ROLL GRADER SIZING OF AGRICULTURAL SEEDS

by

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PREFACE

The work reported in this thesis was conducted as a part of State Project 802, "Development of Improved Machines and Methods for Seedbed Preparation, Planting, and Early Weed Control in Cotton Production", of the Oklahoma Agricultural Experiment Station. One of the objectives of Project 802 has been to develop equipment that would improve the precision or accuracy of placement of seed in planting. One of the results of research on this project has been to grade acid delinted cotton seed to improve metering accuracy of the planter box. The investigations in this study were not limited to cotton seed alone, but did include acid delinted cotton seed as one of the factors. The objective of this study was to obtain basic information concerning an experimental roll grader. Shelled peanut seed and delinted cotton seed were used.

The author is grateful to Professor Jay G. Porterfield, the thesis advisor, for his assistance and counsel during the study and for his comments and suggestions concerning the test of this thesis.

Appreciation is also expressed to the personnel of the Oklahoma Cotton Research Station at Chickasha, Oklahoma, for their cooperation in construction of the test equipment and for their assistance in conducting the tests.

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CHAPTER I

INTRODUCTION

The principle of grading or sizing objects by means of a "go" or "no go" gage has been used for many years. The distance between two fixed points or parallel surfaces was used as a reference to determine whether an object was of a given size.

This principle was utilized in a series of tests using acid delinted cotton seed and shelled peanut seed for evaluation of smooth steel rolls as a grading device. Pre-determined sizes of cotton or peanut seed were run through, or over, the parallel surfaces of two right-circular cylinders consisting of two smooth steel rolls placed with their parallel axes at an angle from the horizontal. The space between the rolls was used as a measuring device. One roll had a constant diameter while the second roll had four different diameters. The different diameters were of such a size that the spacing between the two rolls provided sizing possibilities for the seed to be accepted, by going between the rolls, or to be rejected, by being retained upon the roll's surfaces.

An evaluation of steel rolls as a grading device consisted of determining the grading accuracy, in percent, under certain fixed conditions of roll speed, roll angle, and rate of feed. The effect of these factors at two levels each, was evaluated in a total of eight combinations for three different roll rotation combinations: (1) both rolls turning in opposite directions such that their adjacent surfaces had a tendency to lift the seed, (2) One roll turning in the same manner as above and the other roll stationary, and (3) both rolls turning in the same direction. This made twenty-four different combinations in all.

It was hypothesized that the rolls would grade most accurately at the lower roll speed, at the lowest angle, and that the rate of feed would have considerable influence on grading accuracy, but that the rate of feed would not be critical until the rolls were over-fed; that is, when seeds would tend to ride up on top of the seeds that were in contact with the rolls.

It was hypothesized that the rate of feed could undoubtedly be increased a limited amount with an increase in roll angle and/or roll speed. It was thought that the rate of grading would increase with a greater roll angle but that grading accuracy would decrease.

The acid delinted cotton seeds used in these tests had been selected for the tests by running the seed over an A.T. Farrel and Company Clipper Cleaner fanning mill equipped with round hole screens. The seeds that went through the 12/64th inch round hole screen and were retained on a 11/64th inch round hole screen were then subjected to minor diameter grading by the roll grading device. The seeds that went through the roll section with a spacing of 11/64th of an inch were used for subsequent roll grading tests.

The peanuts used in the tests had previously been graded by a round hole screen at shelling time and were subsequently graded to "through" a 5/16 inch roll spacing on the roll grading device.

Various parameters thought to influence the performance of the roll grading device were investigated. The parameters are presented in the next section of this report.

CHAPTER II

OBJECTIVES

The objectives of these tests were to evaluate the following parameters:

A. To determine the effect of roll speed (200 and 600 rpm), rate of feed (two levels), and roll angle (5° and 15°) on the grading accuracy of (1) smooth steel rolls turning opposite directions such that their adjacent sides were turning upward, (2) one smooth roll turning as in (1) above and the other roll stationary, and (3) both rolls turning the same direction when grading acid delinted cotton seeds.

The object of comparing the three roll rotation combinations was to gain information for future design considerations. If no differences in grading accuracy were found, it would be possible to have more potential roll grading area in one of the combinations. The space between the rolls was the grading area. Increased grading capacity would be provided by adding more roll units. Multiples of the combination of rolls turning in opposite directions would have the least grading area of three roll rotation combinations. The combination of one roll turning could utilize any of several stationary devices to provide a fixed spacing for grading, and would have the greatest potential in grading area utilization. The combination of rolls turning in the same direction would be intermediate in grading area per unit of size.

B. To determine any effect on grading accuracy of smooth steel rolls due to the relative size of the product being graded. This was attempted by conducting the same tests as in A above, but using peanuts instead of acid delinted cotton seed.

C. To determine, if possible, the necessary length of roll section to obtain high grading accuracy under the conditions of objectives A and B above.

D. To arrive at some relationships of the time required for cotton and peanut seeds to travel along a twelve inch roll section at roll speeds of 200, 400, and 600 rpm and roll angles of 5°, 10°, and 15° with the rolls turning (1) opposite directions, (2) one turning and one stationary, and (3) both rolls turning the same direction.

E. To determine the minor diameter distribution of the acid delinted cotton seeds used in the roll grader tests.

F. To establish the percent of damage to cotton and peanut seeds used in grading accuracy tests caused by the metering device and the rolls at the roll speeds of 200 and 600 rpm, rates of feed (two levels), roll angles of 5° and 15° with the rolls turning (1) opposite directions, (2) one roll turning and one stationary, and (3) both rolls turning the same direction.

CHAPTER III

REVIEW OF LITERATURE

A review of literature pertaining to roll grading research provided very little information. There was, however, considerable evidence of commercial use of rolls for sizing or grading of many products.

Preliminary work with roll grading of acid delinted cotton seeds was initiated in 1957 by Schroeder, et al (1). Two rolls were placed with parallel axes at an angle of 6^{o} as shown in Figure 1. One roll

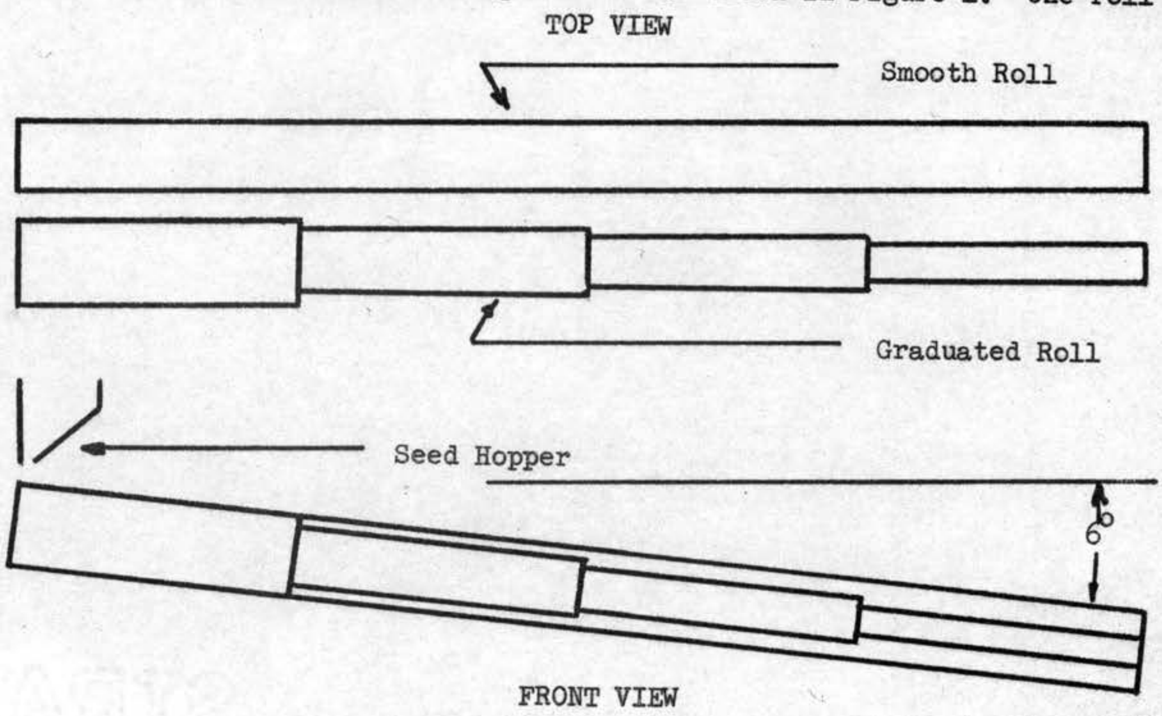


Figure 1. Schematic diagram of an experimental roll grader for grading acid delinted cotton seed.

had a constant diameter along its length while the other roll had different diameters at one foot intervals along its axis. The spacing between the rolls (varied by the different diameters) was such that the smaller seeds would be graded out at the upper end (feed end), and at subsequent spacings increasingly larger seeds would be sized. The spacings were such that seeds could be graded to size in steps of 1/64th inches. The rolls accomplished their grading on the basis of minor diameter of the seed. No formal test data was included. It was reported, however, that a similar machine was used to separate seeds of other types, besides delinted cotton seed, into minor diameter classes. The machine appeared to have possibilities for a wide application for size distribution studies of most types of agricultural seeds. While no commercial value of sizing of cotton seeds (or other types of seeds) was evident, the machine appeared to be an excellent device for measuring minimum diameter because of its high reproducibility and precision.

Roll grading of citrus fruits was reported by Henderson (2). The roll sorters were fast, accurate, and cause little damage to fruit. The fruit, in some cases, was fed across the axis of the rolls, while the rolls conveyed the produce by rotating all in the same direction. The rolls, as shown in Figure 2, were rotating counter-clockwise. The fruit was continuously rotated so that each individual piece had an opportunity to register its minimum dimension with the spacing of the rolls. In most sorters the spacing between rolls, or sections of rolls, increased progressively so that the various sizes of fruit were graded.

Citrus Fruit Sorter

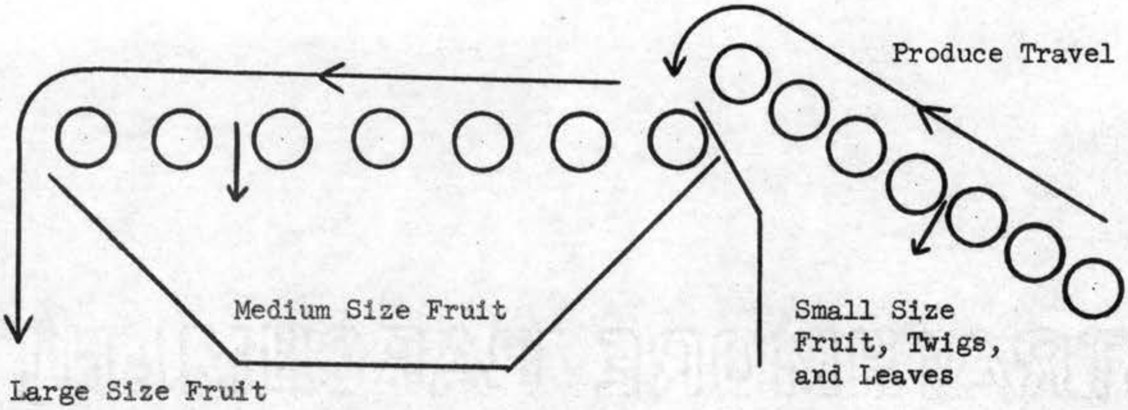


Figure 2. A schematic diagram of a roller sorter (sizer) for citrus fruit.

Another source concerning citrus fruit grading provided additional information as to the machinery available for sizing of citrus fruit (3). Mention was made in this trade bulletin of roll sizers having lengths of 20 to 45 feet with 6 to 8 sizing rolls (see Figure 3) which provides 7 to 9 sizes of fruit. This sizing method differed

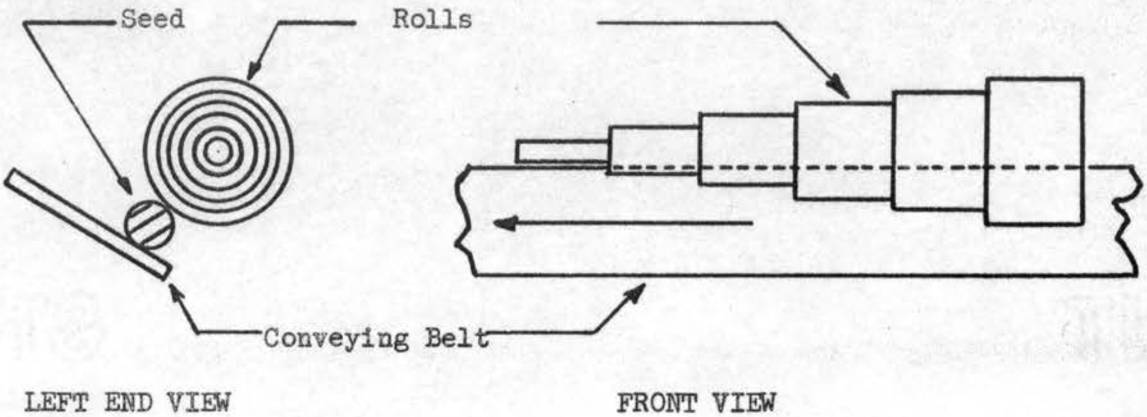


Figure 3. Roll Sizer for orange, grapefruit, or tangerines (roll-to-conveying belt spacing easily adjusted for different fruit sizes).

from that reported by Henderson (2) in that the fruit moved parallel to the axis of the rolls. The sizers were manufactured to handle oranges, grapefruit, or tangerines by a quick adjustment of the roll spacing.

The fruit was supported by the grading rolls and a flat belt. The belt conveyed the fruit along as it ran parallel to the roll axis. The spacing between the rolls and the belt increased in size with each successive roll, due to the smaller roll diameter encountered. This provided a means of sizing fruit; the smaller fruit was graded first. Size adjustment was made by moving the rolls closer to the belt or farther away.

Another fruit grading or sizing machine using rolls for fruit sizing was found in trade literature (4). This machine conveyed the fruit along the roll axis with a soft rubber belt as in the previous sizer just described. This machine differed in that the size adjustment was made by changing sleeves on the master shaft, providing four sizes of apples or peaches.

One other type of roll grader for food processing was found in the literature review. This particular roll design was used for sizing potatoes and onions. Several sources were found; one was a report of research on sorting of potatoes by W. J. West (5). The grading device consisted of a series of specially constructed rubber rolls. The surface of these rolls may most nearly be described as an ellipsoid of revolution. Each shaft has several of the rubber covered rolls mounted along its longitudinal axis. Two or more of these shafts placed side by side formed a series of holes (size of hole varied with shaft spacing and roller spacing on the shaft).

Two sizes of the ellipsoid sections were used to provide three grades or sizes of potatoes. All rolls were turned in the same direction to move the ungraded produce along to the next section. The grading was reported to be efficient so long as the feeding rate was not too high; when too high, some of the potatoes sizes were carried into the next section. An even flow of potatoes was maintained over the sorter, provided the feed conveyor was kept full. If feeding was interrupted and the feed conveyor allowed to become empty, some potatoes remained on the grader and merely rolled around and around without forward travel. These potatoes, if left on the grader for a time, were damaged by the rolls. A schematic diagram of the rolls is shown in Figure 4.

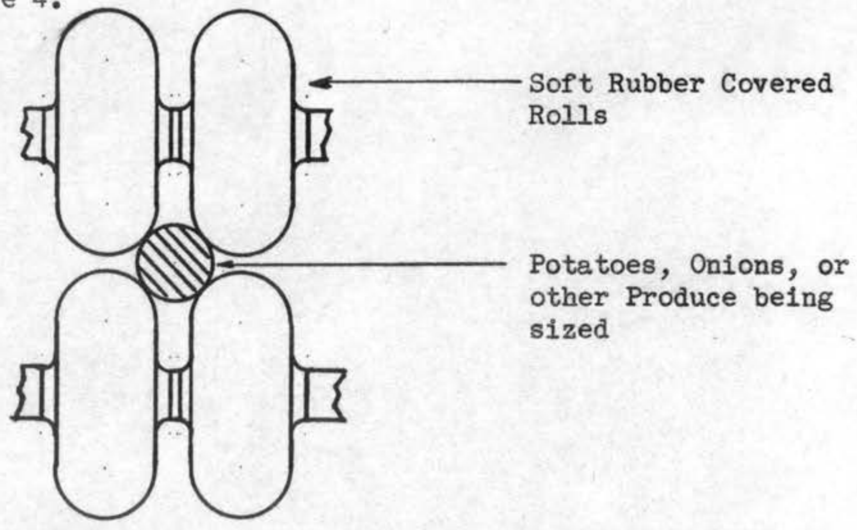


Figure 4. A schematic diagram of rubber covered grading rolls (a top view).

Another source having to do with a machine with similar rolls, differed somewhat by having expanding rolls (6). The ellipsoid sections were mounted on shafts, as in the previous machine. The shafts were different in that they were automatically adjusted in their relative spacing with the next shaft by precision machined rotating spirals. The shafts were mounted as a part of a "slat-type" of conveyor (the shafts replacing the conventional slats). By means of the rotating spirals, the shafts were adjustably spaced to allow for four sizes of potatoes or onions. The spacing increased in size as the conveyor moved the produce along the sizing machine.

An automatic set screw feeding device made use of a small roll grader to orient the various types of set screws and to reject misfits (7). Two rolls made of high quality hardened steel were rotated slowly in opposite directions as shown in Figure 5. The rolls were fed by a feeding device that fed the setscrews onto the rolls in a single file. The setscrews passed along the trough formed by the rolls to a point where matching grooves in the rolls allow the

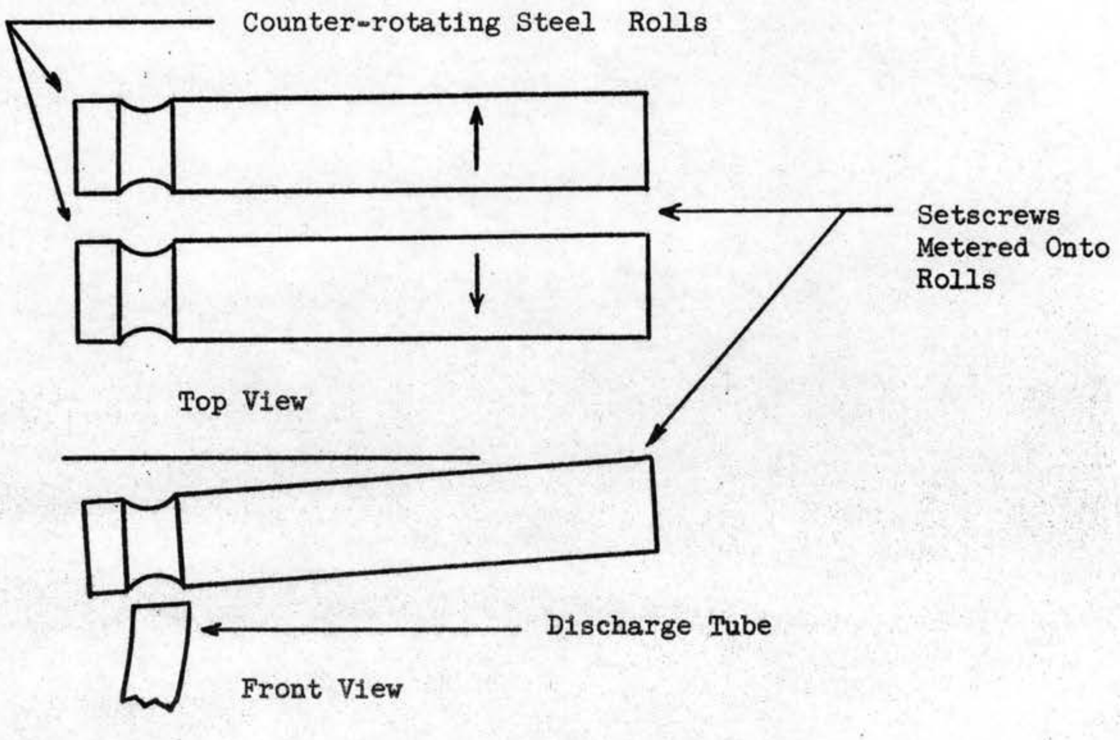


Figure 5. Roller grader-feeding device for setscrews and other parts - (springs, tapered units, etc.).

setscrew to drop into feed tubes with the heavy point ends down. The rolls automatically inspected the setscrews' diameter and rejected misfits. Users of the feeding and orienting device reported production increases from 300 pieces to over 2100 pieces per hour.

Another source reported a similar device that differed by using a pair of tapered rolls to automatically feed such parts as tapered units (fountain pen caps), springs, inserts, and other components having a variable dimension along a given axis (8). Two motor-driven, counter-rotating rolls, aligned parallel to each other, contained a slight taper at one end. The gap between the rolls was arranged so that the parts traveled along the roll surface until they reached the wedge-shaped gap created by the taper. The end of the unit being metered, that had the smaller dimension, then proceeded through the wedge first.

The mechanism handled a wide range of sizes and shapes. Changeover from one size to another was rapidly accomplished simply by adjusting the angle between the rollers. Completely cylindrical rolls could be used, the required wedge being established by a slight divergence of their axes. Grooving one roll facilitated feeding parts at controlled and high advance rates. Grooving both rolls permitted the feeding device to handle T-shaped parts.

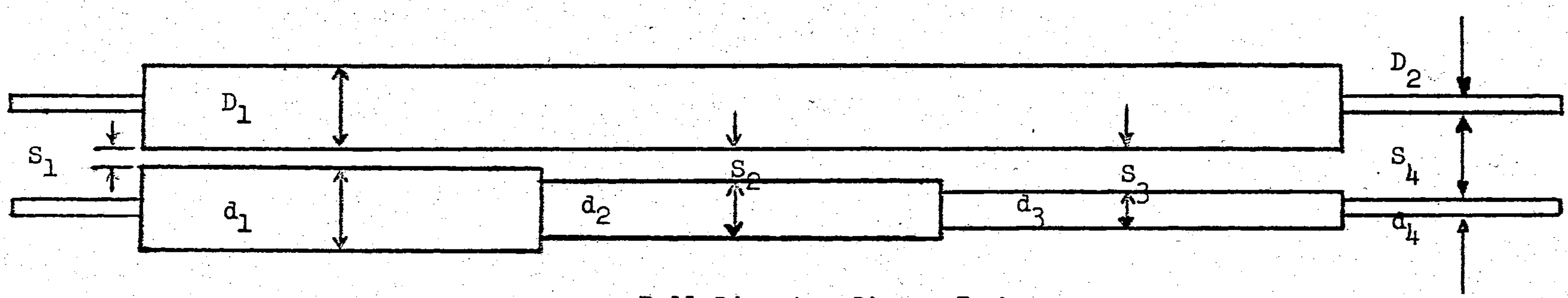
CHAPTER IV

APPARATUS AND TEST EQUIPMENT

The roll grader under test was built at the Oklahoma Cotton Research Station. The rolls were made of cold-rolled steel shafting and cut to the selected size in a lathe. One roll had a constant diameter along its length for three feet plus a drop-out length of smaller diameter. The other roll had three sections, each one foot in length, but of different diameters, plus a fourth section that was much smaller to provide for a positive drop-out area (See Figure 6). The rolls were mounted with their axes parallel. The roll axes were spaced such that in the first one foot section no seed could drop through. This section was provided as a line-up area for the seeds. Efficient grading required that the seed be in contact with the rolls; the line-up area had a definite tendency to place the seeds in single file ready for grading.

Figure 7 shows an over-head view of the rolls. Only a portion of the line-up area was visible as the metering device was in the way. The second one foot section was the first area for grading and was painted black (for the picture) to clearly define this particular area. All of the seed used for the tests had previously been graded on the round hole clipper cleaner and had been run through this second one foot roll section. All of the seed should have gone through this area during the test. The seed that did go through, when converted to a percent of the total, represented the percent of grading accuracy.

Experimental Rolls



Roll Diameter Size - Inches

TYPE OF SEED TEST	D_1	D_2	d_1	d_2	d_3	d_4	S_1	S_2	S_3	S_4
Acid Delinted Cotton Seed	1.2812	0.7500	1.5000	1.3750	1.2500	0.7500	0.1094	0.1719	0.2344	0.7500
Shelled Peanut Seed	1.0000	0.7500	1.5000	1.3750	1.2500	0.7500	0.2500	0.3125	0.3750	0.7500

Figure 6. A Schematic diagram showing a top view of the roll grader used in grading accuracy tests, seed damage tests, seed timing tests, and length of roll tests. The smooth roll used in the peanut tests was smaller in diameter than was the roll used in the cotton seed tests. This was to allow different spacings between the rolls as indicated by the information given above.

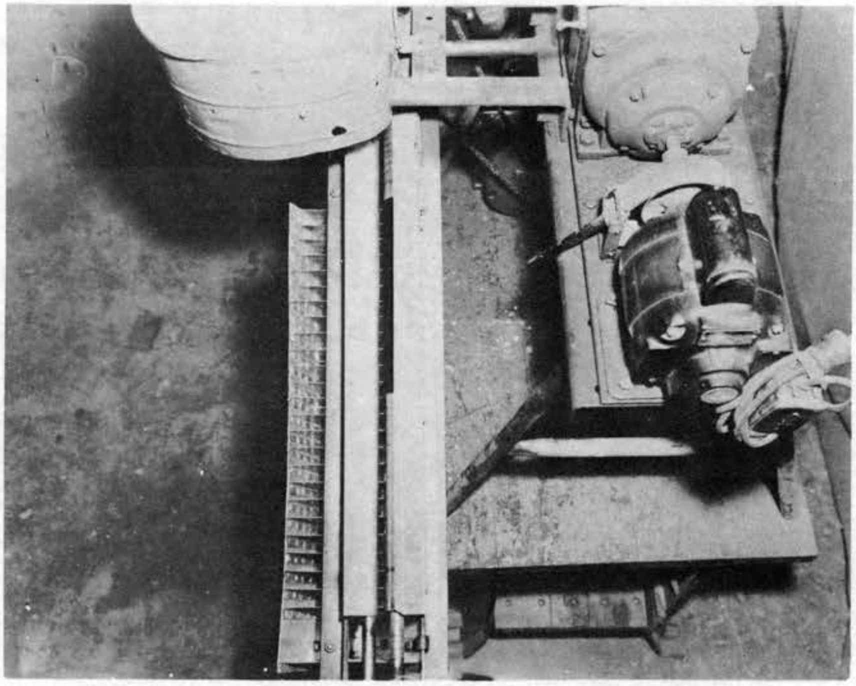


Figure 7. A top view of the roll grader.

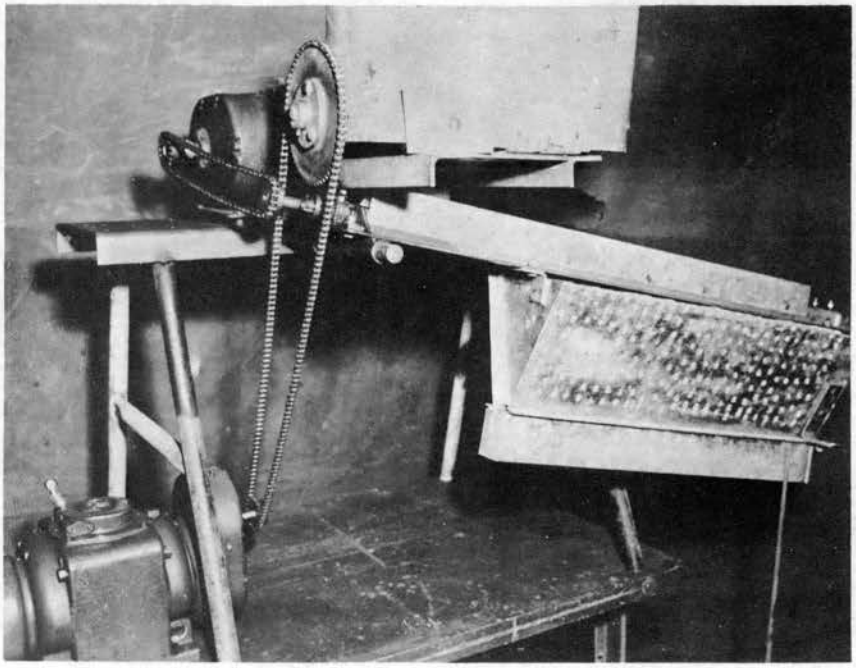


Figure 8. A side view of the roll grader showing drives and the catch pan. Note the one horizontal drive chain which drives the rolls.

The third one foot roll section was used as an additional measure of roll length necessary to contain the seeds under the test conditions. The fourth roll section, approximately six inches in length, was provided as a positive drop-out area.

Two $\frac{1}{4}$ hp Graham variable speed drive units were used for the driving mechanism in these tests. Figure 8 shows the drives used for the test of two rolls turning in opposite directions such that their adjacent surfaces traveled upward. The left roll, as shown, was driven by the variable speed unit and, in turn, drove the right roll through a spur gear. The lower drive unit was used to drive the metering device at a constant speed of 56 rpm. The upper drive unit was used to vary the speed of the rolls (200, 400, or 600 rpm) as specified by the randomization in the test design.

Figure 8 is also the set-up used for driving the test involving one roll turning and one roll stationary with one exception. The spur gear on the right roll was removed so as to not turn this roll when the tests involving one roll turning-one roll stationary were conducted.

Figure 9 illustrates the set-up used to drive both rolls in the same direction. The spur gear on the right roll was removed and a sprocket was placed on the end of the shaft. The outer chain, as shown in Figure 4, drove the left roll in a counter-clockwise direction at the same time that the inner chain drove the right roll in a counter-clockwise direction; both were driven at the same speed.

Figures 8 and 9 show a side view of the catch-pan used in the peanut grading tests while Figure 7 shows a top view of the catch-pan (note the one-inch increments in the pan). The one-inch incre-

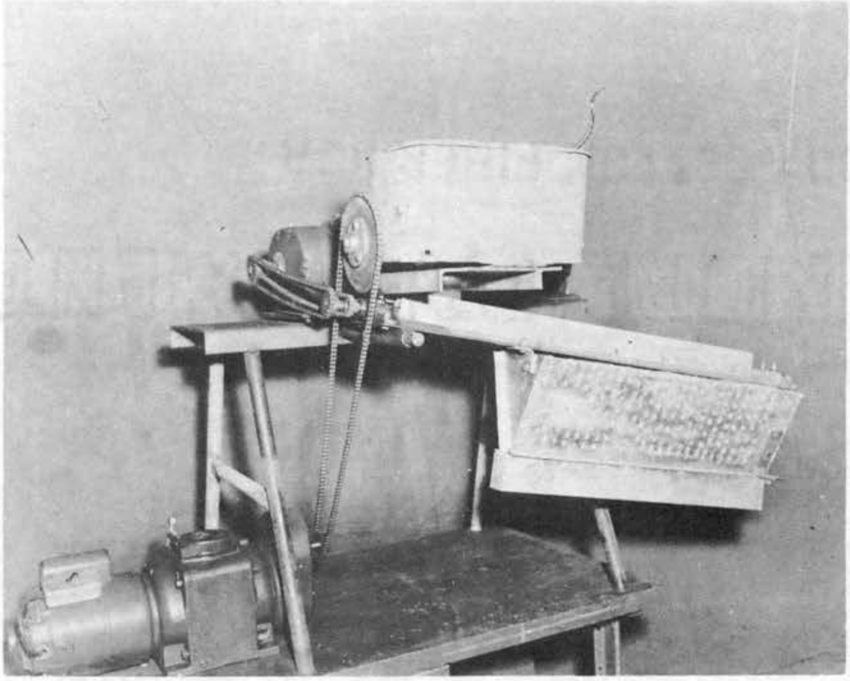


Figure 9. A side view of the roll grader which differs from figure 8 by having two horizontal drive chains to drive the grading rolls.

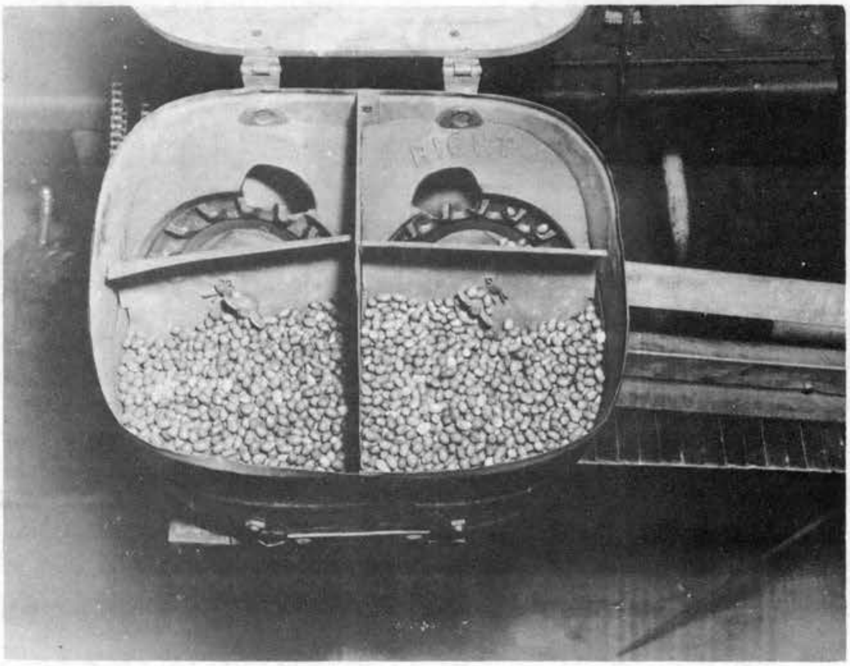


Figure 10. A top view of the metering device used to feed the roll grader. Peanut planter plates are shown.

ments are baffle plates that extend to the bottom slide. Each compartment was separate from the next. The catch-pan provided a means of determining the percent of grading that occurred at each successive one-inch increment. The bottom of the catch pan consisted of a movable slide to empty each unit.

The catch-pan used in the acid delinted cotton seed grading accuracy test had baffle plates each one-half inch apart but, otherwise was like the catch-pan shown in Figures 7 and 8. This provided twenty-four individual "cells" per one foot of roll section in which to catch the cotton seed as graded.

Figure 10 shows a top view of the metering device used in feeding seeds to the roll section during the tests, Figure 9 shows a side view of the metering device. The planter box used was a Cole, Duplex planter box.

The plates consisted of a right and a left hand plate as can be seen by Figure 10. The cells on the plates (delinted cotton seed and peanut seed) were cupped right or left depending upon direction of rotation of the plate. The right hand plate turned counter-clockwise and the left hand plate turned clockwise. The plates were inclined from the horizontal at approximately 45° with a portion of the lower circumference running through the seed supply. The cupped cells picked up a seed when at the bottom position and carried it to a top position where the cell was exposed to the drop-out hole. Seed ejection from the cell was primarily due to gravity and to a lesser degree due to centrifugal force. The plates were operated at a constant speed of 25 rpm.

The rates of feed for the acid delinted cotton seed were varied as to low, medium, and high by using planter plates manufactured for metering sorghum seeds. The lowest rate of feed was metered by one 8 cell plate. The 8 cell plate metered at the rate of approximately 2.7 pounds of delinted cotton seed per hour. Only the 16 cell plate was used for the medium rate and it metered approximately 4.8 pounds of delinted cotton seed per hour. The highest rate, for the cotton metering, was the combination of both plates (8 and 16), and they metered approximately 7.9 pounds per hour.

For peanut seed tests only two feed rates were used and, in this case, the low rate of feed was provided by a 16 cell peanut plate that metered approximately 17.1 pounds of peanuts per hour. The high rate of feed consisted of two 16 cell plates. Together they metered approximately 32.1 pounds of peanuts per hour.

The average weight of the acid delinted Parrott cotton seed was approximately .10 grams and the average weight of the shelled Argentine peanut seed was approximately .30 grams. The minimum diameter of the peanut seeds, as determined by the roll spacing of 5/16 inches, was 1.82 times as large as was the minimum diameter of the acid delinted cotton seeds (roll spacing 11/64th inches).

Calculations concerning the relative size of the minor diameter of the delinted cotton seed to the rolls used in grading (average of the two rolls' diameters) indicated that the cotton seed's minimum diameter was approximately 13% as big as that of the rolls. Calculations for the peanut seeds showed that the peanuts' minimum diameter was approximately 26% of that of the rolls (average of both rolls).

All treatments concerning grading accuracy for delinted cotton seed were conducted for a seed metering period of five minutes as determined by a stop watch; two minutes were used for peanuts.

The seeds caught in the catch-pan increments were weighed separately on a gram scale to the closest .01 gram and were recorded separately.

The damaged seeds in the tests designed to evaluate seed damage were picked out by hand after careful observation. Their weights were recorded according to the roll section that the damage occurred so that "percentage of damage" could be calculated.

The delinted cotton seeds used in determining the minor diameter distribution were measured with a micrometer to the nearest .001 inch. A randomly selected group of seeds was used for these evaluations.

CHAPTER V

THEORETICAL CONSIDERATIONS

Theoretical consideration, thought to have application for these tests, would include the effects of the frictional forces and the physical relationships of the size of the seed-to-grading rolls. The following discussion is presented to inform the reader of these important considerations.

Figure 11 is a diagram of the forces acting in a vertical plane upon the seed in the roll rotation combination of rolls turning in opposite directions. The seed was under gravitational pull; this force was being resisted by the normal forces and the tangential (frictional) forces. Frictional forces were limited by the normal force, the surface conditions of the sliding surfaces, and the type of material in contact. The frictional force was expressed by the following formula:

$$f = \mu n$$

Where: f = frictional force
μ = coefficient of friction
n = normal force (perpendicular to contacting surfaces)

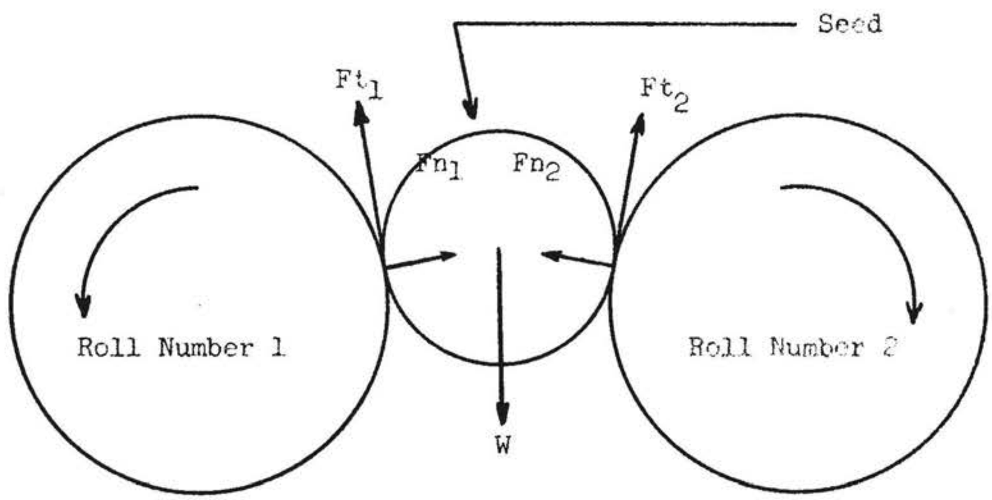
When a seed was small enough to go through the grading space between the rolls, and did go through, the normal force became zero, the frictional force became zero, and the force of gravity had no resisting force. In actual practice the seed may bounce from side to side between the roll surfaces, tending to slow the grading action. It was found, at high roll speed, that some of the seeds were thrown out of the rolls. It was hypothesized that the seeds were not registering their minimum diameter and were "shot" out of the grading area.

Figure 12 shows a condition where the frictional forces tending to lift or hold the seeds were not necessarily uniformly applied. The frictional force (Ft1) had a tendency to lift one side of the seed and to turn the seed in a clockwise direction. The frictional force associated with the stationary roll (F2) had a tendency to prevent the seed from falling through the grading area. The frictional forces were limited by the normal forces and the surface conditions. The seeds probably would have a tendency to rotate as the forces Ft 1 and F 2 would not likely be equal. Sliding friction is generally considered to be less than static friction, therefore, Ft 1 would probably be less than F 2 and the seed would be apt to rotate counter-clockwise.

Figure 13 is a force diagram for the seed as affected by the roll rotation combination number 3 (rolls turning in the same direction). The tangential force from each roll acts to turn the seed clockwise.

Figure 14 is a schematic diagram showing the grading rolls, roll spacing, and a theoretical seed in contact with the rolls. Inscribed between the roll surfaces is a circle having a diameter equal to the roll-to-roll spacing. The radii of the roll, seed, and the circle inscribed between the roll surfaces combine to form a right triangle with a 90° angle and two acute angles, A and B. The tangent to the grading roll at the seed-to-roll contact point makes an angle B^1 equal to angle B (measuring angle B^1 from the horizontal).

ROLL ARRANGEMENT NUMBER 1



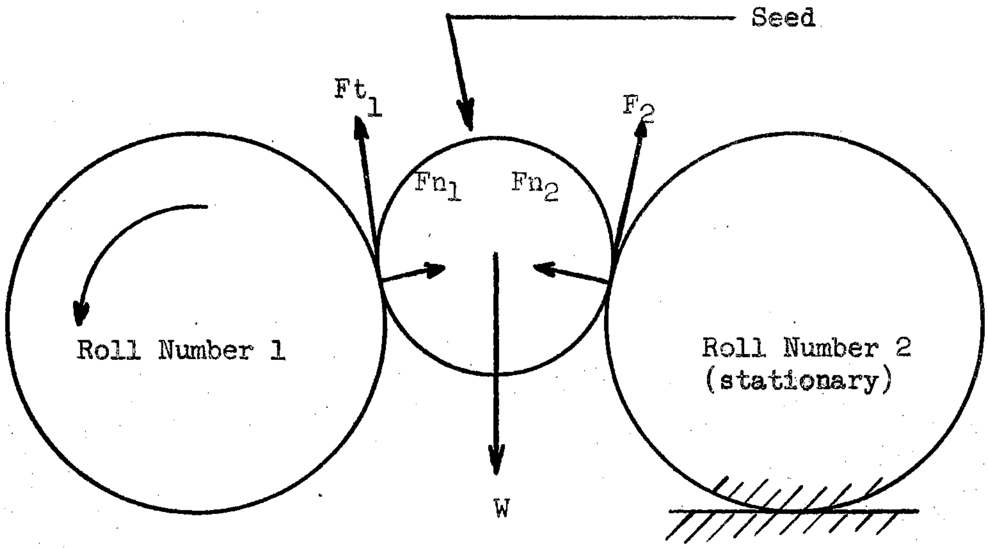
W = weight of seed

Fn (1 or 2) = normal force for rolls 1 or 2

Ft (1 or 2) = tangential force due to rotation of roll 1 or 2 (friction)

Figure 11. A force diagram of a seed or an object being graded with rolls turning in opposite directions.

ROLL ARRANGEMENT NUMBER 2



W = weight of seed

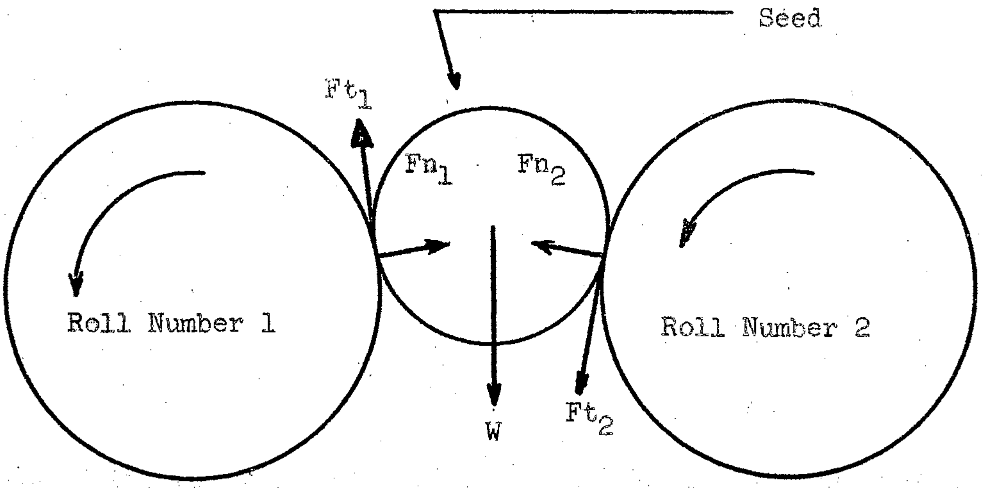
Fn (1 or 2) = normal force for rolls 1 or 2

Ft (1) = tangential force due to rotation of roll number 1 (friction)

F (2) = frictional force resisting gravitational force

Figure 12. A force diagram of a seed or an object being graded with one roll turning and one roll stationary.

ROLL ARRANGEMENT NUMBER 3



W = weight of seed

Fn (1 or 2) = normal force for rolls or 2

Ft (1 or 2) = tangential force due to rotation of roll 1 or 2 (friction)

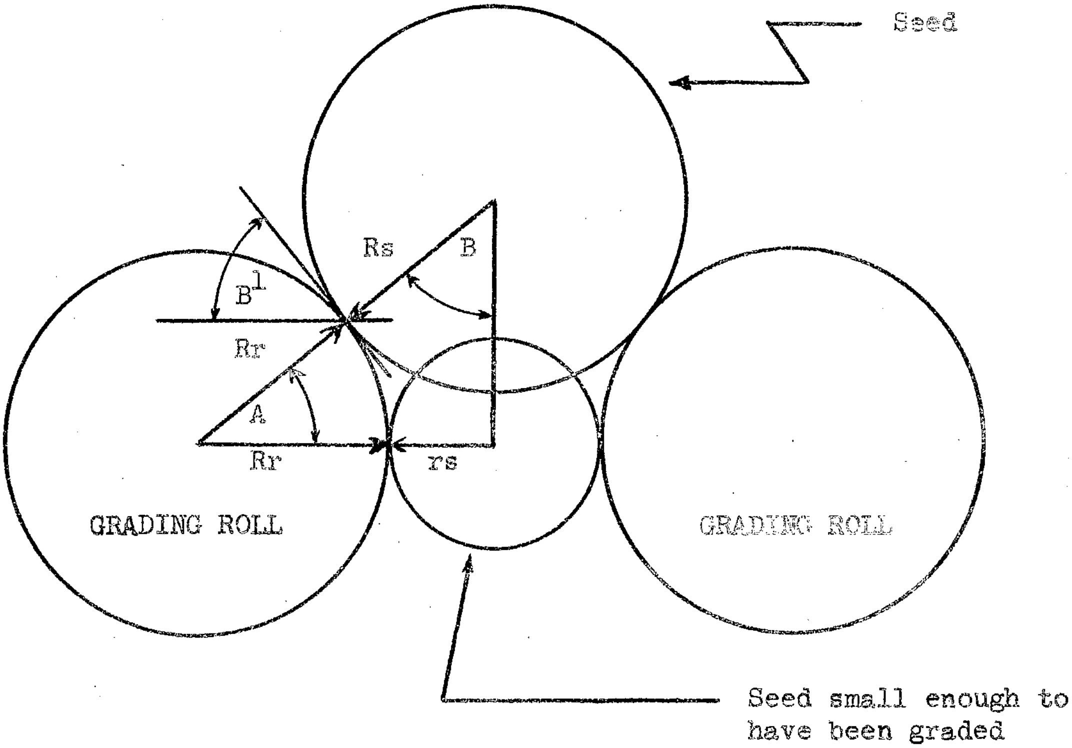
Figure 13. A force diagram of a seed or an object being graded with the rolls turning in the same direction.

Therefore, if the measure of angle A was known, angle B^1 would be equal to 90° - angle A. Angle B^1 is complementary to Angle A.

A test was conducted to determine the "angle of friction" for delinted Parrott cotton seed and shelled Argentine peanut seed. The test was based upon the hypothesis that the angle of inclination of a surface upon which a seed would start to slide depended upon the coefficient of friction. It was further hypothesized that a seed in contact with a steel roll would react in the same manner as would a seed in contact with a flat steel surface that was positioned at the same angle as a tangent to the contact point of the steel roll and seed. This was based upon the assumption that the steel roll and flat steel surface had the same steel-to-seed coefficients of friction. A flat surface of cold rolled steel was burnished with a piece of fine carborundum cloth for this determination. Appendix Data Sheet XXIV gives a tabulation of the results. The average of the trials indicated an angle B^1 of 23.04° for delinted cotton seed and an angle B^1 of 20.68° for shelled peanut seeds with no seed coat (typical for the grading accuracy tests). These values indicated a coefficient of friction (= tan angle B^1) of .4253 for delinted Parrott cotton seed and .3775 for shelled Argentine peanut seeds (with no seed coat).

This information indicated that the point of contact of the delinted cotton seed to the grading roll must be at an angle A (90° - B^1) of 66.96° or less, otherwise the seed would be lifted by the roll out of the grading area. The peanut seed must contact the grading roll at an angle A of 69.32° or less, for the same reason.

GRADING ROLL - SEED RELATIONSHIP



$$\text{Cos A} = \frac{Rr + rs}{Rr + Rs}$$

Where: Rr = Radius of smallest roll
Rs = Radius of seed to be graded
rs = Radius of spherical object (or seed) that will go between the rolls

Angle A = The angle between a line connecting the centers of the rolls and a line connecting the center of the smallest roll and the center of the seed to be graded

Angle B = Angle B^1 = 90° - Angle A

Figure 14. A schematic view of rolls and a seed subject to grading. Certain physical size relationships are given by the above trignometric function.

This would indicate, that due to the lower coefficient of friction for the peanut seeds, that the peanut seed could contact 2.36° higher on the grading rolls than the cotton seeds and still not be carried up and out of the grading area. The differing coefficients of friction for the two seed types were responsible for the differences in the theoritical limiting value of Angle A for the two seed types.

Actual test conditions can be compared to the theoretical limiting conditions (based upon their coefficients of friction). The following calculations are based upon the equation of Figure 14. The Rs values were obtained from the largest minimum seed diameters found in 400 randomly chosen seeds (Bibliography reference 10).

The equation of Figure 14 states:

$$\text{Cos A} = \frac{Rr + rs}{Rr + Rs}$$

For delinted Parrott cotton seed

Rr = 1.2812/2 = 0.6406
rs = 0.1719/2 = 0.08595
Rs = 0.2230/2 = 0.1150

$$\text{Cos A} = \frac{0.6406 + 0.08595}{0.6406 + 0.1150} = 0.96603$$

Angle A (cotton) = 14.98°

For shelled Argentine peanut seed

Rr = 1.0000/2 = 0.5000
rs = 0.3125/2 = 0.15625
Rs = 0.3330/2 = 0.1665

$$\text{Cos A} = \frac{0.5000 + 0.15625}{0.5000 + 0.16650} = 0.98462$$

Angle A (peanuts) = 10.06°

These calculations approximate actual roll grading conditions. The Rs values used for these calculations were based upon larger minimum diameter seed than were used in the grading accuracy tests. The seeds used in the grading accuracy tests were of such a size that Rs (Radius of the seed) was equal to or less than rs (radius of the roll spacing).

CHAPTER VI

PROCEDURE AND DESCRIPTION OF TESTS

A. Preliminary Investigation

Visual observations were made to determine a roll speed range that would give results showing differences in grading accuracy.

The metering device (Cole planter box) was operated at various shaft speeds and under different plate combinations to arrive at an observed upper rate of feed that would tend to over-feed the grading rolls, particularly so at the low angle and low roll speeds.

Various roll angle settings were tried in order to select the angle setting that would provide information on grading accuracy.

The observations and findings of these preliminary trials were used to set up the conditions of the tests and are described under the description of the tests.

B. Description of the Tests

Acid Delinted Cotton Seed

- Grading Accuracy Tests

Acid delinted cotton seeds of the Parrott variety were used for grading accuracy tests. The seeds for all grading accuracy tests were first graded on the basis of major diameter on the Clipper Cleaner fanning mill through a 12/64th of an inch round hole screen, but were retained on the next smaller screen having 11/64th of an inch round holes. The seeds were subsequently run through the roll grader section spaced at 11/64th of an inch. Only the seeds that went through the 11/64th of an inch roll spacing section were used for the test involving acid delinted seed.

An additional measurement was made during the grading accuracy tests. The catch-pan below the roll sections was divided into one-half inch increments such that measurements could be made as to the length of roll section necessary to accurately grade the seed. In the one foot roll section spaced 11/64th of an inch apart, there were twenty-four catch pans and in the entire length of the rolls there were a total of 49 categories. The weights of the seed in each one-half inch increment were individually recorded for each test condition of the various roll rotation combinations.

Test No. 1 - This test involved the use of two rolls turning in opposite directions, such that their adjacent surfaces were turning upward and away from the seed drop-out area.

Test No. 2 - This test differed from Test No. 1 by having only one roll turning, such that the surface adjacent to the other roll (stationary) was turning upward.

Test No. 3 - In this test both rolls were turning in the same direction.

Test conditions for the above three tests were identical. The statistical design was of a 2 x 2 x 2 factorial arrangement of eight treatments in a randomized block design having four replications. The factors involved were as follows:

Treatment No.	Roll Speed	Rate of Feed	Roll Angle
1	200 rpm	8 Cell Plate	5^{o}
2	600 rpm	8 Cell Plate	5^{o}
3	200 rpm	8 Cell Plate	15^{o}
4	600 rpm	8 Cell Plate	15^{o}
5	200 rpm	8 & 16 Cell Plates	5^{o}
6	600 rpm	8 & 16 Cell Plates	5^{o}
7	200 rpm	8 & 16 Cell Plates	15^{o}
8	600 rpm	8 & 16 Cell Plates	15^{o}

- Timing Tests

It was felt that information pertaining to the length of time required for seeds to travel along the one foot roll section might be of value in calculations for future designs. The acid delinted cotton seeds used in these tests were selected on the basis that their minor diameters were too large to allow the seed to go through the 11/64th of an inch roll spacing.

The tests were conducted on the basis of roll speed and roll angle under the test conditions as follows:

Treatment No.	Roll Speed	Roll Angle
1	200 rpm	5^{o}
2	200 rpm	10^{o}
3	200 rpm	15^{o}
4	400 rpm	5^{o}
5	400 rpm	10^{o}
6	400 rpm	15^{o}
7	600 rpm	5^{o}
8	600 rpm	10^{o}
9	600 rpm	15^{o}

The test conditions were identical for test Number 1-T (Both rolls-turning in opposite directions), 2-T (One roll turning and one roll stationary), and 3-T (Both rolls turning the same direction). Rate of feed was not a factor in the timing tests. The three tests were of a 3 x 3 factorial arrangement of the nine treatments in a randomized block design having four replications.

The seeds were placed by hand on the upper roll section. The stop watch was started as the seeds entered the roll section spaced at 11/64ths inches. After the seed had traveled the one foot length, the watch was stopped and the time was recorded. Four seeds were used, one at a time, to get a better estimate of the time required for the seeds to travel the one foot distance. The average time of the four seeds was the basis for the analysis for each test condition.

- Seed Damage Tests

In conducting the grading accuracy tests, using acid delinted Parrott cotton seed, there appeared to be some damage to the seed in the form of the seed coat having been cracked and knocked off. There had been some evidence that the acid delinted Parrott cotton seed used may not have had the acid (used in the delinting process) properly neutralized.

It was thought that the damage that was occurring in roll grading might be due entirely to a drying out of the seed coat (possibly related to excess acid), making them brittle and subject to damage. Therefore, acid delinted Acala 44 seed was used in these tests to evaluate the damage caused in the roll grading tests. No seed damage test was conducted involving the rolls turning in opposite directions as no damage was observed during grading accuracy tests. It was felt that this roll rotation combination would probably exert the least pressure on the seeds as the rolls merely supported the weight of the seed.

The selected seed, graded to over 11/64ths inches on the round hole screen and through 11/64ths inches on the roll grader was very carefully examined visually for damaged seed. The cracked seed and broken seed were removed from the sample to be used.

Three tests were designed to evaluate any damage. Damage tests were of the roll rotation combinations (1) rolls turning the same direction, and (2) one roll turning and one roll stationary, and of the (3) metering device damage.

The length of run for each treatment in tests 1 and 2 was five minutes. The seeds were caught in three categories according to each one foot roll section and the final drop-out area. The total weight of seed in each category was individually recorded; the damaged seeds were determined by visual inspection and were removed, weighed, and their weight recorded. The analysis, however, was based upon the total damage (converted to percent) that occurred for each test condition.

The test conditions for the first two seed damage tests were as follows:

Treatment No.	Roll Speed	Roll Angle	Rate of Feed
1	200 rpm	5°	8 Cell Plate
2	600 rpm	5°	8 Cell Plate
3	200 rpm	15°	8 Cell Plate
4	600 rpm	15°	8 Cell Plate
5	200 rpm	5°	16 Cell Plate
6	600 rpm	5°	16 Cell Plate
7	200 rpm	15°	16 Cell Plate
8	600 rpm	15°	16 Cell Plate

The test consisted of eight treatments in a 2 x 2 x 2 factorial arrangement in a randomized block design having four replications.

Test Number 3 concerned the damage that may have been caused by the metering device (Cole, Duplex planter box). The length of run for this test was for a one minute period for each test condition. The test involved three rates of feed, in a randomized block design having twelve replications. The test conditions were as given below.

Treatment Number	Rate of Feed
1	8 Cell Plate
2	16 Cell Plate
3	8 & 16 Cell Plates

The weight of the seed metered in a one minute period was recorded, the seed was visually checked for damaged seed, weighed, and their weight recorded. The analysis was based upon the damaged seed converted to percent.

Minor Diameter Distribution of the Acid Delinted Parrott Cotton Seed Used for Grading Accuracy Tests

The minor diameter of the seed used for the grading accuracy test was carefully measured with a micrometer. Twenty-five lots of four seeds each were randomly selected for this study. The minor diameters were recorded to the closest .001 inches. The statistics of standard deviation, mean, mode, and range were calculated as well as the frequency distribution (see Figure 23 and Table IX).

Shelled Peanut Seed

Grading Accuracy Tests

Shelled peanuts of the Argentine variety were used for a series of tests. Grading accuracy tests were conducted under the same test conditions as used in the acid delinted cotton seed tests for the purpose of determining if relative size affected grading accuracy. It was necessary to make two changes, however, in the set up. One change was to have one inch increments in the catch-pans instead of the one-half inch increments as used in the cotton seed tests. This was due to the larger size of the peanut seed and the difficulty encountered in getting the seed out of the catch pan. The other change was that of replacing the smooth steel roll used in the cotton tests with a roll that was smaller in diameter to give the proper spacing of 5/16 inches between the rolls (see Figure 6 for exact dimensions).

The seeds had been previously graded by a round hole screen at shelling time. The peanut seeds were run through the one foot roll section spaced at 5/16 inches. Any of the seeds that went on into the next section, spaced at 3/8 inches, were not used in the peanut grading accuracy tests (some of the larger seeds were retained for the timing tests). The seeds that went through the 5/16ths of an inch roll spacing provided a uniform lot of seed for the grading accuracy tests.

Grading accuracy tests were designed with the same test conditions as in the cotton seed tests in a 2 x 2 x 2 factorial arrangement of two levels of roll speed, roll angle, and rate of feed. A randomized block design having four replications was used. Roll rotation combinations used were (1) both rolls turning in opposite directions such that their adjacent surfaces turned upward and (2) one roll turning as in (1) above and the other roll stationary. The test involving the roll rotation combination of both rolls turning the same direction was abandoned because of excessive peanut seed damage (nearly 38% in one case). The length of run for each test treatment was two minutes.

Test conditions for both test (1) and (2) above were identical and were as follows:

Treatment Number	Roll Speed	Roll Angle	Rate of Feed
1	200 rpm	5°	16 Cell Plate
2	600 rpm	15°	16 Cell Plate
3	200 rpm	5°	16 Cell Plate
4	600 rpm	15°	16 Cell Plate
5	200 rpm	5°	Two - 16 Cell Plates
6	600 rpm	15°	Two - 16 Cell Plates
7	200 rpm	5°	Two - 16 Cell Plates
8	600 rpm	15°	Two - 16 Cell Plates

The weight of the seed as graded and caught in each successive one inch increment of the catch-pan was individually recorded. The weight was recorded to the nearest 0.01 gram. A measure of the required length of roll section for adequate grading was thus afforded.

As in the cotton seed tests, all peanuts should have gone through the roll section spaced at 5/16 inches. Based upon the total weight of seeds metered in a two minute period, the seeds that actually were graded in the proper roll spacing were converted to percent for the analysis.

Shelled Peanut Timing Test

Four peanut seeds that were too large to go through the 5/16 inch roll section were placed by hand, one at a time, on the upper roll section (above the roll sections spaced 5/16 inches apart). When each seed entered the 5/16 inch spacing roll section a stop watch was started; when the seed had traveled the one foot length the watch was stopped and the time was then recorded. The average of the time for the four seeds was used as the basis of the analysis for each test condition.

Test conditions were identical for the three roll rotation combinations of (1) rolls turning in opposite directions, (2) one roll turning and one roll stationary, and (3) both rolls turning the same direction. The test conditions were as follows:

Treatment Number	Roll Speed	Roll Angle
1	200 rpm	5°
2	200 rpm	10°
3	200 rpm	15°
4	400 rpm	5°
5	400 rpm	10°
6	600 rpm	15°
7	600 rpm	5°
8	600 rpm	10°
9	600 rpm	15°

Peanut Damage Tests

At the same time as the peanuts were weighed for the grading accuracy tests the damaged seeds were removed and their weight recorded. Therefore the design and randomization of treatments for the peanut damage tests were identical to the grading accuracy tests. Damages to the peanut seeds were based upon splits and broken seeds.

Test conditions for peanut damage tests were as follows:

Treatment Number	Roll Speed	Roll Angle	Rate of Feed
1	200 rpm	5°	16 Cell Plate
2	600 rpm	15°	16 Cell Plate
3	200 rpm	5°	16 Cell Plate
4	600 rpm	15°	16 Cell Plate
5	200 rpm	5°	Two-16 Cell Plates
6	600 rpm	15°	Two-16 Cell Plates
7	200 rpm	5°	Two-16 Cell Plates
8	600 rpm	15°	Two-16 Cell Plates

These conditons of the test were of a 2 x 2 x 2 factorial arrangement in a randomized block design with four replications. The roll rotation combinations were used under these test conditions made up two tests: (1) rolls turning in opposite directions, and (2) one roll turning and one roll stationary. A third test was abandoned due to excessive peanut damage (up to 38% damage in one case). The test that was abandoned consisted of a roll rotation combination having both rolls turning in the same direction. The action of the rolls on the peanut had a tendency to rotate the peanut which apparently caused excessive damage.

The peanut damage test that was actually conducted consisted of determining the damage caused by the metering device (a Cole, Duplex planter box). The peanuts were metered at two rates - (1) using one 16 cell plate and (2) using two 16 cell plates. The test design was that of a completely randomized design having twelve replications.

CHAPTER VII

PRESENTATION AND ANALYSIS OF DATA

The analyses of the data presented are, for the most part, in the form of Duncan's Multiple Range Test (9). The Multiple Range tests are for a significance at the 5% level. The original test data and analysis of variance tables are presented in the appendix.

The values given in the following tables represent the means of the observations in the test being presented. They are the average of at least four replications, and up to twelve replications. The values given in the following tables are presented in the form of graphs for ease of interpretation of Chapter VIII, Discussion of Results.

The rates of feed used for the tests were designated as low, medium, and high, for ease of presentation in place of their actual designation as 8 cell plate (low rate - 2.7#/hour), 16 cell plate (medium rate - 4.8#/hour), and 8 and 16 cell plate (high rate - 7.9#/hour) for the acid delinted cotton seed tests. In the case of the peanut seed tests the 16 cell plate was the low rate (17.1#/hour) and two 16 cell plates were designated as the high rate (32.1#/hour).

Table I is a presentation of the results of three acid delinted cotton seed grading accuracy tests as affected by roll speed, roll angle, and rate of feed. The tests differ only in the roll rotation combinations: (1) both rolls turning in opposite directions, (2) one roll turning and one roll stationary, and (3) both rolls turning in the same direction.

Table II is the result of the peanut grading accuracy tests with the treatments of roll speed, roll angle, and rate of feed as variables in each of two tests: (1) both rolls turning in opposite directions and (2) one roll turning and one roll stationary.

Tables III and IV are presentations of the results of timing tests for acid delinted cotton seeds and shelled peanut seeds, respectively. The tables present the results of three tests, each conducted with the same treatments, (roll speed and roll angle) each at three levels. The tests were concerned with different roll rotation combinations: (1) rolls turning in opposite directions, (2) one roll turning and one roll stationary, and (3) both rolls turning the same direction.

Table V gives the results of the damage (percent) to cotton seeds due to roll speed, roll angle, and rate of feed (each at two levels in three tests): (1) both rolls turning in the same direction, (2) one roll turning and one roll stationary, and (3) metering device damage.

Table VI presents the results of three tests designed to evaluate the damage to the peanuts. Two of the tests are concerned with damage caused by roll speed, roll angle and rate of feed (each at two levels) in the roll arrangement of (1) - both rolls turning in the opposite directions and (2) - one roll turning and one roll stationary. The third test evaluates damage caused by the metering device using two levels of feed rate.

Tables VII and VIII are the results of the length of roll investigations for cotton and peanut seeds, respectively. The data are presented on the basis of one-half inch increments of roll section length (for cotton) required to have graded 10%, 50%, 75%, or 90% of the seed (at a particular combination of test conditions). The peanut results are based upon one inch increments of roll length.

For certain combinations of roll speed, roll angle, and rate of feed there was no data available because not all one foot roll sections graded even as much as 50% of the seed.

Table IX presents the results of the random sampling of the acid delinted Parrott cotton seed used for the grading accuracy tests. The frequency distribution of the minor diameter of the seed is given.

TABLE I

GRADING ACCURACY OF ACID DELINTED COTTON SEED
Grading Accuracy - (Percent)

	Roll Speed	600 rpm				200 rpm			
	Roll Angle	15°		5°		15°		5°	
	Rate of Feed	Low	High	Low	High	Low	High	High	Low
Test No. 1	Treat. No.	4	8	2	6	3	7	5	1
Rolls Turning in Opposite Directions		67.01	69.85	85.84	88.94	98.48	98.69	99.41	99.75

	Roll Speed	600 rpm				200 rpm			
	Roll Angle	15°		5°		15°		5°	
	Rate of Feed	Low	High	Low	High	High	Low	Low	High
Test No. 2	Treat. No.	4	8	2	6	7	3	1	5
One Roll Turning One Roll Stationary		53.62	56.45	65.03	66.34	66.97	67.14	74.14	77.51

	Roll Speed	600 rpm				200 rpm			
	Roll Angle	15°		5°		15°		5°	
	Rate of Feed	Low	High	High	Low	Low	High	High	Low
Test No. 3	Treat. No.	4	8	6	2	3	7	5	1
Rolls Turning in Same Direction		10.38	12.20	23.70	27.54	59.78	66.49	75.46	76.60

TABLE II

GRADING ACCURACY OF SHELLED PEANUT SEED
Grading Accuracy -- (Percent)

Test No. 1	Roll Speed	600 rpm		200 rpm		600 rpm		200 rpm	
	Roll Angle	15°				5°			
	Rate of Feed	Low	High	Low	High	Low	High	High	Low
	Treat. No.	4	8	3	7	2	6	5	1
Rolls Turning in Opposite Directions		85.46	88.92	98.90	99.34	99.50	99.85	100.00	100.00

Test No. 2	Roll Speed	600 rpm			200 rpm	600 rpm	200 rpm		
	Roll Angle	15°		5°	15°	5°	15°	5°	
	Rate of Feed	Low	High	Low	Low	High	High	High	Low
	Treat. No.	4	8	2	3	6	7	5	1
One Roll Turning One Roll Stationary		86.10	87.98	97.35	97.55	98.51	99.40	99.94	100.00

Test No. 3*

Rolls Turning in Same Direction

*Test abandoned due to excessive seed damage.

TABLE III

TIMING OF ACID DELINTED COTTON SEED
Time To Travel One Foot - (Seconds)

Test No. 1										
	Roll Speed	600	400	600	400	200	600	200	400	200
	Roll Angle	15°	15°	10°	10°	15°	5°	10°	5°	5°
	Treat. No.	9	6	8	5	3	7	2	4	1
Rolls Turning in Opposite Directions		0.64	1.10	1.27	2.14	2.32	2.72	4.37	4.64	8.74

Test No. 2										
	Roll Speed	600	400	600	200	400	600	200	400	200
	Roll Angle	15°	15°	10°	15°	10°	5°	10°	5°	5°
	Treat. No.	9	6	8	3	5	7	2	4	1
One Roll Turning One Roll Stationary		1.78	1.91	2.45	3.33	3.26	5.13	5.19	6.87	12.81

Test No. 3										
	Roll Speed	600	400	600	400	200	600	200	400	200
	Roll Angle	15°	15°	10°	10°	15°	5°	10°	5°	5°
	Treat. No.	9	6	8	5	3	7	2	4	1
Rolls Turning in Same Direction		1.07	1.40	1.92	2.29	2.66	4.20	4.65	4.74	6.88

TABLE IV

TIMING OF SHELLED PEANUT SEED
Time To Travel One Foot - (Seconds)*

Test No. 1	Roll Speed	600	600	400	200	600	400	200	400	200
	Roll Angle	15°	10°	15°	15°	5°	10°	10°	5°	5°
	Treat. No.	9	8	6	3	7	5	2	4	1
Rolls Turning in Opposite Directions		0.60	0.90	0.90	2.04	2.40	2.46	3.84	3.90	8.34

Test No. 2	Roll Speed	600	400	600	400	200	600	200	400	200
	Roll Angle	15°	15°	10°	10°	15°	5°	10°	5°	5°
	Treat. No.	9	6	8	5	3	7	2	4	1
One Roll Turning One Roll Stationary		0.96	1.32	1.74	2.70	3.12	3.60	4.86	6.54	12.00

Test No. 3	Roll Speed	600	400	600	400	200	600	400	200	200
	Roll Angle	15°	15°	10°	10°	15°	5°	5°	10°	5°
	Treat. No.	9	6	8	5	3	7	4	2	1
Rolls Turning in Same Direction		0.60	0.60	0.90	1.38	1.92	2.04	2.76	6.06	13.56

*Converted from original time (in minutes) to seconds.

TABLE V

DAMAGE OF ACID DELINTED COTTON SEED
Damage - (Percent)

	Roll Speed	200 rpm		600 rpm		200 rpm		600 rpm	
	Roll Angle	15°	5°	5°	15°	5°	15°	5°	15°
	Rate of Feed	High				Low			
Test No. 1	Treatment No.	7	5	6	8	1	3	2	4
Rolls Turning in Same Direction		.370	.385	.417	.487	.572	.577	.582	.607

	Roll Speed	600 rpm		200 rpm		600 rpm	200 rpm	600 rpm	200 rpm
	Roll Angle	15°	5°	5°	15°	15°	5°	5°	15°
	Rate of Feed	High				Low			
Test No. 2	Treat. No.	8	6	5	7	4	1	2	3
One Roll Turning One Roll Stationary		.317	.447	.457	.560	.592	.860	.882	.977

	Rate of Feed	Med.	Low	High
Test No. 3	Treat. No.	2	1	3
Metering Box Damage		.649	.714	.749

TABLE VI

DAMAGE OF SHELLED PEANUT SEED
Damage - (Percent)

Test No. 1									
	Roll Speed	200 rpm		600 rpm			200 rpm	600 rpm	200 rpm
	Roll Angle	15°	15°	5°	5°	15°	5°	15°	5°
	Rate of Feed	Low	High	High	Low	Low	Low	High	High
	Treat. No.	3	7	6	2	4	1	8	5
Rolls Turning in Opposite Directions		0.00	0.07	0.09	0.13	0.18	0.19	0.22	0.41

Test No. 2									
	Roll Speed	200 rpm				600 rpm			
	Roll Angle	5°		15°		5°		15°	
	Rate of Feed	Low	High	Low	High	Low	High	High	Low
	Treat. No.	1	5	3	7	2	6	8	4
One Roll Turning One Roll Stationary		0.05	0.19	0.19	0.23	0.35	0.56	0.68	0.92

Test No. 3			
	Rate of Feed	High	Low
	Treat. No.	2	1
Metering Box Damage		.28	.39

TABLE VII

LENGTH OF ROLL COMPARISONS FOR ACID DELINTED COTTON SEED
Percent Seed Graded by Increments of Roll Length
(Table Values are Percent)

	Rate of Feed	Low				High			
	Roll Angle	5°		15°		5°		15°	
	Roll Speed	200	600	200	600	200	600	200	600
Test No. 1	Treat. No.	1	2	3	4	5	6	7	8
Rolls Turning in Opposite Directions	Roll Length Inches								
	0 - 1	72.96	26.97	10.67	.10	73.65	30.48	8.28	.05
	1 - 2	19.14	24.56	52.50	3.90	18.25	25.31	57.17	3.59
	2 - 6	6.86	23.61	31.64	43.93	6.85	23.62	29.99	47.92
	6 - 12	.69	10.65	3.63	19.05	.59	9.44	3.19	18.24
	0 - 12	99.65	85.79	98.44	66.98	99.34	88.85	98.63	69.80
Test No. 2									
One Roll Turning One Roll Stationary	0 - 1	47.27	34.81	30.65	9.06	48.31	32.01	29.88	13.46
	1 - 2	11.72	13.09	18.59	17.27	15.48	15.16	19.07	16.81
	2 - 6	6.83	11.48	13.25	18.33	7.40	13.36	13.19	17.87
	6 - 12	8.26	5.64	4.58	8.95	6.49	5.57	4.90	8.23
	0 - 12	74.08	65.02	67.07	53.61	77.68	66.10	67.04	56.37
Test No. 3									
Rolls Turning in Same Direction	0 - 1	35.14	2.29	12.26	.21	27.91	1.65	12.26	.37
	1 - 2	14.84	3.25	14.08	.94	16.07	2.88	14.77	.83
	2 - 6	17.13	11.27	21.10	3.43	20.56	8.87	24.68	4.60
	6 - 12	9.46	10.82	12.16	5.82	10.97	10.28	14.82	6.39
	0 - 12	76.57	27.63	59.60	10.40	75.51	23.68	66.53	12.19

TABLE VIII

LENGTH OF ROLL COMPARISONS FOR SHELLED PEANUT SEED
Percent Seed Graded by Increments of Roll Length
(Table Values are Percent)

	Rate of Feed	Low				High			
	Roll Angle	5°		15°		5°		15°	
	Roll Speed	200	600	200	600	200	600	200	600
Test No. 1	Treat. No.	1	2	3	4	5	6	7	8
Rolls Turning in Opposite Directions	Roll Length Inches								
	0 - 1	95.71	48.18	2.75	.00	59.68	37.19	9.83	.03
	1 - 2	3.37	38.15	81.95	4.44	35.24	49.01	69.19	6.05
	2 - 6	.86	12.16	12.51	63.67	4.88	13.14	19.26	69.46
	6 - 12	.06	.95	1.68	17.44	.22	.51	1.05	14.14
	0 - 12	100.00	99.44	98.89	85.55	100.02	99.85	99.33	89.68
Test No. 2									
One Roll Turning One Roll Stationary									
	0 - 1	64.43	42.11	5.08	1.27	52.54	35.57	6.95	1.11
	1 - 2	28.90	31.35	62.10	45.80	38.43	36.21	54.13	44.91
	2 - 6	6.54	20.40	27.78	29.75	8.88	23.39	36.61	31.74
	6 - 12	.12	3.46	2.59	9.22	.07	3.34	1.71	10.20
	0 - 12	99.99	97.32	97.55	86.04	99.92	98.51	99.40	87.96
Test No. 3*									
Rolls Turning in Same Direction									

*Test abandoned due to excessive seed damage.

TABLE IX

MINOR DIAMETER DISTRIBUTION OF ACID DELINTED COTTON SEED 1/

Minor Diameter - (Inches)

Class Boundaries	Class Midpoint	Frequency (f) 2/	Relative Frequency- (f/n) 3/	Cumulative Frequency (C.F.) 4/
.1275 - .1325	.130	2	.02	2
.1325 - .1375	.135	3	.03	5
.1375 - .1425	.140	3	.03	8
.1425 - .1475	.145	6	.06	14
.1475 - .1525	.150	8	.08	22
.1525 - .1575	.155	24	.24	46
.1575 - .1625	.160	18	.18	64
.1625 - .1675	.165	22	.22	86
.1675 - .1725	.170	14	.14	100

1/ From 100 randomly chosen acid delinted Parrott cotton seeds that had been graded to over 11/64 inches major diameter with a round hole screen and subsequently graded to through 11/64 inches in minor diameter on a roll grader. (See data sheet XXIII in appendix).

2/ Frequency (f) is the number of seeds that were in a particular class boundary.

3/ n = 100 seeds, f/n = Frequency/(n=100).

4/ Cumulative Frequency - (C.F.) is the summation of successive f values.

CHAPTER VIII

DISCUSSION OF RESULTS

The discussion of the results will primarily be based upon Figures 15 through 23. The graphs (Figures) were plotted from data given in Tables I through IX. The plotted points were the means of several observations (replication).

OBJECTIVE A - GRADING ACCURACY

Figures 15, 16, and 17 were from grading accuracy tests involving the roll rotation combinations of (1) one roll turning in opposite directions - Figure 15, (2) one roll turning and one roll stationary - Figure 16, and (3) both rolls turning the same direction. The data has been plotted in three combinations for comparison of various attributes.

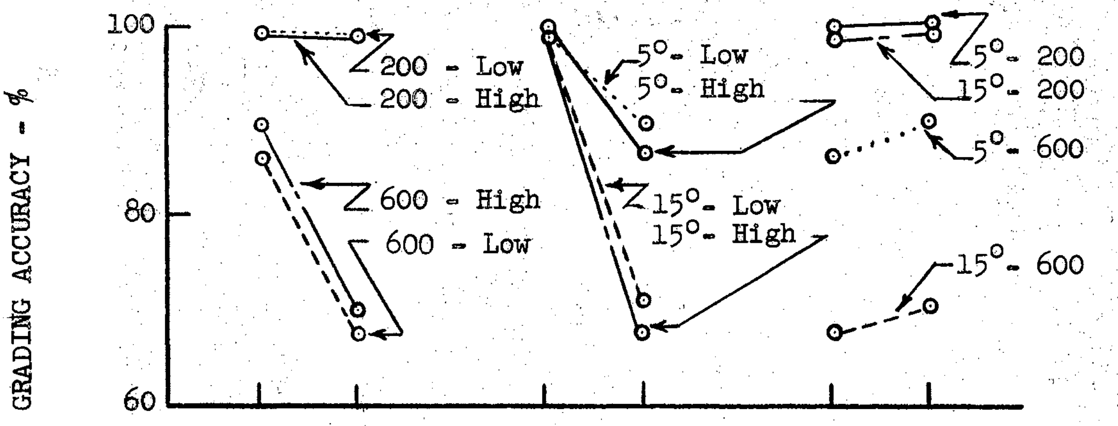
Rolls Turning in Opposite Directions

The grading accuracy graphs for the delinted cotton seed are shown in Figure 15 at the top of the page with the peanut results plotted at the bottom of the page. It was noted that the grading accuracy was consistently reduced for both seed types by higher roll speed, or by a combination of high roll speed and a steep roll angle. This was as would be expected as the faster roll speed, the steeper roll angle, or a combination of both, decreased the length of time the seeds were on the roll grading section. Therefore,

GRADING ACCURACY TEST

ROLLS TURNING IN OPPOSITE DIRECTIONS

Cotton Seed Grading Accuracy Test



Peanut Seed Grading Accuracy Test

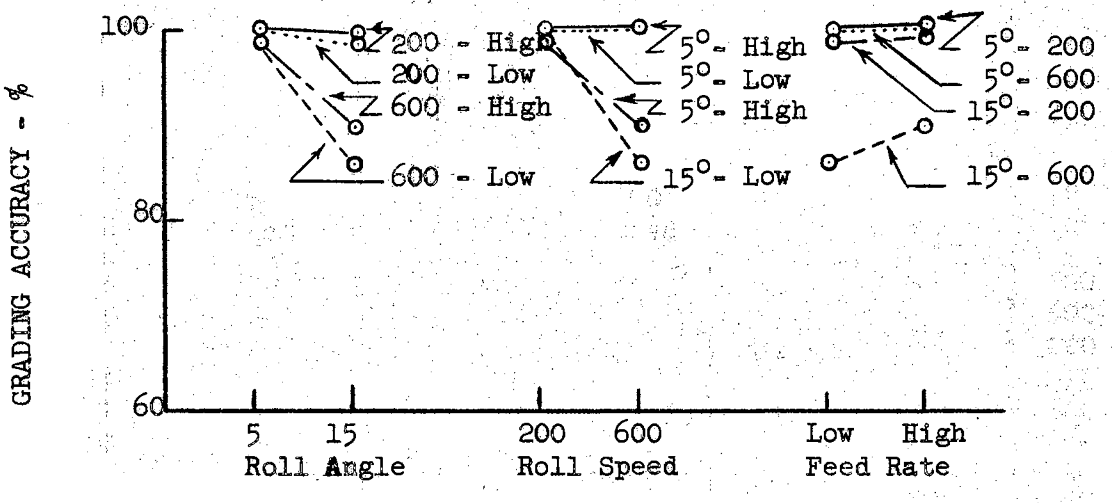


Figure 15. Grading accuracy tests involving the roll rotation combination of <u>rolls turning in opposite direction</u> (cotton seed grading accuracy test results at the top and peanut seed grading accuracy test results at the bottom of the page).

the seeds actually had less opportunity to have been graded. The roll angle had less influence on grading accuracy than did roll speed. This was due to the fact that the steepest angle used in this test (15^{o}) was not steep enough to allow the gravitational force component, parallel to the roll axis, to overcome frictional forces tending to retard the movement of the seed down the roll.

There were no significant differences in grading accuracy for the cotton or peanut seeds due to the rate of feed. There was a consistent trent toward higher grading accuracy at the high rate of feed. This was considered to be due to the fact that the high metering rate caused seed to pile up and as they came in contact with the roll grading area the seeds on top would tend to force the bottom seeds through the open space.

The adverse effect of a high roll speed and a steep angle were not as pronounced for peanut seed as compared to the cottonseed. It was concluded that this was due to a lower coefficient of friction for the peanut seed (as compared to that of the delinted cotton seed). There was very little difference in grading accuracy between the delinted cotton seed and the shelled peanut seed at the low roll speeds and low roll angle, in this case the grading accuracy was relatively high.

One Roll Turning and One Roll Stationary

Figure 16 is a graph showing the results of grading accuracy tests involving a roll rotation combination of one roll turning and one roll stationary for delinted cotton seed and shelled peanut seed.

GRADING ACCURACY TESTS

ONE ROLL TURNING, ONE ROLL STATIONARY
Cotton Seed Grading Accuracy Test

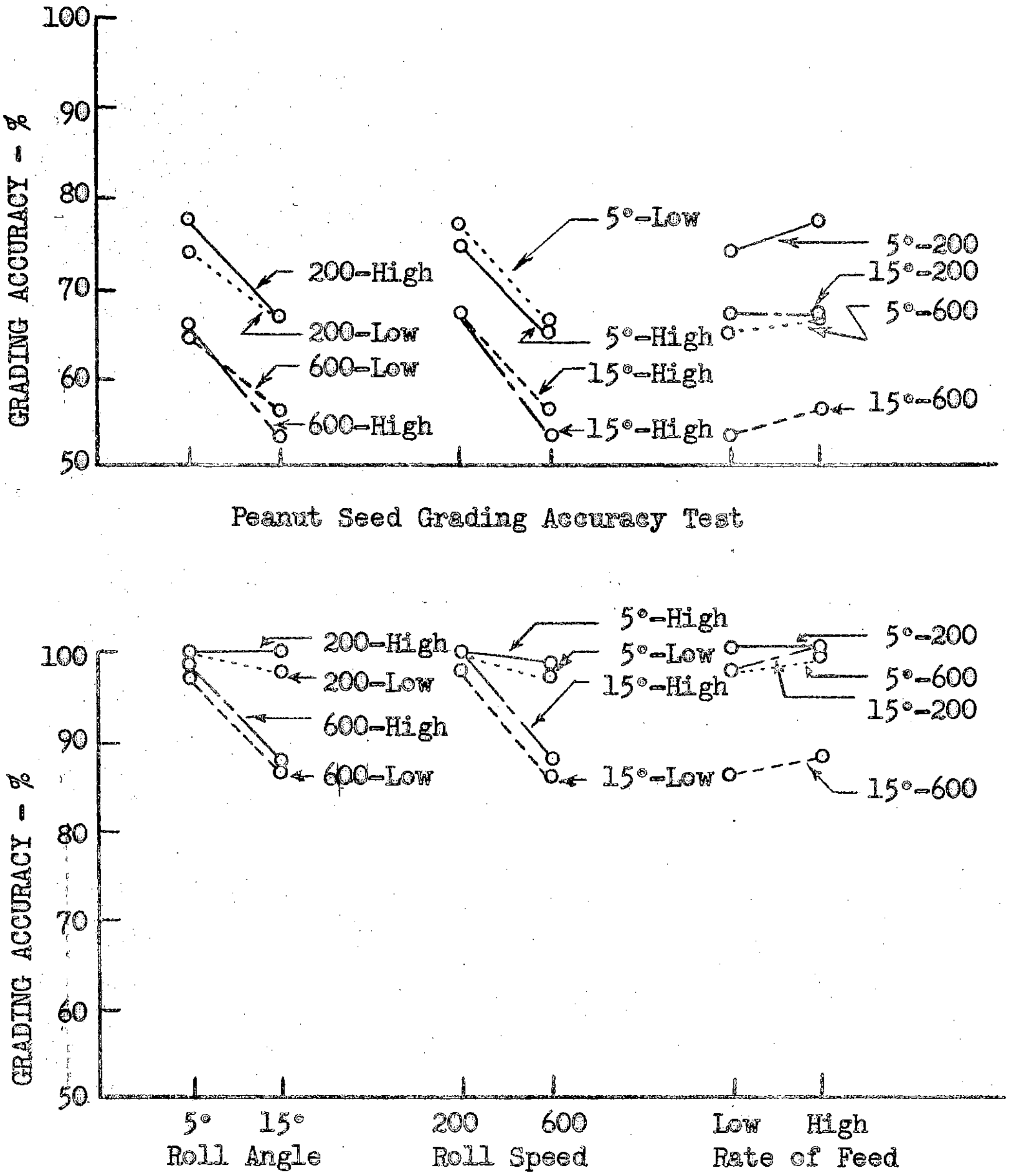


Figure 16. Grading accuracy tests involving the roll rotation combination of <u>one roll turning-one roll stationary</u>. Cotton seed grading accuracy test results are at the top of the page and peanut seed grading accuracy tests results are at the botton of the page.

This graph indicated that the steeper roll angle had about the same influence on grading accuracy that the higher roll speed does. The grading accuracy for the delinted cotton seed had been materially reduced when compared to the roll arrangement of Figure 15. The grading accuracy for the peanut seed did not seem to have been changed much from the peanut results of Figure 15. Again the differences between the two seed types were assumed to be associated with their coefficients of friction.

The higher rate of feed had a definite tendency to have a higher grading accuracy than did the low rate of feed. This held true, as in Figure 15, for both types of seed. The excess of seeds was thought to force some of the seeds through faster.

The roll speed of 200 rpm for the peanut seeds had an accuracy approaching 100% regardless of the rate of feed or roll angle.

Rolls Turning in the Same Direction

Figure 17 is a graph showing the results of the delinted cotton seed test involving a roll rotation combination of rolls turning in the same direction (the peanut seed test of the same treatments was abandoned). In this particular roll combination the graph showed that the steeper angle (15°) materially reduced the grading accuracy, particularly when associated with the higher roll speed (600 rpm). Rate of feed had less influence than did roll speed or roll angle. The high rate of feed had a tendency (not significant) to have higher grading accuracy when associated with the steeper angle (15°) than did the slow rate of feed. This was

GRADING ACCURACY TEST

ROLLS TURNING THE SAME DIRECTION
Cotton Seed Grading Accuracy Test

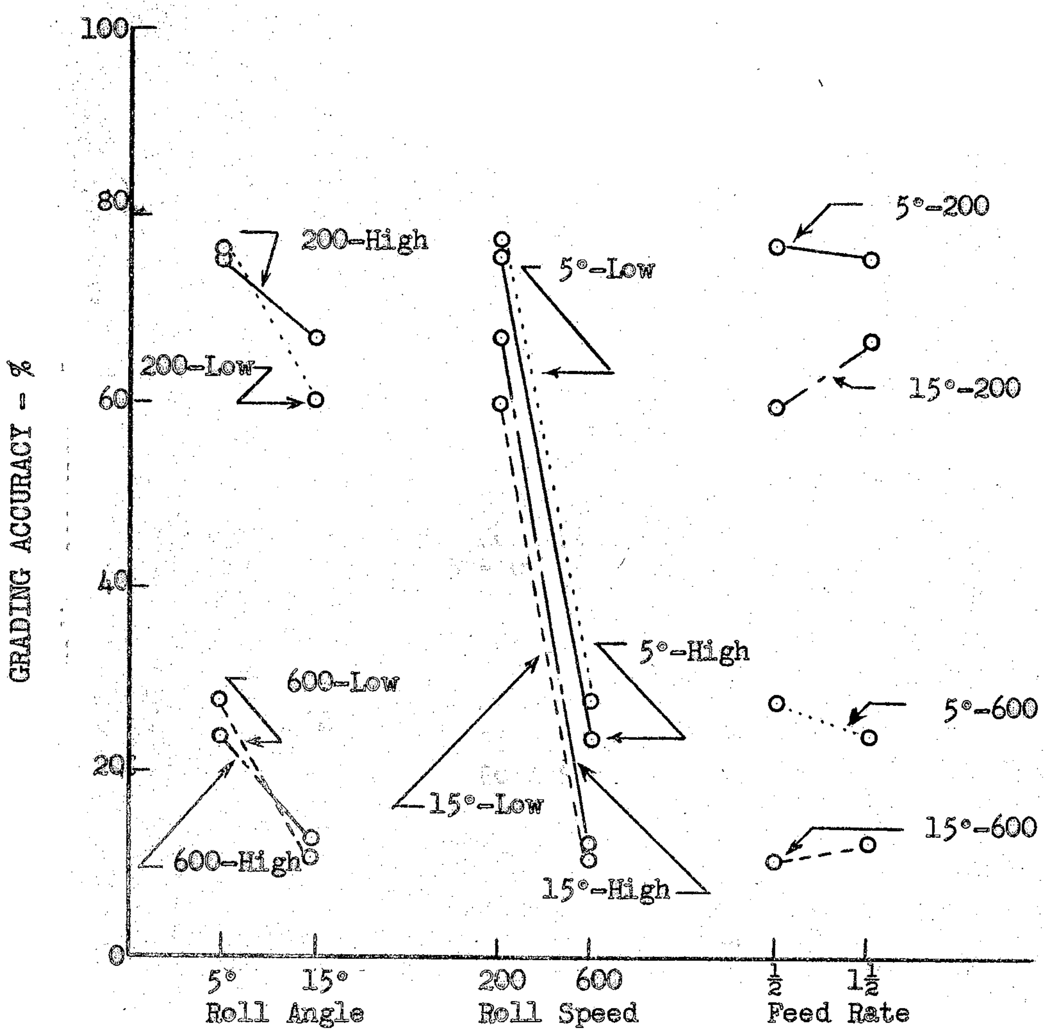


Figure 17. Grading accuracy tests results for acid delinted cotton seed involving a roll rotation combination of two rolls turning in same direction.

thought to be associated with the increased physical contact of seed upon seed that would not occur at the lower feed rate.

This particular roll rotation combination appeared to be the most sensitive of the roll combinations to the adverse effect of increased roll angle and speed. The lowest grading accuracy for any treatment in all roll combinations occurred in this particular test (10.38% as compared to 53.62% for the lowest in another roll arrangement test).

OBJECTIVE B - EFFECT OF RELATIVE SEED SIZE

The effect of the relative seed size on grading accuracy was related to the contact point of the seed with the roll surface. As seed size increased the seed contacted the roll surface at points closer and closer to the top of the roll (under conditions of fixed roll size and roll spacing).

It was concluded from the information obtained that the peanut seeds should have a higher grading accuracy for two reasons. One reason advanced was the lower coefficient of friction (.3775 compared to .4253) and the second reason was based upon the lower angle of contact of the peanut seed with the roll surface (Angle A peanuts = 10.06° compared to 14.98° for delinted cotton seed). Theoretical calculations indicated that the peanut contact point was within 59.26° ($69.32^{\circ} - 10.06^{\circ}$) of reaching the limiting point. The cotton seed contact point was within 51.98° ($66.96^{\circ} - 14.98^{\circ}$) of the limiting point. Therefore, the cotton seed contact point with the roll was 7.28° closer to the limiting condition than was the peanut seed.

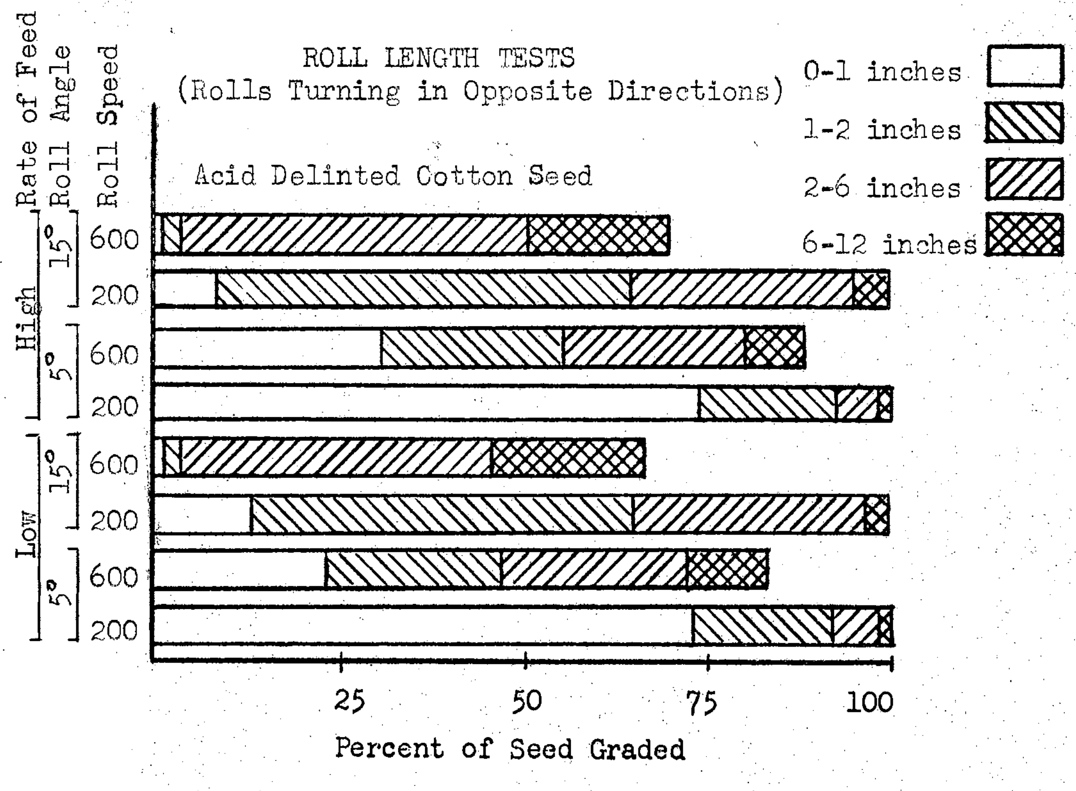
The relative seed size would be important under conditions of fixed roll size and roll spacing. However, the seed size was not critical in this study due to the changes in roll size and roll spacing.

OBJECTIVE C - GRADING ROLL LENGTH

Figures 18, 19, and 20 are plotted from data given in Tables VII and VIII (Table VII concerns delinted cotton seed and Table VIII concerns shelled peanut seed).

The lengths of roll section as plotted were arbitrarily selected at 0 to 1 inch, 1 to 2 inches, 2 to 6 inches, and 6 to 12 inches to present a relative idea of the effect of roll length increments on grading percent. The total length of each section (0-12) indicated precisely the total percent of the seed graded in twelve inches of roll length. The increments of roll length must be compared on the abscissa scale starting at the extreme left (0).

For example, in Figure 18, the bottom bar of the peanut test results, one would determine that approximately 95% of the peanut seeds were graded in the first inch of roll length. The 1 to 2 inch roll segment graded 3% of the seeds, or, in other words, the first two inches of roll length had graded approximately 98% of the seeds. It would appear that each of the two final increments of roll length (2 to 6 inches and 6 to 12 inches) had each graded 1% of the peanut seeds. 100% of the seeds were graded in the 12 inch roll length. Actual plotted values for the peanut results were listed in Table VIII.



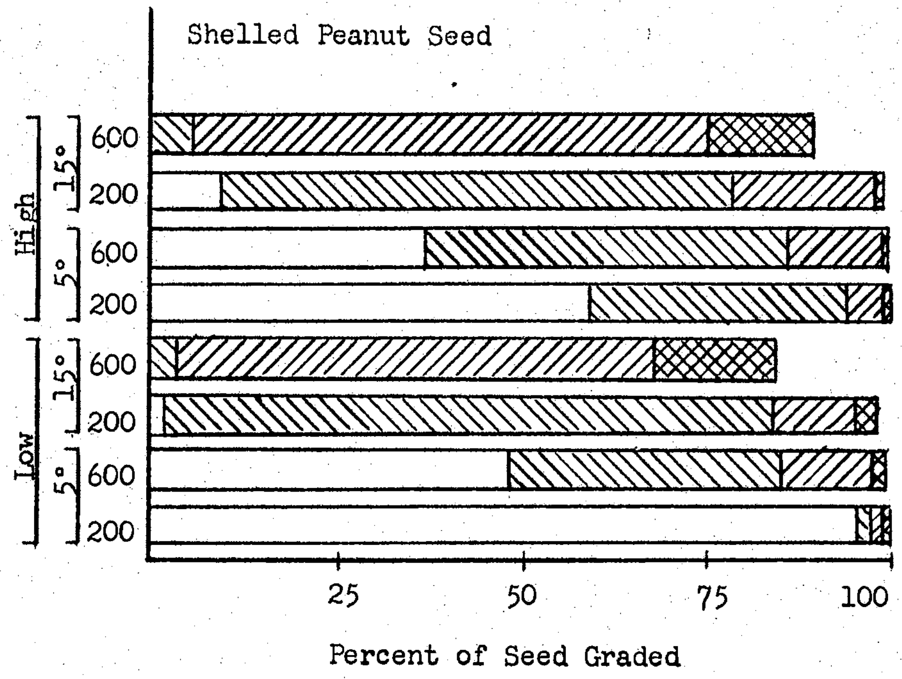


Figure 18. Graphs showing the relative amounts (%) of seed graded in a certain roll length for various combinations or roll speed, roll angle, and rate of feed for <u>rolls turning in opposite direction.</u> The cotton seed results are given above and the peanut seed results are given below.

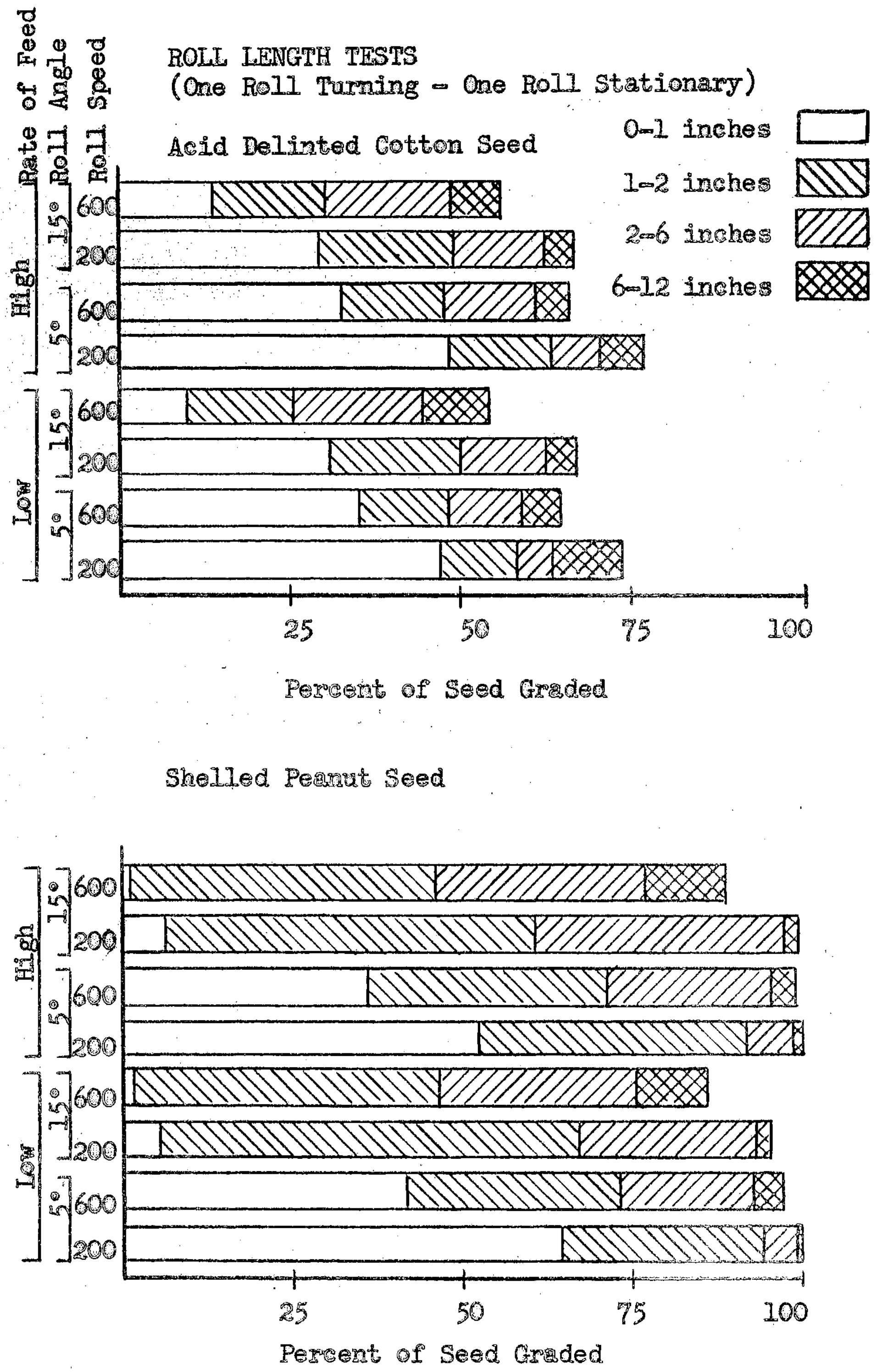


Figure 19. Graphs showing the relative amounts (%) of seed graded in a certain roll length for various combinations of roll speed, roll angle, and rate of feed for <u>one roll turning and one roll stationary</u>. The cotton seed results are given above and the peanut results are given below.

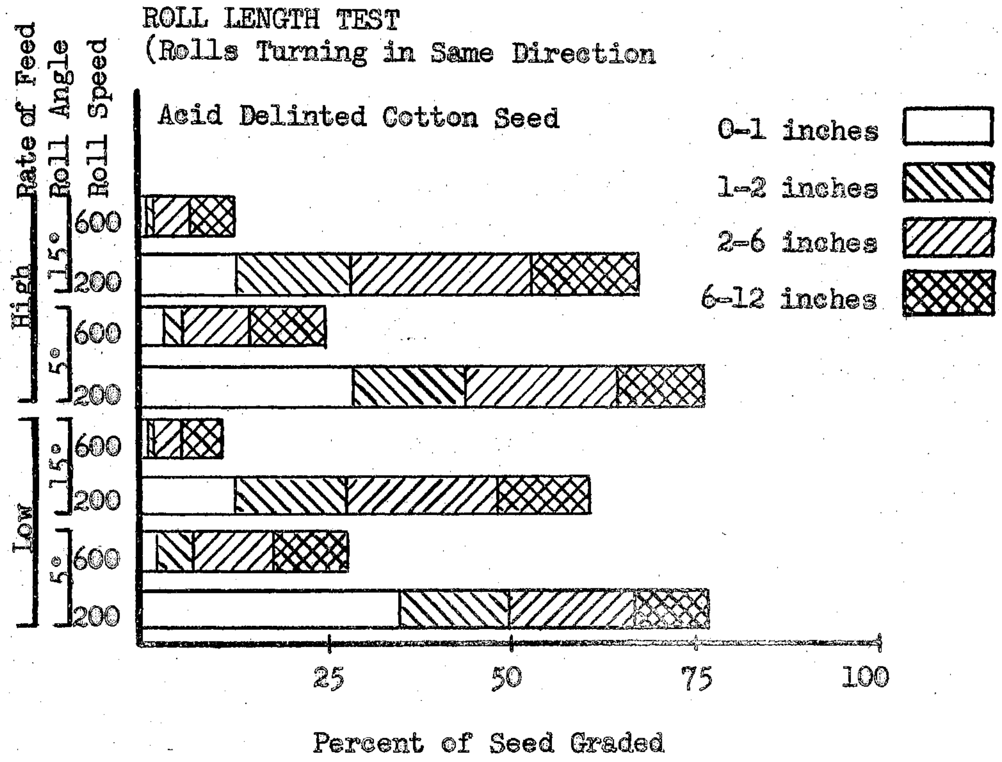


Figure 20. A graph showing the relative amounts (%) of acid delinted cotton seed graded in a certain roll length for various combinations of roll speed, roll angle, and rate of feed for rolls turning in the same direction.

Figure 18 relates to the roll rotation combination of rolls turning in opposite directions, Figure 19 refers to the roll arrangement of one roll turning and one roll stationary, and Figure 20 refers to the roll arrangement of rolls turning in the same direction.

Rolls Turning in Opposite Directions

In Figure 18 some of the effects of the differences between the delinted cotton seeds and the shelled peanut seeds were shown by the length of roll section required to have graded the same percentage of seed. The delinted cotton seed consistently required as much or more roll length to have graded the same percent of seeds. This was associated with the differences in their coefficients of friction as well as their roll contact angle (related to seed size, roll size, and roll spacing.

The detrimental effect of increased roll speed was particularly noticeable for the smaller of the two seed types (delinted cotton) when associated with the rolls turning in opposite directions. This was discussed under the effect of relative seed size and attributed to the coefficient of friction and roll contact angle. The twelve-inch roll section graded less than 90% of the delinted cotton seed at the 600 rpm roll speed and 5° roll angle, and less than 57% of the seeds at 600 rpm and the 15° roll angle.

The peanut seed generally performed as well or better under similar test conditions than did the delinted cotton seed. Roll speed affected the required roll length but the combination of roll speed and a steep roll angle had a more pronounced effect. The higher rate of feed contributed to a slightly higher percent of seed being graded at the 600 rpm roll speed and the 15° roll angle when compared to the low rate of feed under similar test conditions (4 percentage points).

One Roll Turning - One Roll Stationary

Figure 19 is a graph showing the results associated with this roll rotation combination. The delinted cotton seed required twelve or more inches of roll length to grade 75% of the seed, regardless of the roll speed, roll angle, or rate of feed. The low angle and the low rpm (200) required less roll length to do a comparable percentage of grading.

Again the shelled peanuts required less roll length under similar conditions than did the delinted cotton seed to the same job; at least 90% of the peanut seeds were graded in five inches of roll length, except for the most adverse condition of 600 rpm and a 15° roll angle (under both feed rates). Under those conditions, 75% of the peanut seeds were graded with a length of six inches for the low rate of feed and a length of five inches for the high rate of feed.

Rolls Turning in the Same Direction
(Delinted Cotton Seed Only)

Figure 20 is a graph of the delinted cotton seed test only. (The peanut test had too great a seed damage and was abandoned). This roll rotation combination was the most exacting in terms of roll length, that is, longer lengths of roll section were required to grade comparable quantities of cotton seed under similar test conditions. In the most extreme cases only 10 percent to 12 percent of the seed conveyed over the twelve inch roll section was graded (600 rpm, 15°, and both rates of feed). The high rate of feed for the 600 rpm and 15° angle graded slightly more seed than did the low rate of feed (2 percentage points).

OBJECTIVE D - SEED TRAVEL TIME

Figure 21 is a graph showing the relationship of length of seed travel time for the various treatments involving delinted

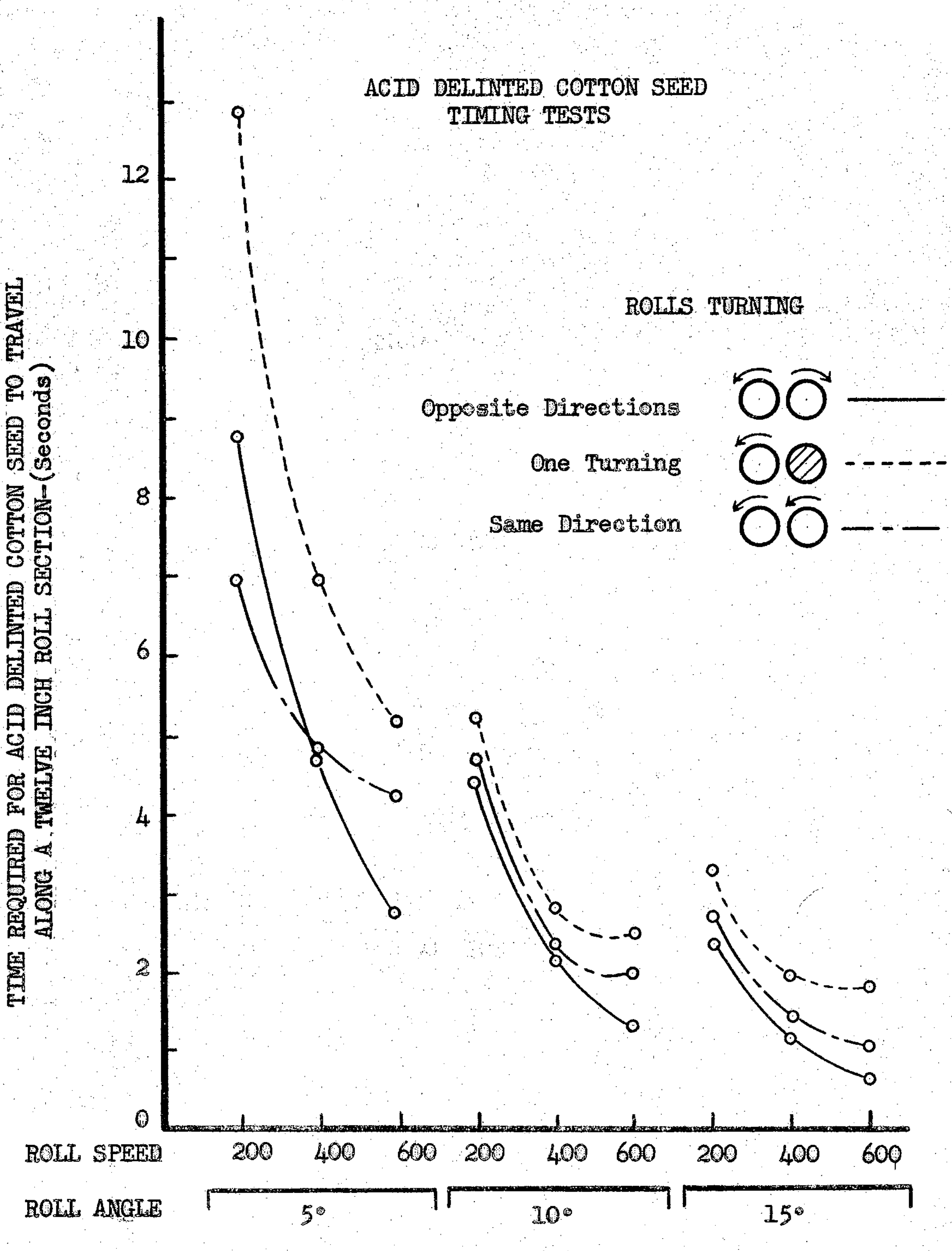


Figure 21. A graph showing the effect of various combinations of roll speed and roll angle of the length of time required for acid delinted Parrott cotton seeds to travel along a twelve inch section of a roll grader.

cotton seed. Figure 22 shows the similar test results associated with shelled peanut seeds.

No apparent, striking differences were shown between the delinted cotton seed timing results and the shelled peanut tests as seen by comparing Figure 21 with 22. There was a definite trend shown, in that the delinted cotton seeds, generally speaking, required more time to travel the twelve inch length of roll section. There were twenty-seven possible comparisons for the cotton and peanut seeds in the three roll arrangement timing tests with nine identical treatments. There were only three out of the twenty seven comparisons where the peanut seeds took more time than the cotton seeds did. It was concluded that differences were due to their respective coefficients of friction. Under similar test conditions the trend was generally the same for the two seed types. The 5° roll angle took the most time, but the time required decreased with an increase in roll speed. This relationship held true for the 10° and the 15° roll angles, also. The 15° roll angle took less time than did the 10° roll angle. The plotted points for each roll rotation combination generally followed the equation $Y = a + bx + cx^2$. The one exception was the roll rotation combination of rolls turning in opposite direction for the peanut timing test at the 10° angle. This particular combination seemed to follow a linear relationship of the general equation of $Y = a + bx$. (equations for some of the curves were calculated but were thought to be of no general value as they apply only to these test conditions).

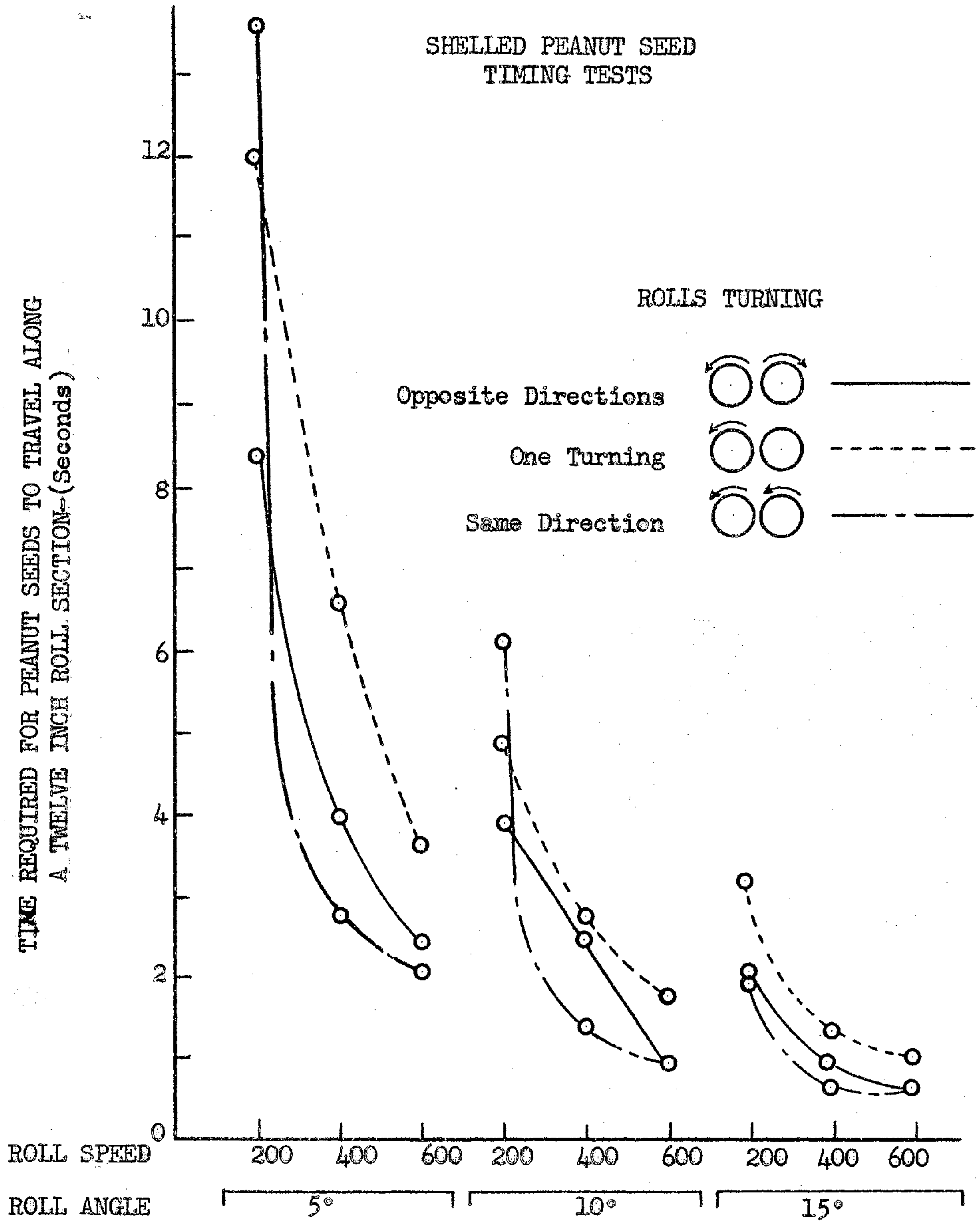


Figure 21. A graph showing the effect of various combinations of roll speed and roll angle on the length of time required for shelled Argentine peanut seeds to travel along a twelve inch section of a roll grader.

OBJECTIVE E - MINOR DIAMETER OF DELINTED COTTON SEEDS

One hundred Parrott cotton seeds were selected at random from the seeds used in grading accuracy tests. Figure 23 is a frequency polygon of the minor diameter distribution as plotted from the data found in Table IX. The measured seed data was placed in Appendix Data Sheet XXIII.

The "mode" or seed size group most often represented in population was associated with the class midpoint of .155 inches (.1525 to .1575 inches). The mean minor diameter of the one hundred seeds was .158 inches. The seeds ranged in size from .130 inches in minor diameter to .171 inches in minor diameter. This was a difference of .041 inches. The median was .159 inches. The standard deviation of the one hundred seeds was calculated to be .010 inches.

OBJECTIVE F - SEED DAMAGE

Tables V and VI show the delinted cotton seed and shelled peanut seed damage, respectively. These determinations were taken because of a suspected difference in damage to the seed caused in grading. Damage of the seeds did not get as high as 1% in the tests completed. The peanut tests involving the roll rotation combination of the rolls turning in the same direction was abandoned due to excessive seed damage (up to 38%).

There were no significant differences in damage to the delinted cotton seed among the treatments. The total range from

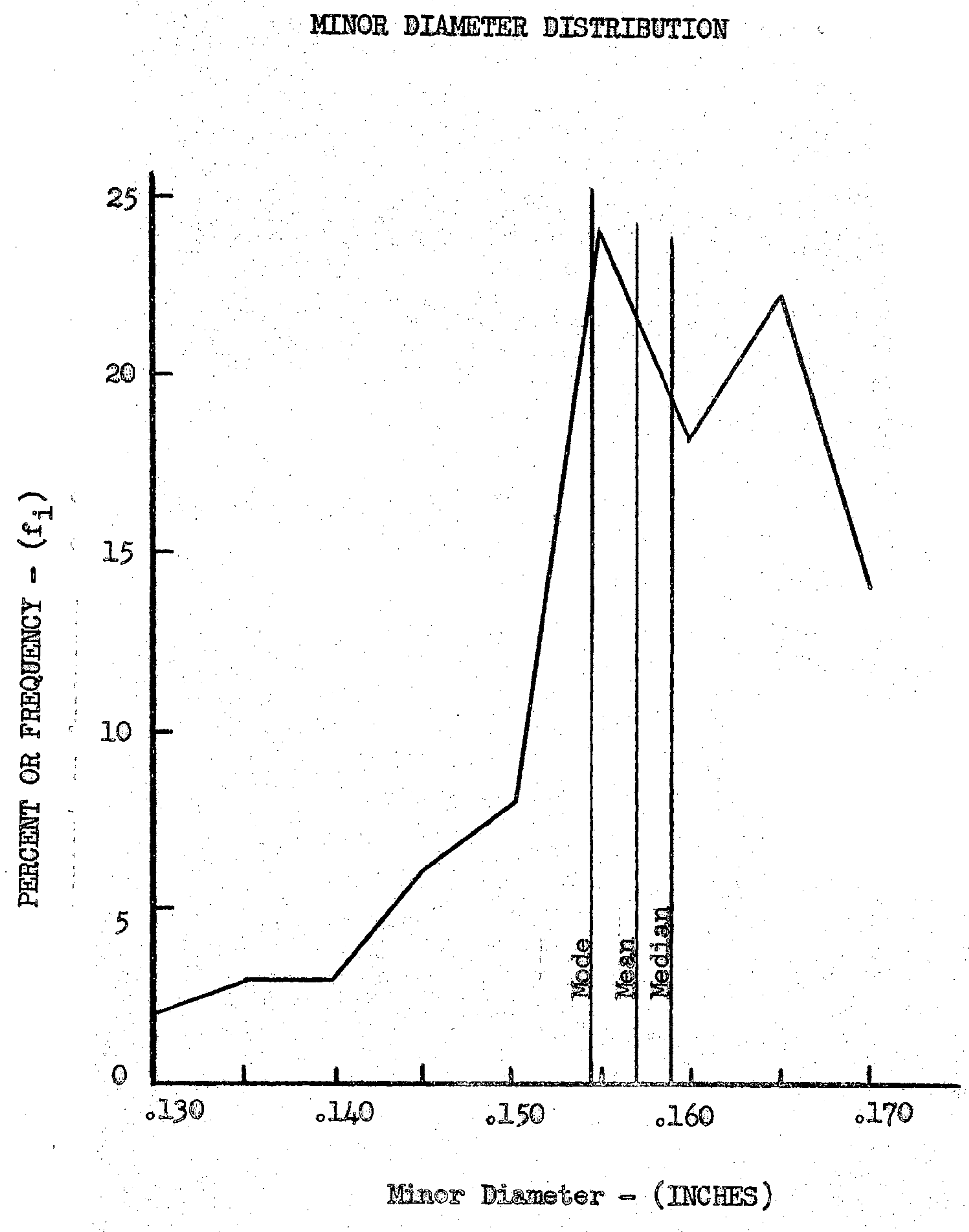


Figure 23. A frequency polygon illustrating the distribution of minor diameter of the acid delinted cotton seeds used in the grading accuracy test.

the lowest to highest was .61 percentage points. There was a trend that indicated that the damage caused by grading was associated with the low rate of feed, this again could have been related to metering. The roll rotation combination of one roll turning-one roll stationary generally had higher seed damage than did the combination of rolls turning the same direction.

The peanut seed damage for the roll rotation combination of rolls turning in opposite directions did not have a distinguishable trend even though there were significant differences. The low roll speed and low roll angle with a high rate of feed had the highest damage (there were no significant differences among all other treatments). This damage was probably higher due to the longer period of time that the seeds were in contact with the rolls.

The roll rotation combination of one roll turning—one roll stationary had the highest damage associated with the high roll speed and the steepest roll angle.

Metering damage was always a part of the grading damage. It is probable that the metering damage was a considerable part of the total seed damage. It was not possible to disassociate the metering damage and the roll grading damage.

CHAPTER IX

SUMMARY AND CONCLUSIONS

This investigation was conducted under certain test conditions as described in the text and the results will apply only to those conditions.

The following conclusions were arrived at in this investigation:

1. The grading accuracy was affected by the roll rotation combination, roll speed, roll angle, and, to a much lesser degree, the rate of feed.

   a. The roll rotation combination of rolls turning in opposite directions generally had a higher grading accuracy under similar test conditions than did the combination of one roll turning-one roll stationary or rolls turning the same directions. The latter combination, generally, had lower grading accuracy.

   b. The higher roll speed (600 rpm), or a combination of the higher roll speed and the steeper roll angle (15°) had the lower grading accuracy.

   c. There were no significant differences in grading accuracy due to rate of feed. There was a trend, however, toward higher grading accuracy at the higher rate of feed.

2. The <u>relative seed size</u> could be an important part of grading accuracy under conditions of fixed roll size and roll spacing. Due to the changes made in roll size and roll spacing, the relative seed size was not critical in this investigation.

3. The <u>length of roll section</u> required to accurately grade the two types of seeds (delinted cotton seed and shelled peanut seed) varied according to the same conditions that grading accuracy did.

Generally speaking, the twelve-inch roll section was long enough only with the low roll speed when using in grading delinted cotton seed with the combination of rolls turning in opposite direction. Neither of the other two roll rotation combinations under any combination of roll speed, rate of feed, or roll angle graded as much as 80% of the seeds.

The peanuts were tested for length of roll section with two roll rotation combinations: rolls turning opposite directions and one roll turning-one roll stationary. For these two combinations, a roll section twelve inches long graded at least 85% of all possible peanut seeds under any of the test conditions used.

4. The <u>seed travel time</u> for a twelve inch roll section was not particularly affected by seed size except for a trend for the larger seed size to take less time. An increase in roll angle, in roll speed, or a combination of the two, resulted in a reduction of time for the seed to travel the length of the roll section.

5. The <u>range of the minor diameter</u> in the delinted Parrott cotton seed ranged from .131 to .171 inches with a mean of .158

inches, and a standard deviation of .010.

6. The seed damage that occurred was caused, to a great extent, by the metering device. The exception to this was that the peanuts were so heavily damaged by the roll rotation combination of rolls turning the same direction that the test was dropped.

Further work would need to be done with seeds that were roll graded to establish parameters of planter seed plate selection for the highest planter efficiency.

The roll grader, as used in this test, had relatively low capacity. The highest rates of feed were approximately 8 pounds of delinted cotton seeds and 32 pounds of shelled peanut seeds per hour. This would indicate that methods for increasing the volume of grading would need to be developed for commercial application of this principle to these seeds.

BIBLIOGRAPHY

(1) Schroeder, E. W., et al, "Cotton Merchanization in Oklahoma" Unpublished Annual Report from the Oklahoma Agricultural Experiment Station, (1957) pgs. 7-12.

(2) Henderson, S. M. and R. L. Perry, Agricultural Processing Engineering, Chp. 7. John Wiley & Sons, Inc., New York, (1955).

(3) "Citrus Sizers", Bulletin No. 2521, American Machinery Corporation, Orlando, Florida.

(4) "Lobee Peach Sizers", Trade Literature Provided by the Lobee Pump and Machinery Co., Gasport, New York.

(5) West, W. J., "Potatoe Sorters", Agricultural Engineering Record, Vol. II, Autumn 47-Summer 49. H. M. Stationery Office, London, England. For National Institute of Agr. Eng., Silsoe Bedfordshire.

(6) "Expanding Roll Sizer", Trade Literature Provided by the Parmount Manufacturing Co., 1615 East Main St., Stockton, California.

(7) Brown, Calvin, "Automatic Setscrew Driving", Automation, April, (1957).

(8) "Wedge-Shaped Gap Between Rollers Automatically Feeds Tapered Parts", Design News. December 22, (1958) Pg. 26-27.

(9) Federer, Walter T., Experimental Design, Chapter 2, McMillan Co., New York, 1st. Printing, (1955).

(10) Porterfield, Jay G., Unpublished Data concerning Roll Grading of Certain Agricultural Seeds, (1958).

(11) Cochran, W. G. and Gertrude M. Cox., Chapter 5 - Factorial Experiments, Experimental Designs, John Wiley & Sons, Inc., New York, 4th. Printing (1955).

(12) Snedecor, George W., Statistical Methods, Chaps. 1-3, Fourth Edition, Sixth Printing, (1955), The Iowa State College Press, Ames, Iowa.

(13) Blair, Dr. Morris M., Elementary Statistics, Chaps.5-7, Revised Edition, Henry Holt and Co., New York - (1944-52).

APPENDIX

DATA AND ANALYSIS SHEET I

Grading Accuracy of Acid Delinted Cotton Seed
Test Number 1

ROLLS TURNING IN OPPOSITE DIRECTION
(Grading Accuracy - %)

Trt. No.	Roll Speed	Roll Angle	Feed Rate	Replication 1	2	3	4
1	200	5°	Low	99.81	100.00	99.34	99.84
2	600	5°	Low	86.65	82.22	82.12	92.36
3	200	15°	Low	96.56	98.41	99.49	99.45
4	600	15°	Low	65.16	71.49	59.94	71.46
5	200	5°	High	98.86	99.13	99.71	99.93
6	600	5°	High	87.04	88.93	90.17	89.64
7	200	15°	High	97.90	98.03	99.17	99.67
8	600	15°	High	70.58	70.47	63.80	74.57

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	31	5299.90		
Replication	3	73.92	24.64	3.16*
Treatment	7	5062.21	723.17	92.71**
Rate	1	16.96	16.96	2.17
Speed	1	3584.93	3584.93	459.61**
Angles	1	796.00	796.00	102.05**
R x S	1	18.46	18.46	2.37
S x A	1	645.48	645.48	82.75**
R x A	1	.05	.05	<1
R x S x A	1	.33	.33	<1
Error	21	163.77	7.80	

Standard Error
of the Trt. Mean 1.3964
of the S x A Mean 0.98742

DATA AND ANALYSIS SHEET II

Grading Accuracy of Acid Delinted Cotton Seed
Test Number 2

ONE ROLL TURNING AND ONE ROLL STATIONARY
(Grading Accuracy - %)

Trt. No.	Roll Speed	Roll Angle	Feed Rate	Replication 1	2	3	4
1	200	5°	Low	66.54	74.17	75.56	80.31
2	600	5°	Low	64.32	62.84	66.20	66.76
3	200	15°	Low	71.38	55.56	68.58	73.05
4	600	15°	Low	58.70	51.81	48.26	55.71
5	200	5°	High	71.85	79.20	75.25	83.74
6	600	5°	High	64.49	64.31	68.99	67.59
7	200	15°	High	71.47	52.80	70.11	73.52
8	600	15°	High	56.12	57.17	53.45	59.08

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	31	2529.78		
Replication	3	240.88	80.29	3.35
Treatment	7	1785.73	255.10	10.65**
Rate	1	26.99	26.99	1.13
Speed	1	982.24	982.24	40.99**
Angle	1	754.18	754.18	58.19**
R x S	1	.46	.46	<1
R x A	1	2.03	2.03	<1
S x A	1	7.08	7.08	<1
R x S x A	1	12.75	12.75	<1
Error	21	503.17	23.96	

Standard of the Treatment Mean 2.4475

DATA AND ANALYSIS SHEET III

Grading Accuracy of Acid Delinted Cotton Seed
Test Number 3

ROLLS TURNING IN THE SAME DIRECTION
(Grading Accuracy - %)

Trt. No.	Roll Speed	Roll Angle	Feed Rate	Replication 1	2	3	4
1	200	5°	Low	76.31	84.77	71.39	73.94
2	600	5°	Low	32.08	26.46	22.31	29.30
3	200	15°	Low	71.36	59.00	39.79	68.99
4	600	15°	Low	9.98	10.26	5.68	15.62
5	200	5°	High	72.37	79.19	67.91	82.38
6	600	5°	High	34.21	14.62	17.14	28.84
7	200	15°	High	67.58	61.90	70.78	65.71
8	600	15°	High	12.34	10.68	10.15	15.65

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	31	23799.67		
Replication	3	452.05	150.68	3.86*
Treatment	7	22527.12	3218.16	82.37**
Rate	1	6.31	6.31	<1
Speed	1	20912.69	20912.69	535.26**
Angle	1	1481.72	1481.72	37.92**
R x S	1	28.74	28.74	<1
R x A	1	91.16	91.16	2.33
S x A	1	4.09	4.09	<1
R x S x A	1	2.41	2.41	<1
Error	21	820.50	39.07	

Standard Error of the Treatment Mean 3.1257

DATA AND ANALYSIS SHEET IV

Grading Accuracy of Shelled Peanut Seed
Test Number 1

ROLLS TURNING IN OPPOSITE DIRECTION
(Grading Accuracy - %)

Trt. No.	Roll Speed	Roll Angle	Feed Rate	Replication 1	2	3	4
1	200	5°	Low	100.00	100.00	100.00	100.00
2	600	5°	Low	98.57	99.42	100.00	100.00
3	200	15°	Low	99.54	97.39	99.15	99.53
4	600	15°	Low	83.79	81.96	89.45	86.63
5	200	5°	High	100.00	100.00	100.00	100.00
6	600	5°	High	99.92	99.65	99.92	99.92
7	200	15°	High	100.00	98.66	99.19	99.53
8	600	15°	High	88.21	82.06	89.44	95.97

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	31	1087.33		
Replication	3	35.94	11.98	2.53
Treatment	7	951.93	135.99	28.69**
Rate	1	9.07	9.07	1.91
Speed	1	300.61	300.61	63.42**
Angle	1	357.11	357.11	75.34**
R x S	1	5.70	5.70	1.20
R x A	1	6.31	6.31	1.33
S x A	1	269.59	269.59	56.87**
R x S x A	1	3.54	3.54	<1
Error	21	99.46	4.74	

Standard Error of the
Treatment Mean 1.08856
S x A Mean 0.76974

DATA AND ANALYSIS SHEET V

Grading Accuracy of Shelled Peanut Seed
Test Number 2

ONE ROLL TURNING - ONE ROLL STATIONARY
(Grading Accuracy - %)

Trt. No.	Roll Speed	Roll Angle	Feed Rate	Replication 1	2	3	4
1	200	5°	Low	100.00	100.00	100.00	100.00
2	600	5°	Low	94.27	98.80	97.29	99.05
3	200	15°	Low	97.53	97.55	96.51	98.62
4	600	15°	Low	84.25	83.70	84.94	91.51
5	200	5°	High	100.00	100.00	99.84	99.91
6	600	5°	High	97.58	98.43	99.03	99.00
7	200	15°	High	99.24	99.58	99.36	99.42
8	600	15°	High	84.26	86.25	88.89	92.53

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	31	959.22		
Replication	3	34.48	11.49	3.89
Treatment	7	862.89	123.27	41.79**
Rate	1	11.64	11.64	3.94
Speed	1	363.01	363.01	123.05**
Angle	1	306.65	306.65	103.95**
R x S	1	.79	.79	<1
R x A	1	3.47	3.47	1.18
S x A	1	176.63	176.63	59.87**
R x S x A	1	.70	.70	<1
Error	21	61.85	2.95	

Standard Error of the	
Treatment Mean	0.8588
S x A Mean	0.6072

DATA AND ANALYSIS SHEET VI

Timing Test of Acid Delinted Cotton Seed
Number 1-T

ROLLS TURNING IN OPPOSITE DIRECTIONS
(Time - Seconds)

Trt. No.	Roll Speed	Roll Angle	Replication 1	2	3	4
1	200	5°	9.57	9.50	7.67	8.22
2	200	10°	4.30	4.50	3.92	4.77
3	200	15°	2.42	1.85	2.35	2.67
4	400	5°	4.85	4.70	4.17	4.82
5	400	10°	2.12	2.42	1.87	2.15
6	400	15°	1.05	0.97	1.22	1.15
7	600	5°	2.65	2.62	2.65	2.95
8	600	10°	1.20	1.27	1.30	1.32
9	600	15°	.67	.67	.60	.60

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	35	207.5286		
Replication	3	.7117	.2372	1.73
Treatment	8	203.5334	25.4417	185.98**
Speed	2	82.0416	41.0208	299.86**
Angle	2	101.2472	50.6286	370.09**
Speed-Angle	4	20.2346	5.0586	36.98**
Error	24	3.2835	.1368	

Standard Error of the	
Treatment	0.1849
Speed Mean	0.1068
Angle Mean	0.1068

DATA AND ANALYSIS SHEET VII

Timing Test of Acid Delinted Cotton Seed
Number 2 - T

ONE ROLL TURNING - ONE ROLL STATIONARY
(Time - Seconds)

Trt. No.	Roll Speed	Roll Angle	Replication 1	2	3	4
1	200	5°	13.57	13.17	13.90	10.60
2	200	10°	6.85	4.62	4.55	4.72
3	200	15°	3.47	3.37	3.15	2.92
4	400	5°	5.70	6.02	8.47	7.27
5	400	10°	3.17	3.27	3.70	2.90
6	400	15°	1.77	1.82	2.17	1.87
7	600	5°	4.20	5.40	5.17	5.75
8	600	10°	2.80	2.32	2.20	2.47
9	600	15°	1.25	2.17	1.95	1.75

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	35	403.9331		
Replication	3	1.4248	.4749	< 1
Treatment	8	386.0347	48.2543	70.30**
Speed	2	103.2844	51.6422	75.24**
Angle	2	235.3023	117.6511	171.40**
Speed - Angle	4	47.4480	11.8620	17.28**
Error	24	16.4736	.6864	

Standard Error of the
Treatmean 0.4142
Speed and Angle Mean 0.2392

DATA AND ANALYSIS SHEET VIII

Timing Test of Acid Delinted Cotton Seed
Number 3 - T

ROLLS TURNING IN THE SAME DIRECTION
(Time - Seconds)

Trt. No.	Roll Speed	Roll Angle	Replication 1	2	3	4
1	200	5°	8.55	7.27	5.92	5.77
2	200	10°	6.42	4.15	3.42	4.62
3	200	15°	2.75	2.75	3.02	2.12
4	400	5°	4.25	4.72	5.60	4.40
5	400	10°	2.55	1.72	2.20	2.70
6	400	15°	1.22	1.27	1.75	1.35
7	600	5°	5.52	4.52	4.17	2.57
8	600	10°	1.55	1.97	1.80	2.37
9	600	15°	1.05	1.40	0.77	1.07

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	35	134.9719		
Replication	3	2.8684	.9561	1.59
Treatment	8	117.6465	14.7058	24.41**
Speed	2	37.1967	18.5983	30.87**
Angle	2	78.4026	39.2013	65.07**
Speed - Angle	4	2.0472	.5118	<1
Error	24	14.4570	.6024	

Standard Error of the
Treatment Mean 0.3881
Speed and Angle Mean 0.2240

DATA AND ANALYSIS SHEET IX

Timing Test of Shelled Peanut Seed
Number 1 - T

ROLLS TURNING IN OPPOSITE DIRECTIONS
(Time - Minutes*)

Trt. No.	Roll Speed	Roll Angle	Replication 1	2	3	4
1	200	5°	.142	.135	.142	.138
2	200	10°	.055	.060	.072	.068
3	200	15°	.032	.035	.028	.042
4	400	5°	.070	.065	.055	.070
5	400	10°	.045	.038	.032	.048
6	400	15°	.015	.017	.015	.012
7	600	5°	.035	.040	.042	.042
8	600	10°	.017	.015	.012	.015
9	600	15°	.010	.010	.010	.010

ANALYSIS OF VARIANCE

Source of Variance	df	SS	MS	F
Total	35	.0520		
Replication	3	.0001	.00003	1.50
Treatment	8	.0513	.00641	320.50**
Speed	2	.0207	.01035	517.50**
Angle	2	.0237	.01185	592.50**
Speed - Angle	4	.0068	.00170	85.00**
Error	24	.0006	.00002	

Standard Error of the
Treatment Mean 0.002236
Speed and Angle Mean 0.001304

*Converted to seconds for presentation in the text.

DATA AND ANALYSIS SHEET X

Timing Test of Shelled Peanut Seed
Number 2 - T

ONE ROLL TURNING - ONE ROLL STATIONARY
(Time - *Minutes)

Trt. No.	Roll Speed	Roll Angle	Replication 1	2	3	4
1	200	5°	.252	.202	.208	.138
2	200	10°	.068	.075	.080	.102
3	200	15°	.042	.060	.045	.060
4	400	5°	.102	.108	.122	.105
5	400	10°	.038	.035	.050	.058
6	400	15°	.022	.020	.020	.028
7	600	5°	.050	.065	.070	.065
8	600	10°	.022	.032	.032	.030
9	600	15°	.018	.012	.018	.015

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	35	.114203		
Replication	3	.000124	.00004	< 1
Treatment	8	.105725	.01321	37.74**
Speed	2	.035629	.01781	50.88**
Angle	2	.057972	.02899	82.83**
Speed - Angle	4	.012124	.00303	8.66**
Error	24	.008354	.00035	

Standard Error of the
Treatment Mean 0.009327
Speed and Angle Mean 0.005385

*Converted to seconds for presentation in the text.

DATA AND ANALYSIS SHEET XI

Timing Test of Shelled Peanut Seed
Number 3 - T

ROLLS TURNING IN THE SAME DIRECTION
(Time - Minutes*)

Trt. No.	Roll Speed	Roll Angle	Replication 1	2	3	4
1	200	5°	.118	.178	.335	.272
2	200	10°	.050	.128	.102	.125
3	200	15°	.038	.025	.035	.030
4	400	5°	.048	.045	.050	.042
5	400	10°	.020	.020	.022	.032
6	400	15°	.010	.010	.010	.010
7	600	5°	.028	.038	.030	.040
8	600	10°	.015	.010	.015	.020
9	600	15°	.010	.010	.012	.010

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	35	.188012		
Replication	3	.005192	.0017	1.54
Treatment	8	.155749	.0195	17.73**
Speed	2	.074707	.0373	33.90**
Angle	2	.044228	.0221	20.09**
Speed - Angle	4	.036814	.0092	8.27**
Error	24	.027071	.0011	

Standard Error of the
Treatment Mean 0.01658
Speed and Angle 0.009592

*Converted to seconds for presentation in the text.

DATA AND ANALYSIS SHEET XII

Damage of Acid Delinted Cotton Seed
Test Number 1

ROLLS TURNING IN THE SAME DIRECTION
(Damage - Percent)

Trt. No.	Roll Speed	Roll Angle	Feed Rate	Replication 1	2	3	4
1	200	5°	Low	.00	.71	.47	1.11
2	600	5°	Low	.31	.68	.65	.69
3	200	15°	Low	.30	.76	.62	.63
4	600	15°	Low	.71	.55	.80	.37
5	200	5°	High	.52	.39	.26	.37
6	600	5°	High	.05	.50	.61	.51
7	200	15°	High	.16	.23	.43	.66
8	600	15°	High	.43	.15	.68	.69

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	31	1.8032		
Replication	3	.4553	.1518	2.94
Treatment	7	.2668	.0381	<1
Feed	1	.2312	.2312	4.49*
Speed	1	.0180	.0180	<1
Angle	1	.0036	.0036	<1
Feed x Speed	1	.0061	.0061	<1
Feed x Angle	1	.0003	.0003	<1
Speed x Angle	1	.0056	.0056	<1
Feed x Speed x Angle	1	.0020	.0020	<1
Error	21	1.0811	.0515	

DATA AND ANALYSIS SHEET XIII

Damage of Acid Delinted Cotton Seed
Test Number 2

ONE ROLL TURNING - ONE ROLL STATIONARY
(Damage - Percent)

Trt. No.	Roll Speed	Roll Angle	Feed Rate	Replication 1	2	3	4
1	200	5°	Low	1.46	.90	.61	.47
2	600	5°	Low	.55	1.33	.62	1.03
3	200	15°	Low	.81	2.25	.56	.29
4	600	15°	Low	.72	.34	1.01	.30
5	200	5°	High	.53	.70	.21	.39
6	600	5°	High	.84	.38	.27	.30
7	200	15°	High	.85	.70	.32	.37
8	600	15°	High	.49	.21	.27	.30

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	31	5.8111		
Replication	3	1.0602	.3534	2.37
Treatment	7	1.6162	.2309	1.55
Feed	1	1.1705	1.1705	7.84*
Speed	1	.1891	.1891	1.27
Angle	1	.0200	.0200	<1
F x S	1	.0060	.0060	<1
F x A	1	.0105	.0105	<1
S x A	1	.2048	.2048	1.37
F x S x A	1	.0153	.0153	
Error	21	3.1347	.1493	

DATA AND ANALYSIS SHEET XIV

Damage of Acid Delinted Cotton Seed
Test Number 3

METERING DEVICE
(Damage - Percent)

	Treatment (Rate of Feed)		
Replication	Low	Medium	High
1	.69	.58	.18
2	.67	1.31	1.46
3	1.13	.67	1.28
4	1.11	1.06	1.07
5	.66	.00	.52
6	.36	.59	.67
7	.73	.33	.58
8	.59	.64	.40
9	.79	1.44	1.23
10	.63	.32	.90
11	1.21	.63	.27
12	.00	.22	.43

ANALYSIS OF VARIANCE

Source of Variance	df	SS	MS	F
Total	35	5.3713		
Replication	11	3.3334	.3030	3.37
Treatment	2	.0618	.0309	<1
Error	22	1.9761	.0898	

DATA AND ANALYSIS SHEET XV

Damage of Shelled Peanut Seed
Test Number 1

ROLLS TURNING IN OPPOSITE DIRECTIONS
(Damage - Percent)

Trt. No.	Roll Speed	Roll Angle	Feed Rate	Replication 1	2	3	4
1	200	5°	Low	.24	.52	.00	.00
2	600	5°	Low	.32	.18	.00	.00
3	200	15°	Low	.00	.00	.00	.00
4	600	15°	Low	.17	.00	.15	.40
5	200	5°	High	.62	.45	.05	.51
6	600	5°	High	.14	.07	.08	.06
7	200	15°	High	.07	.14	.07	.00
8	600	15°	High	.13	.31	.32	.13

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	31	.9975		
Replication	3	.0906	.0302	1.32
Treatment	7	.4266	.0609	2.66*
Rate	1	.0428	.0428	1.87
Speed	1	.0014	.0014	<1
Angles	1	.0569	.0569	2.48
R x S	1	.0399	.0399	1.74
R x A	1	.0023	.0023	<1
S x A	1	.2574	.2574	11.24**
R x S x A	1	.0259	.0259	1.13
Error	21	.4803	.0229	

DATA AND ANALYSIS SHEET XVI

Damage of Shelled Peanut Seed
Test Number 2

ONE ROLL TURNING - ONE ROLL STATIONARY
(Damage - Percent)

Trt. No.	Roll Speed	Roll Angle	Feed Rate	Replication 1	2	3	4
1	200	5°	Low	.00	.06	.00	.14
2	600	5°	Low	.75	.32	.24	.09
3	200	15°	Low	.21	.19	.25	.12
4	600	15°	Low	1.72	.77	.73	.46
5	200	5°	High	.43	.12	.12	.09
6	600	5°	High	.74	.65	.27	.57
7	200	15°	High	.19	.35	.19	.18
8	600	15°	High	.70	1.13	.53	.37

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	31	4.1838		
Replication	3	.5837	.1946	3.61*
Treatment	7	2.4673	.3525	6.54**
Rate	1	.0106	.0106	<1
Speed	1	1.7113	1.7113	31.75**
Angle	1	.3829	.3829	7.10*
R x S	1	.0209	.0209	<1
R x A	1	.1511	.1511	2.80
S x A	1	.1325	.1325	2.45
R x S x A	1	.0580	.0480	1.08
Error	21	1.1328	.0539	

Standard Error of the Treatment Mean 0.1162

DATA AND ANALYSIS SHEET XVII

Damage of Shelled Peanut Seed
Test Number 3

METERING DEVICE
(Damage - Percent)

Rate of Feed*	
Low	High
.46	.64
.28	.15
.37	.50
.39	.21
.31	.48
.88	.05
.37	.10
.12	.43
.30	.48
.83	.15
.10	.16
.29	.00

ANALYSIS OF VARIANCE

Source of Variation	df	SS	MS	F
Total	23	1.2062		
Treatment	1	0.0759	0.0759	1.48
Error	22	1.1303	0.0514	

*Completely randomized, twelve replications.

DATA SHEET XVIII

Roll Grader Length Test - Acid Delinted Parrott Cotton Seed
Test Number 1

ROLLS TURNING IN OPPOSITE DIRECTIONS

(Amount of Cotton Seed as Graded by Increments of Roll Section Length - Table Values are in Percent)

Inches of Roll Length	Feed Rate	Low				High			
	Roll Angle	5°		15°		5°		15°	
	Roll Speed	200	600	200	600	200	600	200	600
	Treat. No.	1	2	3	4	5	6	7	8
0.5		25.11	.98	.75	.00	27.23	.79	.66	.00
1.0		47.85	25.99	9.92	.10	46.42	29.69	7.62	.05
1.5		12.30	16.62	35.70	.43	10.96	16.90	37.81	.16
2.0		6.84	7.94	16.80	3.47	7.29	8.41	19.36	3.43
2.5		2.28	4.96	8.72	10.31	2.08	4.70	9.37	12.19
3.0		1.75	3.50	7.00	7.93	1.17	3.71	6.65	9.51
3.5		.94	3.14	4.42	6.40	1.30	2.79	3.91	7.22
4.0		.55	2.50	2.82	3.41	.73	2.69	2.39	3.89
4.5		.77	3.03	2.96	4.94	.63	3.38	2.80	5.16
5.0		.52	2.68	2.11	4.30	.44	2.39	2.27	3.91
5.5		.00	2.52	2.07	3.60	.26	2.09	1.53	3.36
6.0		.05	1.28	1.54	3.04	.24	1.87	1.07	2.68
6.5		.14	1.72	.97	1.53	.14	1.74	.79	2.57
7.0		.02	2.44	.65	2.42	.10	1.32	.75	2.46
7.5		.10	1.57	.36	1.73	.07	1.40	.54	2.32
8.0		.09	.33	.32	1.62	.06	.94	.35	1.23
8.5		.16	1.41	.28	2.60	.06	1.04	.21	2.09
9.0		.00	.55	.29	2.12	.07	.57	.18	1.39
9.5		.00	1.06	.15	1.54	.02	.57	.16	1.26
10.0		.05	.73	.25	1.29	.04	.89	.03	1.00
10.5		.00	.43	.12	1.32	.00	.73	.10	1.38
11.0		.00	.31	.07	1.11	.00	.10	.05	1.20
11.5		.06	.07	.11	1.25	.01	.05	.00	.86
12.0		.07	.03	.06	.52	.02	.09	.03	.48
Total Percent Graded in twelve inches of roll section		99.65	85.79	98.44	66.98	99.34	88.85	98.63	69.80

DATA SHEET XIX

Roll Grader Length Test - Acid Delinted Parrott Cotton Seed
Test Number 2

ONE ROLL TURNING - ONE ROLL STATIONARY

(Amount of Cotton Seed as Graded by Increments of Roll Section Length - Table Values are in Percent)

Inches	Feed Rate	Low				High			
of	Roll Angle	5°		15°		5°		15°	
Roll	Roll Speed	200	600	200	600	200	600	200	600
Length	Treat. No.	1	2	3	4	5	6	7	8
0.5		25.57	16.68	1.97	.50	26.05	14.76	1.52	.91
1.0		21.70	18.13	28.68	8.56	22.26	17.25	28.36	12.55
1.5		7.80	6.97	11.66	10.21	9.99	9.52	11.71	9.72
2.0		3.92	6.12	6.93	7.06	5.49	5.64	7.36	7.09
2.5		1.73	3.21	3.79	4.51	2.23	3.39	3.82	4.20
3.0		1.31	2.38	2.87	3.61	1.60	2.63	2.99	3.75
3.5		.82	1.71	1.61	2.37	.87	1.98	1.69	2.45
4.0		.49	.93	1.09	1.97	.54	1.25	1.08	1.72
4.5		.66	.91	1.15	1.87	.85	1.44	1.31	2.05
5.0		.68	.98	1.09	1.69	.49	1.08	.98	1.29
5.5		.57	.88	.97	1.24	.49	.96	.70	1.24
6.0		.57	.48	.68	1.07	.33	.63	.62	1.17
6.5		.46	.53	.56	1.44	.42	.68	.52	.89
7.0		.24	.71	.48	.95	.33	.47	.57	.90
7.5		.65	.49	.43	.99	.33	.69	.53	1.01
8.0		.26	.56	.32	.75	.35	.49	.40	.53
8.5		.53	.50	.43	.72	.48	.57	.48	.76
9.0		.40	.48	.39	.58	.30	.47	.38	.70
9.5		.49	.49	.44	.61	.28	.41	.49	.73
10.0		.47	.45	.31	.58	.19	.34	.43	.46
10.5		.16	.32	.37	.85	.19	.38	.38	.63
11.0		.32	.22	.33	.49	.13	.27	.22	.64
11.5		.73	.15	.20	.55	.49	.22	.25	.52
12.0		3.55	.74	.32	.44	3.00	.58	.25	.46
Total Percent Graded in twelve inches of roll section		74.08	65.02	67.07	53.61	77.68	66.10	67.04	56.37

DATA SHEET XX

Roll Grader Length Test - Acid Delinted Parrott Cotton Seed
Test Number 3

ROLLS TURNING IN THE SAME DIRECTION

(Amount of Cotton Seed as Graded by Increments of Roll Section Length - Table Values are in Percent)

Inches of Roll Length	Feed Rate / Roll Angle / Roll Speed / Treat. No.	Low				High			
	Roll Angle	5°		15°		5°		15°	
	Roll Speed	200	600	200	600	200	600	200	600
	Treat. No.	1	2	3	4	5	6	7	8
0.5		19.62	.93	2.70	.09	14.21	.67	3.06	.13
1.0		15.52	1.36	9.56	.12	13.70	.98	9.20	.24
1.5		9.11	1.63	8.11	.40	9.28	1.43	8.27	.36
2.0		5.73	1.62	5.97	.54	6.79	1.45	6.50	.47
2.5		3.83	1.57	4.17	.38	4.09	1.22	4.65	.54
3.0		3.08	1.71	3.78	.41	3.81	1.18	4.36	.61
3.5		2.21	1.46	3.40	.27	3.03	1.16	3.40	.57
4.0		1.56	1.40	2.26	.40	2.15	1.04	2.57	.70
4.5		1.65	1.36	2.35	.58	2.28	1.15	3.37	.67
5.0		1.69	1.22	2.16	.49	2.00	.97	2.30	.56
5.5		1.58	1.40	1.64	.52	1.83	1.16	2.30	.45
6.0		1.53	1.15	1.34	.38	1.37	.99	1.73	.50
6.5		1.26	1.08	1.23	.44	1.42	1.04	1.75	.52
7.0		1.20	1.11	1.20	.44	1.29	.96	1.61	.47
7.5		1.18	1.08	1.57	.38	1.35	1.09	1.80	.50
8.0		.88	.91	.89	.38	.89	.72	1.11	.46
8.5		.91	.98	1.26	.54	1.24	.89	1.60	.59
9.0		.88	.91	.89	.54	.94	.80	1.37	.51
9.5		.77	.81	.83	.46	.87	.71	1.03	.53
10.0		.54	.82	.79	.42	.76	.56	1.05	.54
10.5		.50	.70	.87	.59	.67	.82	1.18	.60
11.0		.32	.70	1.05	.55	.56	.66	.86	.53
11.5		.44	.60	.99	.51	.31	.65	.78	.51
12.0		.58	1.12	.59	.57	.67	1.38	.68	.63
Total Percent		76.57	27.63	59.60	10.40	75.51	23.68	66.53	12.19

Graded in twelve inches of Roll Section

DATA SHEET XXI

Roll Grader Length Test - Shelled Argentine Peanut Seed
Test Number 1

ROLLS TURNING IN OPPOSITE DIRECTIONS

(Amount of Peanut Seed as Graded by Increments of Roll Section Length - Table Values are in Percent)

Inches of Roll Length	Feed Rate / Roll Angle	5°		15°		5°		15°	
	Roll Speed	200	600	200	600	200	600	200	600
	Treat. No.	1	2	3	4	5	6	7	8
1		95.71	48.18	2.75	.00	59.68	37.19	9.83	.03
2		3.37	38.15	81.95	4.44	35.24	49.01	69.19	6.05
3		.86	9.87	7.22	33.90	4.46	11.53	15.90	38.36
4		.00	1.09	3.01	12.23	.19	.96	1.94	14.92
5		.00	.80	1.66	10.67	.12	.36	.86	8.95
6		.00	.40	.62	6.87	.11	.29	.56	7.23
7		.00	.32	.48	3.60	.08	.15	.28	4.13
8		.00	.18	.24	4.31	.02	.11	.26	3.64
9		.00	.20	.30	2.84	.02	.04	.13	2.20
10		.03	.06	.29	2.93	.06	.09	.12	1.62
11		.03	.07	.19	2.21	.02	.04	.18	1.32
12		.00	.12	.18	1.55	.02	.08	.08	1.23
Total Percent Graded in twelve inches of roll section		100.00	99.44	98.89	85.55	100.00	99.85	99.33	89.68

DATA SHEET XXII

Roll Grader Length Test - Shelled Argentine Peanut Seed
Test Number 2*

ONE ROLL TURNING - ONE ROLL STATIONARY

(Amount of Peanut Seed as Graded by Increment of Roll Section Length - Table Values are in Percent)

Inches	Feed	Rate	Low				High			
of	Roll	Angle	5°		15°		5°		15°	
Roll	Roll	Speed	200	600	200	600	200	600	200	600
Length	Treat.	No.	1	2	3	4	5	6	7	8
1			64.43	42.11	5.08	1.27	52.54	35.57	6.95	1.11
2			28.90	31.35	62.10	45.80	38.43	36.21	54.13	44.91
3			5.02	10.05	17.62	13.69	7.35	11.82	26.80	14.86
4			.83	4.30	5.41	7.35	.96	5.21	6.48	7.12
5			.57	3.71	2.91	5.09	.41	3.87	2.09	5.88
6			.12	2.34	1.84	3.62	.16	2.49	1.24	3.88
7			.12	1.08	.99	3.19	.00	1.45	.66	3.50
8			.00	.62	.69	2.64	.02	.66	.45	2.40
9			.00	.57	.16	1.17	.05	.50	.24	1.21
10			.00	.53	.44	.76	.00	.34	.17	1.27
11			.00	.53	.19	.95	.00	.26	.15	1.09
12			.00	.13	.12	.51	.00	.13	.04	.73
Total Percent Graded in twelve inches of roll section.			99.99	97.32	97.55	86.04	99.92	98.51	99.40	87.96

* Test Number Three, for rolls turning the same direction, was abandoned because of excessive peanut seed damage.

DATA SHEET XXIII

Minor Diameter Distribution of Acid Delinted Cotton Seed
in Grading Accuracy Tests
(Minor Diameter in Inches)

Seeds	Lot 1	Lot 2	Lot 3	Lot 4
1	.161	.160	.163	.167
2	.170	.170	.154	.160
3	.148	.156	.159	.153
4	.153	.157	.170	.143
5	.167	.160	.153	.149
6	.163	.164	.155	.157
7	.164	.154	.161	.154
8	.168	.154	.160	.162
9	.164	.159	.165	.130
10	.148	.162	.130	.166
11	.169	.155	.146	.134
12	.169	.160	.153	.158
13	.165	.145	.164	.151
14	.153	.144	.160	.166
15	.150	.165	.170	.168
16	.171	.167	.160	.137
17	.166	.160	.161	.164
18	.151	.168	.169	.157
19	.155	.140	.153	.154
20	.156	.144	.156	.166
21	.161	.165	.157	.163
22	.141	.153	.145	.149
23	.168	.150	.171	.136
24	.164	.160	.154	.170
25	.154	.167	.140	.165

Standard Deviation		0.010
Mean		0.158
Median		0.159
Mode	Class-Midpoint	0.155
Range	0.171 - 0.130 =	0.041

DATA SHEET XXIV

Angle of Repose of Friction*

(Seed upon a smooth flat surface of cold-rolled steel)

Shelled Argentine Peanut Seed (No seed coat)		Acid Delinted Parrott Cottonseed	
23°	18°	30°	18°
24°	23°	25°	22°
21°	22°	23°	30°
13°	25°	12°	18°
15°	23°	25°	19°
21°	22°	17°	23°
24°	23°	23°	24°
20°	19°	20°	32°
20°	17°	27°	23°
24°	9°	25°	17°
20°	20°	16°	27°
25°	22°	23°	29°
24°		26°	
Average - 20.68°		Average - 23.04°	

* The angles that the smooth flat steel surface made with the horizontal were measured at the point that the seeds started to slide.

VITA

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