RL0902

January 2004

Harvesting Methods on Direct Solid Seeded Upright Beans (Final Report)

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Abstract

Edible beans are a very popular irrigated crop in Southern Alberta. The conventional method to grow edible beans is in hilled rows, requiring specialized seeding, management and harvesting equipment. Hilled beans are undercut prior to harvest to stop the plant from growing and to detach the root system from the soil. The undercut bean plants are then easily lifted out of the soil with a special pickup and directed into a conventional harvester. Beans are and have been grown this way for years because no other method has proven to work better with minimal bean losses.

Recently, newer varieties of more upright growing edible beans have been developed. This means the plants grow more bushy than viney. Mature viney plants tend to lay over resulting in the bean pods being very close to the ground level making them un-harvestable. The new upright bean varieties will allow the use of more conventional equipment for seeding and harvesting. This project is to demonstrate the solid seeding and growth of two upright edible bean varieties and the harvesting of the beans with a conventional harvester outfitted with several different header attachments.

The AgTech Centre tested several different header lifter and reel attachments during the harvesting of solid seeded beans. Bean losses at harvest were measured for each header combination setup. Results showed some of the attachments did improve bean loses during harvesting, but the data was inconsistent and inconclusive after two years of testing. Observations during testing concluded that climatic and crop conditions had more to do with the amount of losses than the header attachments alone.

Harvesting Methods on Direct Solid Seeded Upright Beans

Introduction and Background

Edible beans are a very popular irrigated crop in Southern Alberta. Edible beans are traditionally grown in hilled rows requiring specialized seeding, management and harvesting equipment.

Hilled beans are undercut prior to harvest to stop the plant from growing and to detach the root system from the soil. The undercut bean plants are then easily lifted out of the soil with a special pickup and directed into a conventional harvester. Beans are and have been grown this way for years because no other method has proven to work better with minimal bean losses during harvest.

Recent breakthroughs in plant breeding have developed bean varieties that grow upright, allowing the use of more conventional equipment. The upright varieties grow more bushy than viney. Mature viney plants tend to lay over resulting in the bean pods being very close to the ground level making them un-harvestable.

Upright beans can be seeded in narrow rows with conventional equipment. Spraying and harvesting can also be done with the same equipment as used on traditional cereal, pulse and oilseed crops. The new bean varieties grow more upright which allows for straight-cut harvesting which helps to lower harvest losses. Using common conventional equipment and practices reduces the need for expensive specialized equipment and management.

However, using conventional harvest equipment alone still results in high bean losses at harvest time and therefore special header attachments are required. The header attachments are much cheaper than specialized row crop equipment and less management is required to raise the crop conventionally. There have been several types of harvester header attachments developed in recent years, but the benefit from reducing bean harvest losses by each attachment was not studied.

This project demonstrated the solid seeding, management and growth of two upright edible bean varieties. In the Fall of 2002 and 2003 the AgTech Centre tested several harvester header attachments during harvesting of the beans and losses were measured for each system used. The loss results were analyzed, compared and conclusions about the effectiveness of the header attachments to reduce bean harvest losses were made.

Experimental Procedure

An upright edible bean was seeded under half of a pivot irrigation system at the Canada-Alberta Crop Development Initiative farm at Lethbridge, Alberta. The variety was AC Red Bond treated with Maxim, Apron and Agristep. The area seeded was 3.5 ha (8.6 ac). The fields were pre-sprayed with Glyphosate chemical at a rate of 1.8 L/ha (.16 UK gal/ac) on May 15. Edge was applied at 17.6 kg/ha (15.7 lbs/ac) and incorporated twice with a heavy harrow on May 21. The beans were direct seeded into corn stubble, with average soil moisture, at a rate of 112 kg/ha (100 lbs/ac) on May 30. A blend of fertilizer was side banded with the seed at a rate of 198 kg/ha (177 lbs/ac). Nitrogen (46-0-0) was applied at 45 kg/ha (40 lbs/ac N), Phosphate (11-52-0) was applied at 34 kg/ha (30 lbs/ac P), Potash (0-0-62) was applied at 22 kg/ha (20 lbs/ac K) and Zinc was applied at 5.6 kg/ha (5 lbs/ac actual). The field was rolled on May 31. The beans were solid seeded with a double shoot air drill on 23 cm (9 in) spacings**.** The beans were sprayed for in-crop weed control with Basagran at 2.3 L/ha (.2 gal/ac) and Assure II at .55 L/ha (.05 gal/ac) with 173 L/ha (15.4 UK gal/ac) nozzles on a conventional sprayer.

The crop was assessed 4 weeks after general emergence was achieved. The stand looked average, but there was an extremely high amount of volunteer alfalfa from two years ago growing over the bean canopy. A decision was made to run a swather through the crop and cut the tops of the alfalfa plants just above the bean plants to give them a chance to grow over the alfalfa. This helped for a couple weeks until the alfalfa began growing again. The beans had a chance to establish by this time. A 1.2 hectare (3 acre) area of the field was clear of alfalfa and this is where all the harvest loss measurements were made.

The beans were harvested on October 9, 13, 14, 16 and completed on the 27. The span on harvest dates was due to snowy weather. Several different bean lifters and reel systems were used to harvest the beans. Loss measurements were made just prior and just after harvesting.

Bean plant, pod counts, number of seeds on the ground and average number of seeds per pod were measured randomly across the field just prior to harvesting. Several bean pod and seed loss measurements were taken randomly across the field for each lifter and reel combination used during the harvesting of the beans. Pre-harvest bean counts and post-harvest loss measurements were taken in .5 square metre (28 sq in) areas. The lifters and reels used are listed in **Table 1**. The lifter and reel combination test setups are listed in **Table 2**.

Table 1: Lifter and Reel Types

Lifter Number	Lifter Type	Reel Number	Reel Type
1	Edwards/Keho Bean Sweep Lifter	A	Keho Air-reel
2	Gaterman Pickup Guard	B	Pickup-reel with Standard Tines
3	Primary Platform Extender Finger	C	Pickup-reel with HCC Paddle Tines
4	Primary 21 mm Adapt-A-Cap Crop Finger		
5	Harvestaire Crop Lifter		
6	(Check) Standard Case 960 Combine Guard		
7	Gleaner Flex Header		

Table 2: Lifter and Reel Combination Test Setup Configurations

Configuration Number	Test Description Setup
1A	These sweeps were mounted on every Case 960 guard finger for a 1.2 m (4 ft) area of the header during 2003 tests.
2A	The Gaterman lifters were mounted on every other Case 960 guard finger for a 1.2 m (4 ft) area of the header during all tests.
3A	These extender fingers required the special Primary guards. One extender finger mounted on 2 guard fingers. Extenders were mounted on every guard finger for a 1.2 m (4 ft) area of the header. The fingers were run in position #2 during all tests.
4A	Special Primary 4 finger guards are required with these crop fingers. The fingers were placed on every finger for a 1.1 m (3.5 ft) area during most tests.
5A	A lifter was placed on every Case 960 guard finger for a 1.5 m (5 ft) area of the straight cut header during all tests.
6A	A 1.5 m (5 ft) area of straight cut header was left unadjusted. The standard Case 960 combine guards were used as the check in this area during all tests.
1B, 2B, 3B, 4B, 5B, 6B, 7B	All the same lifter setups mentioned above were used with the Pickup-reel with the standard single finger tines. The Gleaner Flex Header was only used with this type of reel because the header was a complete built setup.
1C, 3C, 4C, 5C, 6C	All the same lifter setups mentioned above were used with the Pickup-reel with the Paddle tines except the Gaterman lifters due to clearance of the Paddles.

A Primary Adapt-A-Gap 13mm and 21mm Crop Finger were both used in 2002. There was no measurable difference between the two in 2002 or from initial tests in 2003 and therefore the 13mm was not used this year. The 21mm Crop Fingers (**Figure 1**) were tested by mounting them on every and on every other Primary guard finger. Last year they had to be tested on every other guard finger due to plugging, but that was not the case this year. For all the measured tests, the 21mm Crop Fingers were mounted on every guard finger as recommended by the manufacturer and were tested both ways with the Pickup-reel with straight tines. The Harvestaire Crop Lifters (**Figure 2**) were mounted on every Case 960 guard finger in both years of testing. The Primary guards (**Figure 3**) have 4 fingers, but are the same width as a standard 2 finger guard and only the Primary lifters can mount on the special guard. The Bean Sweep Lifters (**Figure 4**) were mounted on every Case 960 guard finger and every other finger in 2002 but results showed the losses were less when mounted on every other guard finger. All 2003 Bean Sweep Lifter tests were with them mounted on every other Case 960 guard finger. The Primary Platform Extender Fingers (**Figure 5**) had 3 position settings. The setting used was #2 which resulted in the finger tip being 1 in (2.5 cm) above the ground level with the header as low as it could be. The Gaterman Pickup Guards (**Figure 6**) are spring loaded for rock protection and therefore were mounted and set to ride just above or on the ground for the best crop lifting results. All the lifter clearance measurements ranged from .5-1 in (1.3-2.5 cm) above ground at their points. All the above lifters were compared to the standard Case 960 combine guard (**Figure 7**) used as the standard check. Primary has several other types of lifter fingers for their special guard but due to the design of our older test combine and header, the other lifter models were not able to work on our combine. The Gleaner Flex Header was only available this past year for tests. The Flex Header was compared to all the other systems as another header type in combination with a flexible cutter bar as the lifter.

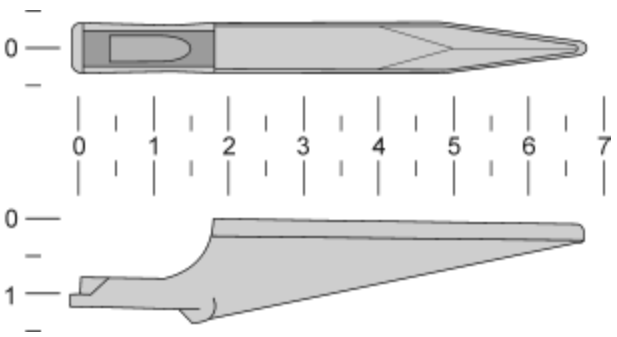


Figure 1: 21mm Primary Adapt-A-Gap Crop Finger

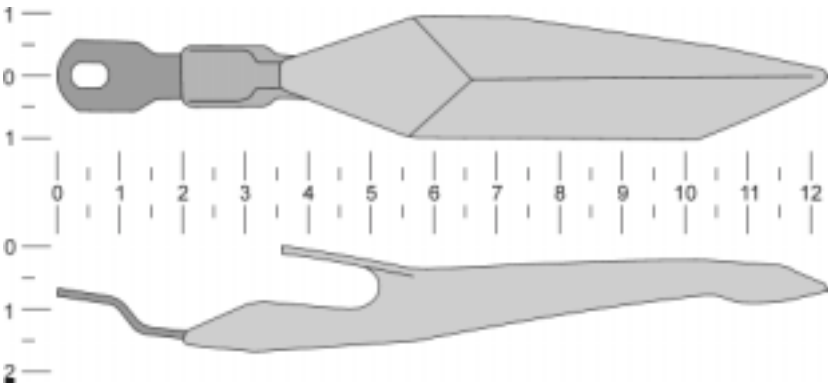


Figure 2: Harvestaire Crop Lifter

The Pickup-reel was outfitted with standard single finger tines which were used as one reel configuration. One half of the 5.5 m (18 ft) reel was setup with special bats mounted with 15 cm (6 in) wide Paddle tines (**Figure 8**) which were used as another reel configuration. The third reel setup was a Keho Air-reel mounted in place of the Pickup-reel. The Air-reel had adjustments for angle, height and velocity of airflow. The Pickup-reel had adjustments for the angle of tine or paddle aggressiveness and for height. These adjustments were critical to ensure the proper functioning of each reel setup. The Gleaner Flex Header had a Pickup-reel with standard single finger tines and the header was tested with the cutter bar riding right on the ground which is the normal procedure for low lying crops.

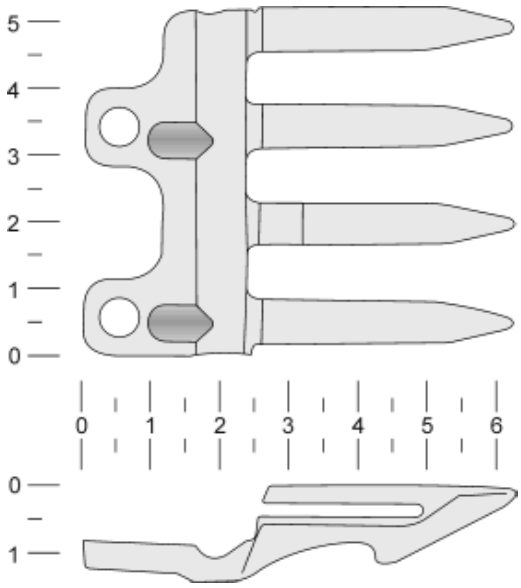


Figure 3: Primary 4-Finger Guard

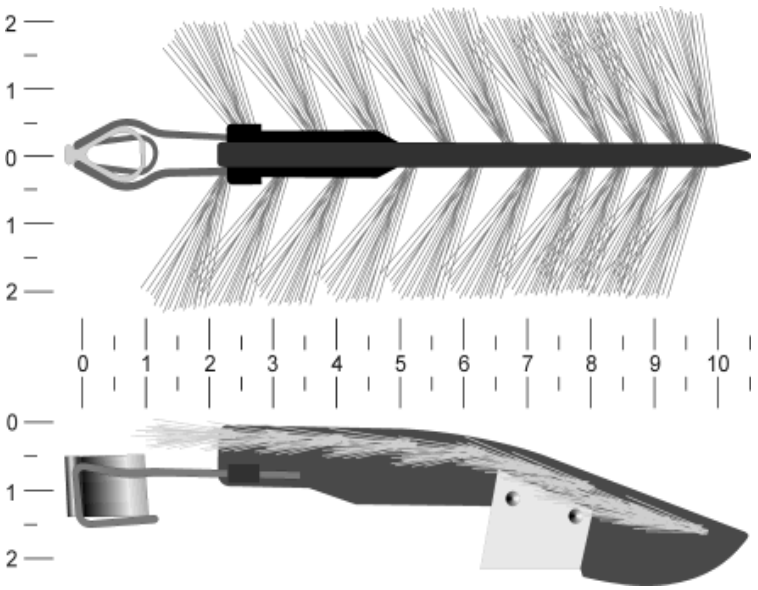


Figure 4: Keho Bean Sweep Lifter

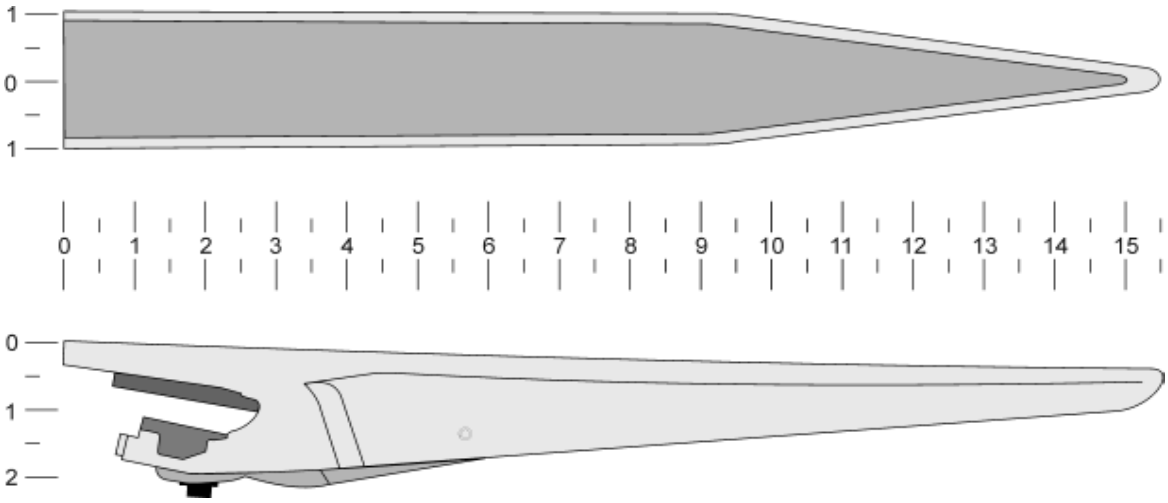


Figure 5: Primary Platform Extender Finger

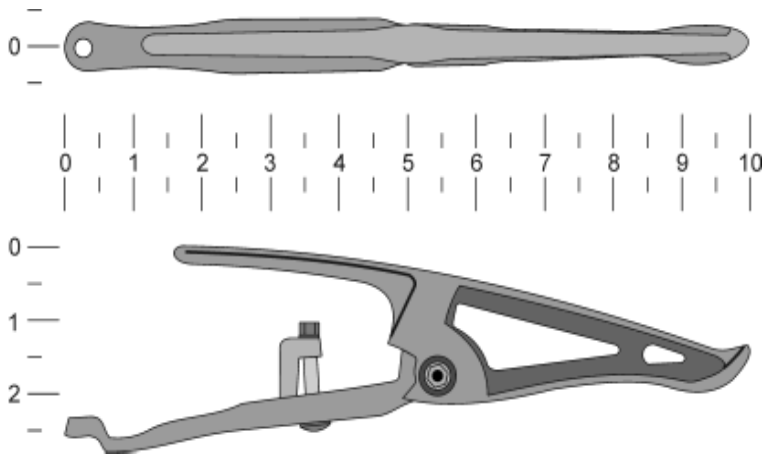


Figure 6: Gaterman Pickup Guard

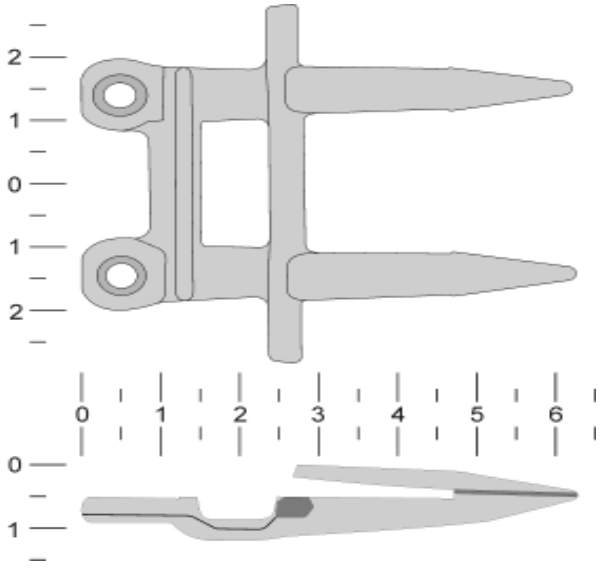


Figure 7: Case 960 Combine Header Guard

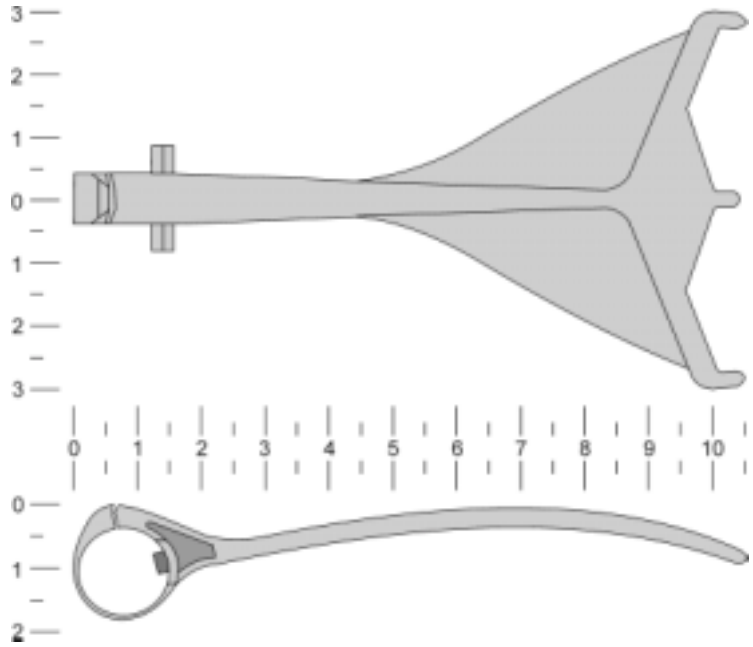


Figure 8: HCC Paddle Tine

The Air-reel was adjusted to the best angle of air flow to push the beans up over the lifters into the header auger. The combine header was set to the lowest point without pushing soil for all the bean loss tests. Every crop lifter was used with each of the 3 reel types and bean losses were measured for each configuration except for the Gaterman. The Gaterman Lifter could not be used with the Paddle Tine on the Pickup-reel because the lifters are taller than the others and therefore the Paddles could not reach in close enough to the ground to do any crop lifting.

The bean plant stand was very thin in 2002 and the thin conditions made it difficult for any of the lifters to work to their best potential. The soil surface was scattered with corn stalk bases and not rolled after seeding in 2002 which all inhibited the performance of the bean lifters. The crop stand was 2 plants/.5 sq m (28 sq in), 1.6 pods/plant and 1.3 seeds/pod better in 2003 which resulted in an approximate yield of 67.4 bu/ac (35 ft^3/ha) which is almost double the yield from 2002. The crop was over ripe at harvest time in 2003 and there were heavy pre-harvest losses already. The crop only dried more as harvest progressed and very heavy losses from pod shattering were suffered throughout the 2003 testing. The timing of harvest and weather were more important than any other factor to reduce losses.

Results and Observations

Bean losses were measured for each configuration of lifter and reel combinations. An Analysis of Variance (ANOVA) was used to analyze the loss measurement data. Some configurations significantly decreased losses compared to others. The results were analyzed in three separate ways, which are single bean seed losses, the full pod losses and the total seed losses (single seeds plus the seeds in the lost pods) An average of 5.3 seeds per pod was measured prior to harvest. The ANOVA indicated there were significant differences in losses between all three measurement type methods. See **Table 3** for the significant differences between the setups tested.

Table 3: Significant differences between combination setups

Test Description Setup	Seed Losses /sq m	Seed Losses /ft2	Significance	Test Description Setup	Pod Losses /sq m	Pod Losses /ft2	Significance	Test Description Setup	Total Seed Losses /sq m	Total Seed Losses /ft2	Significance
3B	39	4	a	4A	12	1	a	4B	134	12	a
4B	43	4	ab	3C	16	1	ab	3B	145	13	a
6B	50	5	abc	4B	17	2	ab	3C	156	14	a
1C	50	5	abc	3A	20	2	ab	6C	170	16	ab
4B*	52	5	abcd	3B	20	2	ab	3A	172	16	ab
2B	54	5	abcde	4C	20	2	ab	5B	180	17	ab
5B	54	5	abcde	6C	21	2	ab	4A	181	17	ab
6C	59	5	abcdef	5C	23	2	ab	4B*	182	17	ab
2A	60	6	abcdefg	5B	24	2	ab	4C	188	17	ab
5A	62	6	abcdefg	4B*	25	2	ab	1C	188	17	ab
1A	62	6	abcdefg	2A	25	2	ab	2A	193	18	ab
3A	68	6	bcdefg	1C	26	2	ab	5C	207	19	abc
3C	71	7	cdefgh	5A	29	3	abc	5A	214	20	abc
7B	79	7	defgh	2B	32	3	abc	2B	222	21	abc
4C	81	7	efgh	6B	35	3	abc	6B	233	22	abcd
5C	84	8	fgh	7B	39	4	bc	7B	285	26	bcd
6A	87	8	gh	6A	48	4	cde	1A	319	30	cd
1B	97	9	hi	1A	49	5	cde	6A	339	31	de
4A	117	11	i	1B	65	6	e	1B	443	41	e

*This setup was with the lifters mounted on every other gaurd finger instead of on every finger.
Any combination setup with a different letter designation than another setup is considered significantly different.

The plant stand was much better and the field was rolled after seeding in 2003. Due to these better conditions, unlike 2002, the lifters all worked well in that they did not plug from debris. There were more pods/plant this year, but there were also more pods close to or laying on the ground which made pod retrieval for any lifter very difficult. All the lifter losses were compared to the standard Case 960 combine guard losses, which was used as the standard check. The following loss measurement data analysis is from the 2003 test season only. See last years report for 2002 data.

ANOVA Stats Analysis

The lowest average bean seed losses in 2003 was with the Primary Extender Fingers with the Pickup-reel and straight tines at 38 seeds/sq m (4 seeds/sq ft). These losses were significantly lower than the Primary Extender Fingers with both other reels, the Gleaner Flex Header, the Primary 21mm lifters with the Air-reel and with the Pickup-reel and Paddle tines, the Harvestaire lifters with the Pickup-reel and Paddle tines, the Bean Sweeps with Pickup-reel and straight tines and the Case 960 guards with the Air-reel. The highest measured losses were with the Primary 21mm lifters with the Air-reel and seeds only at 117 seeds/sq m (11 seeds/sq ft) which is significantly higher than all other lifter and reel combinations except the Bean Sweeps with the Pickup-reel and straight tines with losses of 97 seeds/sq m (9 seeds/sq ft). The Primary 21mm lifters with the

Pickup-reel and straight tines had the second lowest seed losses at 43 seeds/sq m (4 seeds/sq ft). The Primary 21mm lifters had no significant measurable differences in seed losses if they were mounted on every or on every other guard finger. The Case 960 guard with Air-reel setup had significantly higher bean seed losses compared to the Case guard with the Pickup-reel with standard tines or Paddles by 38 and 28 seeds/sq m (3.5 and 2.6 seeds/sq ft). The Case 960 guard and Air-reel also had significantly higher losses than the Harvestaire, Gaterman, Primary 21mm and the Primary Extender Finger lifters all with the Pickup-reel and straight tines and the Bean Sweeps with the Pickup-reel with straight and Paddle tines. **Table 4** shows the harvesting losses with each lifter and reel combination setup.

There were some significant differences in losses of pods. Although the Primary 21mm lifters with the Air-reel had the highest seed losses, they had the lowest pod losses at 12 pods/sq m (1 pod/sq ft). These losses are significantly lower than the Case 960 guards and Bean Sweeps with the Air-reel by 36 pods/sq m (3.3 pods/sq ft), than the Bean Sweeps with Pickup-reel and straight tines by 53 pods/sq m (5 pods/sq ft) and significantly lower than the Gleaner Flex Header by 27 pods/sq m (2.5 pods/sq ft). The Case 960 guards and Bean Sweeps with the Air-reel also had significantly higher losses than all the other lifter and reel setups except the Harvestaire lifters with the Air-reel, the Gaterman lifters, the Case 960 guards with the Pickup-reel with straight tines and the Gleaner Flex Header. The Bean Sweeps with the Pickup-reel with straight tines had significantly higher losses than all other lifter and reel combinations except the Bean Sweep and Case 960 guards with the Air-reel.

When looking at the total seed losses (seeds plus pod seeds), the Primary Extender Fingers were the best. The Extender Fingers with both Pickup-reels had total losses of 144 and 156 seeds/sq m (13.4 and 14.5 seeds/sq ft) which is significantly better than the Case 960 guards and the Bean Sweeps with the Air-reel, the Bean Sweeps with the Pickup-reel with straight tines all by 170, 190 and 208 seeds/sq m (15.8, 17.6 and 19.3 seeds/sq ft) and the Gleaner Flex Header by 135 seeds/sq m (12.5 seeds/sq ft). The Primary 21mm lifters had the lowest overall losses of 134 seeds/sq m (12.4 seeds/sq ft), but were not significantly different from the two earlier mentioned Extender Finger combinations. The Bean Sweeps with the Pickup-reel with straight tines had the overall highest total seed losses at 443 seeds/sq m (41 seeds/sq ft) which is significantly higher than every other lifter and reel combination except the Case 960 guard with the Air-reel.

Overall, the Case 960 guards and Bean Sweeps with the Air-reel, the Bean Sweeps with the Pickup-reel with straight tines and the Gleaner Flex Header had the most consistently significant losses with seeds and pods. The Paddles on the Pickup-reel did help the Bean Sweeps to reduce losses, which is how they are recommended to be operated. Both years results did show that all the lifters improved the seed and pod losses compared to just using the Case 960 guards by themselves with the Pickup-reel with straight tines and with the Air-reel, but the loss measurements were usually insignificant and inconsistent.

When comparing the losses with just the reels there were some significant differences. The Pickup-reel with straight tines and lifters had significantly lower single seed losses than all the other reels (**see Fiqure 9 for results**). The Air-reel resulted in 55 seeds/sq m (5 seeds/sq ft) more loss than the Pickup-reel with straight tines which is opposite than last year. The Air-reel also had 20 seeds/sq m (2 seeds/sq ft) more seed losses than the Pickup-reel with Paddles. The Gleaner Flex Header with Pickup-reel had 6 seeds/sq m (.6 seeds/sq ft) higher losses than the Air-reel. When looking at just pod losses, the Air-reel and the Pickup-reel with straight tines had the same losses and were 20 pods/sq m (2 pods/sq m) higher than the Pickup-reel with paddles. The Flex Header had 37 pods/sq m (3.4 pods/sq ft) higher losses than the Air-reel. The total seed losses resulted in the Air-reel having 60 seeds/sq m (5.6 seeds/sq ft) higher losses than the Pickup-reel with straight tines and 100 seed/sq m (9 seeds/sq ft) higher losses than the Pickup-reel with Paddles. The Flex Header had 185 total seeds/sq m (17 seeds/sq ft) higher losses that the Air-reel which is significant.

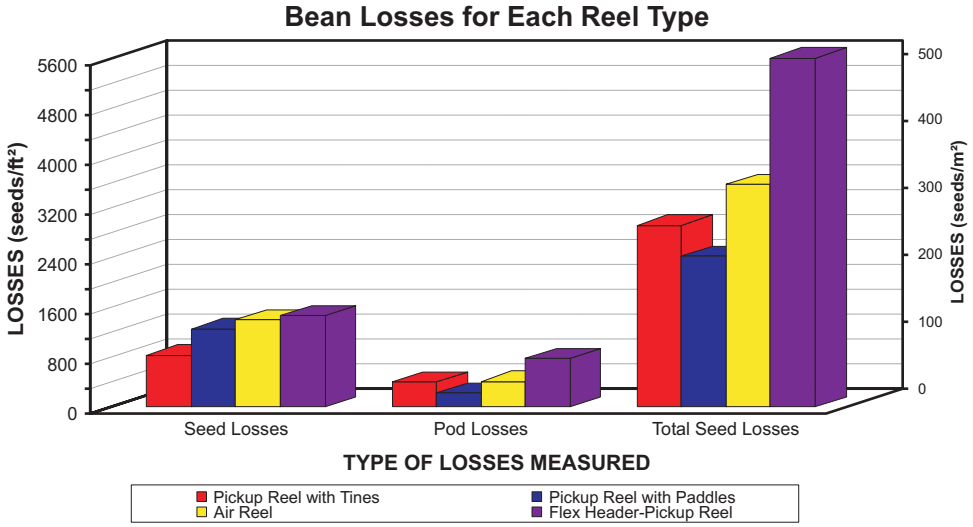


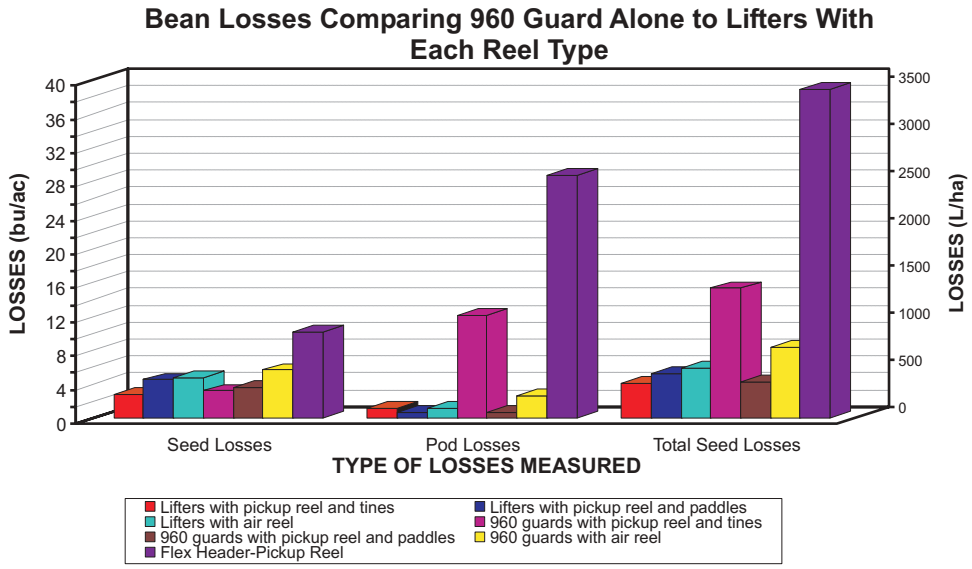
Figure 9: Bean losses for each reel type

Graph Analysis

The Stats program used at the AgTech Centre can not analyze incomplete data. The following results are observations of the L/ha (bu/ac) losses with all the data measurements graphed and compared together. The graphs comparing the lifters and standard Case 960 guard show the lifters did make a difference. There was less than a 90 L/ha (1 bu/ac) gain using the lifters when looking at just the seed losses alone, but there was a difference in the amount of pod losses if lifters were not used. There was a 989 L/ha (11 bu/ac) gain in pod losses if lifters were used with the Pickup-reel and straight tines. There was a 90 L/ha (1 bu/ac) loss of seeds and another 90 L/ha (bus/ac) loss of pods if lifters were used with the Pickup-reel and Paddles. There was just over a 90 L/ha (bu/ac) increase in seed and pod losses if the lifters were used in conjunction with the Air-reel. The Flex Header had the highest losses by 449 L/ha (5 bu/ac) of just seeds over the Case 960 guard with the Air-reel combination. The Flex Header had 2517 L/ha (28 bu/ac) losses in pods which was 1438 L/ha (16 bu/ac) higher than the Case 960 guards with the Pickup-reel and straight tines. Overall the Flex Header had 3416 L/ha (38 bu/ac) total seed losses which was 2067 L/ha (23 bu/ac) higher than the Case 960 guards with the Pickup-reel and straight tines **(see Fiqure 10 for results)**.

When comparing the losses from each lifter to the standard Case 960 guard with the Air-reel, there were some differences. All the lifters except the Primary 21mm resulted in a 180 L/ha (2 bu/ac) gain in seed alone losses over having no lifter. The Primary 21mm resulted in 180 L/ha (2 bu/ac) higher seed losses than the standard Case 960 guards alone. Then when looking at the pod losses, the Case 960 guard and the Bean Sweeps had the same amount of losses at 252 L/ha (2.8 bu/ac) and the Primary 21mm hardly had any losses and the other 3 had around 90 L/ha (1 bu/ac) pod losses. When the total seed losses were worked out, the Case 960 guard had the highest losses (764 L/ha or 8.5 bu/ac) and the Primary 21mm was 45 L/ha (.5 bu/ac) less. The Bean Sweeps had 584 L/ha (6.5 bu/ac) losses and the other 3 had 449 L/ha (5 bu/ac) losses.

Comparing the losses by each lifter compared to the standard Case 960 guard with the Pickup-reel and straight tines showed no loss differences with seeds alone. The Case 960 guard had higher pod losses by 989 L/ha (11 bu/ac) over all the lifters which averaged around 90 L/ha (1 bu/ac) pod losses. The Flex Header had 1528 L/ha (17 bu/ac) higher pod losses than the Case 960 guard. The Flex Header had 629 L/ha (7 bu/ac) higher total seed losses than the Case 960 guards which had losses of 1393 L/ha (15.5 bu/ac). The Flex Headers total losses were 2067 L/ha (23 bu/ac) higher than all the other lifters which averaged around 315 L/ha (3.5 bu/ac) losses which is fairly significant.



Fiqure 10: Losses in bu/ac comparing lifters with different reels to the Case 960 guards (check)

Looking at the lifter losses compared to the standard Case 960 guard all with the Pickup-reel and Paddle tines showed that the Bean Sweeps had the least amount of total losses at 360 L/ha (4 bu/ac). The Case 960 guard had the second least amount of losses and the rest of the lifters had 90-180 L/ha (1-2 bu/ac) more losses than the Bean Sweeps. The same trend followed for the seed alone losses and the pod losses only varied by 63 L/ha (.7 bu/ac) between all systems.

Discussion

During the 2003 harvest, it was difficult to observe any lifters or reel combinations working better than the other. All the lifters worked the way they were supposed to this year as opposed to frequent plugging in 2002. The only noticeable observation was how easily the beans shelled out during operation with all the lifters and reels. It was clear after each harvest pass with all the different lifters and reel combinations that the losses were unacceptably high observed by the seeds present on the ground.

All the lifters had similar seed only losses with the Pickup-reel with straight tines. The Case 960 guard with the Pickup-reel and straight tines had significantly higher pod losses than all the lifters. All the lifters including the Case 960 guard check had similar pod losses with both the Pickup-reel with Paddles and the Air-reel. The Case 960 guard and the Bean Sweeps both had 180 L/ha (2 bu/ac) higher losses than the other lifters with the Air-reel, but this is not very significant. The Flex Header had by far the highest losses than all the other lifters and reel combinations. It appeared that due to the over dry beans and the fact that the Pickup-reel had to lift the plants up over the flexible cutter bar resulted in very high shattering losses. Many of the pods shelled on the cutter bar deflector and then the seeds fell down the ramp and back onto the ground.

Table 4: Harvest losses measured with each lifter and reel configuration. Total bean seed lossess were calculated by using a 5.3 seeds/pod number

Lifter Setup	Reel Type Setup	Material Count Type	Average Less Pre Harvest Losses		Total Seed Losses sq m	Average Yield Lossess		Total Yield Losses Beans + Pods		Avg.Gained Over The Check		% Losses	% of Yield Gained Over the Check
			28 in sq	sq m		L/ha	bu/ac	L/ha	bu/ac	L/ha	bu/ac		
Case 960 Guard **(Standard Check)**	Pickup straight tines	Beans	43.5	86.0	406.5	293.0	3.3	1385.0	15.4	n/a	n/a	22.9	n/a
		Pods	30.6	60.5		1092.0	12.2						
Primary 21mm A	Pickup straight tines	Beans	32.5	64.1	129.6	218.0	2.4	261.0	2.9	1125.0	12.5	4.3	18.6
		Pods	6.3	12.4		42.0	0.5						
Primary 21mm B	Pickup straight tines	Beans	42.4	83.7	219.9	285.0	3.2	373.0	4.2	1012.0	11.3	20.6	2.3
		Pods	13.0	25.7		87.0	1.0						
Gaterman	Pickup straight tines	Beans	36.9	72.9	331.2	248.0	2.8	414.0	4.6	971.0	10.8	6.8	16.0
		Pods	24.7	48.7		166.0	1.9						
Primary Extender fingers - setting #2	Pickup straight tines	Beans	23.2	45.8	148.8	156.0	1.7	223.0	2.5	1163.0	12.9	3.7	19.2
		Pods	9.8	19.4		67.0	0.7						
Harvestaire Lifters	Pickup straight tines	Beans	45.5	90.0	213.9	307.0	3.4	387.0	4.3	999.0	11.1	6.4	16.5
		Pods	11.8	23.4		80.0	0.9						
Bean Sweeps	Pickup straight tines	Beans	49.2	97.2	442.9	332.0	3.7	554.0	6.2	831.0	9.3	9.1	13.7
		Pods	33.0	65.2		222.0	2.5						
Case 960 Guard	Pickup Paddle tines	Beans	48.7	96.2	201.0	328.0	3.7	396.0	4.4	0.0	0.0	6.5	n/a
		Pods	10.0	19.8		67.0	0.8						
Primary 21mm A	Pickup Paddle tines	Beans	70.2	138.7	235.6	473.0	5.3	535.0	6.0	-140.0	-1.6	8.8	-2.3
		Pods	9.3	18.3		62.0	0.7						
Primary Extender fingers - setting #2	Pickup Paddle tines	Beans	61.0	120.5	172.8	411.0	4.6	444.0	4.9	-49.0	-0.5	7.3	-0.8
		Pods	5.0	9.9		33.0	0.4						
Harvestaire Lifters	Pickup Paddle tines	Beans	73.2	144.7	273.0	493.0	5.5	575.0	6.4	-180.0	-2.0	9.5	-3.0
		Pods	12.3	24.2		83.0	0.9						
Bean Sweeps	Pickup Paddle tines	Beans	39.7	78.5	235.6	268.0	3.0	369.0	4.1	27.0	0.3	6.1	0.4
		Pods	15.0	29.6		101.0	1.1						
Case 960 Guard	Air-Reel	Beans	76.5	151.1	533.4	515.0	5.7	760.0	8.5	0.0	0.0	12.6	n/a
		Pods	36.5	72.1		246.0	2.7						
Primary 21mm A	Air-Reel	Beans	106.2	209.9	223.0	716.0	8.0	724.0	8.1	37.0	0.4	11.9	0.6
		Pods	1.3	2.5		8.0	0.1						
Gaterman	Air-Reel	Beans	49.7	98.2	244.9	334.0	3.7	429.0	4.8	332.0	3.7	7.1	5.5
		Pods	14.0	27.7		94.0	1.1						
Primary Extender fingers - setting #2	Air-Reel	Beans	58.0	114.5	203.6	390.0	4.3	448.0	5.0	313.0	3.5	7.4	5.2
		Pods	8.5	16.8		58.0	0.6						
Harvestaire Lifters	Air-Reel	Beans	51.7	102.2	288.1	348.0	3.9	467.0	5.2	293.0	3.3	7.7	4.8
		Pods	17.8	35.1		120.0	1.3						
Bean Sweeps	Air-Reel	Beans	52.0	102.7	495.5	350.0	3.9	602.0	6.7	158.0	1.8	9.9	2.0
		Pods	37.5	74.1		253.0	2.8						
Gleaner Flex Header	Pickup Reel	Beans	68.9	136.0	519.5	464.0	5.2	710.0	7.9	50.0	0.6	11.7	0.8
		Pods	36.6	72.3		246.0	2.7						

The Primary 21 mm A setup is with the lifters mounted on every guard finger and B is with them on every other finger

Overall the Primary 21mm and Extender Fingers had the most consistently lower losses with each reel type when looking at seed alone, pod or total seed losses. The Primary 21mm lifters with the Air-reel did have the highest seed alone measured losses with the Pickup-reel and Paddle tines but had first or second lowest losses in every other situation. It appeared that the Primary 21mm and Extender Finger lifters worked better because they are mounted very close together and have a gradual climb into the cutter bar. Due to the wider, flat surfaces, loose seeds are more frequently caught and then pushed by the reel or following plants into the header. The Gaterman lifters are not recommended for use in beans, but we included them in this test due to their wide ranging availability. As a result the Gaterman lifters caused little problems and did decrease bean losses in some cases.

The Bean Sweeps did improve losses in some cases, however, they are still in the development stage and need further modifications to better reduce losses. The bristles on the Bean Sweeps were too firm and pushed some plants over before lifting the pods up and then the plant stalk was cut resulting in lost pods. The angle of the Bean Sweeps also appeared to need modification to allow a more gradual flow of the plants and pods up and over the bristles.

Conclusions

In general, all the lifters and reel combinations decreased the bean losses during harvest when measuring either seed, pod or total seed losses. For example, one lifter and reel combination decreased seed only losses compared to the Case 960 guard whereas another reduced only the pod losses and some reduced both types of losses. There were significant differences between several lifter and reel combinations depending on what type of loss was measured. In some instances though, the Case 960 guards resulted in the lowest measured losses which makes the conclusions a little inconclusive.

The first season (2002) of testing was in poor crop establishment conditions. There were far less plants per area than desired. The thin stand resulted in not enough plants to help push other plants continuously and smoothly through the lifters into the header. Also, more plants close together would help hold each plant stem and their pods upright and higher off the ground enabling the header and lifters to retrieve more pods and seeds. This past season testing was in more desirable plant stand conditions, but the losses were far higher than the first season. Plant stand did not appear to be a factor in helping to reduce losses in 2003.

The harvest results in 2003 showed that the Pickup-reel with straight tines used in conjunction with all the lifter configurations helped the most to reduce seed alone losses compared to the lifters with the Pickup-reel with Paddles or the Air-reel. The Pickup-reel with Paddles in conjunction with all the lifter configurations helped the most to reduce pod losses compared to the other reel and lifter configurations. There does not seem to be much difference in better total seed loss measurements between any of the reel and lifter configurations other than the standard Case 960 guard had significantly higher losses with the Pickup-reel with straight tines compared to all other lifters. The 2002 season testing indicated that the Air-reel is less damaging than the physical process of the Pickup-reel. It appeared that the air did not cause the pods to shell as easily during cutting indicated by less seeds on the ground after a harvest pass. In the 2003 season, with the exceptionally dry beans, the statistics indicated the Pickup-reel with straight tines had significantly less losses than the Paddles, Air-reel and Flex Header.

The Bean Sweeps are still in the development stage and they were used in these tests to determine what modifications could be made to help them work better and reduce losses.

In the first season of testing the Paddles on the Pickup-reel bats were mounted so that one paddle covered a 15 cm (6 in) area once every revolution. This was recommended by the manufacturer to cut costs of setting up a whole reel. The Paddles did not seem to help much with one per revolution so in the last season the Paddles were mounted such that 2 covered each 15 cm (6 in) area every reel revolution. This definitely seemed to improve the performance of the Paddles to reduce losses. The Paddles were not able to work with all the lifter combinations due to some of the lifter designs.

Results showed that several of the attachments did improve bean losses during harvesting, but the data was inconsistent and inconclusive after two years of testing. Observations during testing indicate that climatic and crop conditions have a lot to do with the amount of losses and whether the header attachments are going to help or not.

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