Effect of Bulk Handling on Runner Peanut Seed Quality

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ABSTRACT

Tests were conducted to measure the effect of using bulk seed tenders to load peanut seed into planters. Treated seed were transferred using one of two bulk seed tenders, a pneumatic seed tender and a belt seed tender, and their quality compared to conventional bagged seed (control). Information recorded from each transfer of peanut included the mass of seed in each container and the time required to fill the container. Samples obtained during seed transfer were evaluated for mechanical damage and germination. Seed from both bulk tenders and control treatments were planted and field emergence evaluated periodically until 30 days after planting (DAP). Bulk handling increased mechanical damage when compared to the bagged seed. The pneumatic seed tender had the most damaged seed at 2.5%, compared to 1.1% damage by the belt seed tender. The amount of damaged seed was only 0.5% when bagged. Peanut seed loaded by the belt system had an average germination rate of 89% while germination of bagged and pneumatic treatments was 95 and 96%, respectively. Significant differences in emergence due to the seed handling treatment occurred throughout the first 30 DAP. Eleven DAP, field emergence of the bagged and belt conveyer seed was similar at 45% and 47% respectively, but fewer seeds from the pneumatic treatment had emerged (31%). Thirty DAP, field emergence in bagged (76%) and the belt (75%) treatments were similar, and greater than the 69% that emerged in the pneumatically handled seed. Economic feasibility of investing in a bulk handling system for peanuts depends on several factors including investment cost, operating cost, and cost of tote bags versus labor and paper bag cost used in traditional seed handling. Farmers must have at least 324 ha for savings in labor and time to offset the capital cost of the bulk handling system.

Key Words: Conveyors, germination, handling, seed, seed quality.

Planting peanut is a very labor intensive and time-consuming operation requiring both skilled and unskilled labor. Intense manual labor is required to load seed hoppers on the planter. A seeding rate of 112 kg/ha requires 4480 kg of seed to plant 40 ha, or 195 bags weighing 23 kg each. A six-row planter planting in a twin-row pattern must be filled approximately 12 times while planting 40 ha and in a single-row planting pattern would have to be filled 24 times.

Bulk seed tenders have been an accepted practice in the Midwestern United States to plant corn (*Zea mays L.*), soybean [*Glycine max (L.) Merr.*], and small grains for quite some time. Tenders utilize a hopper bin feeding either a mechanical or pneumatic transport mechanism to transfer the seed from the large bin to the individual planter hoppers. The hopper bin is filled by the seed vendor or seed are delivered to the grower in 1-t tote bags typically used in transporting shelled peanuts (American Peanut Council, 2005). The totes can be lifted into the bin before the spout is opened, allowing the seed to flow gently from the tote into the bulk seed hopper. This eliminates the need for strenuous physical labor during the planting operation reducing driver fatigue, and possibly loading time. Bulk seed handling eliminates the need to dispose of seed bags and other debris because the totes are returned to the vendor and refilled.

Mechanical systems consist of an auger or an enclosed belt conveyor to elevate the seed from the bin outlet where the seed discharges into a chute held over the planter hopper. The pneumatic systems utilize a high velocity air stream to transport the seed from the bin to a cyclone held over the planter hopper. In both systems, the operator controls the flow of seed by remote controls located at the discharge spout.

None of these bulk handling systems have been used for handling peanut seed due to the fragile nature of peanut seed and potential excessive losses due to mechanical damage. In tests to determine mechanical damage due to free-fall impact, Slay (1976) found that split kernels increased significantly as the height from which shelled peanuts were dropped increased. Splits were significantly

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less when peanuts impacted peanuts than when peanuts impacted on wood, steel, or concrete. Slay (1976) presented inconclusive data regarding the effect that impact had on germination. However, the germination tended to decrease as drop height increased. Maximum impact velocity in these tests was 8.3 m/s.

The objective of this study was to determine the effect of bulk handling on mechanical damage, germination, and plant emergence on peanut seed.

Materials and Methods

Tests were conducted to measure the mechanical damage to peanut seed due to handling in bags, a belt-type bulk seed tender (Crustbuster 242, Speed King, Inc., Dodge City, KS), and a pneumatic bulk seed tender (Seed Jet II Demonstrator, Yetter Mfg., Colchester, IL). Twenty 23-kg bags of treated Georgia Green peanut seed were obtained and each bag poured through a riffle divider, dividing the seed into two 11.5-kg samples. A 500-g subsample was retained for germination analysis. A 1000-g sample was retained and combined with other 1000-g samples for subsequent planting. Approximately one-half of the peanuts from each bag were loaded into the belt seed tender and half loaded into the pneumatic seed tender. After all peanut seed were divided and loaded into the bulk seed tenders, each tender was operated and approximately 12 kg of peanut seed were loaded into a plastic container to simulate loading a seed hopper on a planter.

The belt tender was powered by a 4 kW gasoline engine operated by pulling a rope attached to the engine throttle. As the engine reached maximum speed, the centrifugal clutch engaged the belt, carrying the peanut seed up to the top of a telescoping chute that the operator used to direct the seed into the planter hopper. Once the desired fill level was reached, the operator released the rope, immediately reducing the engine speed to an idle, and stopping the conveyor belt. There was less than 1-s lag time between releasing the throttle and the cessation of flow of seed. The flow rate for the belt seed handler was controlled by opening and closing the gates on the bulk seed bin.

The pneumatic seed handler had a 8-kW gasoline engine operating at full throttle and turned a blower through a belt drive. The alternator on the engine was used to power an electric air-lock valve to control the flow of peanuts into the conveyor. An on/off switch located on the spout activated the electric air-lock valve. There was a 1 to 2 s delay from the time the switch was turned on before the seed were discharged into the seed hopper and about a 3 s delay for seed flow to stop once the air-lock valve was disengaged.

Total weight of peanut seed and the time required to transfer the seed from the bin to the container were recorded. Mass flow rate was controlled by opening and closing the gates on the feed hopper. A 500-g and a 1000-g sample were retained from each 12-kg sample for analysis and planting, respectively. This was repeated until all the peanuts in each tender were transferred for a total of 18–20 replications for each system. The 1000-g samples from each handling system were combined to form a 20-kg composite sample to plant for the 2005 crop year.

Each 500-g sample was examined to remove broken, split, and bald seed. The weight and count of broken/split seed and bald seed were recorded. For the purposes of these tests, a bald seed was a seed with at least 25% of the testa missing. The whole seed were sent to the Georgia Department of Agriculture Seed Lab in Tifton for germination analysis. Standard and cold germination (AOSA, 2003) tests were conducted. The cold germination test (15 C) stresses peanut so that lower seed vigor is detected (Guerke, 2005). Seed damage and germination data were subjected to analysis of variance and Duncan/Waller tests for means separation. (SAS, 2005)

Peanut seed from the bagged control, the belt conveyor, and pneumatic conveyor samples were planted in a twin-row planting pattern using a vacuum planter (2×2 NG Plus, A.T.I./Monosem, Inc., Lenexa, KS) on 15 May 2005. Soil at the test site near Dawson, GA was a Greenville fine sandy loam (fine, kaolinitic, thermic Rhodic Kandiudults). Each plot consisted of six 13.7 m rows planted with the outside row of the twin spaced 91 cm apart. Treatments were planted in a randomized complete block design with three treatments (control, belt, pneumatic) and twelve replications each on 15 May 2005. The seeding rate was measured on eighteen of the thirty-six plots by uncovering and counting the seed in 91 cm of row on 16 May 2005. Seeding rate ranged from 20.5 to 21.5 seed/m of twin-row. Plant emergence counts were obtained in each plot on 6.1 m of row at 12, 14, 16, 19, 21, 27, and 30 DAP. Seeding rate was tested for difference in means using analysis of variance and Duncan/Waller tests. Percent emergence was calculated by dividing the number of plants emerged per m of row by the counted number of seed per m of twin-row. Significance of the seed handling treatment and days after planting on percent emergence was determined using a repeated measures analysis.

Table 1. Summary of sample weights and mass flow rates using two bulk handling methods for peanut seed.

Seed Handling Method	Total Seed	Reps				Flow Rate		
		Number	Avg.	Max.	Min.	Avg.	Max	Min
	kg		kg			kg/min		
Belt	199	18	11	13	8	106	135	29
Pneumatic	201	18	11	15	6	72	105	40

Results and Discussion

Approximately 200 kg of seed were processed through each seed tender (Table 1). Eighteen repetitions resulted in an average sample weight of 11 kg for both type seed tenders. Samples collected using the belt seed handler ranged from 8 to 13 kg, while the samples from the pneumatic handler ranged from 6 to 15 kg. The last sample from the pneumatic system was the smallest because the feed hopper was emptied.

The flow rate for the belt handler ranged from 29 kg/min to 135 kg/min and averaged 106 kg/min over all samples (Table 1). The time required to fill a 34-kg capacity seed hopper at the average flow rate would be about 20 s. The average flow rate of peanuts was 72 kg/min and ranged from 40 to 105 kg/min. At the average flow rate, about 28 s would be required to fill a 34-kg capacity seed hopper.

Less than 0.2% of the seed by weight were split or broken in the bags, and about 0.3% of the seed in bags had loose or missing testa (Table 2). The bulk handling systems did not change the amount of intact seed with missing seed coats. However, both bulk handling systems increased the amount of split or broken seed. The belt system had 0.8% split seed while the pneumatic system had 2.2% splits. There were more broken seed pieces from the pneumatic and belt systems as compared to the control. The fact that the broken seed increased and the percent bald seed did not suggests that if the seed coat was damaged, the seed was also broken in the process. Total damaged seed was less than 0.5% of the bagged seed, compared to 1.1 and 2.5 % for the belt and pneumatic seed handling systems, respectively.

The seed fell approximately 3 m from the end of the conveyor down the chute into the container in the belt handling system. Based on research by Slay (1976), approximately 5% split kernels would be expected if the seed were free falling that 3 m height. Based on the difference between the actual and expected split kernels found, one can conclude that the seed are sliding down the delivery chute into the hopper with an equivalent drop height of about 0.5 m.

Mechanical damage with both bulk loading systems would be expected to reduce germination of the remaining whole seed. However, both the conventional and cold germination tests indicated no difference in germination of the whole seed in the bagged seed or seed transferred in the pneumatic system (Table 3). Germination in the conventional germination test for these two treatments was approximately 95% with germination observed using the cold test approximately 2% lower. Surprisingly, seed loaded using the belt system had a germination of only 89%. Cold test germination rates averaged only 1% less than the conventional test using the belt loader. Under ideal planting conditions and accounting for the damaged seed, one might expect 95% of the bagged seed to emerge compared to 88% and 93% of the belt- and pneumatically-loaded seed to emerge, respectively.

In-row seeding rates ranged from 20.5 to 21.5 seeds/m. No significant differences in seeding rate among seed handling treatments were noted (Table 3). Therefore, any differences in plant

Table 2. Mechanical damage of peanut as a result of seed handled in bulk peanut handling tests[a].

Seed Handling Method	N	Split and Broken Seed		Bald Seed[b]		Total damage
		%	No./kg	%	No./kg	%
Control (bagged)	20	0.16 a	4.70 a	0.31 a	5.24 a	0.47 a
Belt	18	0.79 b	25.18 b	0.29 a	4.84 a	1.08 b
Pneumatic	18	2.16 c	80.16 c	0.38 a	6.76 a	2.54 c

[a]Means in the same column followed by the same letter are not significantly different ($p \leq 0.05$).
[b]Bald seed are those seed missing at least 25% of the testa.

Table 3. Germination percentage of peanut seed in bulk seed handling tests[a].

Seed Handling Method	N	Germination	
		Conventional Test	Cold Test
		%	
Control (bagged))	20	95.1 a	93.2 a
Belt	18	89.1 b	88.2 b
Pneumatic	18	95.6 a	93.2 a

[a]Means in the same column followed by the same letter are not significantly different ($p \leq 0.05$)

emergence were not caused by differences in seeding rate. The emergence rates of the bagged seed and the seed handled by the belt loader were similar throughout the first 30 DAP. However, the pneumatically handled seed had a consistently lower emergence rate (Figure 1). Pneumatically handled seed had an emergence rate of 31% compared to 45 and 47% for the bagged and belt loaded seed 12 DAP. Maximum emergence rate occurred 21 DAP for all seed handling treatments. Bagged and belt-loaded seed had a maximum emergence rate of 91 and 89%, respectively, compared to 77% for the pneumatically loaded seed. At 30 DAP, 76% of the bagged seed emerged but fewer, only 69%, of the pneumatically loaded seed had emerged. Emergence observed 30 DAP in the plots planted with bagged and belt-loaded seed averaged 75.4%, resulting in a plant population of 15.8 plants/m. To achieve the same plant population, the pneumatic seeding rate would have to be increased from 21 seeds/m to 28 seeds/m (33%). Assuming that 21 seeds/m is equivalent to 112 kg/ha, the seeding rate would increase to 145 kg/ha. At a cost of $0.77/kg, the seed cost would be $112/ha using the pneumatic seed handler compared to $86/ha for seed loaded from bags or using the belt seed handler.

A tractor operator planting at an average speed of 6 km/h using a six-row, twin-row planter can plant approximately 40 ha per 12 h day. The typical planter has 12 seed boxes that will hold about 34 kg of seed or 1.5 bags per box. Loading the planter using bagged seed takes two persons approximately 20 minutes. One person using the seed tender can load the 12 seed boxes in approximately 10 minutes. The bin on a typical bulk seed tender has a capacity of approximately 5500 kg of seed. This is enough seed to plant 49 ha at a seeding rate of 112 kg/ha. Therefore, the tender can be filled once daily for a typical planting operation reducing or eliminating the travel to replenish the seed supply. By eliminating the need to handle bags and travel to replenish seed supplies during the day, bulk seed tenders can eliminate the need for a second person for a planting operation. In addition, bulk seed handling systems will eliminate the need for disposal of the paper seed bags. Seed can be loaded directly into the seed tender or can be loaded from the 1-t polyethylene totes typically used for handling and transporting shelled edible peanuts. Used totes can be returned to the seed processor and reused.

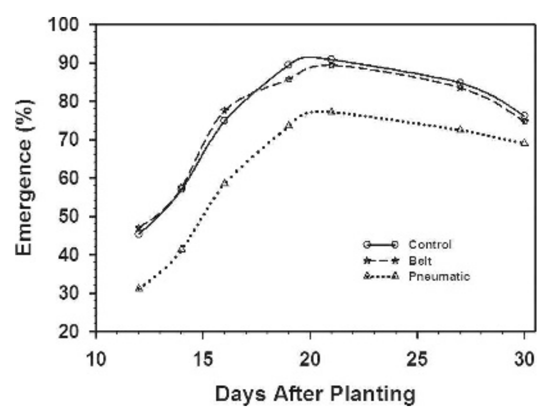

Fig. 1. Emergence rates of seed loaded using bulk seed tenders compared to conventional bagged seed during the first 30 days.

Converting from traditional bagged seed to a bulk handling system requires the purchase of a bulk seed handler as a capital investment. The economic feasibility of investing in a bulk seed tender was calculated as follows. Depending on the type of system purchased, spot checks with equipment dealers suggested that bulk handling systems range $5,000 to $10,000 thus $7,500 will be used in this analysis. The investment was amortized for 7 years at 10% interest with an assumed useful life of 10 years. The bulk handling system requires one less unskilled laborer valued at $7.00/h than handling traditional bagged seed. The cost of paper bags, valued at $0.36 each based on spot checks with seed processors, is replaced with reusable totes with a bulk seed tender. The tote bag charge for this system is $7.00 per bag which equates to $1.08/ha for the tote bag assuming a typical seeding rate of 112 kg/ha. At $7.00/h for 12 h, the labor cost of planting can be reduced by $2.10/ha using a bulk seed tender. Seed bags are also be eliminated which cost $2.22/ha. Thus, an estimated $4.32/ha is associated with traditional bagged seed handling

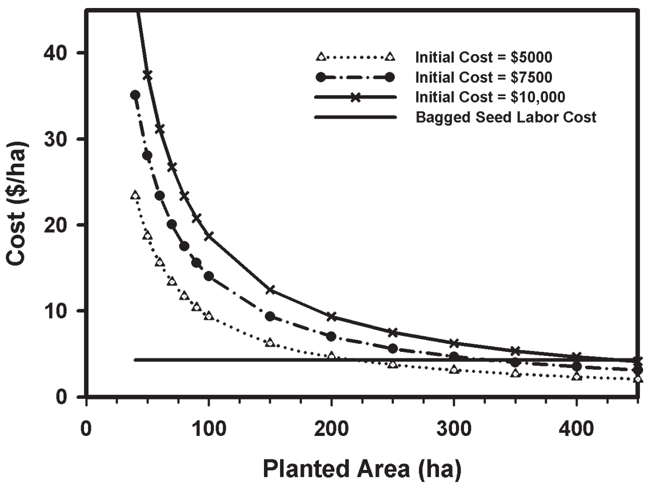

Fig. 2. Cost ($/ha) comparing investment in a bulk seed handling system for peanuts versus traditional bagged seed handling.

for labor and bag cost. This cost must be compared to the cost associated with purchasing and operating a bulk seed tender. The investment cost for the bulk seed tender declines with planted hectares and the ability of the producer to effectively spread this annual cost determines the feasibility of the investment. Figure 2 compares the cost ($/ha) of owning a bulk seed tender with a traditional seed bag system. The belt seed tender and traditional bag system have the same cost per hectare at 324 ha. When the planted area is less than 324 ha, the cost of the bulk seed tender is greater than the traditional bag system. If more than 324 ha are planted, then the cost of owning and operating a bulk seed tender is less than handling bagged seed. As mentioned previously, spot checks revealed a range of cost for bulk send handlers from $5,000 to $10,000. At $5,000, the breakeven occurs when 202 ha are planted, and 410 ha for a $10,000 investment. Therefore, producers must consider the hectares planted when determining the investment level in the equipment.

Subjective observations of the use of the two types of units were made and include the following. Hearing protection should be used by the operator and those workers in the general vicinity of the pneumatic unit. A loud, high pitched whine was generated by the blower. There appeared to be more peanut seed spilled from the discharge of the pneumatic unit, due to difficulty accounting for the lag time between the switch shut off and the flow of seed stopping. However, this could be overcome with use and experience. The seed bin of the conveyor unit emptied well, leaving less than a handful of seed in the bin after the test was completed.

Summary and Conclusions

Tests were conducted to assess the mechanical damage to peanut seed using commercially available bulk seed tenders. Flow rates were similar and ranged from 29 to 135 kg/min. Mechanical damage did increase using the bulk seed tenders compared to handling seed in conventional 23-kg bags. The belt conveyor resulted in about 1% total handling loss, including bald kernels. The pneumatic conveyor had about 2.5% total damage. Seed loaded using the belt conveyor had a lower germination rate than either the bagged or pneumatic conveyor. However, emergence data showed that 30-d plant populations were reduced in plots planted with seed that had been through the pneumatic system. Seed rates would have to be increased by 32% to account for the reduced emergence. Bulk seed tenders can significantly reduce the labor cost and down time planting peanut.

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