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Research Report 238

Combine Modifications

A Co-operative Program Between
ALBERTA FARM MACHINERY RESEARCH CENTRE
PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

INTRODUCTION

This report presents research results assessing the value of field modifications to grain combines. The research was initiated as a result of recommended modifications and claims made by Mr. R. Stueckle in his book[1] and in many farmer combine clinics held throughout the prairies. It is in response to questions from many farmers concerning the value of the suggested modifications.

This report is divided into three parts. Part I presents field comparison results on two John Deere Model 6600 Sidehill combines. One of these combines was a standard production model, while the header, concave, cylinder, shoe and straw walkers of the second combine had been modified by Mr. Stueckle to agree with the recommendations outlined in his book. Part II describes laboratory comparisons of standard and modified cylinder-concave assemblies. Concaves from a Massey Ferguson Model 750 and a John Deere Model 6600 combine were used in this study. Part III presents Mr. Stueckle's comments and interpretations of the research findings.

Acknowledgements: *Field comparisons were conducted in cooperation with Mr. R. Stueckle, who modified the John Deere 6600 combine supplied by Mr. B. Wildfong of Craik, Saskatchewan.*

Laboratory comparisons were conducted by Mr. W. B. Reed, Agricultural Engineering Department, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0.

SUMMARY OF RESEARCH FINDINGS

Field tests have confirmed earlier laboratory findings, showing that currently advocated combine modifications do not increase combine capacity.

Combine modifications had little effect on capacity or grain damage in dry Neepawa wheat. In tough Neepawa wheat, combine modifications had little effect on capacity, but increased grain damage. The standard combine had about 40% more capacity than the modified combine in dry Hector barley and about 90% more capacity than the modified combine in tough Hector barley, with similar grain damage. The standard combine had about 30% less capacity than the modified combine in dry Candle canola, however, modifications increasscl grain damage. The capacity increase in Candle canola was due to installing wire mesh on the straw walkers, and was not a result of modifying the cylinder, concave or shoe. This latter increase in canola can be expected only in very dry crops where straw breakup is excessive.

Combining the effects of grain damage with cylinder, shoe and walker loss also demonstrated that at normal combining speeds there wa8 very little difference in overall performance of the standard and modified combines in wheat and canola. The standard combine saved more grain than the modified combine in barley.

Combine modifications increased dockage. In most cases, the modified combine had twice as much trash in the grain tank as the standard combine.

Altering the concave shape caused cylinder backfeeding at normal to high feedretes since it prevented the rear beater from effectively stripping the crop from the cylinder. Laboratory studies using high speed photography confirmed this behavior.

High speed photography also confirmed that threshing occurs by impact, and not by rubbing with much of the grain being threehed even before it enters the concave.

While the improved uniformity of modified cylinder and concave components enabled more accurate settings, no capacity increess8 or reduced grain damage occurred as a result of theee modifications.

In laboratory tests, no benefit was gained in barley or wheat by modifying the cylinder and concave, as capacity wa8 reduced, and what was gained in reducing grain damage was lost by increasing the unthreshed loss.

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[1]*Stueckle, R. "Combine Settings for Better Harvesting." (Available from R. Stueckle, Caldwell, Idaho 83605 U.S.A.)*

PART I: FIELD COMPARISON OF STANDARD AND MODIFIED COMBINES

OBJECTIVE

The purpose of this study was to determine the overall effect of header, concave, cylinder, shoe and straw walker modifications on field performance and combine capacity.

SCOPE

The field performance of a standard production model combine and a modified combine was compared in wheat, barley and canola over a range of moisture contents. The standard combine was set for optimum performance according to manufacturer's recommendations while the other combine was modified and set for each crop by Mr. R. Stueckle.

DESCRIPTION OF TEST COMBINES

Both test machines were similar John Deere Model 6600 Sidehill combines. Each combine was equipped with a 3350 mm (132 in) windrow pickup mounted on a 3 660 mm (12 ft) header, a diesel engine and a hydrostatic traction drive. The combines were identical except that one combine was modified as follows:

(i) The table auger flighting was hard-surfaced and squared to the auger tubing. Feeder paddle timing was altered from the manufacturer's recommended out-of-phase setting to an in-phase setting.

(ii) The cylinder rasp bars were shimmed to be within 0.6 mm (.024 in) concentricity.

(iii) The concave was reshaped to conform to an arc of a circle with a diameter 3 mm (0.12 in) greater than cylinder diameter. The front four intervals of the concave were blanked and every wire removed from the rear eight intervals (FIGURE 1).

(iv) The fan blades were slotted and moved outwards, increasing the fan diameter from 510 mm (20 in) to 523 mm (20.6 in). Air deflectors were removed from the fan throat, and an air block placed across the rear of the sieve. The shoe shake was altered by reversing the hanger supports, and slots were cut in the combine side to accommodate the greater throw.

(v) The rear beater grate was removed, the straw walker risers removed and the walker extension pans fully extended. In barley, cover plates were added behind each walker step, while in canola, strips of wire mesh having a 6 mm (0.25 in) wire spacing were attached to the walkers.

TEST PROCEDURE

Standard field tests[2] were conducted to determine the grain loss characteristics and relative capacities of both combines. Both were equipped with identical loss collection equipment.

Comparisons were made in five windrowed crops: dry and tough Neepawa wheat, dry and tough Hector barley and dry Candle canola. The standard combine was adjusted to its optimum according to the manufacturer's recommendations. It was originally planned that the modified combine would be adjusted according to the recommended settings given in the book "Combine Settings for Better Harvesting". Information gained from laboratory testing of the recommended modifications however indicated that the reduced cylinder speeds recommended in this book decreased combine capacity. Consequently, to take full advantage of the potential of the modifications, higher cylinder speeds were used for field testing of the modified combine. Combine settings for each crop are given in APPENDIX II.

[2]*PAMI T761-R78, "Detailed Test Procedures for Grain Combines".*

RESULTS AND DISCUSSION

COMPARISON OF COMBINE CAPACITY

Capacity results for the modified and standard combines in the five crops described in TABLES 1 and 2 are presented in FIGURES 2 to 20.

Dry Neepawa Wheat: The modified combine (FIGURE 2) had straw walker, shoe and cylinder losses nearly equal to those of the standard combine (FIGURE 3). The wider front concave clearance (APPENDIX II) and the blanked front concave intervals on the modified combine reduced straw breakup and increased straw walker efficiency, but at the same time blanking reduced concave separation efficiency and discharged more grain on to the straw walkers. The net result was no reduction in straw walker loss. Shoe losses were similar for both combines. Shoe modifications did not improve shoe performance. Cylinder losses were similar for both combines. The blanking on the modified combine reduced the amount of unthreshed heads, while the wider front concave clearance increased the amount of unthreshed heads, with the net result that concave and cylinder modifications did not improve threshing efficiency.

Grain damage was similar for both combines (FIGURE 5), and no benefit was obtained from the modifications in reducing grain damage. While the increased front concave clearance reduced cracking, blanking of the front four intervals increased cracking. No differences in grain damage could be attributed to cylinder speed, since cylinder speeds were similar on both combines.

Since the combine modifications did not affect capacity (FIGURE 4) and did not reduce grain damage, they are of questionable benefit in dry Neepawa wheat.

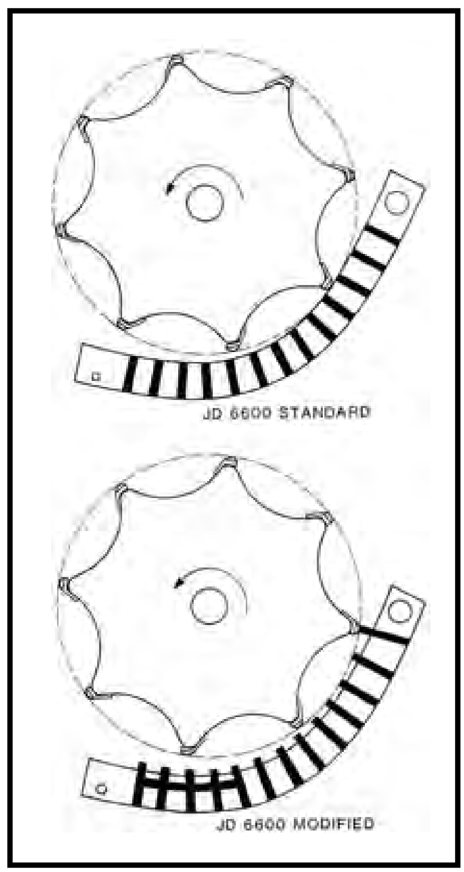

FIGURE 1. Concave Configuration on John Deere 6600 Combine.

TABLE 1. Capacity of the Modified Combine at a Total Loss of 3% of Yield

CROP CONDITIONS									CAPACITY						
CROP	VARIETY	WIDTH OF CUT m	(ft)	GRAIN YIELD t/ha	(bu/ac)	MOISTURE CONTENT (%) STRAW	GRAIN	MOG/G	MOG FEEDRATE t/h	(lb/min)	GRAIN FEEDRATE t/h	(bu/h)	GROUND SPEED km/h	(mph)	LOSS CURVE
Wheat (dry)	Neepawa	6.1	(20)	2.72	(41)	7.8	12.7	0.91	9.4	(345)	10.3	(379)	6.2	(3.8)	FIGS. 3 & 5
Wheat (tough)	Neepawa	6.1	(20)	2.74	(41)	10.5	17.8	0.89	9.8	(360)	11.0	(404)	6.6	(4.1)	FIGS. 7 & 9
Barley (dry)	Hector	6.1	(20)	3.84	(71)	13.3	13.8	0.70	4.9	(180)	7.0	(322)	3.0	(1.9)	FIGS. 11 & 13
Barley (tough)	Hector	6.4	(21)	3.62	(67)	16.6	15.6	0.74	3.5	(129)	4.7	(216)	2.0	(1.3)	FIGS. 15 & 17
Canola	Candle	6.4	(21)	1.62	(29)	9.0	7.7	1.79	8.4	(309)	4.7	(207)	4.5	(2.8)	FIGS. 19 & 21

TABLE 2. Capacity of the Standard Combine at a Total Loss of 3% of Yield

CROP CONDITIONS									CAPACITY						
CROP	VARIETY	WIDTH OF CUT m	(ft)	GRAIN YIELD t/ha	(bu/ac)	MOISTURE CONTENT (%) STRAW	GRAIN	MOG/G	MOG FEEDRATE t/h	(lb/min)	GRAIN FEEDRATE t/h	(bu/h)	GROUND SPEED km/h	(mph)	LOSS CURVE
Wheat (dry)	Neepawa	6.1	(20)	2.67	(40)	7.6	12.7	0.95	9.7	(357)	10.2	(375)	6.3	(3.9)	FIGS. 4 & 5
Wheat (tough)	Neepawa	6.1	(20)	3.27	(49)	12.1	18.5	0.87	10.1	(371)	11.6	(426)	5.8	(3.6)	FIGS. 8 & 9
Barley (dry)	Hector	6.1	(20)	3.16	(59)	13.4	14.4	0.69	6.8	(250)	9.9	(455)	5.1	(3.2)	FIGS. 12 & 13
Barley (tough)	Hector	6.4	(21)	4.02	(75)	15.5	15.8	0.73	6.7	(246)	9.2	(423)	3.6	(2.2)	FIGS. 16 & 17
Canola	Candle	6.4	(21)	1.67	(30)	9.9	8.7	1.72	5.7	(210)	3.3	(146)	3.1	(1.9)	FIGS. 20 & 21

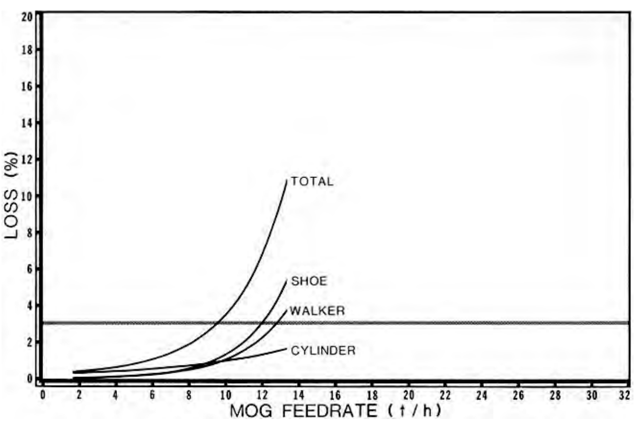

FIGURE 2. Grain Loss for the Modified Combine in Dry Neepawa Wheat.

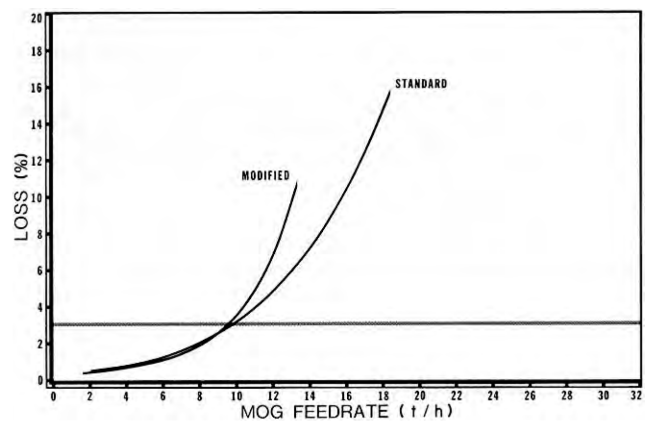

FIGURE 4. Capacity Comparison in Dry Neepawa Wheat.

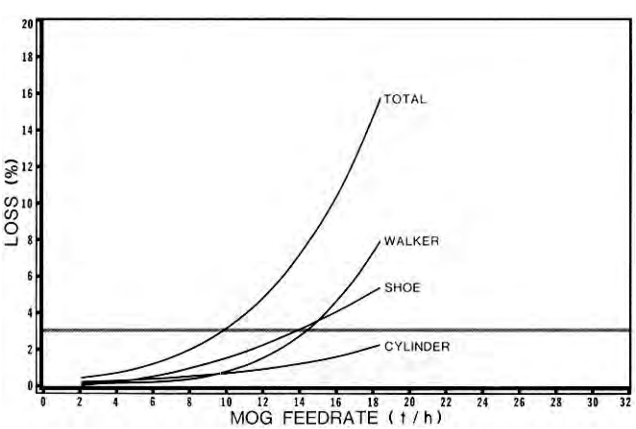

FIGURE 3. Grain Loss for the Standard Combine in Dry Neepawa Wheat.

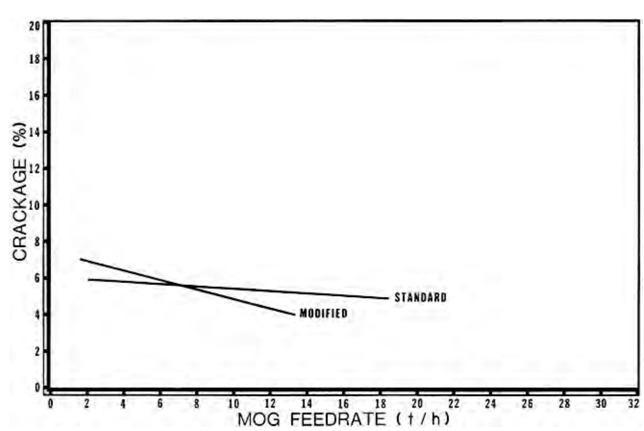

FIGURE 5. Grain Damage in Dry Neepawa Wheat.

Tough Neepawa Wheat: The modified combine (FIGURE 6) had straw walker, shoe and cylinder losses nearly equal to those of the standard combine (FIGURE 7). The wider front concave clearance (APPENDIX II) and the blanked front concave intervals of the modified combine reduced straw breakup and increased straw walker efficiency, but simultaneously reduced concave separation efficiency, discharging more grain to the walkers. The net result was no reduction in straw walker loss. Since shoe losses were not significantly different, shoe modifications did not improve shoe performance. Cylinder losses were similar on both combines. The slightly higher cylinder speed used on the modified combine and blanking reduced unthreshed heads, but the wider front concave clearance increased unthreshed heads with the net result that concave and cylinder modifications did not improve threshing efficiency. Grain damage was higher on the modified combine (FIGURE 9) due to the higher cylinder speed and concave blanking.

Since the combine modifications had very little effect on capacity (FIGURE 8), but increased grain damage, they reduced overall combine performance in tough Neepawa wheat.

Dry Hector Barley: The modified combine (FIGURE 10) had higher straw walker losses and higher shoe losses, but slightly lower cylinder loss than the standard combine (FIGURE 11). The wider front concave clearance (APPENDIX II) and the blanked concave intervals on the modified combine greatly reduced concave separation efficiency, discharging much more grain onto the walkers, increasing walker loss. The modified combine had higher shoe losses than the standard combine, and the shoe modifications actually resulted in increased shoe loss. Cylinder loss was slightly lower for the modified combine as blanking reduced the amount of unthreshed heads. The overall result was that the standard combine had about 40% more capacity than the modified combine in this crop (FIGURE 12).

Grain damage was similar for both combines (FIGURE 13), and although the increased front concave clearance reduced cracking, blanking of the front four intervals increase cracking. Cylinder speeds were similar, so differences in grain damage could not be attributed to cylinder speed.

Since modifications severely reduced capacity, it can be concluded that the modifications are detrimental in dry Hector barley.

Tough Hector Barley: The modified combine (FIGURE 14) had higher straw walker and higher cylinder losses than the standard combine (FIGURE 15), but had similar shoe loss. Since cylinder speed was lower (APPENDIX II), front concave clearance wider and the concave blanked in the front four intervals, concave separation efficiency was greatly reduced. This discharged much more grain onto the walkers, increasing walker loss. The modified combine had higher cylinder loss than the standard combine due to reduced cylinder speed and a wider front concave clearance. The overall result was that the standard combine had about 90% more capacity than the modified combine in this crop (FIGURE 16).

Grain damage was similar for both combines (FIGURE 17), as the reduced cylinder speed of the modified combine did not compensate for the damage caused by concave blanking.

Combine modifications greatly reduced capacity and are definitely detrimental to performance in tough Hector barley.

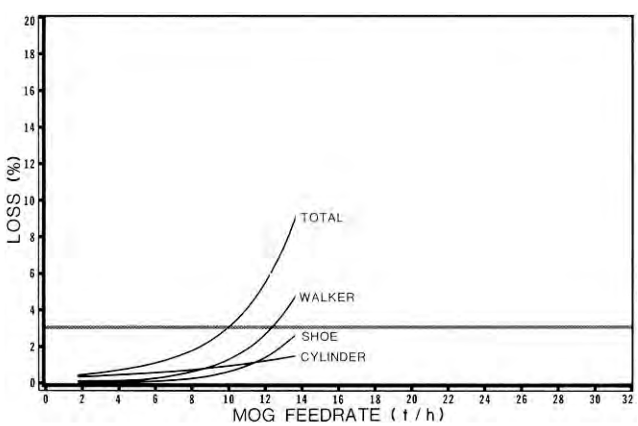

FIGURE 6. Grain Loss for the Modified Combine in Tough Neepawa Wheat.

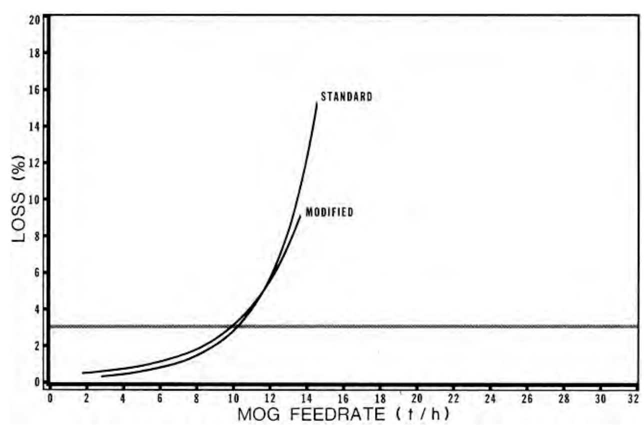

FIGURE 8. Capacity Comparison in Tough Neepawa Wheat.

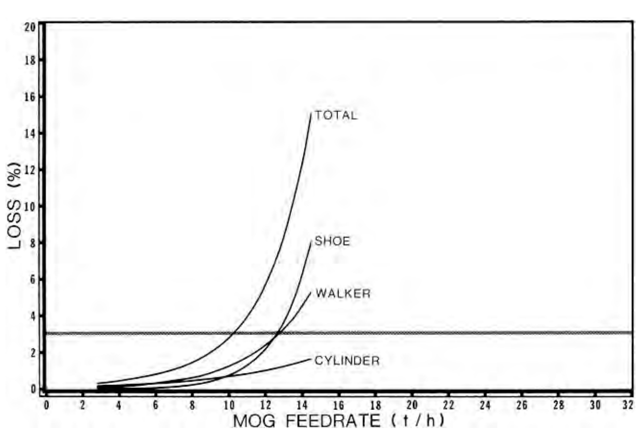

FIGURE 7. Grain Loss for the Standard Combine in Tough Neepawa Wheat.

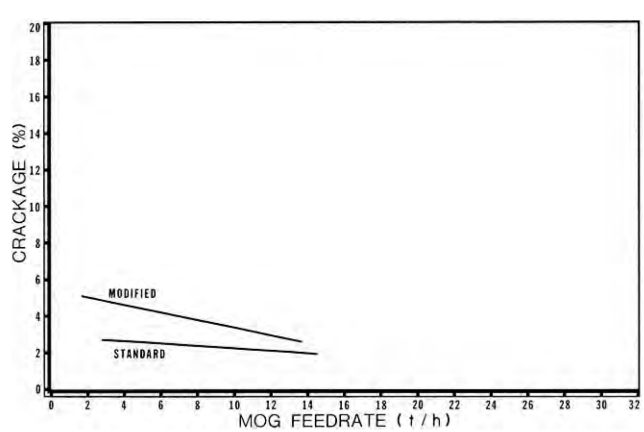

FIGURE 9. Grain Damage in Tough Neepawa Wheat.

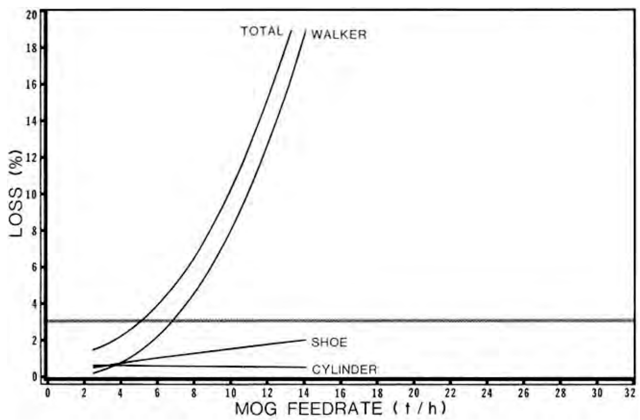

FIGURE 10. Grain Loss for the Modified Combine in Dry Hector Barley.

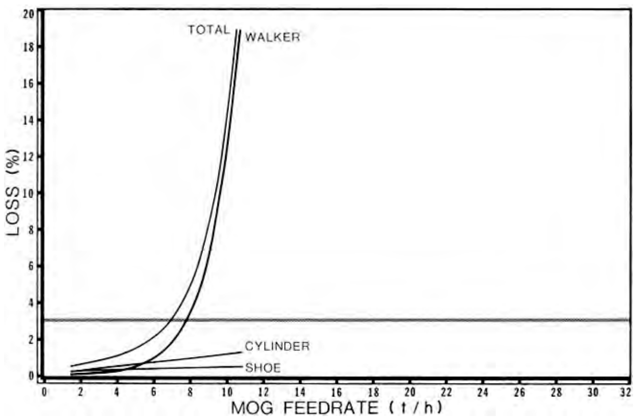

FIGURE 11. Grain Loss for the Standard Combine in Dry Hector Barley.

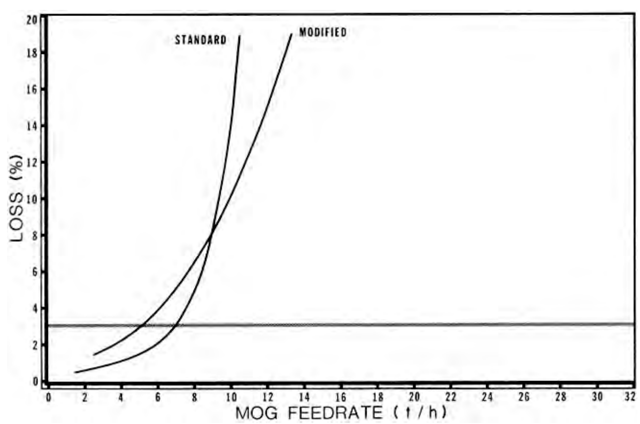

FIGURE 12. Capacity Comparison in Dry Hector Barley.

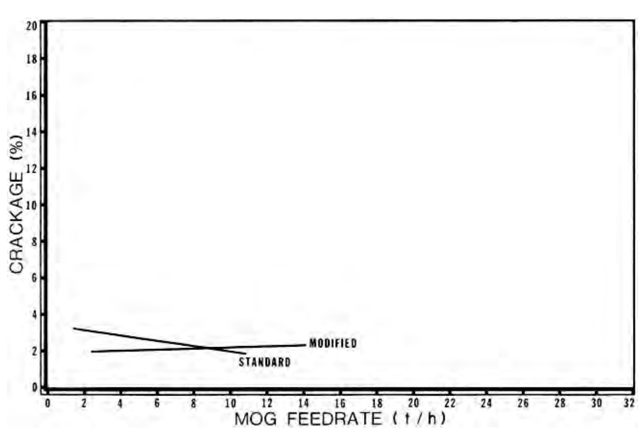

FIGURE 13. Grain Damage in Dry Hector Barley.

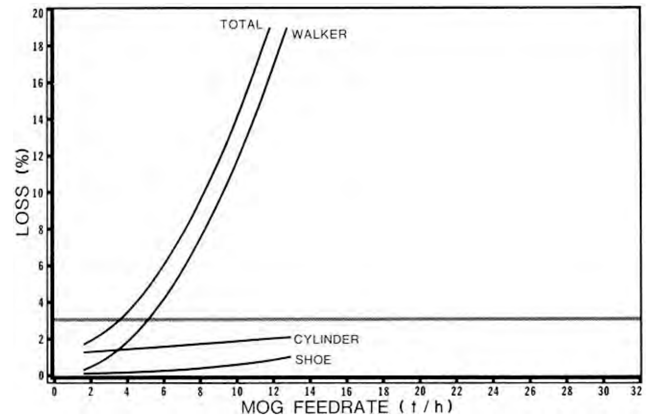

FIGURE 14. Grain Loss for the Modified Combine in Tough Hector Barley.

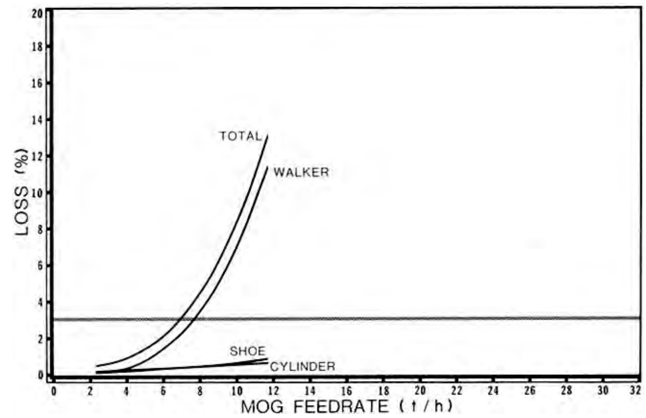

FIGURE 15. Grain Loss for the Standard Combine in Tough Hector Barley.

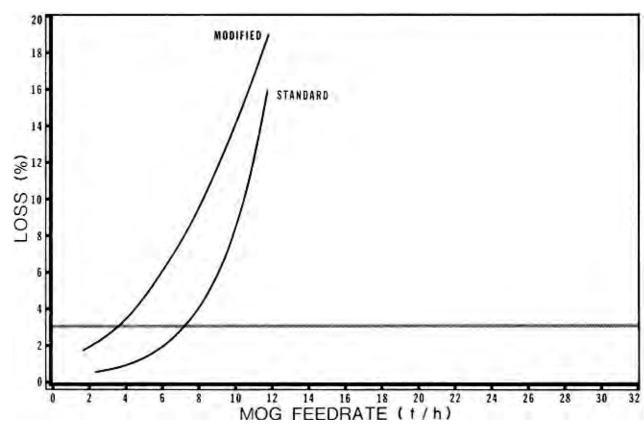

FIGURE 16. Capacity Comparison in Tough Hector Barley.

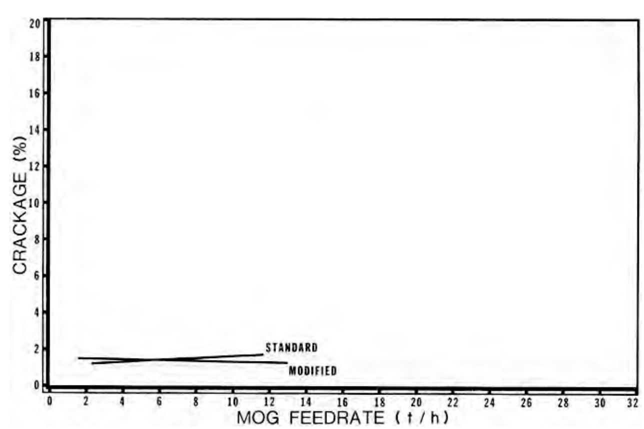

FIGURE 17. Grain Damage in Tough Hector Barley.

Dry Candle Canola: The modified combine (FIGURE 18) had higher straw walker loss than the standard combine (FIGURE 19), but had lower shoe and cylinder losses. Lower shoe loss for the modified combine was attributed to the effect of the wire mesh installed on the top on the straw walkers, and was not due to cylinder, concave, or shoe modifications. The mesh reduced the amount of trash falling through the walkers onto the shoe, thereby reducing the shoe load. The walker loss was increased due to more walker retention of broken stems and pods. The increased walker loss was however less than the decrease in shoe loss. Since the modified combine was operated at a much higher cylinder speed than the standard machine, (APPENDIX II), cylinder loss was low. The net result was that the standard combine had about 30% less capacity than the modified combine in this crop (FIGURE 20).

The modified combine had higher grain damage than the standard combine (FIGURE 21), due to the increased cylinder speed and the effect of concave blanking.

Although the standard combine had about 30% less capacity than the modified combine in dry Candle canola, differences were due only to the addition of wire mesh on the straw walkers and cannot be attributed to concave, shoe or cylinder modifications. Benefits from adding walker screens can be expected only in very dry canola where straw breakup is excessive.

OVERALL FIELD PERFORMANCE

FIGURES 2 to 21 present cylinder loss, shoe loss, straw walker loss and grain damage as a percent of yield over a range of MOG feedrates. FIGURES 22 to 26 summarize cylinder, shoe and walker losses and grain damage for the standard and modified combines operating at identical forward ground speeds.

FIGURE 22 shows similar walker, shoe and cylinder lossrates for the standard and modified combines in dry Neepawa wheat. The grain damage lossrate was very high for both combines, and both combines saved the same amount of grain. Since the combine modifications did not save more grain, they are of questionable benefit in dry Neepawa wheat.

FIGURE 23 also shows similar walker, shoe and cylinder lossrates for the standard and modified combines in tough Neepawa wheat. The modified combine damaged more grain than the standard combine, and as a result saved less grain than the standard combine. Combine modifications reduced overall combine performance in tough Neepawa wheat.

The modified combine had higher shoe and walker lossrates than the standard combine, but similar cylinder lossrates and similar grain damage lossrates (FIGURE 24) in dry Hector barley. Combine modifications resulted in less grain in the tank, and were detrimental in dry Hector barley.

The modified combine had higher cylinder and walker lossrates than the standard combine, but similar shoe lossrates and similar grain damage (FIGURE 25) in tough Hector barley. Combine modifications resulted in much less grain in the tank, and are definitely detrimental in tough Hector barley.

The modified combine had a higher straw walker lossrate and a higher grain damage lossrate than the standard combine, but a lower shoe and cylinder lossrate (FIGURE 26) in Candle canola. Although the modified combine had slightly more grain in the tank, differences were due only to the addition of wire mesh on the straw walkers and cannot be attributed to concave, cylinder or shoe modifications.

In conclusion, at normal combining speeds, there was very little difference in overall performance of the standard and modified combines in wheat and canola. The standard combine saved more grain than the modified combine in barley.

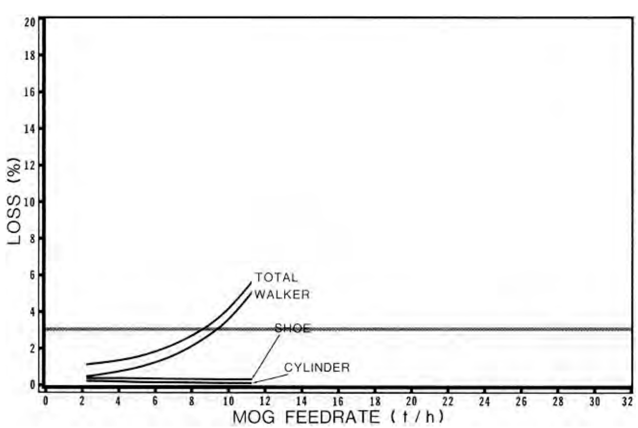

FIGURE 18. Grain Loss for the Modified Combine in Candle Canola.

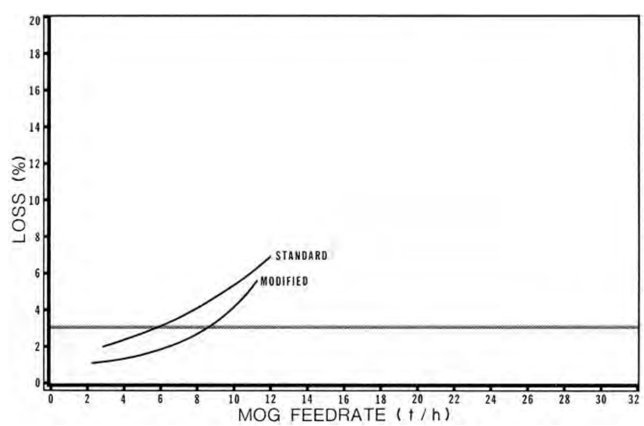

FIGURE 20. Capacity Comparison in Candle Canola.

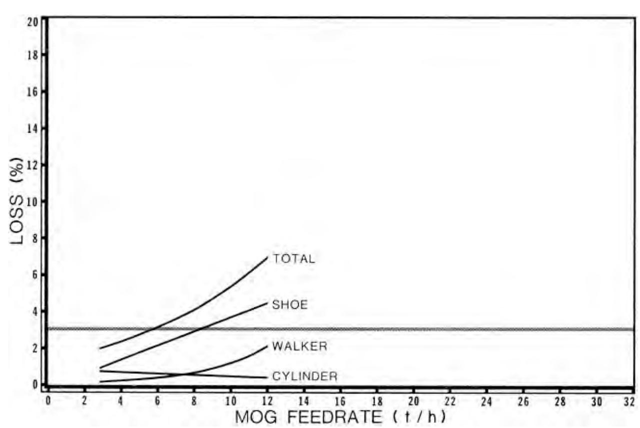

FIGURE 19. Grain Loss for the Standard Combine in Candle Canola.

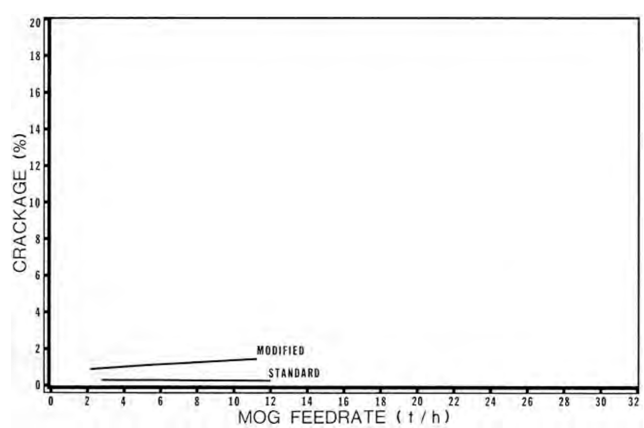

FIGURE 21. Grain Damage in Candle Canola.

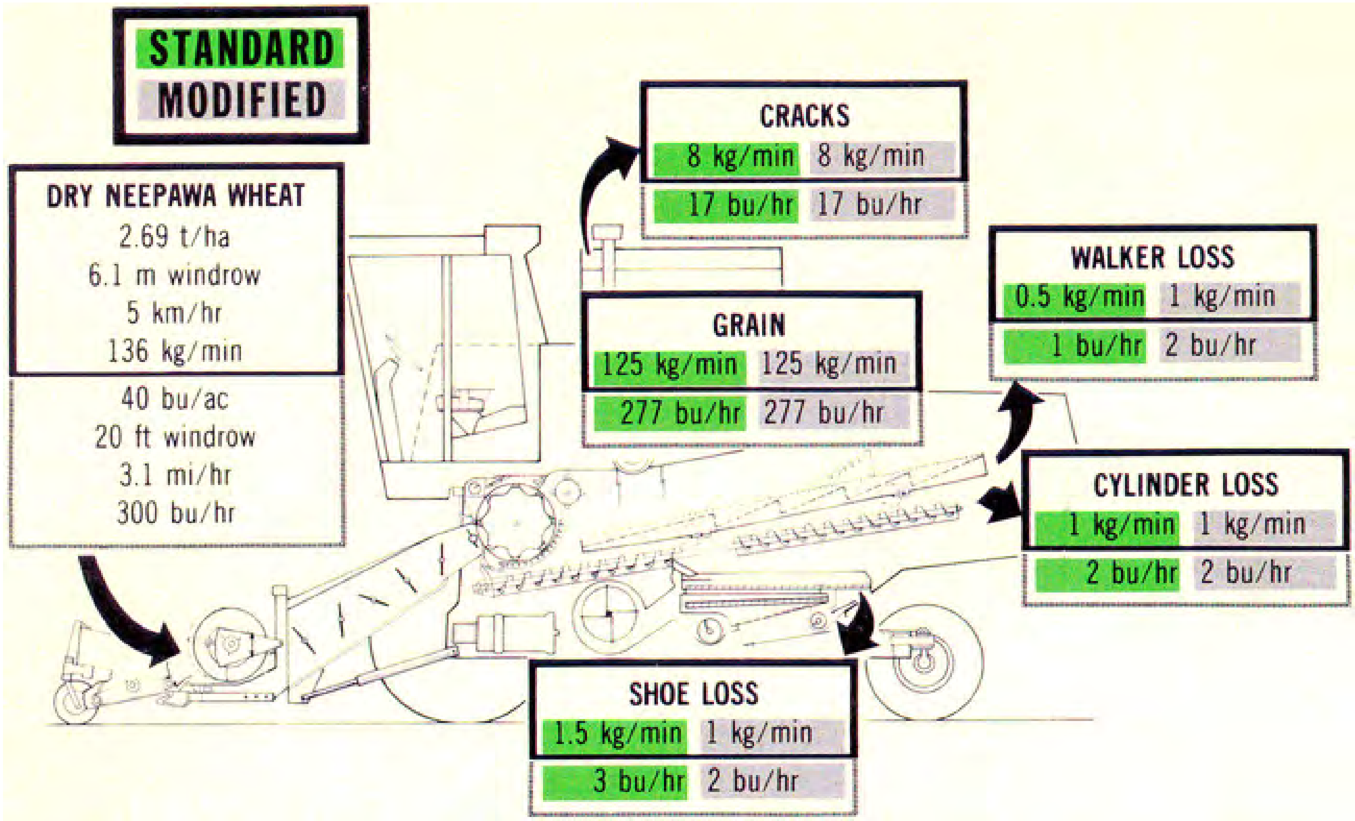

FIGURE 22. Combine Lossrates in Dry Neepawa Wheat.

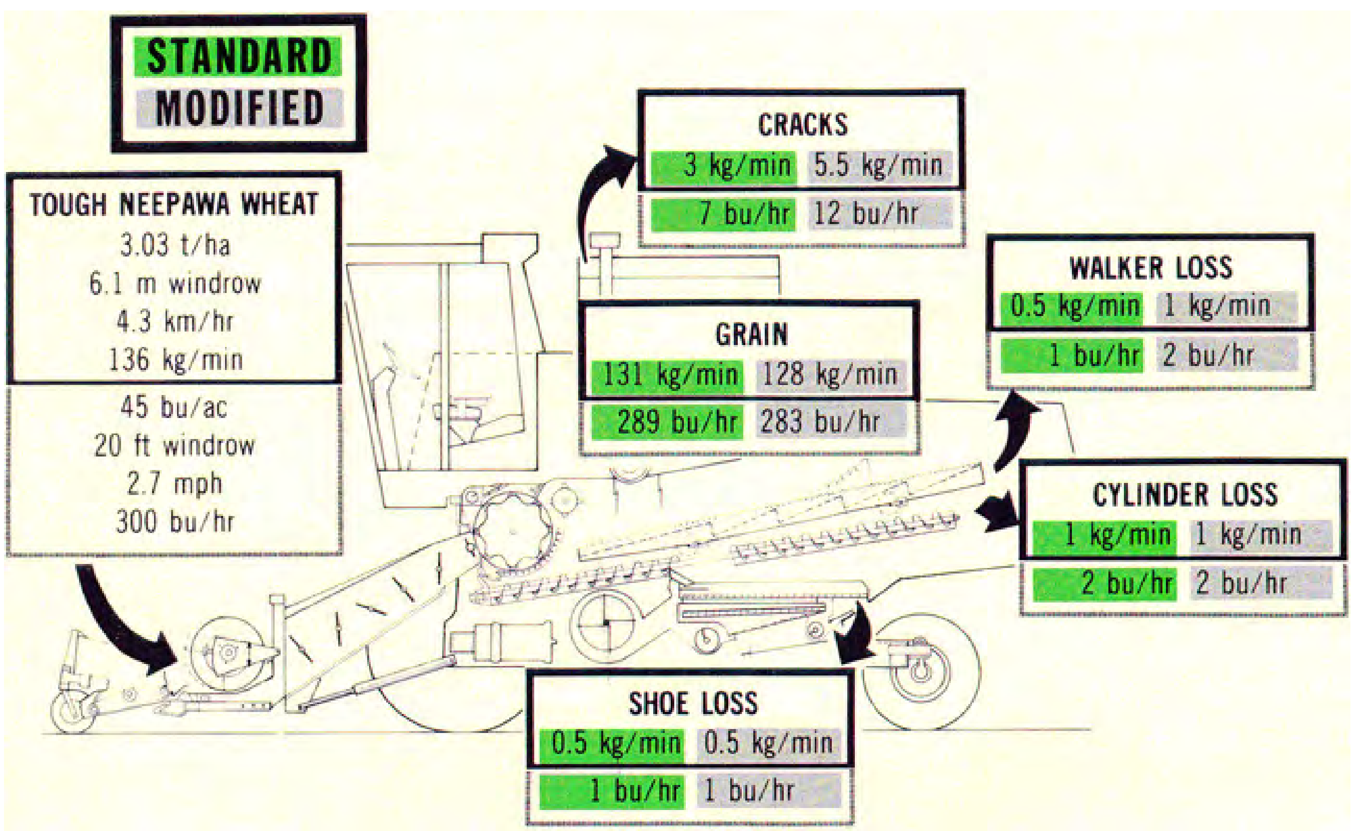

FIGURE 23. Combine Lossrates in Tough Neepawa Wheat.

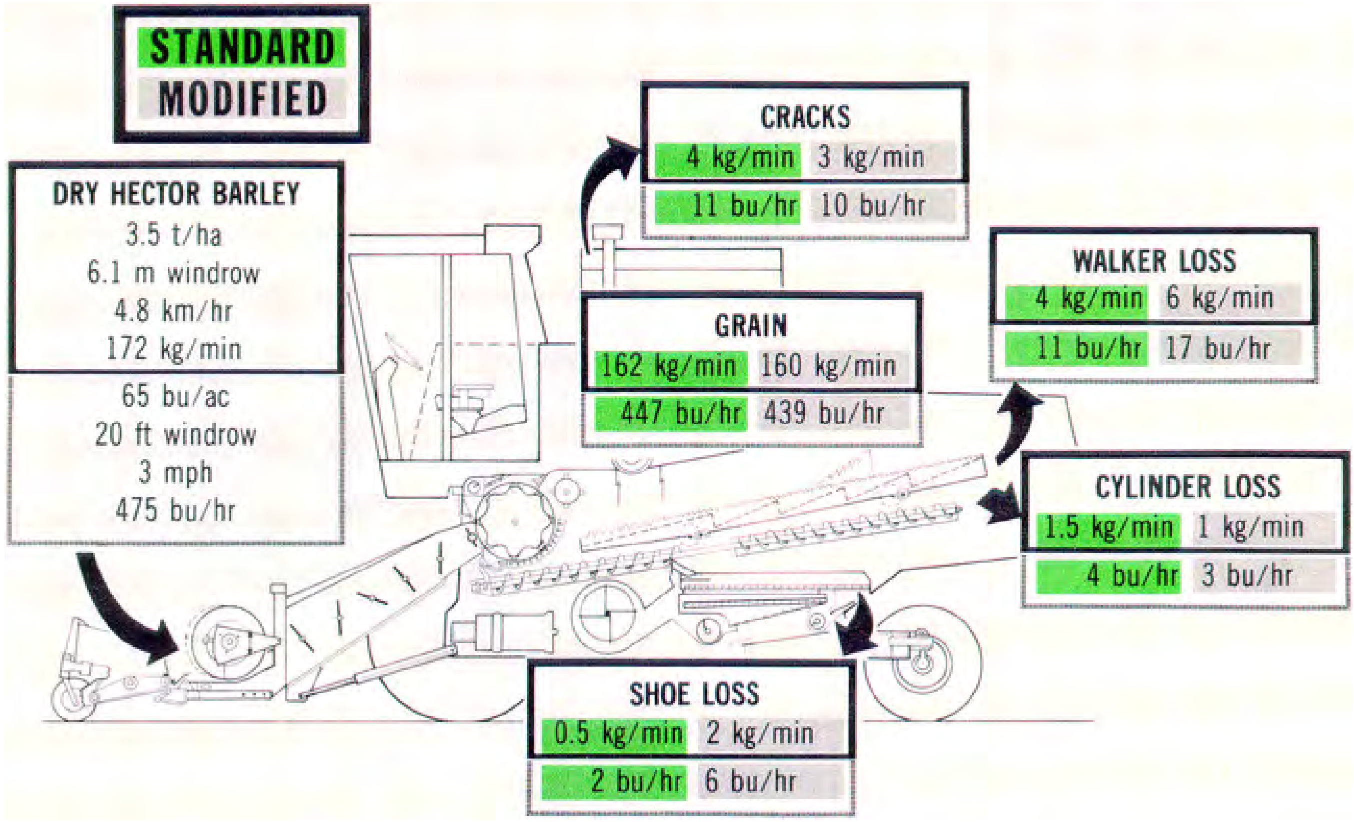

FIGURE 24. Combine Lossrates in Dry Hector Barley.

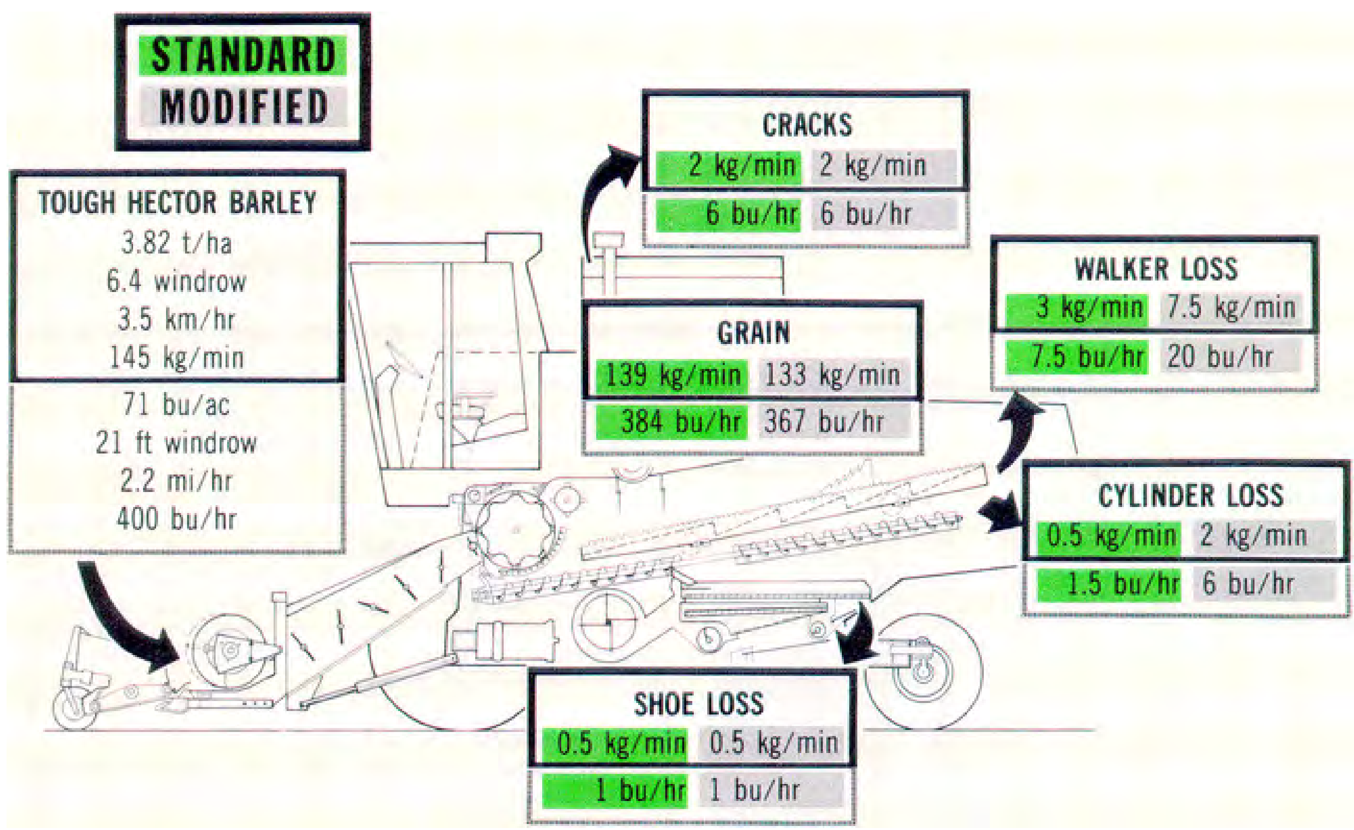

FIGURE 25. Combine Lossrates in Tough Hector Barley.

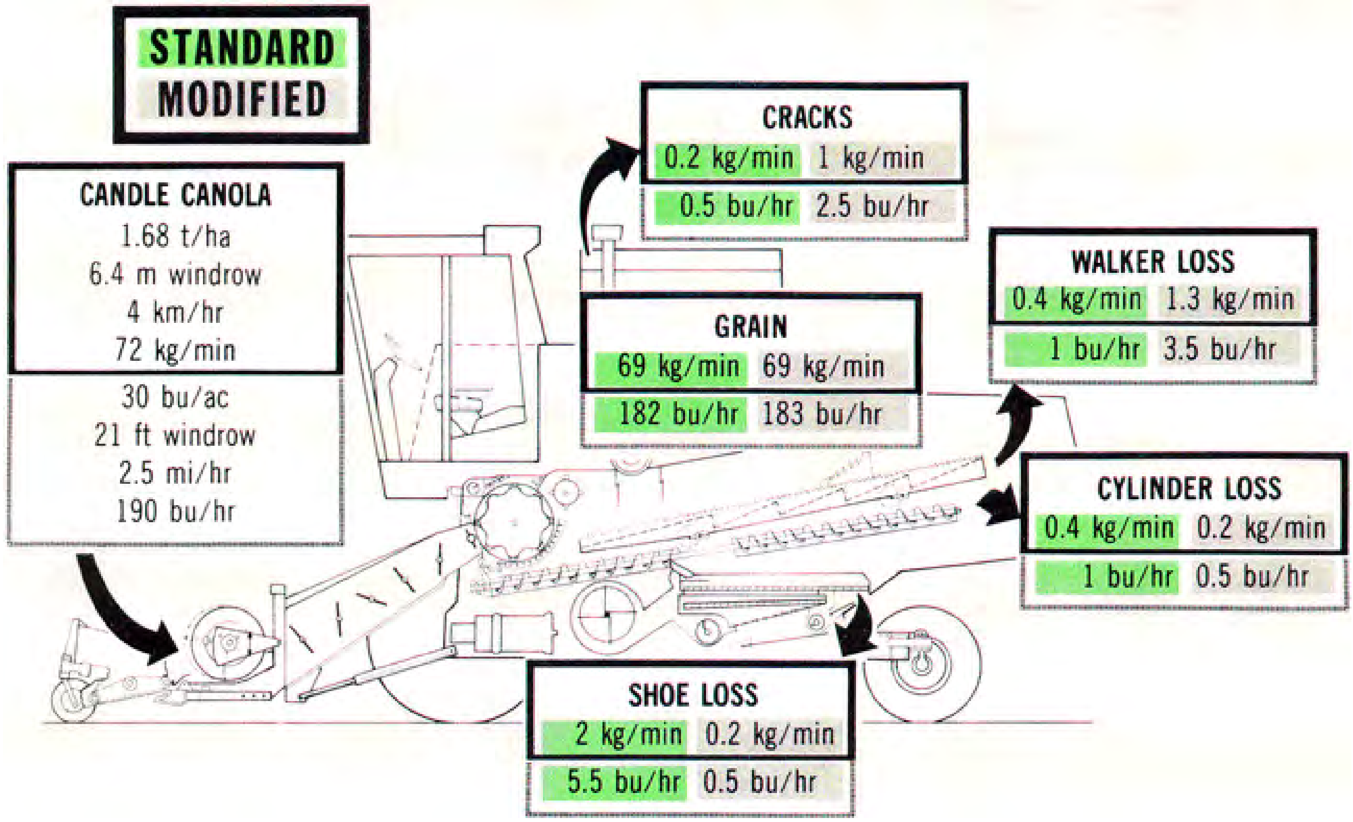

FIGURE 26. Combine Lossrates in Candle Canola.

DOCKAGE

Trash in the grain tank was increased by combine modifications. TABLE 3 shows the average amount of trash by weight in samples taken from the grain tanks of the modified and standard combine. The modified combine had about twice as much trash in the grain tank in barley and canola, and an even greater amount in wheat.

TABLE 3.
Foreign Material in Grain Sample (% by weight)

	MODIFIED	STANDARD
Dry Neepawa Wheat	1.8	0.4
Tough Neepawa Wheat	2.4	0.4
Dry Hector Barley	0.6	0.3
Tough Hector Barley	1.6	0.8
Dry Candle Canola	0.7	0.4

BACKFEEDING

Backfeeding was observed when operating the modified combine at normal to high feedrates, with straw and chaff returned down the feeder housing. Backfeeding was severe at high feedrates. The standard combine had little backfeeding and fed much more evenly.

PART II: LABORATORY STUDY OF CYLINDER-CONCAVE MODIFICATIONS

OBJECTIVE

The purpose of this study was to determine the effect of cylinder and concave modifications and adjustments on combine performance and capacity.

SCOPE

The performance of standard and modified cylinder-concave assemblies from a Massey Ferguson 750 and a John Deere 6600 combine were compared in wheat and barley. A variety of cylinder and concave modifications and adjustments were assessed to determine their effect on concave separation efficiency, straw walker efficiency, straw walker loss, cylinder loss, total loss and grain damage.

DESCRIPTION OF TEST CONCAVES

MASSEY FERGUSON 750 CONCAVES

The standard and modified concaves are shown in FIGURE 27, while concave specifications are given in TABLE 4. The Massey Ferguson 750 concave, as manufactured, conformed to a circle so the modifications did not include any change to concave shape. The modifications included the removal of all the larger diameter wires, plugging of the wire holes and the addition of blanks to the front four intervals.

JOHN DEERE 6600 CONCAVES

The standard and modified concaves are shown in FIGURE 28 while concave specifications are given in TABLE 4. The John

Deere 6600 concave, as manufactured, did not conform to a circle over its entire arc length as the front and rear dropped away from the cylinder diameter. The modified concave was built up and machined to conform to an arc of circle with diameter 3 mm (0.12 in) greater than cylinder diameter. The modifications also included the removal of every other wire, plugging of the wire holes and the addition of blanks to the front four intervals.

TABLE 4. Concave Specifications

CONCAVE	CONFIGURATION	WRAP	AREA (m^2) TOTAL	OPEN	OPEN AREA
Standard MF 750	10 intervals with alternating 6.4 mm (0.25 in) and 5.6 mm (0.22 in) wires and regular 6.7 mm (0.26 in) spaces.	103°	0.633	0.228	36%
Modified MF 750	4 intervals blanked 6 intervals with 5.6 mm (0.27 in) wires and regular 19.7 mm (0.78 in) spaces	103°	0.633	0.204	32%
Standard JD 6600	12 intervals with 6.4 mm (0.25 in) wires and regular 17.5 mm (0.69 in) spaces	100°	0.569	0.323	57%
Modified JD 6600	4 intervals blanked 8 intervals with 6.4 mm (0.25 in) wires and regular 41.3 mm (1.63 in) spaces	100°	0.553	0.249	45%

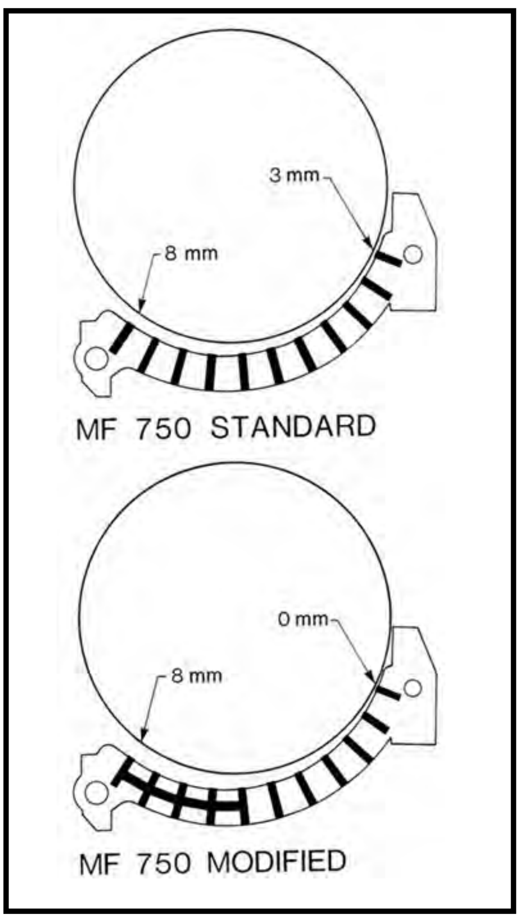

FIGURE 27. Concave Configurations on Massey Ferguson 750 Combine.

TEST PROCEDURE

Equipment for evaluating the combine concaves was assembled to closely approximate an actual combine (FIGURE 29). Crop was placed on the feed conveyor to simulate a windrow. Windrow size was varied to provide a range of MOG feedrates from 2 to 12 t/h (75 to 450 lb/min). Grain and straw samples were collected at the locations shown in FIGURE 30. TABLE 5 shows the range of cylinder and concave settings used in the trials.

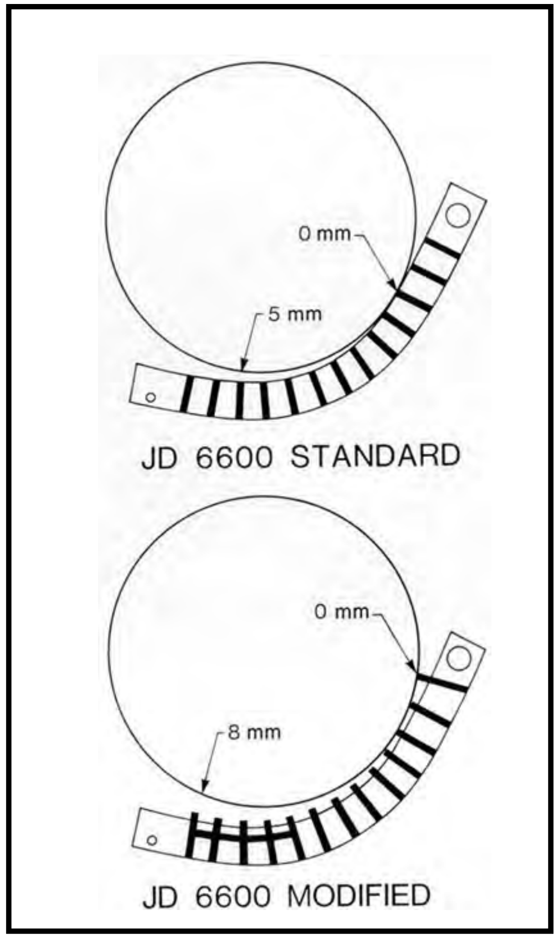

FIGURE 28. Concave Configurations on John Deere 6600 Combine.

FIGURE 29. Laboratory Test Apparatus.

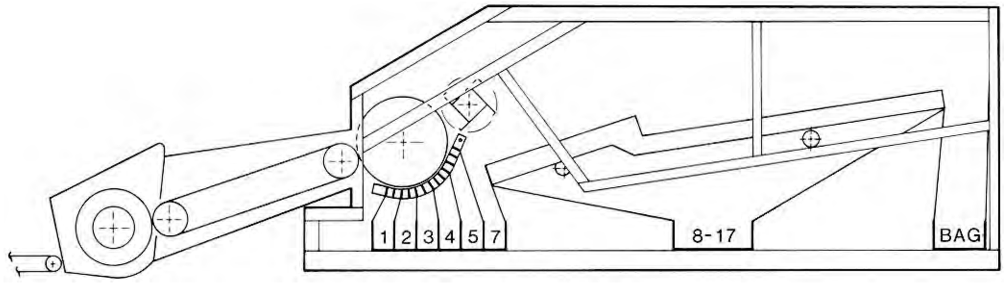

FIGURE 30. Sampling Locations.

TABLE 5. Operating Conditions for Laboratory Tests

TRIAL	CROP	CONCAVE		CYLINDER		MOISTURE CONTENT (%)	
		TYPE	CLEARANCE	MODIFICATIONS	SPEED (rpm)	GRAIN	STRAW
1	Melvin Barley	Standard MF 750	8 mm, front 3 mm, rear	Standard	800	11.8	11.3
2		Modified MF 750	8 mm, front	Shimmed	600	12.8	12.2
3			0 mm, rear		800	12.0	11.1
4	Neepawa Wheat	Standard JD 6600	5 mm, front	Standard	1050	12.3	9.0
5			0 mm, rear		800	12.3	10.3
6		Modified JD 6600	8 mm, front	Shimmed	800	12.9	10.3
7			0 mm, rear		1050	13.2	10.8

RESULTS AND DISCUSSION

THRESHING PRINCIPLE

High speed movies taken at 5000 frames/second clearly showed that threshing occurred mainly by impact when fast-moving rasp bars shattered the relatively slow-moving heads (FIGURE 31). Each head was struck several times before threshing was complete. Since much of the threshing occurred before the crop entered the concave, it was evident that a surface against which the rasp bars could rub the crop was not important as long as some means existed for bringing the partly shattered heads back into the path of the rasp bars.

CYLINDER AND CONCAVE UNIFORMITY

Detailed measurements were made on the standard and modified cylinders and concaves. While uniformity was improved by modification, and the higher tolerances allowed more accurate setting of cylinder-concave clearances, no significant capacity increases or reduction in grain damage occurred as a result of the modifications.

The need for high cylinder tolerances was found unnecessary. For example, when operating at 1050 rpm cylinder speed, the stationary clearance had to be set at 0.45 mm (0.02 in) to obtain zero clearance at operating speed. This was due to vibration and to normal stretch of the cylinder assembly, rasp bars, and the retaining bolts at operating speed. Since the concave also deforms under load, it must be concluded that original manufacturer tolerances are satisfactory. This does not however reduce the need for a regular inspection to ensure than the rasp bars and concave are in good condition.

MASSEY FERGUSON 750 CONCAVES

Performance of the standard MF 750 cylinder and concave in Melvin barley was compared to the performance of the modified cylinder and concave at several cylinder speeds (TABLE 5, Trials 1, 2 and 3).

At the 600 rpm speed, as recommended in "Combine Settings for Better Harvesting", concave separation efficiency was 15% lower for the modified concave than for the standard concave. This reduction in efficiency was largely due to cylinder speed (FIGURE 32). When the modified assembly was operated at 800 rpm concave separation efficiency was identical to that of the standard assembly operated at the manufacturer's recommended 800 rpm speed.

At 800 rpm cylinder speed, straw walker efficiency was slightly higher with the modified assembly than with the standard assembly (FIGURE 33). This was due to the effect of concave blanking, which caused a reduction in straw breakup. Straw walker efficiency for the modified assembly was higher at 800 rpm cylinder speed than at 600 rpm, since the effect of cylinder speed on straw breakup was not as great as the effect of cylinder speed on threshing. Because a large number of awns were retained on the barley kernels at the lower speeds, grain separation on the walkers was restricted and efficiency reduced.

Both straw walker loss and cylinder loss were significantly higher with the modified assembly operated at 600 rpm than for the standard assembly (FIGURE 34). The full modifications caused a 21% decrease in capacity. When the modified assembly was operated at 800 rpm, capacity of the modified assembly was similar to the capacity of the standard assembly.

(a)

(b)

(c)

(d)

FIGURE 31. A Sequence of High Speed Movies Showing Threshing by Impact.

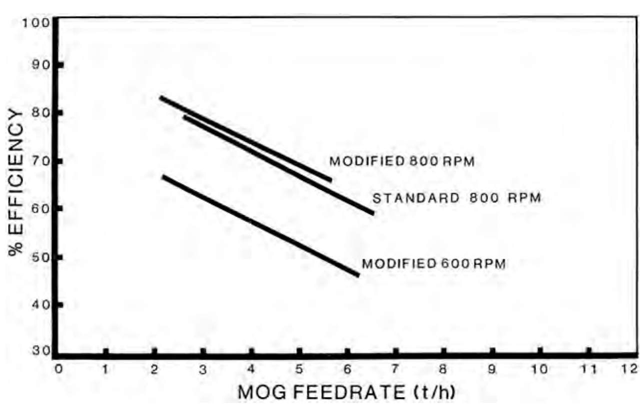

FIGURE 32. Concave Separation Efficiency for the MF 750 Concave in Barley.

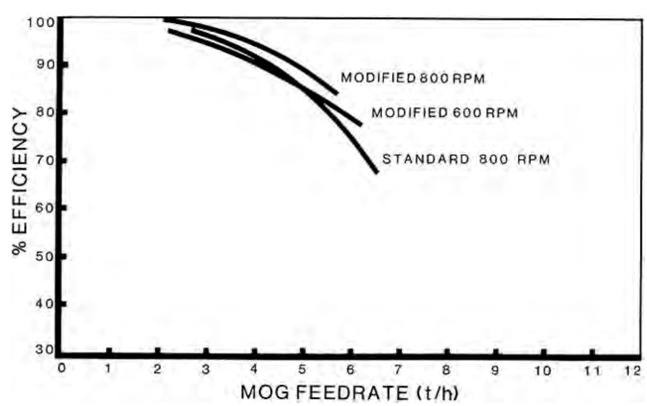

FIGURE 33. Straw Walker Efficiency for the MF 750 Concave in Barley.

At low feedrates, grain damage was lower with the modified assembly than with the standard assembly, but at higher feedrates grain damage was nearly equal (FIGURE 35). When the modified assembly was operated at 800 rpm, grain damage was higher than with the standard assembly. As can be seen by comparing FIGURES 34 and 35, the standard concave assembly had better performance than the modified assembly since it minimized both grain damage and cylinder losses at normal operating feedrates.

It may be concluded from this study that no benefits can be gained by modifying the MF 750 cylinder concave assembly.

JOHN DEERE 6600 CONCAVES

Performance of the standard John Deere 6600 concave in Neepawa wheat was compared to performance of a modified concave at several cylinder speeds (TABLE 5, Trials 4, 5, 6 and 7).

At a cylinder speed of 800 rpm, as recommended in "Combine Settings for Better Harvesting", concave separation efficiency of the modified concave was significantly lower than that of the standard concave with the cylinder operated at the manufacturer's recommended speed of 1050 rpm (FIGURE 36). When operated at a similar cylinder speed, there was no significant difference in concave separation efficiency between the modified or standard assemblies. Concave separation efficiency depended only on cylinder speed and was not influenced by concave modifications.

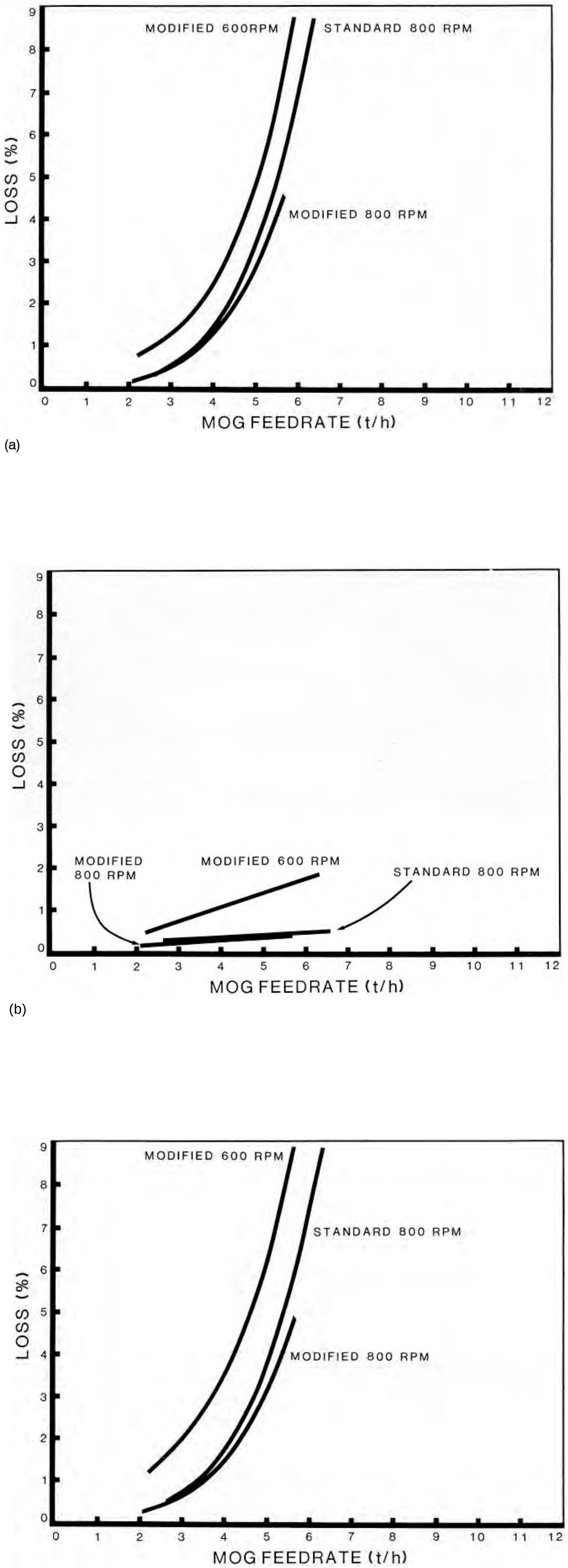

FIGURE 34. Grain Loss for the MF 750 Concave in Barley: (a) Walker Loss, (b) Cylinder Loss, (c) Total Loss.

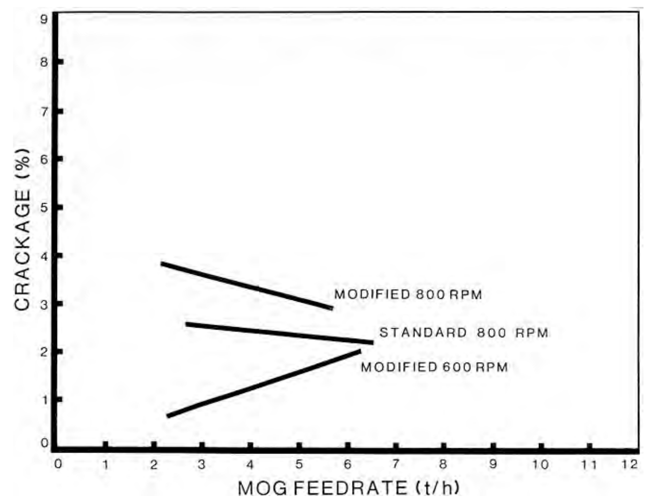

FIGURE 35. Grain Damage for the MF 750 Concave in Barley.

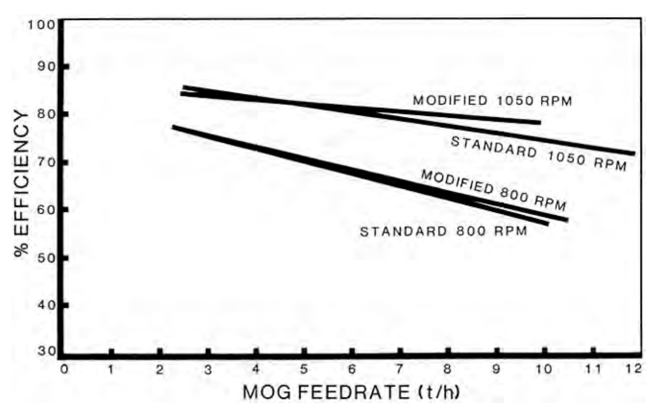

FIGURE 36. Concave Separation Efficiency for the JD 6600 in Wheat.

Concave modifications, combined with low cylinder speeds, increased straw walker efficiency at high feedrates (FIGURE 37), as a result of reduced straw breakup. Although straw walker efficiency increased, this was offset by a decrease in concave separation efficiency, with the net result that straw walker losses were nearly equal for both the standard and modified assemblies.

While straw walker losses were nearly equal for the modified concave with cylinder speed at 800 rpm, and the standard concave and normal cylinder speed, cylinder losses increased significantly resulting in a 12% reduction in capacity because of modifications (FIGURE 38). When operating the modified assembly at 1050 rpm cylinder speed, capacity was similar to that of the standard concave.

Grain damage for the two concaves at 800 and 1050 rpm cylinder speeds is shown in FIGURE 39. At 800 rpm, grain damage was similar for both the modified and standard concaves. At 1050 rpm, the modified concave had reduced grain damage at higher feedrates. This may have been a result of increased cushioning resulting from the straw mat over the blanked intervals, or may have been due to other factors. Cylinder loss plus grain damage were lowest at the 1050 rpm cylinder speed and highest at the 800 rpm cylinder speed, with no real benefit shown for the modified concave. Keeping the cylinder speed sufficiently high to minimize the sum of grain damage and cylinder loss, demonstrated little need for concave modification.

Modifying the JD 6600 concave resulted in severe backfeedIng at moderate to high feedrates. High speed photography showed that with the standard concave, the cylinder discharge hit the centre of the beater (FIGURE 40). With the modified concave, the cylinder discharge hit the front tip of the beater causing backfeeding (FIGURE 41). Because of this problem, combined with no beneficial effects, concave modification should be avoided.

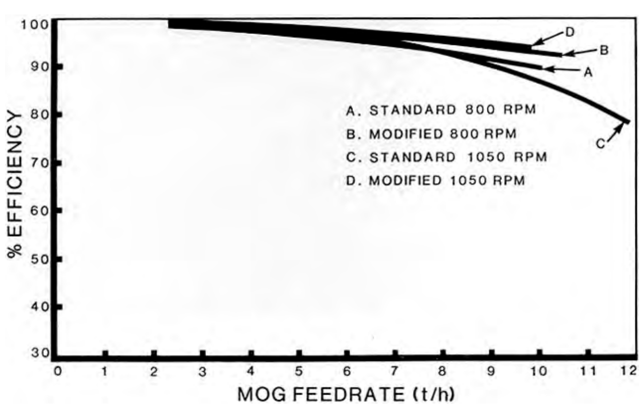

FIGURE 37. Straw Walker Efficiency for the JD 6600 Concave In Wheat.

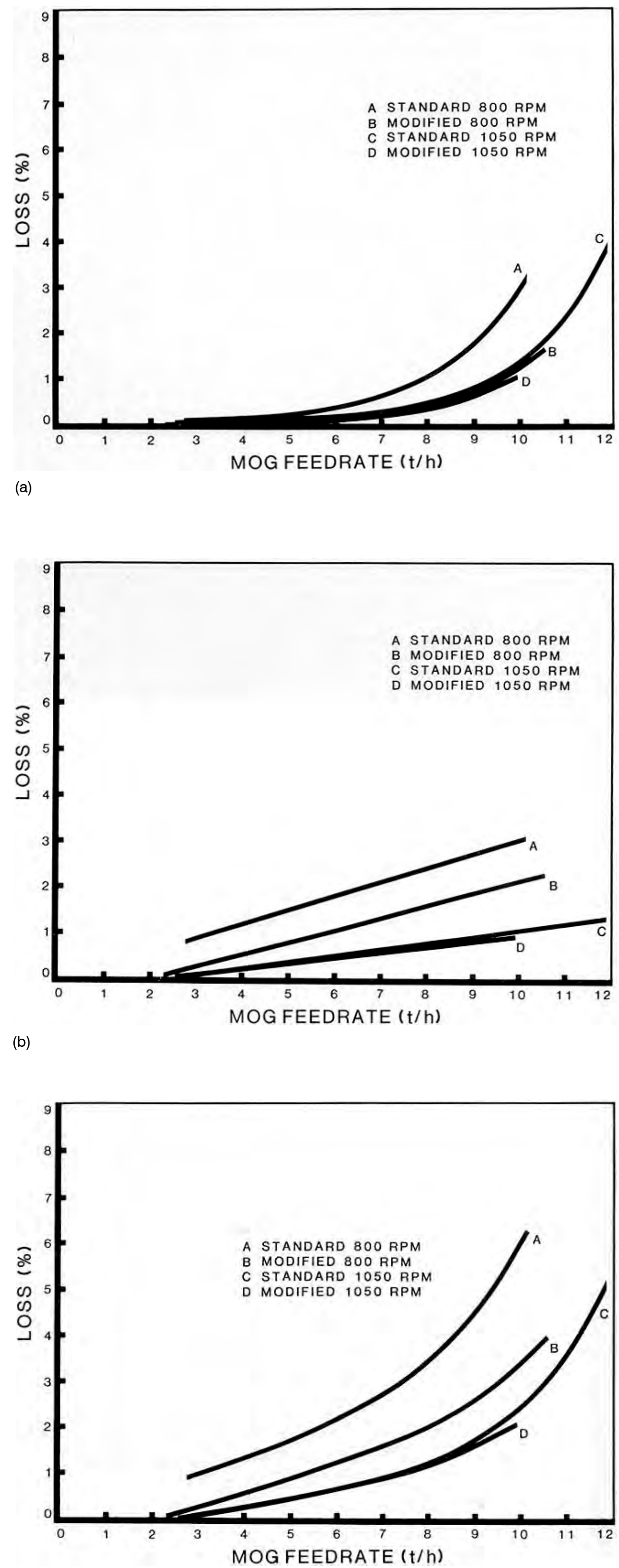

FIGURE 38. Grain Loss for the JD 6600 Concave in Wheat: (a) Walker Loss, (b) Cylinder Loss, (c) Total Loss.

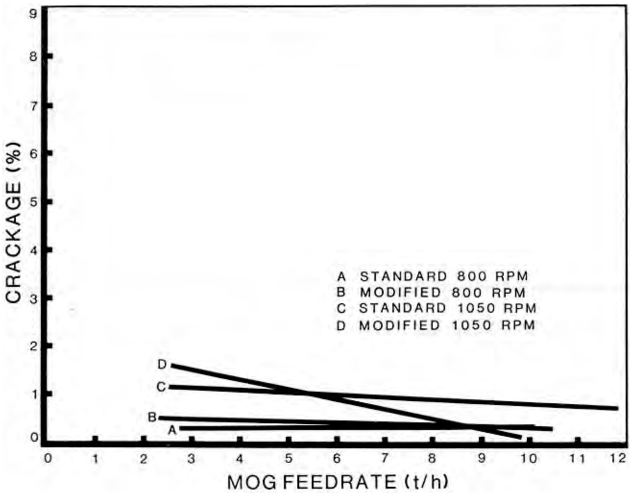

FIGURE 39. Grain Damage for the JD 6600 Concave in Wheat.

FIGURE 41. Crop Discharge to the Rear Beater (Modified).

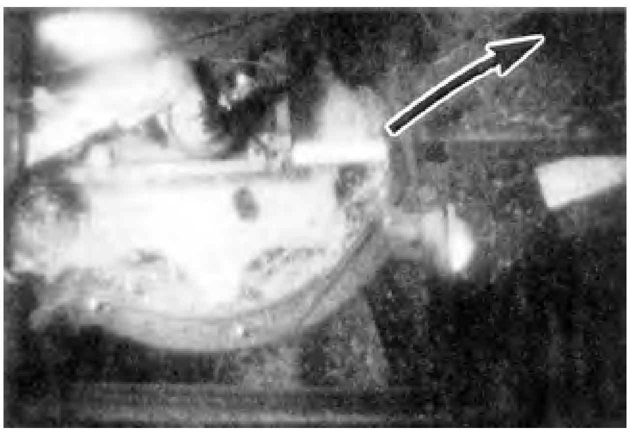

FIGURE 40. Crop Discharge to the Rear Beater (Standard).

PART III: COMMENTS AND INTERPRETATIONS BY RAY STUECKLE

The following replies were provided by Mr. Stueckle after review of this report:

To me, the test results raise more questions than they answer. One of the questions concerns this statement in the SUMMARY OF RESEARCH FINDINGS: "Altering the concave shape caused cylinder backfeeding at normal to high feedrates since it prevented the rear beater from effectively stripping the crop from the cylinder. Laboratory studies using high speed photography confirmed this behavior."

My question is: How was this result obtained? I know for certain there was absolutely NO backfeeding because the concave I used in this combine had the two back concave bars removed and placed on the front of the concave, which left the same length of concave as the standard. The concave was machined to fit the cylinder and the first four spaces were covered. Removing the last two bars released the straw approximately the same place as the conventional 6600. This allowed the straw to get underneath the beater rather than in front of it.

The test combine was run at the high feedrate twice in damp Neepawa wheat. In the distance that was traveled, if there had been any refeeding at all, the combine would have been plugged up. I was there and there was no plugging.

In order to check this, I had painted the front door and the shield above the cylinder with blue paint. If there had been any refeed, it would have removed the paint in a very short time. Even after finishing the whole harvest, the paint is still there.

Was the conclusion that there was refeeding in the test combine based upon lab tests only without confirming the results in the field? If so, is this the same method used in the rest of the tests?

Another statement I question is found on page 2, under point (iii), as follows: "The front four intervals of the concave were blanked and every second wire removed from the rear eight intervals." In actual fact, this concave was built without provision for any wires in the rear. It did not have every other wire; it has no wires at all in the rear eight spaces thus this statement is false.

Again, in the DESCRIPTION OF THE TEST COMBINES, page 2, point (i): "The table auger flighting (on the modified combine) was hard-surfaced and squared to the auger tubing. Feeder paddle timing was altered from the manufacturer's recommended out-of-phase setting to an in-phase setting."

I have two corrections to make in this one statement. (1) The auger had NEVER been hard-faced. (2) The feeder paddle timing was NOT altered from the out-of-phase setting.

When scientific research comes up with such grossly inaccurate statements as those quoted above, it leaves me with grave doubts as to the validity of other statements included in the test results.

PAMI Replies:

The modified combine concave used in the field test was different from the concave Mr. Stueckle originally recommended. During field testing, backfeeding occurred as evidenced by slugging and straw and chaff returning down the feeder housing. Backfeeding resulted either from concave design or from removal of the rear beater grate.

The draft copy sent to Mr. Stueckle contained an error on concave configuration, which has been corrected in the report.

The table auger and feeder paddle timing were noted, at the time of the field tests, to be different from the standard combine, and were assumed to have been modified by Mr. Stueckle in accordance with his recommendations.

It is noteworthy that with the latest version of concave modifications, the modified combine still did not perform as well as the standard combine.

APPENDIX I

TERMINOLOGY

Capacity: Combine capacity is the maximum rate at which a combine can harvest a crop at a specified total loss level, when adjusted for optimum performance. Many crop variables affect combine capacity. Crop type and variety, grain and straw yield and local climatic conditions during the growing season all affect the threshing and separating ability of a combine.

When determining combine capacity, combine performance and crop conditions must be expressed in a meaningful way. The loss characteristics of a combine in a certain crop depend mainly on two factors, the quantity of the straw and chaff being processed and the quantity of grain being processed.

MOG Feedrate: The weight of straw and chaff passing through a combine per unit time is called the MOG feedrate. MOG is an abbreviation for "material-other-than-grain" and represents the weight of all plant material passing through the combine except for the grain or seed.

Grain Feedrate: The weight of grain or seed passing through a combine per unit time is identified as the Grain Feedrate.

MOG/G Ratio: The ratio of MOG Feedrate to Grain Feedrate, which is abbreviated as MOG/G, gives an indication of how difficult a crop is to separate. For example, if a combine is used in two wheat fields of identical grain yield but one with long straw and one with short straw, the combine will have better separation ability in the short crop and will be able to operate faster. This crop variable is expressed with the MOG/G ratio when determining combine capacity. MOG/G ratios for prairie wheat crops vary from about 0.5 to 1.5.

Grain Loss: Grain losses from a combine are of two main types, unthreshed grain in the head and threshed grain or seed which is discharged with the straw and chaff. Unthreshed grain is called cylinder loss. Free grain in the straw and chaff is called separator loss and consists of shoe loss and walker loss. Losses are expressed as a percent of total grain passing through the combine. Combine capacity is expressed as the maximum MOG Feedrate at which total grain loss (cylinder loss plus separator loss) is 3% of the total grain yield.

Concave Separation Efficiency: The amount of grain separated at the concave compared to the amount of grain entering the concave is identified as concave separation efficiency. Reduced cylinder speed, increased concave clearance, reduced concave area and increased feedrate all decrease concave separation efficiency, resulting in more grin on the straw walkers.

Straw Walker Efficiency*:* The amount of grain separated at the straw walkers compared to the amount of grain entering the walkers is identified as straw walker efficiency. Increased feedrate and increased straw breakup decrease straw walker efficiency resulting in higher straw walker loss.

Grain Damage: The amount of cracked kernels present in a sample taken from the grain tank during a test were determined in accordance with methods used by the Canadian Grain Commission.

Dockage: The amount of straw, chaff and whitecaps present in a sample taken from the grain tank during a test were determined in accordance with methods used by the Canadian Grain Commission.

APPENDIX II

COMBINE SETTINGS FOR FIELD TESTS

The settings shown below for the standard combine were selected by PAMI in accordance with the manufacturer's recommendations. The settings shown for the modified combine were selected by Mr. Stueckle, and are not always in agreement with settings specified in "Combine Settings for Better Harvesting". In general, cylinder speeds used on the modified combine are from 200 to 300 rpm higher and front concave clearance was about 8 mm (0.3 in) greater than recommended in the above mentioned book.

TABLE A(1). Combine Settings for Dry Neepawa Wheat.

	MODIFIED	STANDARD
Cylinder Speed (rpm)	1050	1050
Concave Clearance		
--Front mm (in)	17 (0.67)	5 (0.20)
--Rear mm (in)	0	1 (0.04)
Fan Speed (rpm)	810	940
Chaffer--Front mm (in)	25 (0.98)	22 (0.87)
--Rear mm (in)	25 (0.98)	19 (0.75)
Sieve mm (in)	5 (0.20)	5 (0.20)

TABLE A(2). Combine Settings for Tough Neepawa Wheat.

	MODIFIED	STANDARD
Cylinder Speed (rpm)	1150	1100
Concave Clearance		
--Front mm (in)	17 (0.67)	5 (0.20)
--Rear mm (in)	0	1 (0.04)
Fan Speed (rpm)	580	990
Chaffer --Front mm (in)	25 (0.98)	20 (0.79)
--Rear mm (in)	20 (0.79)	21 (0.83)
Sieve mm (in)	6 (0.24)	6 (0.24)

TABLE A (3). Combine Settings for Dry Hector Barley.

	MODIFIED	STANDARD
Cylinder Speed (rpm)	800	825
Concave Clearance		
--Front mm (in)	17 (0.67)	8 (0.31)
--Rear mm (in)	0	3 (0.12)
Fan Speed (rpm)	700	940
Chaffer --Front mm (in)	17 (0.67)	22 (0.87)
--Rear mm (in)	17 (0.67)	22 (0.87)
Sieve mm (in)	9 (0.35)	6 (0.24)

TABLE A(4). Combine Settings for Tough Hector Barley.

	MODIFIED	STANDARD
Cylinder Speed (rpm)	700	850
Concave Clearance		
--Front mm (in)	16 (0.63)	8 (0.31)
--Rear mm (in)	0	3 (0.12)
Fan Speed (rpm)	680	920
Chaffer --Front mm (in)	18 (0.71)	21 (0.83)
--Rear mm (in)	15 (0.59)	21 (0.83)
Sieve mm (in)	27 (1.06)	9 (0.35)

TABLE A(5). Combine Settings for Candle Canola.

	MODIFIED	STANDARD
Cylinder Speed (rpm)	800	500
Concave Clearance		
--Front mm (in)	25 (0.98)	18 (0.71)
--Rear mm (in)	0	6 (0.24)
Fan Speed (rpm)	500	580
Chaffer --Front mm (in)	13 (0.51)	19 (0.75)
--Rear mm (in)	12 (0.47)	13 (0.51)
Sieve mm (in)	3 (0.12)	3 (0.12)

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