Reprinted from 2002 *Columbia Basin Agricultural Research Annual Report. Spec. Rpt. 1040,* pp. 37-43, 2002
Oregon State University in cooperation with USDA-Agricultural Research Service, Pendleton, OR

EFFECTS OF HEADER MODIFICATIONS ON GARBANZO BEAN HARVESTING LOSSES

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Abstract

Due to the lack of specialized equipment, harvesting losses of garbanzo beans (*Cicer arietinum* L.) can be excessive as compared to other major crops like wheat, corn, and soybeans. This study was conducted to determine if recently developed header technologies would reduce harvesting losses. Six different combine header configurations were investigated on a field site that yielded approximately 1,000 lb/acre during the 2001 crop year. Equipment evaluated in the study included two types of knife guards, two guard attachments, a stripper header, and two types of pickup reels. Depending on the header configuration used, harvesting losses ranged from a low of 11 percent to a high of nearly 26 percent. Double density guards were found to reduce losses by 45 percent (116 lb/acre) as compared to single density guards. Short and long plastic fingers, which attach to specially made double density knife guards, did not affect combine header losses, total loss, or yield when compared to the standard knife guard without the attachments. The experimental air reel tested reduced header losses by 30 percent (45 lb/acre), but this difference was not statistically significant ($P = 0.05$). The stripper header had the highest losses (290 lb/acre) and least combine yield (693 lb/acre), but due to the improper header height used, the results found in this study may not accurately reflect stripper header performance. Header losses were nearly identical to total combine losses for all experiments, indicating that header loss is the dominant factor in harvesting losses for garbanzo beans and that threshing, separating, and cleaning losses are minimal. The losses reported in this study may be higher than conventional field losses due to the late harvest date and the improper header height used. They do, however, suggest that garbanzo bean harvesting losses can be economically significant and that header configuration can dramatically affect harvesting losses.

Key Words
Harvest loss, combine performance, harvesting technology, chickpea, garbanzo

Introduction

One of the problems associated with the economic viability of garbanzo beans (*Cicer arietinum* L.) and other specialty crops is the lack of specialized equipment needed to seed, harvest, and process the crop in a cost effective manner. Harvesting losses for major crops like wheat, corn, and soybeans are typically less than 7 percent (Hunt 1977, Doane Information Services 1981); however, when conventional equipment is used to harvest garbanzo beans, harvesting losses can be as high as 25 percent (M.C. Siemens, unpublished data, 2001). Primary Sales of Australia[1] manufactures plastic fingers (Fig. 1) that attach to specially made double density knife guards and have been used to significantly reduce header losses for lupin, a legume crop with short stature similar to that of garbanzo beans (G. Riethmuller, personal communication,

[1] Reference to a product or company is for specific information only and does not endorse or recommend that product or company to the exclusion of others that may be suitable.

2001). These devices come in a variety of shapes and sizes and are designed to support plants from below and prevent them from falling off the front of the header. Riethmuller (1995) reported additional technologies that were shown to reduce header loss for legume crops. These devices include double density knife guards and air reels. Double density guards reduce the distance the plant is moved prior to being cut, since they have twice as many cutting surfaces per unit length compared to single density guards. This limits plant shaking and therefore cutter bar harvesting losses. Air reels reduce shatter loss by delivering the crop to the header with a blast of air rather than mechanically with bats or fingers. It is expected that these devices will reduce garbanzo bean harvesting losses, but they have not been thoroughly evaluated in the Pacific Northwest. To address this, a research study was initiated to investigate the effectiveness of these devices relative to a conventional header equipped with a bat reel and single density guards.

Objectives

The objectives of this study were to:

1. determine garbanzo bean header loss from various header configurations, and

2. evaluate the economic implications of header modifications for the garbanzo bean grower.

Figure 1. Double density guard with plastic finger attachment.

Methods

The effect of various types of header configurations on garbanzo bean harvesting losses was investigated during the 2001 crop year. Two types of knife guards, two guard attachments, a stripper header, and two types of pickup reels were examined in the study. This resulted in six unique treatments (Table 1). The two types of knife guards tested included single density guards with individual guards spaced 3 in apart and double density guards with 1.5 in guard spacing. Single density knife guards were mounted on a John Deere 7700 combine equipped with a 22-ft platform and a bat reel header. The double density guards were tested on a Wintersteiger plot combine with a 5.5-ft-wide draper type platform. This platform was also used to test two types of the previously mentioned plastic finger guard attachments that mount on specially designed double density knife guards.

The two guard attachments evaluated included short and long finger attachments that measure 5 in long by 0.75 in wide and 15.75 in long x 2 in wide respectively (Fig. 2). The short plastic finger attachments

Table 1. Description of equipment configurations and treatments examined for garbanzo bean harvesting loss study, Adams, Oregon, 2001.

Treatment number	Combine make	Header width	Header/reel type	Guard density	Guard attachment
		ft			
1	John Deere 7700	22	Bat reel	Single	None
2	Wintersteiger	51/2	Bat reel	Double	None
3	Wintersteiger	51/2	Air reel	Double	None
4	Wintersteiger	51/2	Air reel	Double	Short fingers
5	Wintersteiger	51/2	Air reel	Double	Long fingers
6	Gleaner F-Series	12	Stripper	None	None

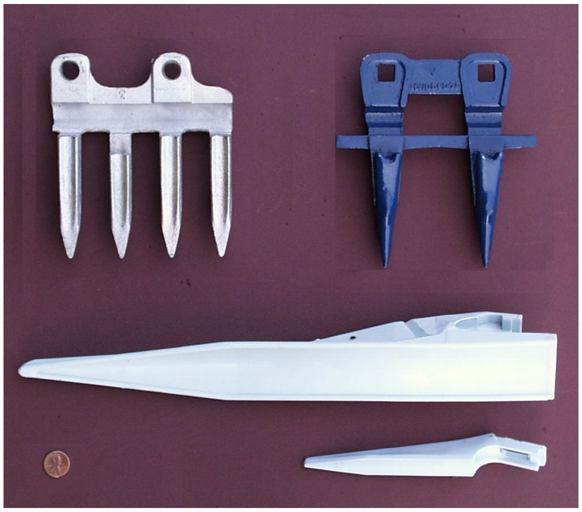

Figure 2. Single and double density knife guards and short and long plastic finger guard attachments.

were mounted on each double density knife guard according to the manufacturer's instructions. Each long finger guard attachment fits over two double density knife guards and were mounted on the header with one knife guard between each plastic guard attachment.

Three types of crop gathering devices were tested including a bat reel, an air reel, and a stripper header. Conventional bat reels were evaluated on the previously mentioned John Deere 7700 combine with a 22-ft-wide platform and on the Wintersteiger plot combine with a 5.5-ft-wide platform. The air reel is an experimental unit designed and developed by the USDA-ARS in Pendleton, Oregon for use on a Wintersteiger plot combine. The device was patterned after commercially available air reels and is principally comprised of a 5-in-diameter aluminum tube that serves as the main plenum, a Gandy impeller blower, flexible tubing, and a 5.5-HP Honda engine (Fig. 3). Extending from the main plenum are 1-in inner diameter tubes spaced 10 in apart, which direct streams of air towards the header during operation. The stripper header evaluated was a 12-ft-wide,

Figure 3. Experimental air reel attached to the header of a plot combine.

Shelbourne Reynolds model mounted on an F-series Gleaner combine.

The study was conducted at the Columbia Basin Agricultural Research Center near Adams, Oregon on a field that was planted to 'Sinaloa' garbanzo beans on April 24, 2001. A John Deere 9400 deep furrow drill with 10-in row spacing was used to plant the crop at a rate of 150 lb/acre. Inoculum and 75 lb/acre of starter fertilizer (16-20-0-14) were mixed with the seed at planting. Weed control consisted of a preplant application of glyphosate (24 oz/acre) and trifluralin (1.5 pt/acre) incorporated to a depth of 3 in with a cultivator.

Test plots, 100 ft in length, were laid out in a completely randomized block design with 5 replications and 5 treatments in each block. The sixth treatment, the JD 7700 combine with single density guards and a bat reel, was tested on an area immediately adjacent to the blocked plot area due to limitations in available plot area. Prior to conducting the combine harvest loss portion of the study, plants were manually collected from each plot from a sample area measuring 3.28 ft long by 3.33 ft wide (4 rows). The plants were later threshed by hand to determine harvestable yield. Also, two harvest loss sample areas were established in each plot

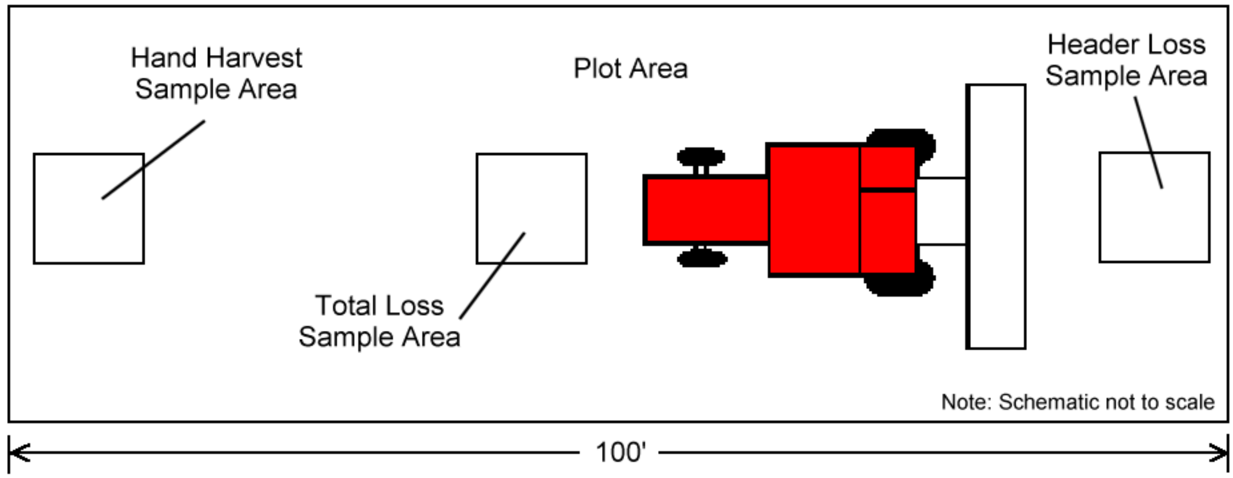

Figure 4. Sample area locations for hand harvest, combine header loss, and combine total loss for harvesting loss study.

and marked with paint, one near the middle of the plot and the other close to the end of the plot (Fig. 4). Sample areas measured 3.28 ft long by 3.33 ft wide (4 rows). Pods and seeds from each of these areas were collected, threshed, and weighed to determine preharvest loss. The first sample area near the middle of the plot was used to determine total harvesting losses, which includes header losses and machine losses due to threshing, separating, and cleaning. The second area near the end of the plot area was used to determine header losses. Header losses were determined by running the combine at operating speed to the end of the plot and then stopping abruptly. With the combine stopped, the residue remaining in the combine discharged out of the rear of the combine into an area behind and outside of the sample area. After harvesting the plot areas, pods and seeds in the sample areas were collected manually, threshed and weighed to determine header and total harvest loss. Combine grain samples were collected to determine combine yield.

Results

During the experiment, two problems were encountered that may have impacted the study's results. First, while harvesting with the Wintersteiger combine, it was observed that cut plant material lodged on the outside edges of the header and would not feed properly into the machine. The plot combine's header is designed and works well for wheat, but for short stature crops like garbanzo beans, the belt feeding mechanism is too narrow and the baffling too steep to properly feed the cut crop. As a result, using this header probably caused excessive loss as compared to using one with a different geometry. The other major problem encountered was the tall ridges of soil between crop rows that were formed by the deep furrow drill used to seed the crop. These soil ridges prevented the combine operator from being able to lower the header to the proper operating height and therefore also caused atypical harvest losses.

Table 2. Average[1] combine yield, combine losses, and hand harvest yield of garbanzo beans in 2001, Adams, Oregon.

Yield source	Yield
	lb/acre
Combine grain	826
Combine losses	169
Total harvestable grain	995
Hand harvest grain	1,010

[1] Sample size n = 30.

Due to the late harvest date of September 5, 2001, preharvest losses were high and averaged nearly 350 lb/acre. Over all treatments, the average combine yield was 826 lb/acre, while the average total combine loss was 169 lb/acre. The sum of these two, 995 lb/acre, reflects the total harvestable grain yield and compares favorably to the hand harvested grain yield of 1,010 lb/acre (Table 2). This result suggests that plot and sample size were sufficiently large to obtain accurate results.

The effect of guard type, guard attachment, and header type on garbanzo bean header loss, total combine loss, combine yield, value of lost crop, and cost of modification are shown in Table 3. Compared to single density guards, the double density guards reduced total combine harvesting losses from 255 lb/acre to 139 lb/acre, or 45 percent. This difference of 116 lb/acre was statistically significant at the 95 percent confidence level. According to Ferrel (2002), garbanzo bean prices typically average between \$0.18/lb and \$0.23/lb and have fluctuated from a low of \$0.14/lb to a high of \$0.47/lb over the last 15 years. Assuming a historically low, but current price of \$0.15/lb (G.D. Ferrel, personal communication, 2002), reducing losses by 116 lb/acre would represent a savings of \$17.40/acre. Depending on the manufacturer, double density guards cost between \$30/ft and \$70/ft of header width. The higher cost of \$70/ft is for the special double density guards that accommodate the plastic finger attachments, while the lower cost of \$30/ft is for standard double density

Table 3. Effect of header configuration on combine header loss, total loss, combine yield, lost crop value, and modification cost for garbanzo beans in 2001, Adams, Oregon.

Treatment	Header loss	Total loss	Combine yield	Value of crop loss[1]	Modification cost[2]
	lb/acre	lb/acre	lb/acre	\$/acre	\$/ft
Guard type					
Double density	---	139 a	807	21	30-70
Single density	---	255 b	---	38	---
Guard attachment					
None	107 a[3]	102 a	873 a	16	---
Long	125 a	116 a	868 a	18	41
Short	236 a	126 a	890 a	19	9-18
Header/reel type					
Air reel	107 a	102 a	873 a	16	8,900
Bat reel	160 a	139 a	807 a	22	---
Stripper	290 b	281 b	693 b	43	30,000[4]

[1] Value is average of header loss and total combine loss multiplied by \$0.15/lb.
[2] Modification cost for replacing single density knife guards and bat reel with alternative indicated (a 30-ft header width is assumed).
[3] Within columns and treatment category, means followed by the same letter are not significantly different by Duncan's new multiple range test (P = 0.05).
[4] Trade in value of 30-ft bat reel header not accounted for in this estimate.

Figure 5. Short plastic finger attachment mounted on every other double density knife guard.

guards. Assuming this reduction in losses of 116 lb/acre would carry over to a commercial field, the $30/ft double density guards mounted on a 30-ft header would pay for themselves on as few as 50 acres.

Compared to the treatment where no guard attachments were used, the long plastic finger attachments had little effect on header loss, total loss, or combine yield and no statistically significant differences were found. Within treatments, total combine losses were similar (within 9 lb/acre), but lower than header losses, indicating that combine threshing, separating, and cleaning losses were insignificant when compared to header losses.

The header loss data were consistent and reasonable with the exception of one trial where the short finger attachments were used. In this trial, header losses of 236 lb/acre were found and were nearly twice as high as the total combine harvest losses of 126 lb/acre. This unexpected result can be explained by the fact that as the combine moved across the field, the density of plastic fingers was such that the crop was pushed towards the end of the plot, rather than fed into the combine. After harvesting two replications with this configuration, the plastic finger density was halved by removing every other plastic finger (Fig. 5). In subsequent trials, crop feeding improved substantially and header losses were reduced to values that were comparable to total combine losses. Consequently, header loss sampling error over all replications was high and no statistically significant differences in header losses were found between trials with different guard attachments. A separate analysis was conducted comparing just the long finger attachment header losses with the no finger attachment header losses because of this high header loss sampling error. Again, no statistically significant differences between treatments were found. Although measured header losses were higher when the short plastic fingers were used, total harvesting losses of 126 lb/acre and combine yields of 890 lb/acre were similar to and not statistically different from the total loss and combine yield values found in trials where the long fingers or no attachments were used.

Despite finding no significant reduction in harvesting loss, it is the author's opinion that the short finger attachments have the potential to reduce losses in certain garbanzo bean harvesting conditions. They may also be economically feasible given their relatively low cost ($9/ft if used on every other guard). The long plastic fingers were considered to be oversized and too expensive ($41/ft) to show much promise of improving garbanzo bean harvesting efficiency, either mechanically or economically.

Compared to the conventional bat reel header and stripper header, the air reel had the lowest header loss (107 lb/acre), the lowest total combine loss (102 lb/acre), and the highest combine yield (873 lb/acre). Although this represents approximately 30 percent less loss than the bat reel header, these differences were not statistically significant. Use of the stripper header resulted in significantly higher losses (300 lb/acre) and lower combine yields (700 lb/acre). A large percentage of these losses was probably due to operating the header too high rather than at the recommended setting. Therefore, these results may not accurately reflect stripper header harvesting performance.

Conclusions

Garbanzo bean harvesting losses can be high and of significant economic importance to growers. Depending on the header configuration used, harvesting losses ranged from a low of 11 percent to a high of nearly 26 percent. Double density guards reduced losses by 45 percent (116 lb/acre) compared to single density guards. Double density guards are commercially available for $30/ft and would pay for themselves in less than 50 acres, assuming a loss reduction of 116 lb/acre, a 30-ft header, and garbanzo beans priced at $0.15/lb. Short and long plastic fingers, which attach to specially made double density knife guards, did not affect combine header loss, total loss, or yield compared to the standard double density knife guard without any attachments. It is the author's opinion that the short plastic fingers may be beneficial in certain harvesting conditions, while the long plastic fingers are oversized for garbanzos and hold little promise for improving garbanzo bean harvesting efficiency. The experimental air reel reduced header losses by 30 percent (45 lb/acre) compared to a bat reel, but this difference was not statistically significant. The stripper header had the highest losses (290 lb/acre) and least combine yield (693 lb/acre) of any header tested, but due to the improper header height used, the results found in this study may not accurately reflect stripper header performance. The losses reported in this study may be higher than conventional field losses due to the late harvest date and the improper header height used. The results should therefore be interpreted with some caution. They do, however, suggest that garbanzo bean harvesting losses can be economically significant and that header configuration can dramatically affect harvesting losses. Further testing of these devices is planned for 2002.

Acknowledgment

The authors would like to thank Byron Wysocki for his diligence and hard work in helping conduct this experiment. A special thank you is also extended to Golden Plains Agricultural Technologies of Colby, Kansas for supplying components at a discounted rate.

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