AN EVALUATION OF DEVICES FOR REDUCING DRY BEAN HARVESTING LOSSES

L.E. Zyla and R.L. Kushwaha
Department of Agricultural and Bioresource Engineering
University of Saskatchewan
Saskatoon, Saskatchewan

ABSTRACT

A preliminary evaluation of three concepts for reducing dry bean harvest (gathering) losses and a more detailed field evaluation of the air-jet guard concept were completed in 1992. Preliminary concept evaluations included the effectiveness of the air reel as a harvest aid, the feasibility of stripping bean pods and seed from the plant, and the effectiveness of three crop lifters under field test conditions. Field testing of the air-jet guard concept was undertaken at six commercial pinto bean sites in Saskatchewan. The air-jet guards did not reduce gathering losses below ten percent, which is considered the minimum acceptable commercial loss level. Losses were variable, but averaged 460 kg/ha (410 lbs/acre). The variability encountered during field testing was investigated by collecting plant samples from each site to determine moisture content. Plant height measurements for the samples were obtained using image processing.

INTRODUCTION

Saskatchewan dryland farmers grew dry bean (pinto, cultivar Othello) on a trial basis for the past three years. In an attempt to keep capital costs low, growers are using the same equipment for harvesting dry bean as they use for harvesting lentil. Gathering losses in dry bean, using these methods, can be 50% or greater (Whatley, 1992). Losses occur primarily when the cutterbar of the swather or combine cuts through the pods that have developed in the lower canopy. Further increase in the area of the crop in the province will not be possible until gathering losses are reduced. This could be accomplished by breeding a bean plant that is more easily harvested (currently underway), or through the design of improved harvesting equipment, or a combination of both.

During 1992, the Department of Agricultural & Bioresource Engineering, University of Saskatchewan, conducted research into the development of harvesting devices for reducing gathering losses in dry bean. A review of equipment for harvesting lentil, soybean and cereal crops was completed. Four

devices were identified for evaluation in dry bean. These were the stripper concept, crop lifters, a modified air reel and the air-jet guard concept. Preliminary evaluations were completed to test the feasibility of each device. On the basis of the results of the preliminary evaluations, the most promising devices were chosen for a more comprehensive field test evaluation. This paper summarizes the methodology used and the results obtained.

OBJECTIVES

The objectives of this research project were to:

1) Perform preliminary evaluations on the effectiveness of four devices for reducing dry bean gathering losses. These devices were to be low in cost and easily adaptable to conventional harvest equipment. A target loss level of ten percent or less was considered commercially acceptable.

2) Perform a comprehensive field test of the most promising devices based on the results of the preliminary evaluations.

PRELIMINARY EVALUATIONS

Laboratory Evaluation of the Stripper Concept

Harvesting crops by the stripper method is not new. Neale et al (1987) developed a stripper header for peas and cereal grains. A counter rotating drum, equipped with stripping belts fastened to the outside of the drum, removes the seed from the plant and leaves the stem anchored in the soil.

A short section of a stripper device, similar to Neale's, was built for use in the department soil bin. Dry bean plants were fastened to a plywood base and the stripper apparatus passed over the plants. Losses were unacceptably high in all test runs completed. It was concluded that design changes to the stripper apparatus were necessary. Due to time restrictions, this work was left for future work.

Laboratory Evaluation of the Air Reel

A short section of a commercially available air reel was purchased. Individual bean plants were conditioned for moisture (5% to 30%) in an environmental chamber and placed in the air stream of the air reel. The action of the air on the plants was recorded on video tape and the number of pods "lifted"

determined. Lift was defined as the percentage of pods the air was able to lift or tilt above a height of 38 mm (1.5 inches); a typical minimum cutting height for a combine or swather.

Of the pods hanging within the 38 mm boundary, 45% were lifted above 38 mm. However, this lift was not reliable. Many pods did not remain above 38 mm and often moved erratically in the air stream. Two reasons for this poor performance were identified: firstly, the cultivar Othello develops pods grouped closely around a central stem. This does not allow the air stream to lift the pods. Secondly, the pods are stiff and immovable when dry (i.e., less than ten percent moisture content).

The air reel test showed that air would not be as effective in reducing dry bean gathering losses as initially thought. However, it was concluded that air in combination with crop lifters should be tested more thoroughly during field evaluation of the air-jet guard concept. It was also concluded that development and evaluation of a modified air reel should not be pursued.

Field Evaluation of Crop Lifters

Three crop lifter types were available for evaluation. Two were fabricated; a third was a commercially available crop lifter. The crop lifters were mounted on a Westward Parts 7000 self-propelled swather. The lifters were spaced 76 mm (3 in) apart. Two problems appeared during evaluation of the crop lifters: firstly, the lifters often plugged with crop and weed material. Secondly, many bean plants passed between the lifters resulting in high losses. Lifters were tested more thoroughly during field testing of the air-jet guard concept.

FIELD EVALUATION OF THE AIR-JET GUARD CONCEPT

Equipment and Procedure

The air-jet guards were installed on an International Harvester #93 combine. This combine has a 3 m (10 ft) header and a 37 kW (50 hp) engine. The header of the combine was split into two portions. The left half of the header, as viewed from the operator's seat, had the air-jet guards and all other modifications added to it; the right half was chosen as a control side and remained unmodified. A brush was added to the pickup reel on the modified side in an attempt to improve contact of the reel with the plants.

Six air-jet guards were added to the header spaced 230 mm (9 in) apart (Fig. 1). Each air-jet guard consisted of a flood jet nozzle (1K450) silver soldered to 32 mm (1 1/4 in) square tubing. The square tubing was welded to the underside of the header. Air was pumped through the nozzle and directed back toward the header to provide a fairly uniform flood of air over the cutterbar. In theory, the air was to perform two functions: firstly, it was to keep the cutterbar clean and prevent loose seed from being lost. Secondly, it was to lift and tilt pods above the cutterbar to prevent them from being cut.

Six commercial pinto bean fields were visited in Saskatchewan and three equipment options or combinations were tested at each site. Option one consisted of the air-jet guards alone; option two consisted of the air-jet guards with lifters mounted between the air-jet guards and option three consisted of option two, but with the air supply turned off. Five variables were kept constant during testing. These variables were forward speed (2.9 km per hr), header height (ground level), reel index (1.7), and horizontal and vertical position of the reel.

Prior to testing, two variables were identified as likely to have a significant effect on test results. These were the variability of plant height among sites and the variation in pod moisture content during testing. In an attempt to address this variability, plants were collected from each bean site for subsequent analysis.

Results and Discussion

Figure two shows the results obtained for the three equipment combinations tested at five sites. The average reduction in loss for the air only option varied from 0 % to 40 % and averaged 24 %. For the lifter air option, losses varied from 0 % to 35 % and averaged 29 %. For the lifter only option, losses varied from a 17 % increase to an 18% reduction and averaged a 4 % reduction. A paired t-test performed on the data showed the air only combination to be significantly different at the 1 % level. The lifter air combination was significantly different at the 0.1 % level and the lifter only combination showed no significant difference.

Although the results were encouraging, the overall reduction in loss was not reduced to the commercially acceptable loss level of 10 %. Average losses were 38 % (460 kg/ha) for the air only option, 39 % for the lifter air option and 49 % for the lifter only option. Even though the lifter air combination showed the largest reduction in loss, the crop lifters plugged often when heavy crop or weed conditions were encountered.

Height measurements for the plants collected from each site were completed using an image analysis procedure (Zyla, 1992). The critical measurement obtained from this analysis was the distance from ground level to the tip of the lowest hanging pod (LowPod). LowPod was less than 38 mm for the five sites used for data analysis. Moisture measurements indicated pod moisture content varied from less than 5 % to 20 % (w.b.).

CONCLUSIONS

1) As an effective tool for reducing dry bean gathering losses, air is expected to be more successful when used on improved cultivars. Future cultivars will have a higher pod set with the pods positioned further from the central stem.

2) The concept of stripping bean seed and pods from the plant shows promise. More work on a stripper or stripper brush combination will reduce losses significantly from those obtained during the preliminary evaluations.

3) Improved crop lifters in combination with an air or brush assist, may reduce losses. The problem of crop lifter plugging needs to be investigated further.

ACKNOWLEDGMENTS

This research was funded by the Saskatchewan Irrigation Development Centre, Outlook, Saskatchewan, the Canadian Agri-Food Development Initiative and the Saskatchewan Pulse Crop Development Board. The combine was supplied by the Saskatchewan Irrigation Development Centre.

REFERENCES

Nave, W.R., J.W. Hummel and R.R. Yoerger. 1977. Air-jet and row-crop header for soybeans. Transactions of the ASAE 20(6):1037-1041, 1044.

Neale, M.A, W.E. Klinner and R.E. Arnold. 1987. A new stripping head for combine harvesters. Agricultural Engineer 42(1):9-14.

Whatley, N. 1992. Dryland Bean Production Trial: Final Report. Agriculture Development Fund, Saskatchewan Agriculture & Food. Project D-90-CP-0732.

Zyla, L.E. 1992. Image analysis for measuring dry bean pod height. ASAE Paper No. 923580. American Society of Agricultural Engineers, St. Joseph, MI:ASAE.

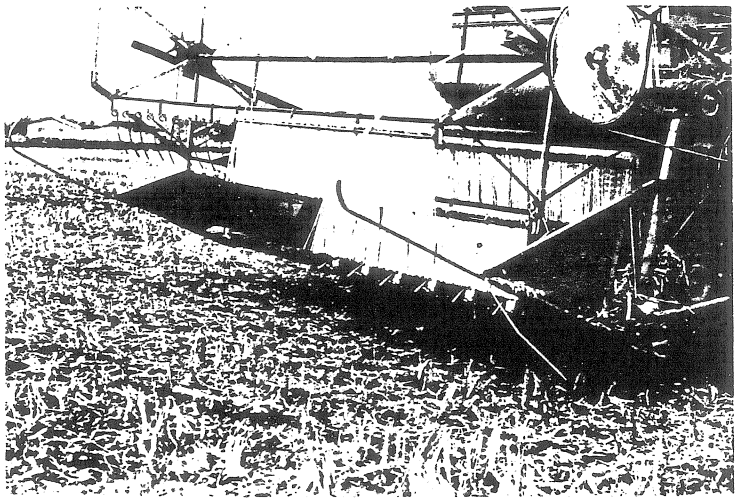

Figure 1. Location of air-jet guards on header.

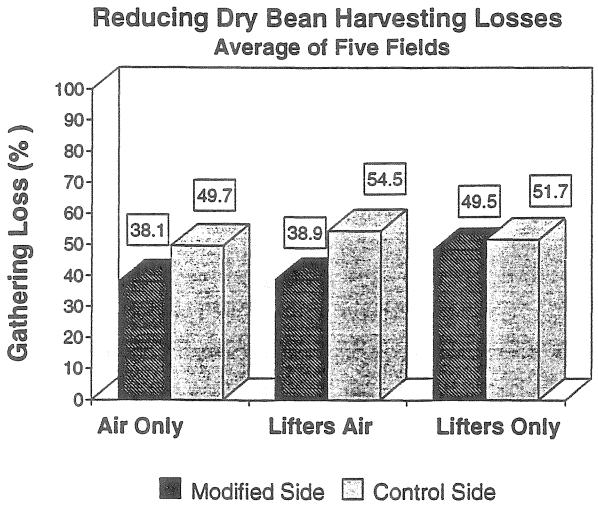

Figure 2. Gathering loss results for five fields.