Conditioning Shriveled Soybean Seed Part II. Correlation of Physiological Characteristics With Physical Properties

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Abstract

The physiological properties of samples at different stages during conditioning of shrivelled soybean seedlots were analyzed and correlated with physical properties. Conditioning improved seed viability and vigor. Operation capacities needed to be reduced to obtain optimal separation of shrivelled seeds with minimal loss of good seeds. Correlations of shrivelled seeds with germination, cold, stress, oil and yield tests presented a negative trend.
Keywords. Soybean conditioning, Physiological properties.

Introduction

In a previous article (Risse et al., 1990), variations in physical properties of shriveled soybean seeds collected at different stages of conditioning were presented. In this article, changes in physiological properties of soybean seeds during conditioning are analyzed and then correlated with physical properties.

Literature Review

Gregg (1969) graded 19 seedlots of cotton on a gravity separator. The gravity separator sorted cotton seeds in fractions differing in volume, weight, and bulk density. Laboratory tests indicating viability and vigor, such as germination, cold test and accelerated aging test, showed significant positive correlations with bulk density. In addition, mechanical damage was found to be high in seedlots with low bulk density. Field studies showed that seedling height and the dry weight of radicle, hypocotyl, and cotyledon leaves seven days after planting, increased with increases in bulk density.

Hoy and Gamble (1987) reported the effects of kernel density and size on the field performance of soybean seeds. Large and low density seeds had the smallest emergence percentage and the slowest germination speed. Density effects were greater when seeds were subjected to greater field stresses of low temperature and of wet or compacted soils. High density seeds produced larger yields than low density seeds did at later planting dates. Low density has also been associated with low laboratory germination for vegetable seeds such as lettuce, tomato, onion (Hill et al., 1989), and sorghum seeds (Maranville and Clegg, 1977).

Cundiff and Williamson (1976) sorted tobacco seeds through an air column. Seeds lifted at lower air velocities (2.77 to 3.31 m/s) did not reach 80% emergence standards. Kunze et al. (1969) reported aerodynamic separations in cotton seeds. Higher density seeds had greater germination and field emergence percentages. Smith et al. (1973) reported lettuce seeds separated through an air column more vigorous than seeds sorted by vibrating screens.

Generally, protein content in soybeans has been negatively associated with yield (Johnson et al., 1955; Kwon and Torrie, 1964). Other studies (Byth et al., 1969; Simpson and Wilcox, 1983), however, have shown considerable variation between protein content and yield in soybeans.

Many physical seed quality traits have been correlated with protein or oil content percentages. Baudet (1987) reported a positive relation among protein content, seed weight, and seed size in corn. Large seeds were correlated with high protein and low oil content in soybeans by Fehr and Weber (1968). Conversely, Weber (1950) reported that large seeds were associated with high oil content and low protein among lines from an interspecific cross.

Presently, the standard germination test is the widely accepted test for seed viability, and procedures for conducting germination tests of soybeans are presented in the Rules for Testing Seeds (AOSA, 1986). Seed vigor, however, has been an area of major debate, and several investigators (McDonald, 1975; Edje and Burris, 1970; Tekrony et al., 1980) have studied seed vigor and vigor tests.

Material and Methods

Five soybean seedlots of different varieties ranging from 5 to 38% shriveled soybeans were included in the study. Each seedlot was passed through a sequence of an air-screen cleaner, a spiral separator, and a gravity table. Samples were collected at different stages in conditioning. The sample collection points were as follows: initial screenings that passed through the first sifting screen of the air-screen cleaner (CS1), screenings that passed through the second sifting screen of the air-screen cleaner (CS2), bottom air lifting of the air-screen cleaner (CL), good seeds after the air-screen cleaner (AC), discards from the spiral separator (SD), and three fractions of the gravity table: gravity discard (GD), gravity middle (GM), and final. More details on equipment and sampling are presented in Risse et al. (1990).

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The samples were evaluated for standard germination, cold germination, stress test, protein and oil content, and yield. Table 1 shows the initial physiological quality characteristics for each seedlot.

Standard germination evaluations were made according to the Rules for Testing Seeds (AOSA, 1986). Cold tests were conducted according to the "tray" procedure described in the Seed Vigor Testing Handbook (AOSA, 1983). The stress test was conducted by placing the seed in open petri dishes in a chamber at 42° C for 30 h and supplying humidity by a water pan in the chamber. Samples of approximately 150 g were ground and then measured for protein and oil content in a near infrared reflectance analyzer (NIR). The values for protein and oil were corrected to 13% moisture (wet basis) by a computer program and were reported.

The standard germination, cold, and stress tests were performed for the pure seed portion only (AOSA, 1986). Therefore, these values were multiplied by the corresponding purity percentages. Impurities were determined by weighing the portion of the sample passing through a 3.97 × 19.05 mm (10/64 × 3/4 in.) slot hand screen. Any particle passing through the hand-screen and consisting of more than half a soybean, was returned to the pure seed portion. The purity percentages at different steps in conditioning for each seedlot are presented in Table 2.

The yield experiments were conducted at the Iowa State University Curtiss Farm. A randomized complete block experimental design with four replications was used. Seeds were planted on two dates (5 and 15 May 1989) in rows 5.03 m long and 1.52 m apart, at a rate of one seed for each 5 cm spacing. After maturity, when seeds dried in the field to about 14% moisture content, plants were cut, tied in bundles, and stored in a ventilated shed. After moisture content equalized among plants to approximately 8%, a plot thresher was used to thresh seeds for yield evaluation. Results were averaged in tons/ha and reported as yield 1 and yield 2, for first and second date of planting, respectively.

Results and Discussion

Viability (germination) was improved due to conditioning for all seedlots except lot 5 (Tables 3-7). Germination decreased in seedlot 5 after conditioning, which may be explained by the low moisture of the seedlot (Table 1) at the time of conditioning. As shown in Tables 3 and 4, seedlots 1 and 2 had significant increases in vigor also as measured by both cold and stress test. The discards from the air-screen cleaner were distinctly low in germination and vigor (See CS1 and CL in Tables 3-7). The discards from the spiral separator and from the gravity table were also lower in quality than the final sample.

TABLE 1. Initial physiological quality properties of each soybean seedlot*

Seed lot	Moist Cont. (%)	Warm Germ. (%)	Cold Test. (%)	Str. Test. (%)	Prot. Cont. (%)	Oil Cont. (%)	Yield 1 (ton/ha)	Yield 2 (ton/ha)
1	10.1	76 a	46 ab	80 a	36.90a	17.80c	1.76ab	2.07a
2	11.2	54 b	35 b	54 c	37.49a	16.98d	1.37b	2.28a
3	9.7	74 a	52 a	81 a	35.35b	18.59b	1.54ab	2.77a
4	10.0	74 a	20 c	62 b	34.77b	18.99ab	1.56ab	2.36a
5	9.2	75 a	56 a	77 a	33.35c	19.52a	2.13a	2.38a

* Means followed by the same letter in a column are not statistically different ($p < 0.05$) according to the T-test.

TABLE 2. Purity percentage for each seedlot at different stages in conditioning

Condition Steps	Seedlot 1	2	3	4	5
Initial	95.8	93.5	98.9	96.5	95.0
CS1	48.0	58.0	32.4	50.3	9.5
CS2	98.1	67.5	91.7	94.5	91.6
CL	97.7	68.8	90.9	89.1	63.1
AC	99.4	98.9	99.7	99.5	99.6
SD	99.5	90.3	96.1	95.3	92.7
GD	98.3	94.2	98.9	98.9	97.6
GM	99.9	98.8	100.0	99.8	99.7
Final	99.9	99.7	100.0	100.0	99.8

Conditioning operations did not affect protein or oil contents of soybeans. A slight tendency toward an increase in oil content and a decrease in protein was noted (Tables 3-7). The yields of the final samples were not significantly different from those of initial samples (Tables 3-7).

Correlation coefficients among physiological properties are presented in Table 8. As expected, warm germination, cold test, and stress test were positively correlated. Seed viability and seed vigor (cold test and stress test) were positively related with yield. Johnson and Wax (1978) found the cold test to effectively predict field performance of soybean seeds.

Protein content was negatively associated with oil content (Table 8). Hartwig and Hinson (1972) reported a similar relation between protein and oil percentages. Simpson and Wilcox (1983) found negative correlations, ranging from -0.15 to -0.96, between protein and oil contents in soybean seeds. Associations of protein content with seed viability, vigor, and yield had a negative trend, but usually were not statistically significant.

Percentages of protein and yield were inversely associated in this study (Table 8), a finding supported by several other investigators (Shannon et al., 1972; Hartwig and Hinson, 1972). In contrast, Shorter et al. (1976) reported weak correlations and, in some soybean crosses, positive relations between protein content and yield.

Associations between physical and physiological properties are listed in Table 9. Correlations of shriveled seeds with warm germination, cold, stress, oil content, and yield tests presented a negative trend. Green et al. (1965) also found shriveled soybean seeds related to low germination and field emergence percentages. Dornbos (1988) reported an inverse linear relations between environmental stress intensity and seed viability and seed vigor.

Bulk density was positively related to viability and vigor (Table 9). In addition, associations of bulk density and seed yield were highly positive. Gregg (1969) reported high positive correlations between bulk density and certain physiological properties, which is in agreement with our results.

Seed weight and seed volume were positively associated with warm germination, vigor, and yield (Table 9). These results are in agreement with those of Smith and Camper (1975). Singh et al. (1972) reported a lack of relations between soybean seed size and field performance, which contrasts with our results.

TABLE 3. Physiological properties of seedlot 1 conditioned through the air-screen cleaner, spiral separator, and gravity table*

Condition. Step	Warm Germ. (%)	Cold Test (%)	Stress Test (%)	Protein Content (%)	Oil Content (%)	Yield 1 (ton/ha)	Yield 2 (ton/ha)
Initial	76 cd	46 c	80 de	36.90 bcd	17.80 abc	1.76a	2.07 ab
CS1	35 d	12 g	32 f	37.23 ab	17.52 cd	0.71b	0.90 c
CS2	75 c	40 de	76 e	37.80 a	17.37 d	1.48ab	2.33 ab
CL	77 cb	24 f	81 bcde	37.24 ab	17.56 bcd	1.19 ab	2.35 ab
AC	82 abc	60 b	87 ab	37.20 abc	17.89 a	1.62 a	2.91 a
SD	83 abc	37 e	84 abcd	37.06 bcd	17.84 ab	1.23 ab	2.67 a
GD	84 ab	43 cd	80 cde	36.54 cd	17.86 ab	1.46 ab	1.56 b
GM	84 ab	60 b	86 abc	36.40 d	17.98 a	1.40 ab	2.22 ab
Final	87 a	66 a	89 a	36.92 bcd	17.84 ab	1.62 a	2.30 ab
Overall change (Initial - Final)	11.0	20.0	9.0	0.02	0.04	-0.14	0.23

* Means followed by the same letter in a column are not statistically different ($p < 0.05$) according to the T-test.

TABLE 4. Physiological properties of seedlot 2 conditioned through the air-screen cleaner, spiral separator, and gravity table*

Condition. Step	Warm Germ. (%)	Cold Test (%)	Stress Test (%)	Protein Content (%)	Oil Content (%)	Yield 1 (ton/ha)	Yield 2 (ton/ha)
Initial	54 cb	35 c	54 c	37.49 b	16.98 d	1.37 b	2.28 a
CS1	22 d	8 d	25 d	38.42 a	16.19 e	0.72c	1.26 b
CS2	48 c	13 d	34 d	38.56 a	16.28 e	0.98bc	1.52 b
CL	48 c	20 d	35 d	36.78 bc	17.60 c	1.19b	1.62 b
AC	72 ab	52 ab	66 ab	35.90 cde	18.58 a	2.07a	2.54 a
SD	64 abc	42 bc	54 c	36.53 cd	17.86 bc	1.88a	2.36 a
GD	61 abc	40 bc	55 bc	35.64 de	18.40 ab	1.91a	2.34 a
GM	72 ab	56 a	60 abc	35.16 e	18.76 a	1.90a	2.56 a
Final	75 a	58 a	69 a	35.59 e	18.58 a	1.96a	2.61 a
Overall change (Initial - Final)	21.0	23.0	15.0	-1.9	1.6	0.59	0.33

* Means followed by the same letter in a column are not statistically different ($p < 0.05$) according t the T-test.

TABLE 5. Physiological properties of seedlot 3 conditioned through the air-screen cleaner, spiral separator, and gravity table*

Condition. Step	Warm Germ. (%)	Cold Test (%)	Stress Test (%)	Protein Content (%)	Oil Content (%)	Yield 1 (ton/ha)	Yield 2 (ton/ha)
Initial	74 a	52 a	81 a	35.35 ab	18.59 bc	1.54 ab	2.77 a
CS1	22 c	7 c	24 c	36.14 a	17.78 d	0.43 c	0.67 b
CS2	73 ab	38 b	76 ab	35.87 ab	17.50 d	1.72 ab	2.17 a
CL	69 b	50 a	75 ab	35.75 ab	18.46 c	1.39 ab	2.24 a
AC	79 a	50 a	78 ab	35.25 ab	19.08 ab	2.02 a	2.26 a
SD	74 ab	58 a	80 ab	35.00 b	19.10 a	1.85 a	2.37 a
GD	68 b	47 ab	70 b	35.24 ab	19.09 a	1.01 b	2.24 a
GM	73 ab	56 a	72 ab	35.00 b	19.17 a	1.60ab	2.55 a
Final	76 ab	53 a	79 ab	35.04 b	19.15 a	1.71ab	2.60 a
Overall change (Initial - Final)	2.0	1.0	-2.0	-0.31	0.56	0.17	-0.17

* Means followed by the same letter in a column are not statistically different ($p < 0.05$) according t the T-test.

Terminal velocity was found a satisfactory indicator of seed viability, seed vigor, and yield (Table 9). Smith et al. (1973), working with vegetable seeds, reported similar results.

The laboratory and field evaluations of the initial samples (Table 1) demonstrate a natural significant heterogeneity among seedlots; nevertheless, separation based on physical properties produced improvements in physiological performance. Therefore, a number of recommendations are derived from the information presented in Part I and Part II to assist the seed conditioner in optimizing the operation of seed conditioning equipment:

1. In this research, the gravity separator was run with a

TABLE 6. Physiological properties of seedlot 4 conditioned through the air-screen cleaner, spiral separator, and gravity table*

Condition. Step	Warm Germ. (%)	Cold Test (%)	Stress Test (%)	Protein Content (%)	Oil Content (%)	Yield 1 (ton/ha)	Yield 2 (ton/ha)
Initial	74 bcd	20 abc	62 bc	34.77 cde	18.98 ab	1.56ab	2.36 ab
CS1	39 f	9 d	34 e	36.21 a	18.10 d	0.80c	0.84 d
CS2	66 e	19 abc	66 ab	35.40 b	18.30 cd	1.14bc	1.95 abc
CL	67 de	16 c	50 d	35.03 c	18.48 c	1.45abc	1.66 bcd
AC	75 abc	23 a	65 b	34.48 e	19.15 ab	1.16bc	2.34 abc
SD	70 cde	22 ab	58 c	35.06 c	18.84 b	1.32 abc	2.00 abc
GD	74 bc	11 d	46 d	34.78 cd	19.14 ab	1.46 ab	1.53 cd
GM	81 a	18 bc	63 bc	34.58 de	19.28 a	1.49 ab	2.29 abc
Final	77 ab	22 a	70 a	34.58 de	19.16 ab	1.78 a	2.62 a
Overall change (Initial - Final)	3.0	2.0	8.0	-0.19	0.18	0.22	0.26

* Means followed by the same letter in a column are not statistically different ($p < 0.05$) according to the T-test.

TABLE 7. Physiological properties of seedlot 5 conditioned through the air-screen cleaner, spiral separator, and gravity table*

Condition. Step	Warm Germ. (%)	Cold Test (%)	Stress Test (%)	Protein Content (%)	Oil Content (%)	Yield 1 (ton/ha)	Yield 2 (ton/ha)
Initial	75 a	56 bc	77 a	33.34 bc	19.52 c	2.13 a	2.38 a
CS1	6 e	2 f	6 d	33.88 b	18.45 d	0.17 d	0.19 c
CS2	61 c	45 d	70 ab	34.90 a	18.52 d	2.06a	2.20 ab
CL	40 d	31 e	44 c	33.56 bc	19.56 c	1.18c	1.60 b
AC	74 a	71 a	73 ab	33.18 bc	20.12 ab	2.38a	2.62 a
SD	61 c	46 cd	64 b	33.58 bc	19.82 bc	1.34bc	2.52 a
GD	62 bc	53 bcd	64 b	32.86 c	20.20 ab	1.82ab	2.41 a
GM	71 ab	62 ab	69 ab	32.86 c	20.34 a	2.17a	2.56 a
Final	70 ab	67 a	78 a	33.17 bc	20.10 ab	2.20a	2.70 a
Overall change (Initial - Final)	5.0	11.0	1.0	-0.17	0.58	0.07	0.32

* Means followed by the same letter in a column are not statistically different ($p < 0.05$) according t the T-test.

shallow seed depth on the deck. Although this procedure reduced the capacity of the machine, it was necessary to assure maximum removal of shriveled soybeans with a minimal loss of good seeds.

2. The screens of the air-screen cleaner often became plugged during cleaning. Several actions can be taken to alleviate the frustration of stopping the machine several times during operation which include: a) increase the pitch of the screen if a variable-pitch adjustment is available; b) increase the speed; c) readjust the brushes under the screen if brushes are used; d) insure that the balls have good bounce if rubber balls are used under the screen; e) use the screen tappers.

3. Because of the great amount of discard during conditioning, the discard conveyor or jump legs were overloaded and became plugged. To solve this problem, the feed rate can be reduced.

4. Because shriveled soybeans do not flow as well as normal (round) soybeans, plug-ups may occur at any

TABLE 8. Correlations among physiological properties of soybean seeds conditioned by the air screen cleaner, spiral separator, and gravity table

	Cold Test	Stress Test	Protein Content	Oil Content	Yield 1	Yield 2
Warm germ	0.62*	0.91*	-0.10	0.30	0.69*	0.81*
Cold test		0.76*	-0.28	0.42†	0.77*	0.75*
Stress test			-0.10	0.28	0.67*	0.83*
Protein content				-0.95*	-0.39*	-0.21
Oil content					0.50*	0.39*
Yield 1						0.78*

* $p < 0.01$.
† $p < 0.05$.

TABLE 9. Correlations between physical and physiological properties among soybean seeds conditioned by the air-screen cleaner, spiral separator, and gravity table

	Warm Germ.	Cold Test	Stress Test	Protein Content	Oil Content	Yield 1	Yield 2
Shriveled seeds	-0.67*	-0.69*	90.62*	0.55*	-0.68*	-0.76*	-0.74*
Bulk density	0.78*	0.66*	0.77*	-0.06	0.27	0.72*	0.81*
Weight	0.60*	0.66*	0.59*	-0.58*	0.72*	0.692*	0.68*
Volume	0.58*	0.65*	0.58*	-0.63*	0.63*	0.63*	0.68*
Kernel density	0.06	0.10	0.13	0.49*	-0.40*	-0.15	-0.01
Terminal velocity	0.71*	0.73*	0.69*	-0.31†	0.50*	0.65*	0.74*

* $p < 0.01$.
† $p \leq 0.05$.

location where the slope is not adequate, and the conditioner must pay special attention to the flow of product in gravity spouts and spiral separators.

Conclusions

The sequence of an air-screen cleaner, a spiral separator, and a gravity table was able to produce significant improvements in physical and physiological seed qualities. After the air-screen cleaner, seeds were heavier and bigger and had improved physiological properties (seed viability and vigor). The spiral separator improved the purity and appearance.

Conditioning machines were more effective for seedlots with lower initial quality. Operation capacities needed to be reduced to obtain optimal separation of shriveled seeds with minimal loss of good seeds.

Correlations of shriveled seeds with warm germination, cold, stress, oil content, and yield tests presented a negative trend. Bulk density was positively related with viability (warm germination) and vigor (cold and stress tests). Seed weight and volume were found to be positively associated with warm germination, vigor, and yield.

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