

MACHINE LOSSES FROM CONVENTIONAL VERSUS NARROW ROW CORN HARVEST

H. M. Hanna, K. D. Kohl, D. A. Haden

ABSTRACT. Growers of 38-cm (15-in.) narrow row corn typically use either a wider row cornhead or locally modify an existing head to this row spacing. A three-year field experiment compared visible machine losses of a 76-cm (30-in.) cornhead used on 76-cm (30-in.) and 38-cm (15-in.) rows and a single gathering chain 38-cm (15-in.) cornhead used on 38-cm (15-in.) rows. Total machine losses were divided into head and threshing/separating losses.

On matched row spacing, machine losses were generally similar between the 76- and 38-cm (30- and 15-in.) cornhead. However, one-year losses from the 76-cm (30-in.) cornhead were statistically lower. Machine ear drop losses were excessive [0.9 to 1.3 Mg/ha (15 to 20 bu/acre) in two of three years] and unacceptable when a 76-cm (30-in.) cornhead was used even at low 3.2-km/h (2-mph) travel speeds to harvest corn in 38-cm (15-in.) rows. At low feed rates, over 90% of machine losses occurred at the cornhead rather than in the threshing, separating, and cleaning areas. Header losses occurred due to ear drop from late season harvest and negligible losses inside the machine when operated at 4.8 km/h (3 mph). Although shelling of kernels on the stalk rolls was about 1% of harvested yield or less, ear drop loss from the cornhead was greater than this amount in two of three years.

Keywords. Corn, Cornheads, Combines, Harvesting machinery, Losses, Narrow row, Row spacing.

In recent years, growers have expressed renewed interest in producing corn in row spacings narrower than 76 cm (30 in.). Research comparing corn yields with 76-cm (30-in.) row spacing to yields with 51- and 25-cm (20- and 10-in.) row spacing (Porter et al., 1997; Johnson et al., 1998) has shown equal or greater yields with narrow rows in the northern U.S. Cornbelt. Harvest of corn in narrow row plots has either been done with a cornhead matched to the row spacing (different from the 76-cm (30-in.) cornhead used in wide row plots) or plots have been hand harvested. Some commercial producers using rows narrower than 76 cm (30 in.) on a limited area have used a 76-cm (30-in.) cornhead at a slower speed and ignored field losses. Some researchers harvesting narrow rows on a limited area with a mismatched cornhead have estimated field losses.

Ayres et al. (1972) measured visible in-field losses of 84 combines in north-central Iowa. They found that a cornhead row spacing difference of 5 cm (2 in.) from the harvested rows resulted in an additional 0.082 Mg/ha

(1.3 bu/acre) visible machine loss and that 65% of machine loss was at the cornhead. Total visible machine loss was generally independent of ground speed; however, machine ear drop losses were somewhat greater and stalk-roll shelling losses were somewhat less as machine travel speed increased above 4.8 km/h (3.0 mph). Gliem et al. (1990) found Ohio farmers to have total visible field losses in corn of approximately 1% of estimated yield with good harvesting conditions. The average travel speed of 52 combines measured in cornfields was 4.5 km/h (2.8 mph).

To determine if visible machine harvest losses differed between narrow and wide cornheads and the extent of visible machine harvest loss when 38-cm (15-in.) rows are harvested by a 76-cm (30-in.) row cornhead, an experiment was set up with the following objectives.

OBJECTIVES

1. To determine if there was a difference in visible machine harvest losses between a 76- and 38-cm (30- and 15-in.) row cornhead when used to harvest corn of the same row spacing.
2. To determine if there was a difference in visible machine harvest losses between a 76- and 38-cm (30- and 15-in.) row cornhead when used to harvest 38-cm (15-in.) row corn.
3. To determine additional visible threshing and separating loss of the machine and evaluate loss at the cornhead as a proportion of total machine loss.

MATERIALS AND METHODS

The experiment was conducted for three years at the Iowa State University Northwest Research Farm near Calumet, Iowa. Three treatments included: 1) corn planted in 76-cm (30-in.) rows, harvested by a 76-cm (30-in.) head (3030);

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2) corn planted in 38-cm (15-in.) rows, harvested by a 38-cm (15-in.) head (1515); and 3) corn planted in 38-cm (15-in.) rows, harvested by a 76-cm (30-in.) head (1530). Four replicated blocks consisted of 91-m (300-ft) long randomized plots of each of the three treatments. Corn planted in 76-cm (30-in.) rows was planted by a four-row planter. Corn planted in 38-cm (15-in.) rows was planted by a seven-row planter (i.e., the four-row planter with three “split” rows on a second toolbar positioned between the original four rows). The corn variety planted was AgriPro 9560 in 1997, and DeKalb 493 in 1998 and 1999. Because the objective was to compare cornhead harvest losses between narrow and wide rows, the planter was adjusted each year to drop an equal number of seeds per acre so that the potential number of plants harvested would be roughly equal for each treatment.

Each year was considered a different experiment due to weather effects on stalk strength and crop and also a slight difference in cornheads furnished by the local equipment dealer. A CaseIH 1620 Axial-Flow combine was used each year. The 38-cm (15-in.) cornhead was an eight-row, experimental single gathering chain row unit provided from CaseIH for the first two years with set up by the local dealer. The third year the same 38-cm (15-in.) cornhead was provided solely through the local dealer. The 76-cm (30-in.) cornhead used was a four-row International 843 for the first two years and a six-row CaseIH 1063 for the third year. Row units on each cornhead were identified by number beginning always with the left row unit as viewed by the combine operator as number one.

Combine travel speed was 4.8 km/h (3 mph) except in 38-cm (15-in.) rows harvested by the 76-cm (30-in.) cornhead where combine travel speed was slowed to 3.2 km/h (2 mph). Although these speeds are less than those speeds reported by Iowa growers in good harvesting conditions, slowing combine travel speed when a head is mismatched to row spacing is a common technique among farmers and researchers. These speeds were used in an effort to limit potential dropped ear losses at the cornhead (Ayres et al., 1972) and to keep speeds comparable for all treatments. They were also comparable to the average speed [4.5 km/h (2.8 mph)] as measured in the field by Gliem et al. (1990) in Ohio for corn combines during good conditions. Settings and adjustments on the cornheads and combine were unchanged and remained as they came from the local dealer.

To eliminate harvest of “guess” rows that were not aligned by planter units properly spaced on the planter toolbar, only seven rows were harvested in the 1515 treatment plots using the first seven rows of the eight-row cornhead. To ensure that two rows, spaced 38 cm (15 in.) apart were harvested by each row unit in the 1530 treatment, only six rows were harvested using the first three rows of the 76-cm (30-in.) cornhead. Because only the first three rows of the 76-cm (30-in.) cornhead were tested for losses in the 1530 treatment, just these first three rows of the same cornhead were tested in the 3030 treatment [i.e. only three of four possible 76-cm (30-in.) rows were harvested]. Because only six 38-cm (15-in.) rows and three 76-cm (30-in.) rows were to be harvested in the 1530 and 3030 treatments, respectively, outside rows were removed from these plots prior to machine harvest measurement.

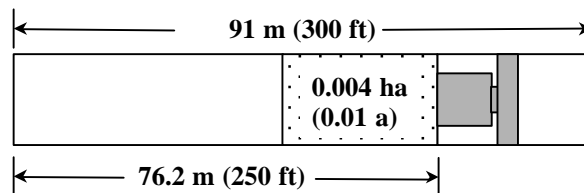


Figure 1. Ear drop measurement area [0.004 ha (0.01 acre)] in individual plot (not to scale).

Harvest losses were measured by a procedure described by Hanna and VanFossen (1990). Pre-harvest (ear drop) losses were measured the afternoon before harvest in a 0.004-ha (0.01-acre) area (fig. 1). These ear drop areas began 58.5 m (192 ft) for 1530 and 3030 treatments or 61.1 m (200 ft) for 1515 treatment into the plot and ended 76.2 m (250 ft) into each plot. All dropped ears were weighed and removed from the area before harvest. After harvest, newly dropped ears into the same area were collected and weighed as a measurement of machine ear loss. Ears were not shelled but instead dropped ear losses (pre-harvest or machine) were calculated by dividing the weight of dropped ears by the density of ears [kg/m^3 (lb/bu)] adjusted for moisture content of grain in the plot (Schmidt, 1948).

Corn was harvested 13 November 1997, 3 November 1998, and 2 November 1999. Harvest dates were somewhat later than average for the area due to equipment availability and also a desire to measure losses later in the harvest season when stalk or ear shank strength might be somewhat weakened. During harvest, a clean grain sample was collected during 15.2 m (50 ft) of combine travel in the first part of each plot prior to entering the ear drop area. The sample was weighed and checked for moisture content to determine harvested yield. After operating the combine through the ear drop area and approximately 85 m (280 ft) into the plot, the combine stopped moving forward, power to the cornhead was quickly disengaged (stopping the stalk rolls and gathering chains), and the separator was disengaged. The operator then moved the combine approximately 5 m (15 ft) in reverse, put the transmission into park, and stopped the engine. Stalk roll shelling loss by the cornhead was then measured by counting kernels in a 3.72-m² (40-ft²) area in front of the combine, traversed by the cornhead, but not the separator or cleaning shoe. Total machine kernel loss was measured in a 3.72 m² (40 ft²) area directly behind the stopped combine. Dimensions of loss measurement areas for each treatment are listed in table 1.

Kernels still attached to shelled cobs behind the combine were designated as cylinder loss. Kernel counts were taken

Table 1. Dimensions of loss measurement areas.

Treatment ^[a]	Measurement Area, m × m (ft × ft)		
	Pre-Harvest	Cornhead	Total Machine
3030	17.71 × 2.29 (58.1 × 7.5)	1.62 × 2.29 (5.3 × 7.5)	1.62 × 2.29 (5.3 × 7.5)
	15.18 × 2.67 (49.8 × 8.75)	1.39 × 2.67 (4.6 × 8.75)	1.39 × 2.67 (4.6 × 8.75)
1515	17.71 × 2.29 (58.1 × 7.5)	1.62 × 2.29 (5.3 × 7.5)	1.62 × 2.29 (5.3 × 7.5)
	15.18 × 2.67 (49.8 × 8.75)	1.39 × 2.67 (4.6 × 8.75)	1.39 × 2.67 (4.6 × 8.75)

^[a] 3030 = 76-cm (30-in.) rows, 76-cm (30-in.) head; 1515 = 38-cm (15-in.) rows, 38-cm (15-in.) head; 1530 = 38-cm (15-in.) rows, 76-cm (30-in.) head.

from within individual wooden frames the same width as the row spacing on the cornhead to determine if some row units on the head had greater losses than other row units. This method allowed identification of any particular “problem” row that might be due to an individual stripper bar position or other adjustment. Harvest losses as measured by kernels were calculated based on 343 kernels/m² equaling 1 Mg/ha (two kernels of corn/ft² equaling 1 bu/acre).

Total visible machine loss was calculated as the sum of total machine kernel loss behind the combine and machine ear loss. Separating loss was determined by subtracting stalk roll shelling and cylinder losses from total machine kernel loss. Harvested corn population was measured in 1998 and 1999.

RESULTS AND DISCUSSION

In 1998, although the number of seeds dropped by the planter was the same for all treatments, corn population was unexpectedly greater in the narrow row treatments. Final corn populations at harvest were 66,200, 79,800, and 79,800 plants/ha (26,800, 32,300, and 32,300 plants/acre) for the 3030, 1515, and 1530 treatments, respectively. Populations in 1999 were statistically similar and averaged 61,300 plants/ha (24,800 plants/acre) across the treatments.

Corn harvesting losses for 1997, 1998, and 1999 are listed in tables 2, 3, and 4, respectively. The largest loss difference between treatments was in ear drop at the cornhead. Even at a slower travel speed, when the 76-cm (30-in.) cornhead was used to harvest 38-cm (15-in.) rows, many ears escaped capture. The cornhead failed to gather all the ears when stalks with normal ear height were pushed underneath the head as it advanced so that in some cases the ear shank was below the head before the stalk rolls firmly engaged the stalk (fig. 2). In 1997, the crop was moderately lodged, but in 1998 and 1999 lodging was assessed as slight to nonexistent. Severe ear loss even during 1999, with a crop standing well, indicated that apparent lack of lodging in the field was not a good predictor of combine ear loss when row spacing of the head was badly mismatched from planted row spacing. The level of pre-harvest dropped ears was somewhat high, however, and may have indicated fragile shanks where the ear was attached to the stalk.

Table 2. 1997 Corn harvesting losses.^[a]

	Treatment ^[b]						LSD _{0.05} ^[c]	
	3030		1515		1530			
Machine ear loss	0.10	(1.6)	0.20	(3.2)	1.05	(16.8)	0.48	(7.7)
Stalk roll shelling	0.05	(0.8)	0.11	(1.8)	0.23	(3.7)	NS ^[d]	(NS)
Cylinder loss	0.01	(0.1)	0.01	(0.1)	0.01	(0.2)	NS	(NS)
Separating loss	0.01	(0.1)	0.06	(0.9)	-0.10 ^[e]	(-1.6) ^[e]	NS	(NS)
Total visible machine loss	0.17	(2.7)	0.37	(6.0)	1.20	(19.1)	0.54	(8.6)
Pre-harvest dropped ears	0.41	(6.5)	0.48	(7.6)	0.56	(8.9)	NS	(NS)
Total visible loss	0.58	(9.2)	0.85	(13.6)	1.76	(28.0)		
Harvested yield	8.26	(131.6)	9.02	(143.7)	7.01	(111.6)	NS	(NS)
Total yield	8.84	(140.8)	9.87	(157.2)	8.76	(139.5)		

^[a] Mg/ha (bu/acre).

^[b] 3030 = 76-cm (30-in.) rows, 76-cm (30-in.) head; 1515 = 38-cm (15-in.) rows, 38-cm (15-in.) head; 1530 = 38-cm (15-in.) rows, 76-cm (30-in.) head.

^[c] Least significant difference for values within row at 95% confidence level (four replications).

^[d] Differences are not statistically significant.

^[e] Actual separating loss \equiv 0. Negative separating loss occurred because the total of stalk roll shelling and separating losses measured in a random location behind the combine were less than stalk roll shelling measured after passage of just the cornhead in a different random location.

When the cornhead was matched to row spacing, losses were usually statistically similar, although there was a slight trend toward increased loss with the narrow-row head. In 1999, total machine loss was greater with the narrow-row head than the wide-row head. Greater loss with the narrow row head seemed to be due to greater machine ear loss (statistically different between these treatments at an expanded confidence level of 90%). A trend toward increased loss with the narrow-row head may reflect that this was a relatively early prototype with less development time for potential modifications compared with the wide-row heads.

Table 3. 1998 Corn harvesting losses.^[a]

	Treatment ^[b]						LSD _{0.05} ^[c]	
	3030		1515		1530			
Machine ear loss	0.06	(0.9)	0.08	(1.2)	0.25	(4.0)	0.11	(1.8)
Stalk roll shelling	0.11	(1.7)	0.13	(2.0)	0.13	(2.0)	NS ^[d]	(NS)
Cylinder loss	0.00	(0)	0.00	(0)	0.00	(0)	NS	(NS)
Separating loss	0.03	(0.4)	-0.06 ^[e]	(-0.9) ^[e]	0.03	(0.4)	NS	(NS)
Total visible machine loss	0.19	(3.0)	0.14	(2.3)	0.40	(6.3)	0.18	(2.9)
Pre-harvest dropped ears	0.03	(0.5)	0.11	(1.7)	0.11	(1.8)	NS	(NS)
Total visible loss	0.22	(3.5)	0.25	(4.0)	0.51	(8.1)		
Harvested yield	9.92	(158.0)	11.70	(186.4)	10.74	(171.1)	1.08	(17.2)
Total yield	10.14	(161.5)	11.95	(190.4)	11.25	(179.2)		

^[a] Mg/ha (bu/acre).

^[b] 3030 = 76-cm (30-in.) rows, 76-cm (30-in.) head; 1515 = 38-cm (15-in.) rows, 38-cm (15-in.) head; 1530 = 38-cm (15-in.) rows, 76-cm (30-in.) head.

^[c] Least significant difference for values within row at 95% confidence level (four replications).

^[d] Differences are not statistically significant.

^[e] Actual separating loss \equiv 0. Negative separating loss occurred because the total of stalk roll shelling and separating losses measured in a random location behind the combine were less than stalk roll shelling measured after passage of just the cornhead in a different random location.

Table 4. 1999 Corn harvesting losses.^[a]

	Treatment ^[b]						LSD _{0.05} ^[c]	
	3030		1515		1530			
Machine ear loss	0.07	(1.1)	0.18	(2.9)	1.25	(19.9)	0.13	(2.0)
Stalk roll shelling	0.05	(0.8)	0.09	(1.4)	0.10	(1.6)	NS ^[d]	(NS)
Cylinder loss	0.00	(0)	0.00	(0)	0.00	(0)	NS	(NS)
Separating loss	0.01	(0.1)	-0.01 ^[e]	(-0.2) ^[e]	-0.05 ^[e]	(-0.8) ^[e]	NS	(NS)
Total visible machine loss	0.13	(2.0)	0.26	(4.1)	1.30	(20.7)	0.13	(2.0)
Pre-harvest dropped ears	0.28	(4.4)	0.31	(5.0)	0.40	(6.4)	NS	(NS)
Total visible loss	0.40	(6.4)	0.57	(9.1)	1.70	(27.1)		
Harvested yield	10.28	(163.7)	10.27	(163.6)	9.37	(149.3)	0.77	(12.2)
Total yield	10.68	(170.1)	10.84	(172.7)	11.07	(176.4)		

^[a] Mg/ha (bu/acre).

^[b] 3030 = 76-cm (30-in.) rows, 76-cm (30-in.) head; 1515 = 38-cm (15-in.) rows, 38-cm (15-in.) head; 1530 = 38-cm (15-in.) rows, 76-cm (30-in.) head.

^[c] Least significant difference for values within row at 95% confidence level (four replications).

^[d] Differences are not statistically significant.

^[e] Actual separating loss \cong 0. Negative separating loss occurred because the total of stalk roll shelling and separating losses measured in a random location behind the combine were less than stalk roll shelling measured after passage of just the cornhead in a different random location.

Other losses, particularly cylinder and separating losses, were very low and indicated minor losses from inside the machine. Negative separating losses occurred when total machine kernel loss in the area randomly selected behind the combine was measured as less than stalk roll shelling loss in the (different) area ahead of the combine. Because these losses were so low compared to stalk roll shelling, negative separating losses were calculated in almost half of the treatment/year combinations. Actual stalk roll shelling losses may have been somewhat less than measured if some kernels fell off the cornhead as the combine moved backward (even though power to the cornhead was quickly disengaged after forward harvest progress stopped).

Losses at the cornhead ranged from 83 to 139% of total machine loss (cornhead losses greater than 100% occurred with negligible cylinder loss and negative separator loss). When cornhead loss was limited to no more than 100% of total machine loss for each of the three treatments during the three years, average cornhead loss for the 3030, 1515, and 1530 treatments was 90, 94, and 98% of the total machine loss, respectively. The percentage losses in ear drop and high percentage of losses at the cornhead were greater than those reported by Ayres et al. (1972). The high percentage of total machine loss at the cornhead was likely due to travel speed of 4.8 km/h (3 mph) not fully loading the threshing and

separating capacity of the combine in the 1515 and 3030 treatments (keeping cylinder and separating losses low). In the 1530 treatment, the mismatched head exaggerated losses and was responsible for the cornhead supplying almost all of machine loss. Also, machine ear loss may have been greater in these late season harvests if ear shank attachments had become weaker with time.

Stalk roll shelling ranged from 0.5 to 3.3% of harvested yield and averaged 0.7 and 1.1% for the 3030 and 1515 treatments, respectively, across all three years. Stalk roll shelling losses were not statistically different between rows for each cornhead or between cornheads themselves in each of the three years. Total machine loss ranged from 1.2 to 17.1% of harvested yield and averaged 1.7, 2.6, and 11.6% for the 3030, 1515, and 1530 treatments, respectively, across all three years. Machine losses for machines with matched row spacing were slightly greater than those observed by Gliem et al. (1990) and may have been due to harvesting late in the season.

Pre-harvest dropped ear loss was higher in 1997 and 1999 than in 1998. Pre-harvest losses appeared to be caused by a combination of wind, corn borer damage, and stalk rot in 1997; however, such damage was not apparent in 1999. Ear drop the third year may have been due to a weaker connection of the shank between the ear and the stalk related to interaction of the year's weather conditions and the corn variety.

In 1998, harvested yield of the 38-cm (15-in.) row treatments showed an advantage, if corn was harvested with a 38-cm (15-in.) row cornhead. In 1999, harvested yield of the 38-cm (15-in.) row treatment was less than the 76-cm (30-in.) row treatment unless a 38-cm (15-in.) cornhead was used for harvest.

CONCLUSIONS

Within the range of conditions tested, the data support the following conclusions:

- On matched row spacing machine losses were generally similar between the conventional 76-cm (30-in.) cornhead and the single gathering chain 38-cm (15-in.) cornhead; however, there was a trend for slightly lower losses from the conventional 76-cm (30-in.) cornhead.



Figure 2. Some ears in 38-cm (15-in.) rows harvested by a 76-cm (30-in.) cornhead were lost as stalks were pushed forward before engagement by the snapping rolls.

Total machine loss of the conventional cornhead was statistically less than the single gathering chain cornhead during one year.

- Machine ear drop losses were excessive and unacceptable when a 76-cm (30-in.) cornhead was used even at a slow 3.2-km/h (2-mph) travel speed to harvest corn late in the season in 38-cm (15-in.) rows. Losses were 0.9 to 1.3 Mg/ha (15 to 20 bu/acre) in two of three years when ears were not well attached to the cornstalk.
- Over 90% of machine losses occurred at the cornhead rather than in the threshing, separating, and cleaning areas. This may have occurred due to ear drop from late season harvest or negligible losses inside the machine when it was operated at 4.8 km/h (3 mph) and not fully loaded. Although shelling of kernels on the stalk rolls was somewhat consistent at about 1% of harvested yield or less, ear drop loss from the cornhead was greater than this amount in two of three years.

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REFERENCES

- Ayres, G. E., C. E. Babcock, and D. O. Hull. 1972. Corn combine field performance in Iowa. In *Grain Damage Symposium*, 1–17. Columbus, Ohio: The Ohio State University.
- Gliem, J. A., R. G. Holmes, and R. K. Wood. 1990. Corn and soybean harvesting losses. ASAE Paper No. 901563. St. Joseph, Mich.: ASAE.
- Hanna, H. M., and L. D. VanFossen. 1990. Profitable corn harvesting. Iowa State University Extension pamphlet Pm-574. Ames, Iowa, Iowa State University.
- Johnson, G. A., T. R. Hoverstad, and R. E. Greenwald. 1998. Integrated weed management using narrow corn row spacing, herbicides, and cultivation. *Agronomy J.* 90(1): 40–46.
- Porter, P. M., D. R. Hicks, W. E. Lueschen, J. H. Ford, D. D. Warnes, and T. R. Hoverstad. 1997. Corn response to row width and plant population in the northern corn belt. *J. of Production Agriculture* 10(2): 293–300.
- Schmidt, J. L. 1948. How to reduce ear corn to bushels of shelled corn. *Agricultural Engineering* 29(7): 294–296.

