	3	6
	Accelerated Aging %		
Calland	81	74	66
Cumberland	76	72	68
Williams	73	67	68
DeSoto	79	75	75
Pomona	82	74	76
Douglas	70	68	61
Crawford	80	76	72
Essex	85	83	75
LSD .05 = 5			

Table 3.5 Influence of Seed Temperature and Year on the Vigor of Eight Cultivars.

	1980		1981	
	Seed Temperature (oC)			
	-18	21	-18	21
	Accelerated Aging			
Calland	77	85	69	64
Cumberland	78	81	63	66
Williams	76	72	62	66
DeSoto	75	82	74	74
Pomona	72	73	83	83
Douglas	63	66	68	67
Crawford	70	77	79	77
Essex	71	69	91	93

LSD .05 within and between years = 6.

Table 3.6. Influence of Seed Moisture Level and Drop Height on the Viability of Eight Cultivars, 1980-1981.

	Seed Moisture Level (%)					
	8			13		
	Drop Height m					
	0	3	6	0	3	6
	Warm Germination %					
Calland	88	78	73	82	84	82
Cumberland	90	90	83	90	87	86
Williams	90	86	86	91	88	83
DeSoto	89	86	84	87	86	83
Pomona	87	82	70	92	87	86
Douglas	88	85	80	89	85	79
Crawford	82	78	77	88	88	87
Essex	92	88	87	95	94	93
LSD .05 = 5						

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CHAPTER IV

THE INFLUENCE OF PLANTING DATE AND IRRIGATION ON THE INCIDENCE OF ETCHED SEEDCOATS AND SUBSEQUENT SEED QUALITY

INTRODUCTION

The production of high quality soybean (Glycine max (L.) Merr.) seed is essential for successful establishment of subsequent crops. Several factors that influence the quality of soybean seed are affected by the weather. Fitting the growing season of the seed crop to the most favorable climatic conditions would help to produce high quality seedlots. One-way of fitting the crop to the weather patterns of an area is to alter planting dates.

Studies have been conducted in several areas of the United States concerning the effect of planting date on various characteristics of soybean seed. These studies investigated the influence of planting dates on seed quality, seed weight, maturity, lodging, plant height, iodine number of oil and protein content (3,4,5,6,7). The effects of planting date on yield have been inconclusive. Some researchers (3,9) have concluded that early plantings for early maturing types (6). Weiss et al. (9) found no significant difference for yield of early maturing types between planting dates.

Seed quality of early maturing varieties has been shown to be poorer when early plantings were used (3). Planting dates of later maturing types had less effect on quality, with some decreases in quality as planting is delayed (5,7). Feaster (3) concluded that development and maturation of soybean seed under hot, dry weather conditions was not condusive to good wuality seed.

The effect of planting dates on seed size is believed by some to be dependent on the maturity of the variety involved. Seed size of early maturing types was greater at later plantings, while seed size of later types decreased with delayed planting in Maryland (5).

In Virginia (7), seed produced from later dates of planting were usually smaller than seed from earlier dates. One study showed no difference in seed size between planting dates for earlier maturing types (9).

Leffel (5) concluded that variations in soil moisture affected varietal performance and that future studies should be irrigated. Since soybeans can be grown only with the supplimented water in some areas of Kansas, the influence of irrigation was included in this study to examine the effect of planting date on seed quality characteristics, especially the occurence of seedcoat etching.

MATERIALS AND METHODS

This experiment was conducted at the Ashland Agronomy Farm at Manhattan, Kansas in 1980 and 1981. 1980 plots were planted in a Muir silt loam, classified as a Pachic Haplustoll, fine silty, mixed, mesic. In early May, 2.4 l/ha trifluralin (a,a,a,triflouro-2,6-dinitro-N,N-dipropyl-p-toluidine) and at planting, 3.37 kg/ha chloramben (3-amino-2,5-dichlorobenzoic acid) was applied for weed control. 1981 plots were planted in a Eudora silt loam classified as a Fluventic Hapludoll, coarse-silty, mixed, mesic. 110 kg/ha 18-46-0 fertilizer was applied in late April. Herbicides applied were 2.4 l/ha trifluralin in mid-April and 3.37 kg/ha chloramben at planting.

Experimental design was a split-plot with irrigation and dates as whole plots with genotypes as subplots replicated 3 times. Planting dates were May 25 and June 30 in 1980 and May 21 and July 1 in 1981. Genotypes chosen for evaluation were Calland, Cumberland, Williams (maturity group III), DeSoto, Douglas, Crawford (maturity group IV) and Essex (maturity group V).

Environmental conditions in 1980 were generally hotter and dryer than normal (30-year average 1951-1980). The mean monthly temperature for June, July, August and September were 2.1, 5.0, 3.0, and 1.8^{o}C above normal, respectively. Rainfall deficits were 68.6 mm in May, 63.5 m in June, 71.2 mm in July, 7.7 mm in August and 38.1 mm in September. The 1981 growing season was cooler and wetter than the 1980 season. Average monthly temperatures were near or below, the 30-year normal. Rainfall in May, June and July were above normal by 65.0 mm, 31.5 mm and 40.6 mm, respectively.

After harvest, seed quality scores, 100 seed weight, percent etched and wrinkled seed and warm germination (WG) were taken on each seedlot. Seed quality was a visual evaluation using a scale of 1 to 5 with 1 being good and 5 being poor. Characteristics such as diseased, green, etched, wrinkled or rotten seed were taken into account for evaluating seed quality. WG was conducted according to the AOSA Rules for Testing Seeds (1) using the rolled towel method.

Analysis of variance were run on the data using seed quality, seed weight, etched and wrinkled percent, and WG as dependent variables with genotype, data of planting, irrigation treatment, year and their interactions as independent variables.

RESULTS AND DISCUSSION

The effect of date of planting and irrigation as well as genotypic differences for seed weight, seed quality, etched seed percent and germination are shown in Table 4.1. Significant genotypic differences were found in each of the four categories listed. Essex exhibited the smallest seed size, and highest visual seed quality. Cumberland, Williams, Crawford, Essex had similar amounts of seedcoat etching with Crawford and Essex having the highest warm germination. Douglas exhibited the highest seed weight, lowest visual seed quality, highest percentage etched seed, but was not significantly different from Calland, Williams and DeSoto for viability. Cumberland was similar to Douglas in seed weight, similar to DeSoto for seed quality, but had significantly lower germination than the remaining genotypes.

The first date of planting exhibited significantly higher seed weight and seed quality and significantly lower etched seed percent and WG scores, than the second date of planting. Irrigation treatments were not significantly different except that seedlots from non-irrigated plots germinated 2.2% less than those that were irrigated.

Seed produced in 1980 exhibited significantly lower seed weight and visual seed quality and had nearly four times as much etching as in 1981. The more favorable weather conditions in 1981 caused these differences in seedlot characteristics along with the significantly higher WG over 1980.

Significant genotypic difference for planting data across years was found for seed quality, etched seed percentage and WG.

The data in Table 4.2 showed a significant reduction in visual seed quality at the second planting date in 1980 for all genotypes. Essex, Crawford, and Williams exhibited a smaller decrease in quality than did Cumberland, DeSoto and Douglas as planting was delayed. Calland exhibited the smallest reduction in quality between the first and second planting dates, but it had the poorest quality at the first planting date in 1980. In 1981, Douglas exhibited an increase in seed quality at the second planting date, while all of the remaining genotypes were not significantly different for quality between planting dates.

Table 4.3 shows the interaction of genotypes, planting dates, and years for etched seed percentage. The trends seen in etched seed percentage are very similar to those fo seed quality. In 1980, all genotypes showed a significantly higher amount of etched seed in the second planting date over the first date. Essex and Williams, in 1980, showed the smallest increase in etched seed at the second planting date. In 1981, Douglas showed a significant decrease in etched percentage at the second planting date, with the remaining genotypes not significantly different between the two dates of planting.

Planting date caused significant differences in germination for five of the seven genotypes in 1980, but there were no significant differences between planting dates in 1981 (Table 4.4). Cumberland showed the largest increase in germination as planting date was delayed, with a 19% increase at the second planting date. Calland, Williams and DeSoto showed similar increasesin WG at the second planting date, while Crawford and Essex showed no significant difference between planting dates. Germination of all genotypes was generally significantly higher in 1981 for the respective planting dates, than those in 1980.

The difference in years and planting dates for the various seedlot characteristics presented was caused by the different climatic conditions prevelant during the 1980 and 1981 growing seasons. The low seed weight, seed quality and high incidence of ethced seed along with the subsequent low germination was caused by the hot, dry weather in 1980. Feaster (3) stated that such weather was not conducive to high quality seed.

The observation that delayed planting of early maturing soybeans improved seed quality, was based on the assumption that the seeds would mature during more favorable weather (3,4). Since the weather in 1980 was not favorable during the entire growing season, especially July through September, the late planted group was exposed to adverse weather conditions throughout their entire growth and reproductive cycle. This would explain the significant decrease in quality and increase in etched seeds for the second planting date for all genotypes in 1980. However, the viability of the earlier maturing genotypes, Calland, Cumberland, Williams and DeSoto, showed significant increases at the second planting date. This rise in germination and decrease in visual seed quality showed that the appearance of a seedlot is not a reliable indicator of true quality.

The more favorable weather throughout 1981 caused the largely non-significant differences between planting dates for the seedlot characteristics examined.

Correlations between etched seed percent, visual seed quality, seed weight and germination are presented in Table 4.5. Etched seed percentage was very highly, negatively correlated with visual seed quality. This was expected, since etched seed is one of the criteria used in the visual quality evaluation. Correlations between etched seed and seed weight were not significant. There was a small, negative correlation between etched seed percent and WG. Visual seed quality was not significantly correlated with seed weight, but was correlated wigh WG. This low, but significant correlation coefficient of 0.2802 supported the observation made earlier; that the appearance of a seedlot was not a reliable indication of viability.

SUMMARY AND CONCLUSIONS

Significant differences were found for seed weight, visual seed quality, etched seed percentage and germination between planting dates and years. Irrigation did not effect these seedlot characteristics with the exception of germination, which slowed a small increase when supplimental water was added.

Differences in the weather between the two years, significantly influenced the seedlot characteristics examined. The hot, dry weather in 1980 resulted in low seed weight, visual quality, and germination. The more favorable weather in 1981 resulted in a 16% increase in seed weight, approximately one-fourth the amount of etching, and a 9.7% increase in viability.

The influence of planting date was also significant for all of the characteristics examined in 1980, but was mostly non-significant in 1981. The second planting date in 1980 exhibited significantly more etched seed and significantly lower visual seed quality, but significantly higher germination for the four earliest maturing genotypes. Although the data presented does not support the findings of other authors who advocate later planting dates for better seed quality, it must be recognized that the two-years of this study were very different. Later planting dates may help reduce the amount of seedcoat etching in a seedlot in a normal year. Burris (2) found that the etching trait was not expressed until 40 to 50 days after flowering. If planting dates were manipulated to cause this stage of development to miss adverse weather periods the amount of seedcoat etching may be reduced.

Since the seedmans' objective is to produce seedlots with a high percent of viability, delayed plantings of earlier maturing genotypes may be helpful in obtaining that goal. Later maturing genotypes showed only marginal gains in viability as planting was delayed. Supplimental irrigation had a small, positive effect on germination. The seed grower must keep in mind, however, that these gains in viability and quality from delayed planting may be offset by a reduction in yield.

Table 4.1 Effect of Date of Planting, Irrigation, and Year on Seed Weight, Seed Quality, Etched Seed Percent and Germination of Seven Cultivars, Manhattan, Kansas, 1980-1981.

	Seed Weight	Seed Quality	Etched Seed	Warm Germination
	g/100	Score	%	
Cultivar				
Calland	15.6 bc	2.6 d[+]	11.0 b	86 b
Cumberland	16.6 a	2.2 c	8.3 a	83 c
Williams	15.9 b	1.9 b	6.2 a	87 b
DeSoto	15.3 c	2.3 c	10.4 b	88 b
Douglas	17.0 a	3.2 e	26.3 c	88 b
Crawford	14.5 d	1.9 b	8.5 ab	92 a
Essex	11.1 e	1.5 a	5.8 a	92 a
Date of Planting				
1 (Early)	15. 4 a	1.9 a	7.1 a	86 b
2 (Late)	14.8 b	2.5 b	14.7 b	90 a
Irrigation Treatment				
Irrigated	15.3 a	2.2 a	11.6 a	89 a
Non-Irrigated	14.9 a	2.2 a	10.2 a	87 b
Year				
1980	13.8 b	2.6 b	16.9 b	84 b
1981	16.4 a	1.7 a	4.9 a	93 a

+ Means followed by the same letter are not significantly different using Duncan's Multiple Range Test α=0.05.

Table 4.2. Influence of Date of Planting on the Seed Quality of Seven Cultivars in 1980 and 1981.

	Seed Quality			
	1980		1981	
	Planting Date		Planting Date	
	5/25	6/30	5/21	7/1
	Score +			
Calland	3.0	3.5	1.9	1.9
Cumberland	1.8	3.8	1.7	1.5
Williams	1.8	2.7	1.6	1.5
DeSoto	1.7	3.9	1.6	1.7
Douglas	2.4	3.9	4.1	2.4
Crawford	1.9	2.9	1.5	1.3
Essex	1.5	2.5	1.1	1.2

LSD .05 within Years = 0.2

between Years = 0.3

+ Score based on visual evaluation 1-5, 1-good; 5-poor.

Table 4.3 Influence of Date of Planting on Etched Seed Percent of Seven Cultivars in 1980 and 1981.

	1980 Planting Date		1981 Planting Date	
	5/25	6/30	5/21	7/1
	Etched Seed %			
Calland	12.3	26.0	3.8	2.0
Cumberland	3.7	22.0	3.0	4.3
Williams	4.7	16.0	2.3	1.8
DeSoto	4.8	30.7	3.3	2.7
Douglas	20.2	43.0	30.5	11.3
Crawford	3.5	27.8	0.3	2.2
Essex	6.5	15.1	0.5	1.3

LSD .05 Within Years = 5

Between Years = 6

Table 4.4. Influence of Planting Date on Germination of Seven Cultivars in 1980 and 1981.

	1980		1981	
	Planting Date		Planting Date	
	5/25	6/30	5/21	7/1
	Warm Germination %			
Calland	77	85	91	92
Cumberland	68	84	88	91
Williams	79	85	93	91
DeSoto	78	87	95	93
Douglas	89	83	90	92
Crawford	88	91	93	96
Essex	87	91	94	97

LSD .05 = Within Years = 5

Between Years = 6

Table 4.5. Correlations between Etched Seed Percent, Seed Quality, Seed Weight and Germination, Manhattan, Kansas, 1980-1981.

	Seed Quality	Seed Weight	Germination
Etched Seed Percent	-0.8719**	0.0822 NS	-0.1957*
Seed Quality	--------	-0.0267 NS	0.2802**
Seed Weight	--------	----------	0.0312 NS

*,** Correlation values are significant at the 0.05 and 0.01 levels of probability, respectively.

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INFLUENCE OF ETCHED SEEDCOATS ON THE DURABILITY OF SOYBEAN SEED DURING CONDITIONING, WEATHERABILITY IN THE FIELD, AND, THE EFFECT OF CULTURAL PRACTICES ON THE INCIDENCE OF ETCHED SEEDCOATS IN A SEEDLOT

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ABSTRACT

The influence of etched seedcoats on the durability of soybean (*Glycine max* (L.) Merr.) seed during conditioning was examined in 1980 and 1981. The effect of etched seedcoats on field weatherability and cultural practices that may influence the amount of etched seed in a seedlot was also studied.

To determine the effect of etched seed on durability during conditioning, seed from four genotypes were separated into etched and non-etched seedlots. After being moisture and temperature conditioned, they were dropped from varying heights onto a steel plate. Seedlots of etched seeds were found to be lower in viability and vigor, as assessed by warm germination (WG) and accelerated aging (AA), respectively. They were also less able to withstand damage from falls, and were damaged to a greater extent from low drop heights than were non-etched seeds. Low seed moisture and seed temperature adversely affected etched seed more than non-etched seed.

Etched seedlots, separated from three genotypes, were found to lose viability and vigor faster than non-etched seeds when harvest was delayed. Etched seedlots from the later harvest dates were significantly less able to withstand damage from handling than were non-etched seedlots. The presence of seed-borne fungus on etched seed was approximately twice that on non-etched seed.

Varietal durability of eight genotypes containing varying amounts of etched seed was examined without separating the seedlots into etched and non-etched categories. Seedlots at low moisture levels and temperatures and those with higher percentages of etched seed were more easily damaged than those at higher moisture levels and good visual seed quality.

Variations in maturity and seed moisture at harvest made genetic differences in durability difficult to pinpoint.

The influence of planting date on the amount of etching present in seven genotypes was not consistent across years. There was no significant difference between irrigated and non-irrigated plots for the presence of etched seed.