EFFECT OF DIFFERENT THRESHING CYLINDERS ON SOYBEAN QUALITY

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ABSTRACT
This study was carried out to determine the effects of spike-tooth and rasp-bar threshing cylinders on soybean quality. "Anidaso" variety at 10% moisture content (m.c.) wet basis was used as test sample. Four cylinder speeds (316, 376, 500 and 620 rpm) were selected with a replication. The results from this experiment showed that the lowest seed-coat damage of 5.36% was obtained with the spike- tooth cylinder at 316 rpm as against 7.17% at the same speed for the rasp-bar cylinder. Rasp-bar cylinder gave the lowest split loss of 0.68% as against 1.64% for spike-tooth at 376 and 316 rpm respectively. For undamaged whole bean, the respective highest values were 90.63 and 90.99% for rasp-bar and spike-tooth, respectively, at 316 rpm. The germination loss was lowest at rasp-bar threshing cylinder speed of 316 rpm. Better results were achieved at the lowest cylinder speed in both cases. In general, spike-tooth cylinder gave better results compared to the rasp-bar cylinder in soybean threshing at 10% m.c.

Keywords: Spike-tooth, Rasp-bar, Threshing cylinder, Soybean, Quality

INTRODUCTION
Soybean (*Glycine max* (L.) Merrill) is an industrial crop cultivated for oil and protein. Despite the relatively low oil content of the seed (about 20% on moisture-free basis), soybeans are the largest single source of edible oil and account for roughly 50% of the total oilseed production of the world (Berk, 1992). Most soybeans are harvested and threshed simultaneously by modern combines and by simple hand or motor-driven machines in a few cases.

Soybean quality is affected by combine harvester conditions (Paulsen et al., 1981) and other threshing methods. Studies have shown that fast cylinder speed is the main cause of threshing damage. Cain and Holmes (1997) observed that both the percentage of splits and the percentage of beans with cracked seedcoats increased as impact velocity increased and as bean moisture content decreased. Leudders and Burris (1979) found that as the percentage of broken soybean coats caused by mechanical damage increased, germination and field emergence decreased. In a similar finding, Stanway (1974) found that soybeans with shattered seed coats had less than 30 percent germination, whereas those without damage had 76 percent germination.

The Grains and Legumes Development Board (GLDB), an agency that supplies seeds to farmers, uses spike-tooth and rasp-bar power threshers for soybean threshing. There are reports that the rasp-bar type causes more damage to the beans, especially at low moisture content (m.c.) of 10% wet basis. But no reliable data on the true level of soybean quality from both machines are available. The objectives of the study reported herein, therefore, were:

1. To determine the effect of the different cylinder speeds on soybean damage at a low m.c. of 10% wet basis (w.b.).
2. To compare the germination rate of soybean from both threshing cylinders at different speeds.

MATERIALS AND METHODS

Test Equipment

In this study, two throw-in type mobile threshers (Alvan Blanch Development Co. Ltd., model ASPRA MASTER D) with conventional spike-tooth and rasp-bar threshing cylinders were used to thresh the soybeans.

Test Procedure

Soybeans, "Anidaso" variety, grown on field plots of GLDB were hand harvested in December 2003 when seed m.c. reached 10% (w.b.) as against optimum conditions of 12-14%. The thresher operator was instructed to adjust the speed of the thresher to a level normally done in the field. The speed recorded with a tachometer was 620 revolutions per minute (rpm). This speed was considered to be the highest because of the proportions of damaged beans in the outlet. Additionally, three lower speeds (316, 375 and 500 rpm) were selected accordingly. The concave clearances remained constant throughout each test. There were two replications for each speed.

Seeds were threshed with throw-in type mechanical threshers. Samples of 15 kg of unthreshed soybean were weighed and threshed. A stopwatch was used to record the threshing duration and the throughput was determined. The grain/matter other than grain (MOG) varied within each test because the harvested soybean had a variable MOG. Therefore, the total throughput was controlled by the experimental design instead of the output capacity (kilogrammes beans threshed).

The seeds were cleaned manually from materials other than seed. Samples of 500-g were collected from a Boerner divider and kept in the laboratory for quality analysis. The sample was tested for moisture content, percentages of whole beans, splits and seed coat cracks. Damage to the threshed soybeans was evaluated in a two-step process according to the method adopted by Evans *et al.* (1990). First, each seed was inspected visually through a magnifying lens for seed-coat crack, broken or splits (hereinafter, brokens or splits will be referred to as splits). The beans were separated by hand and the percentage of each fraction determined as that of the total weight (whole beans, splits and seed-coat cracks). Secondly, all seeds which were not externally damaged were then tested for internal or physiological damage using germination test. Hand threshed beans were used as control.

Germination Test

The seeds were germinated using the standard rolled towel germination test at a constant temperature of 25°C for seven days according the method of Association of Official Seed Analysts (AOSA) (1981). Control seeds were hand threshed. Only seeds which developed into normal seedlings (AOSA, 1981) were considered germinated. Germination was recorded as the percentage of the original 50-seed sample.

Statistical Analysis

Microsoft® Excel (2000) was used to perform analysis of variance (ANOVA) on the data to determine if significance differences existed between the cylinder speeds and the quality parameters for both cylinders.

RESULTS AND DISCUSSION

Throughput

Figure 1 represents the variation of throughput with increasing speed for both threshers. The throughput increased with increasing speed. This is due to the fact that at higher speed, the plant material passed through the threshing unit with less time. The throughput rate for spike-tooth was 271 kg/h at 316 rpm and remained constant at 375 rpm. It increased to a maximum feed rate of 338 kg/h at a cylinder speed of 620 rpm.

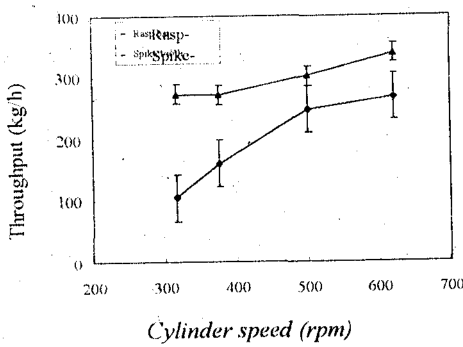

Fig. 1: Relationship between throughout and cylinder speed. Error bars represent the standard error of the mean.

Likewise, for the rasp-bar threshing cylinder, the feed rate was 105 kg/h at 316 rpm but steadily increased to 246 kg/h at 500 rpm with a further increase to 266 kg/h at 620 rpm. The difference in throughput was highest at 316 rpm than at 620 rpm. ANOVA results indicated significant difference ($p<0.05$) between cylinder types. The higher throughput values for the spike-tooth threshing cylinder were due to impact of the spikes against the pods and stalk, which were reduced in size. In addition, even at lower speeds, the spikes impacted higher velocity to the stalk and pods to exit from the thresher as compared to the rasp-bar that had flat threshing surface.

The influence of cylinder speed on seed-coat crack is shown in Figure 2. With increasing speed percentage cracked coat by spike-tooth increased from 7% at 316 rpm to 11% at 500 rpm, but decreased to 8% at 620 rpm. Whereas for the rasp-bar cylinder, percentage cracked coat increased from a lower value of 5% at 316

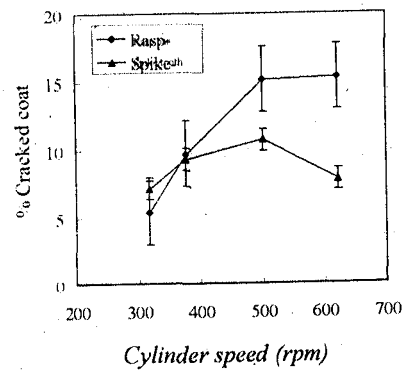

Fig. 2: Relationship between percentage of seed-coat crack and cylinder speed. Error bars represent

rpm to 15% at 500 rpm and remained constant at 620 rpm. Between speeds of 316 and 375 rpm, the difference was small but began to increase as threshing drum increased. The results showed no significant difference ($p<0.05$) between both thresher. The higher percentage of losses due to seed coat crack in the case of rasp-bar cylinder when cylinder speed increased could be due to the rubbing effect of the bar and concave during threshing.

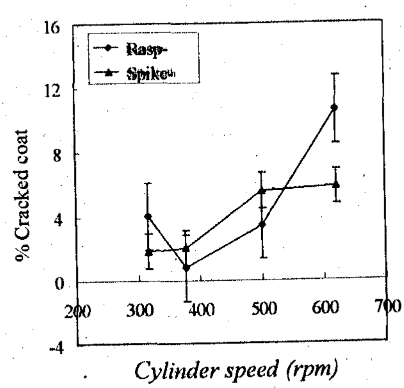

Fig. 3: Relationship between percentage of split bean and cylinder speed. Error bars represent the standard

Percent Split bean

Figure 3 shows the effect of increasing cylinder speed on split beans. At 316 rpm, the percentage split beans from rasp-bar cylinder was 4% compared to 2% in the case of the spike-tooth cylinder. It decreased to 0.8% for the rasp-bar at 375 rpm, but increased to about 10% at 620 rpm. For spike tooth, there was a gradual increase to 5% at 500 and a further increase to 5.2% at 620 rpm. The data from both threshers showed no significant difference ($p<0.05$). It was observed that low speed material was retained longer in the threshing unit in the case of the rasp-bar than spike-tooth causing more splits. These findings are in agreement with the results of Newbery *et al.* (1980) and Cain and Holmes (1977) who observed that both the percentage of splits and the percentage of beans with cracked seedcoats increased as impact velocity increased. Bartsch et al (1986) also reported significant increase in split beans when the impactor speed increased as moisture content decreased.

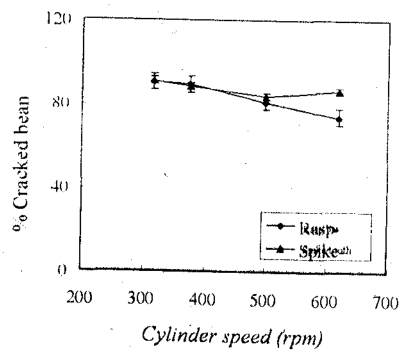

Fig. 4: Relationship between percentage of undamaged bean and cylinder speed. Error bars represent

Percent Undamaged bean

The undamaged bean in the case of both cylinders decreased with increasing speed as shown in Figure 4. The difference in percentage undamaged bean was not clear from 316 to 500 rpm, but was clearer at 620 rpm. At 316 rpm, the undamaged percentage for the rasp-bar cylinder was 90.63%. It decreased to 89.52% at 376 rpm, and further reduced to 81.44% and 74.12% at 500 and 620 rpm respectively. Although spike-tooth also showed a decrease in undamaged bean from 90.99% at 316 rpm to 83.68% at 500 rpm, there was an increase to 86.3% at 620 rpm. There was no significant difference ($p<0.05$) between both threshers. It is evident from figures 2 and 3 that as cylinder speed increased, rasp-bar caused less seed-coat cracks but more splits than spike-tooth.

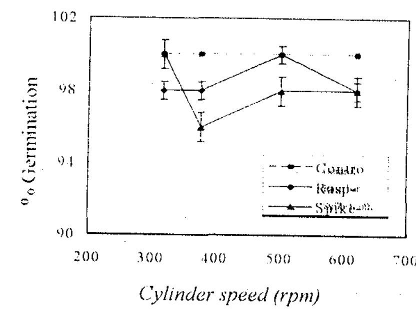

Fig. 5: Relationship between percentage of germinated bean and cylinder speed. Error bars represent

Germination rate

The effect of increasing cylinder speed on percentage germination of 50 seeds is shown in figure 5. The germination rate of seeds for control was 100%. The percentage germination for rasp-bar was 98% at 316 rpm and remained constant at 98% at 376 rpm. The value increased to 100% at 500 rpm but decreased to 98% at 620 rpm. However, the percentage germination for spike-tooth was 100% at 316 rpm. This decreased to 96% at 376 rpm, but increased to 98% at 500 rpm and 620 rpm. There was clear difference in germination rate at all speeds except at 620 rpm. Very high percentage germination was recorded for both cylinders and no significant difference ($p<0.05$) existed between both threshers.

CONCLUSIONS AND RECOMMENDATION

From the tests and analyses, the conclusions and recommendation can be stated as:

1. The cylinder type affected the percentage of cracked coat and split beans. The least percentage of cracked coat for rasp-bar and spike-tooth cylinders occurred at 316 rpm. The split bean percentage was lowest for rasp-bar cylinder and spike-tooth cylinders at 375 and 316 rpm respectively.
2. The rasp-bar and spike-tooth cylinders showed the least percentage of undamaged beans at 620 and 500 rpm respectively.
3. The germination percentage was highest for rasp-bar and spike-tooth at 316 rpm, but reduced to the lowest value for spike-tooth and rasp-bar cylinder at 376 and 620 rpm respectively.
4. To produce lower percentage of split beans and maintaining higher percentage of undamaged beans at a low m.c. of 10%, the operator should keep cylinder speeds between 316 and 375 rpm.

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