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Evaluation Report 54

White 8650 Pull - Type Combine

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

WHITE 8650 PULL-TYPE COMBINE

MANUFACTURER:
White Farm Equipment
148 Mohawk St.
Brantford, Ontario
N3T 5R7

DISTRIBUTOR:
White Farm Equipment
2201 First Ave.
Regina, Sask.
S4P 3A3

RETAIL PRICE:
$24,754.63, July, 1978, f.o.b. Humboldt, with 3960 mm (13 ft) table, 3048 mm (120 in) belt pickup, straw chopper, stone guards, table stand and rear stand.

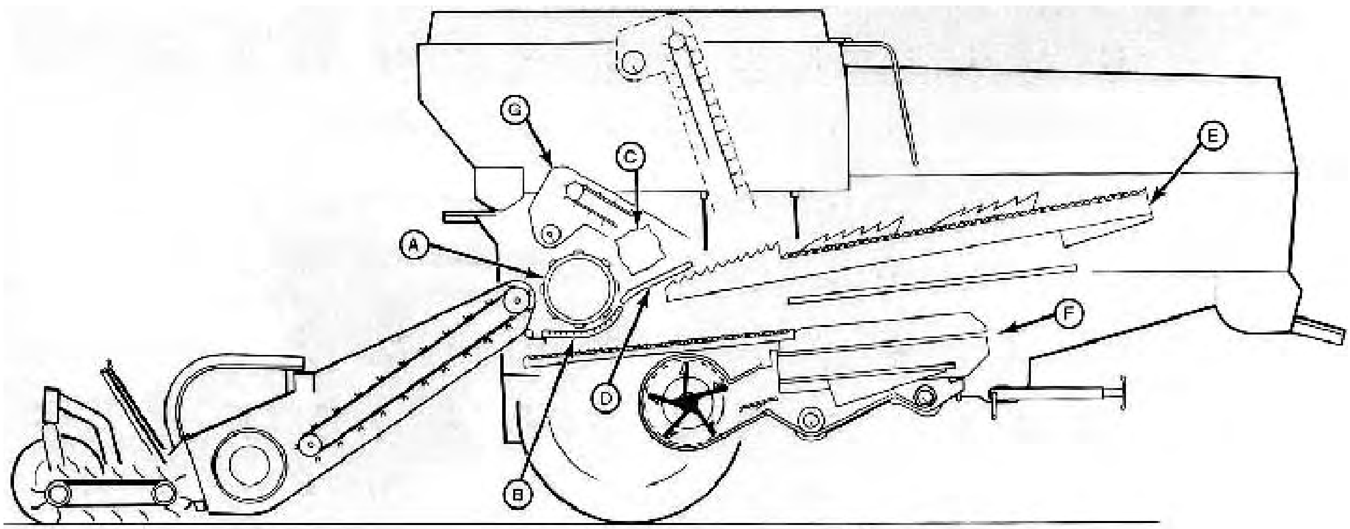

FIGURE 1. White 8650: (A) Cylinder, (B) Concave, (C) Back Beater, (D) Beater Grate, (E) Straw Walkers, (F) Shoe, (G) Tailings Return.

SUMMARY AND CONCLUSIONS

Functional performance of the White 8650 pull-type combine was very good in dry grain and oilseed crops. Functional performance was good to fair in tough and damp crops.

The MOG feedrate[1] at 3% total grain loss varied from 9.7 t/h (356 lb/min) in 3.28 t/ha (49 bu/ac) Neepawa Wheat to 7.6 t/h (279 lb/min) in 3.14 t/ha (58 bu/ac) Betzes barley. The capacity of the White 8650 was similar to the capacity of the PAMI reference combine for a similar total grain loss. Straw walker loss limited capacity in most crops. A reduction in grain loss over the straw walkers would have permitted higher combining rates. Cylinder and shoe losses usually were small, in comparison to straw walker loss. Significant shoe losses in rapeseed were reduced by adding optional fan doors to reduce the air blast.

At a 3% total grain loss, average power requirements were 30 kW (40 hp) in wheat and 21 kW (28 hp) in barley. Although the manufacturer recommends a minimum 75 kW (100) hp tractor, a 90 kW (120 hp) was needed when combining damp crops in soft or hilly fields.

The White 8650 was very maneuverable. Header visibility and handling depended on the tractor used while feedrate control depended upon the type of tractor transmission and its available range of ground speeds.

All controls were conveniently operated from the tractor seat. Grain tank visibility was good as the front of the tank contained a window. The unloading auger had sufficient reach for efficient unloading on-the-go. As is common with pull-type combines, modern tractor cabs create a quieter operator environment than most self-propelled combine cabs. As a result, operator feel for combine performance is reduced and suitable monitoring instruments are important. The nine channel monitor, which is supplied as standard equipment, monitored shaft speeds and also contained a digital tachometer to alternately indicate cylinder, cleaning fan and power take-off speed.

The White 8650 was easy to adjust for a specific field condition if a second person was available. Return tailings were easy to inspect. Setting the cylinder speed was inconvenient since the cylinder sprocket had to be changed. Ease of servicing was very good. All grease fittings were accessible.

The table auger, and feeder had very good capacity in dry grain crops and plugging was infrequent. Capacity was reduced in heavy bunchy rapeseed and in damp grain crops due to choking and plugging of the table auger and feeder. Cylinder plugging never occurred during the test. Cylinder access was relatively inconvenient.

The stone trap stopped most stones before they entered the cylinder. The stone trap was easy to service.

The pickup had good feeding characteristics in all crops. In rapeseed the wind guard had to be removed to prevent plugging between the pickup and the table auger.

The hitch was convenient to swing into transport or field position. It was difficult to secure the unloading auger support in field position as there was no suitable place to stand. The White 8650 transported well at speeds of up to 32 km/h (20 mph). Transport width was narrow enough for safe and easy movement on most roads.

No serious safety hazards were noticed when operated according to the manufacturer's recommended procedures. The operator's manuals were well illustrated and contained useful information on servicing and adjustments for most crops.

Durability problems occurred with the power take-off drive line and the feeder conveyor drive.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifying the pickup drive variable speed control to widen the speed range and to permit safer adjustment, or alternately, providing an optional variable speed pickup drive, adjustable from the tractor seat.

[1]MOG Feedrate (Material-Other-than Grain Feedrate) is the weight of straw and chaff passing through a combine per unit time.

2. Providing a rocking hub on the table auger drive to facilitate unplugging.
3. Providing front inspection holes to aid in initial concave levelling and adjustment.
4. Modifications to improve the ease of placing the grain unloading auger in field position.
5. Modifications to reduce power drive line failures.
6. Modifying the header jack support to eliminate possible deformation of the feeder house bottom.
7. Modifying the feeder conveyor drive to eliminate roll pin failure.
8. Modifications to reduce cylinder drive chain wear.
9. Providing a hitch safety chain as standard equipment.

Chief Engineer - E. O. Nyborg
Senior Engineer - L. G. Smith
Project Engineer - P. D. Wrubleski

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. An optional hydraulic variable speed pickup drive, controlled from the tractor, is under consideration. An improved variable belt drive is presently being developed.
2. This recommendation will be taken into consideration on future designs.
3. Front concave clearance adjustments are usually required only on initial preparation for the field and can be easily done before the feeder house is installed.
4. This recommendation is under consideration.
5. Changes have been incorporated to limit the high driveline peak torques which can be created by tractors with non-feathering hydraulic power take-off clutches when the power take-off is engaged at high engine speeds. A paragraph has been added to the Operator's Manual to provide detailed instruction on the proper procedure to engage the power take-off drive.
6. This suggestion is being evaluated. The jack support was designed to support the feeder and header assembly when the combine is backed away. It was not anticipated that the entire weight of the pickup, header, and feeder would be applied to this jack.
7. The feeder conveyor clutch hub and shaft have been modified to eliminate this problem.
8. Modifications have been made to the drive to extend the chain life. Additional improvements are also being evaluated.
9. A safety chain is available for the combine. It is not included with each combine as many customers use one safety chain for all towed equipment.

GENERAL DESCRIPTION

The White 8650 Harvest Boss is a power take-off driven pull-type combine with a 3048 mm (120 in) two-roller belt pickup mounted on a 3960 (13 ft) offset header. A minimum 75 kW (100 hp) tractor, with 1000 rpm power take-off and one hydraulic outlet is needed.

The separator drive is controlled with the tractor power take-off clutch and header height with the tractor hydraulic system. Header and unloading auger drives are controlled through electric clutches from the tractor seat. Harvesting functions are monitored with an electronic monitor placed in the tractor cab.

Concave clearance is adjusted with a multi-position lever while cylinder speed is adjusted by changing sprockets on the cylinder shaft. Fan speed is adjusted with a crank operated variable speed belt drive. Return tailings may be inspected through a slide at the bottom of the return elevator. The chaffer and sieve are adjusted with levers at the rear of the shoe. Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The White 8650 Harvest Boss was operated in a variety of Saskatchewan crops (TABLES 1 AND 2) for 114 hours while harvesting about 201 ha (496 ac). It was evaluated for ease of operation, ease of adjustment, rate of work, grain loss characteristics, power requirements, operator safety and suitability of the operator's manual. Throughout the test, comparisons were made to the PAMI reference combine.

TABLE 1. Operating Conditions

Crop	Variety	Average Yield		Swath Width		Hours	Field Area	
		t/ha	bu/ac	m	ft		ha	ac
Wheat	Neepawa	2.8	42	4.9-6.1	16-20	18	27	67
Barley	Betzes	3.1	58	4.9-5.5	16-18	14	37	67
Barley	Bonanza	3.3	61	5.5-7.3	18-24	52	90	222
Barley	Conquest	3.5	65	7.3	24	6	9	22
Barley	Fergus	1.9	35	5.5	18	6	12	30
Barley	Klondike	2.2	42	7.3	24	3	8	20
Rapeseed	Tower	1.7	31	4.9-5.5	16-18	15	28	69
Total						114	201	497

TABLE 2. Operation in Stony Fields

Field Conditions	Hours	Field Area	
		ha	ac
Stone Free	68	114	282
Occasional Stones	46	87	215
Total	114	201	497

RESULTS AND DISCUSSION

EASE OF OPERATION

Hitching: A tractor with 1000 rpm power take-off with a standard 35 mm (1.38 in) spline and with a 12 V, negative ground electrical system was needed to power the White 8650. The following adjustments had to be made when initially attaching the combine to a tractor. The control and harvester monitor box had to be installed at a suitable location on the tractor (FIGURE 2). The adjustable drawpole clevis had to be positioned to level the drawpole when attached to the tractor. The tractor drawbar also had to be pinned in line with the power take-off shaft, the tractor drawbar extended to provide the standard 406 mm (16 in) distance between the end of the tractor power take-off shaft and the hitch pin centre and the drive line height on the combine had to be adjusted to obtain minimum drive shaft angles. The drawpole tire bumpers also had to be positioned to contact the tractor tires on tight turns. In addition, one bank of the tractor hydraulic system had to be converted to single-acting to suit the header lift cylinder.

FIGURE 2. Harvester Monitor Installed in Tractor.

Once the above initial adjustments had been made, hitching or unhitching was safe and easy. A convenient hitch jack was attached to the drawpole, the drive line contained a quick coupler, while the control box cable was equipped with a multi-pronged plug. Although the hitch pin must be secured, to prevent falling out during operation, pin diameter should be about 6 mm (0.25 in) less than the diameter of the hole in either the hitch or the tractor drawbar to provide flexibility on uneven terrain. No hitch safety chain was supplied with the White 8650. It is recommended that a safety chain be used, especially when transporting or when working on hilly fields.

Maneuverability: The White 8650 was very maneuverable. As is common with pull-type combines, picking windrows around tight corners was easier than with most self-propelled combines as the tractor could be turned to pivot the combine about the centre of the pickup. The maximum permissible tractor wheel spacing depended on the size of the windrower and the width of the windrow. It was easy to feed the windrow directly into the feed throat opening in all crops (FIGURE 3), since the drawpole position allowed a maximum outside tractor wheel width of 3200 mm (126 in) even in wide uffy windrows such as rapeseed. The minimum width of swather to permit passing between windrows on back and forth combining was 4875 mm (16 ft) when combining uffy windrows with a 2440 mm (96 in) tractor width.

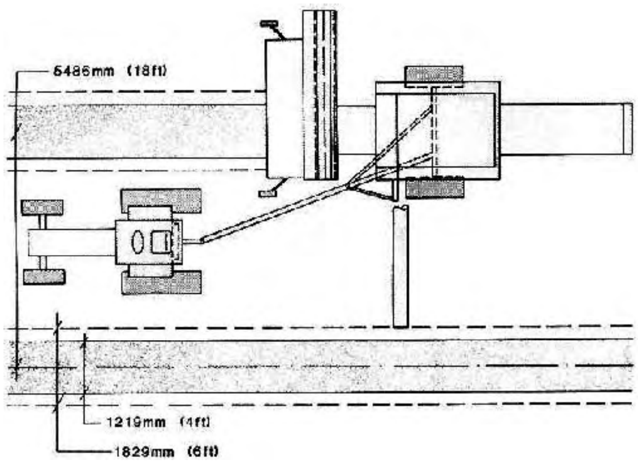

FIGURE 3. Tractor Wheel and Windrow Spacing Needed for In-Line Feeding.

Operator Location: With a pull-type combine, operator comfort and visibility depends mainly on the type of tractor used. With most modern tractors, operator comfort is better than on self-propelled combines because of lower noise levels and less dust, both due to the location of the tractor away from the combine, and better cabs. At the same time operator feel for combining performance is reduced and combine monitoring equipment becomes more important.

Controls: The main separator drive was controlled with the tractor power take-off clutch while header height was controlled with one bank of the tractor hydraulics. In addition to the main power switch, the combine control box had switches for the header drive and the combine lights and a switch and warning light for the grain unloading auger. Feedrate control was entirely dependent upon the tractor used, its type of transmission and its selection of suitable ground speeds. The tractor used in the test had 12 forward speeds, and a power shift transmission which could be shifted on-the-go within ranges. Only four of the speeds were suitable for most elds harvested during the test.

Harvester Monitor: The harvester monitor (FIGURE 4) contained nine channels for monitoring the header auger, cleaning shoe, cleaning fan, clean grain elevator, return elevator, straw walkers, straw chopper, rack load and grain bin level. In addition, the cylinder, cleaning fan or the power take-off speeds could alternately be read on a digital tachometer.

The harvester monitor was very useful in detecting component malfunction or imminent plugging. The digital tachometer allowed the operator to set the power take-off speed at 1000 rpm under load.

FIGURE 4. Harvester Monitor and Control Switches.

Lights: The White 8650 was equipped with four eld lights; two for the header, one for the grain tank, and one for the unloading auger. Also provided were warning lights and suitable re ectors for road transport.

Stability: The White 8650 was quite stable, even with a full grain tank. The centre of gravity, with the grain tank three-quarters full, was about 2030 mm (80 in) above ground, 280 mm (11 in) ahead of the combine axle and 75 mm (3 in) left of the combine centre line. Normal care had to be used when turning corners on hillsides and the tractor also had to be properly ballasted on hilly elds. The hitch load with a three-quarters full grain tank became negative when travelling up hills with a slope greater than 11 degrees.

Grain Tank: The grain tank held 5.3 m^3 (147 bu) of wheat. Unloading a full hopper of dry wheat took 87 seconds. The grain tank lled evenly in all crops and the monitor signalled when the grain bin was full.

The unloading auger had ample reach and clearance for easy on-the-go unloading. Placing the unloading auger in eld position was aided by a spring loaded securing catch. The support rod was dif cult to secure due to the height and location of its retainer. It is recommended that the manufacturer consider modi cations to improve the ease of placing the grain unloading auger in eld position.

When received, the unloading auger could not be placed in eld position. The engaging dowel on the folding portion of the unloading auger was ground to eliminate interference with the alignment dowel on the transverse unloading auger. After this modi cation, no further problems occurred.

Straw Chopper: The optional straw chopper attachment performed well in all crops. Length of cut could be adjusted by varying the clearance between the rotor hammers and concave. Although the straw de ectors were adjustable to control spreading width, maximum width was about 5 m (16 ft) and varied depending on the straw and wind conditions (FIGURE 5).

FIGURE 5. Spreading of Chopped Straw.

If the straw was to be windrowed, it was not necessary to remove the chopper as it moved forward on rails. The chopper lled with chaff and straw during windrowing and had to be cleaned before the chopper could be repositioned for chopping. Moving the chopper from cutting to windrow position took one man about 15 minutes.

Plugging: The table auger and feeder were quite aggressive in dry grain crops and plugging was infrequent at normal feedrates. At higher than normal feedrates, such as when attempting to combine in a higher tractor gear than suitable, occasional feeder and table auger plugging occurred, especially in wild oat patches. In heavy, bunchy rapeseed and damp grain crops, choking and plugging of the table auger and feeder occurred frequently. Plugging could be reduced by careful control of the feedrate. In damp or bunchy crops, capacity could be increased appreciably by using a tractor with an in nitely variable traction drive. Otherwise, it was usually necessary to travel one gear slower than normal to avoid feeder plugging.

An auger ight extension was added to eliminate plugging between the right side of the feeder housing and the table auger.

Unplugging the table auger or feeder was dif cult as no rocking hub was provided. The pickup windguard restricted access for unplugging. It is recommended that the manufacturer provide a rocking hub on the table auger drive to facilitate unplugging.

The cylinder was very aggressive and never plugged during the test. A rocking hub was provided on the cylinder shaft. Cylinder access was through a front door above the feeder housing and was inconvenient.

As with most combines, dust and chaff collected inside the cylinder rasp bars, causing cylinder imbalance. The inside of the rasp bars occasionally had to be cleaned to prevent cylinder vibration.

Stone Trap: The White 8650 was equipped with a stone trap in front of the cylinder (FIGURE 6). The stone trap was quite effective, capturing most roots or stones before they entered the cylinder. As with most combines, if a large stone was inadvertently picked, it could damage the table auger or feeder before being stopped by the stone trap. The stone trap emptied onto the grain pan. Throughout the test, all captured stones were small enough to pass between the grain pan and the bottom of the concave without causing damage.

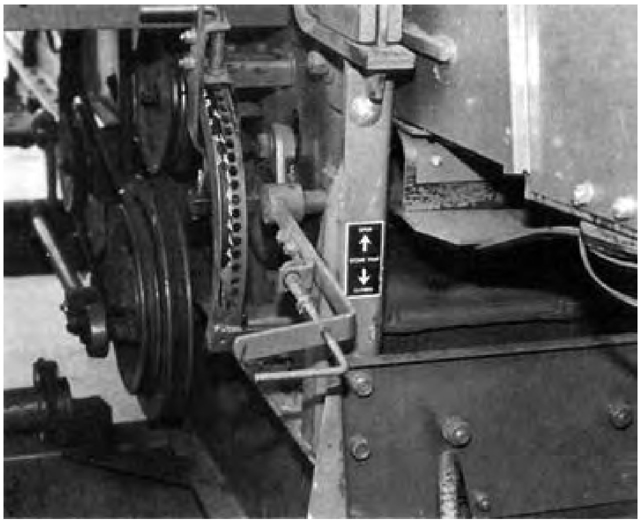

FIGURE 6. Stone Trap Release.

Pickup: The White 8650 was equipped with a 3048 mm (120 in) two roller belt pickup with plastic teeth. Pickup performance was good and optimum performance occurred with a pitch of about 30°. Decreasing the pitch resulted in better feeding under the table auger, but also resulted in more tooth wear. Increasing the pitch above 30° fed the material into or above the table auger. Pickup pitch was controlled by header height and by adjusting the length of the support chains. Lowering the rear pickup roller was bene cial in normal to heavy crops.

In tough crops, especially in wild oat patches, straw jammed between the rear of the pickup roller and stripper bar. This did not occur in dry crops. In rapeseed, the pickup windguard had to be removed as it retarded the crop ow, resulting in bunchy feeding, leading to table auger plugging. With the windguard removed, the pickup performance in rapeseed was good.

Pickup speed was controlled by a crank operated variable speed drive on the combine. Adjusting pickup speed was somewhat hazardous as the speed control crank had to be turned while the combine was running. The proximity of the crank to the pickup frame often caused skinned knuckles (FIGURE 7).

The range of pickup speeds obtainable on the combine, as delivered, was too high and was not suitable for normal combining speeds. By interchanging pickup and jackshaft sheaves a pickup belt speed range from 1.1 to 1.8 m/sec (210 to 340 ft/min) was obtained. This sheave combination, which was not speci ed in the operator's manual, was suitable for ground speeds from 3.2 to 6.4 km/h (2 to 4 mph).

It is recommended that the manufacturer modify the pickup variable speed control to widen the speed range and to permit safer adjustment. Consideration should also be given to providing an optional variable speed pickup drive, which is adjustable from the tractor seat.

Machine Cleaning: As with most combines, completely cleaning the White 8650 for combining seed grain was laborious and time consuming. Since the stone trap dumped onto the grain pan, it could not be cleaned from the outside. In damp crops, material accumulated in the trap and had to be removed with a suitably fabricated cleaning poker. The chaffer and sieve were easily removed for cleaning the tailings and clean grain augers. The grain tank contained some ledges and obstructions, which retained grain and weed seeds. To thoroughly clean the grain tank, the discharge auger covers had to be raised to their maximum height. A clean out door was located under the unloading auger.

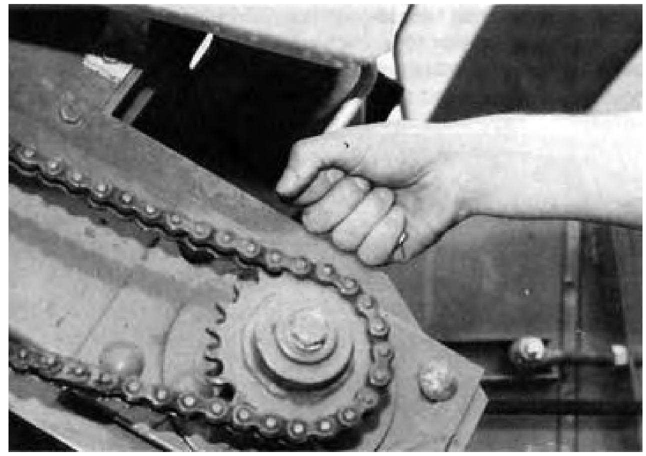

FIGURE 7. Pickup Drive Variable Speed Control.

Transporting: Swinging the hitch was an easy one man job. The hitch locking wedge had to be removed by hand and the tractor either backed or driven ahead to pivot the drawpole.

The White 8650 transported well at speeds up to 32 km/h (20 mph). Rear visibility in transport was restricted. The combine was adequately equipped with re ectors, warning lights, and a slow-moving vehicle sign for safe transport on public roads.

Lubrication: The White 8650 had 24 pressure grease ttings. Fifteen needed greasing every 10 hours and nine needed greasing every 50 hours. Most grease ttings were very accessible.

The main drive gearbox oil level needed checking every week while the wheel bearings needed checking every season.

EASE OF ADJUSTMENT

Field Adjustments: The White 8650 was easy to adjust. As with all pull-type combines, having a second person available when setting was bene cial and it was dif cult to determine when to change settings during the day as return tailings and clean grain could not easily be inspected by the operator.

Concave Adjustment: The White 8650 had a single segment concave. The concave has to be initially levelled and adjusted with shims at the front and eyebolts at the rear. Front concave clearance may be gauged through the front cylinder access door while the rear may be gauged through inspection holes on both sides of the combine. It is recommended that the manufacturer consider providing front inspection holes to simplify initial concave adjustment.

Once the concave had been initially set, clearance was easily adjusted with an external lever (FIGURE 8). The control linkage was designed so that the leading concave bar opened faster than the trailing bar. The concave lever moved in 1.6 mm (0.06 in) increments and had two ranges. The most commonly used range was from 0 to 19 mm (0 to 0.75 in). Clearances greater than 19 mm (0.75 in) were obtained by repositioning the lever. The lever could then be adjusted from 19 to 29 mm (0.75 to 1.13 in).

Suitable concave control lever settings were from 5 to 11 mm (0.15 to 0.44 in) in wheat, 10 to 14 mm (0.38 to 0.56 in) in barley and 19 to 25 mm (0.75 to 1 in) in rapeseed. The front three concave intervals could be blanked by installation of a pan beneath the front of the concave. Pan installation was easiest if the feeder housing was detached from the combine body. Optimum results were obtained in wheat with the pan installed and in barley and rapeseed with the pan removed.

Cylinder Adjustments: Cylinder speed could be adjusted by changing the cylinder sprocket (FIGURE 9). With the standard sprockets, speeds of 1040 and 942 rpm were possible. Speeds of 815, 670, 520 and 470 rpm could be obtained with optional sprockets.

Suitable cylinder speeds were 1040 and 942 rpm in wheat, 942 and 815 rpm in barley and 670 rpm in rapeseed. Measured grain crackage varied from 0.5 to 2% in Betzes and Bonanza barley, and from 1 to 6% in Neepawa wheat (FIGURE 10). Crackage varied from 0.4 to 0.8% in Tower rapeseed.

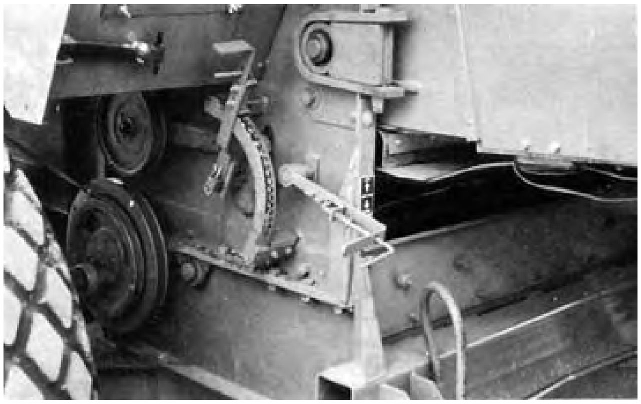

FIGURE 8. Concave Adjustment.

FIGURE 9. Cylinder Speed Adjustments.

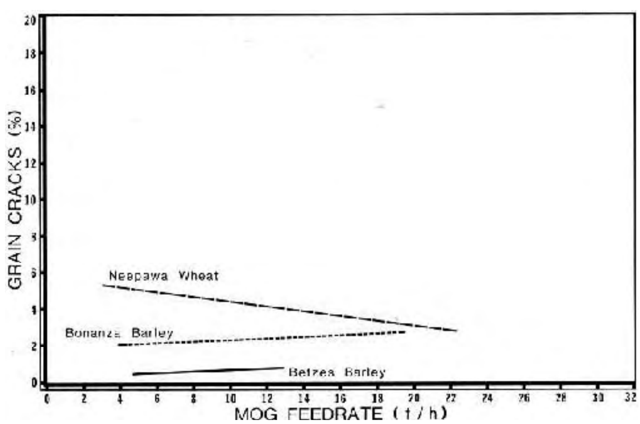

FIGURE 10. Grain Damage in Barley and Wheat.

Shoe Adjustment: The shoe was convenient to adjust. The fan had two speed ranges and speed within each range could be varied with a hand crank (FIGURE 11). Fan speed was indicated on the harvest monitor tachometer. The chaffer, chaffer extension and clean grain sieve were adjusted with levers at the rear of the shoe, while return tailings could easily be sampled through a sliding gate under the lower tailings auger. A windboard was provided to direct the air blast to the chaffer and clean grain sieves, while a second windboard could be added for special crop conditions. Optional fan doors had to be used in rapeseed.

Setting the shoe took longer than on some combines because, in addition to the regular settings, optimum positions for the windboards and fan doors had to be determined. In cereal grain the chaffer could be set at its maximum open position with the fan set at the maximum speed which would just prevent grain from being blown over the shoe when the windboards were set to direct the air blast to the front of the shoe. Total dockage in grain varied from 0.5 to 3.5% when properly adjusted.

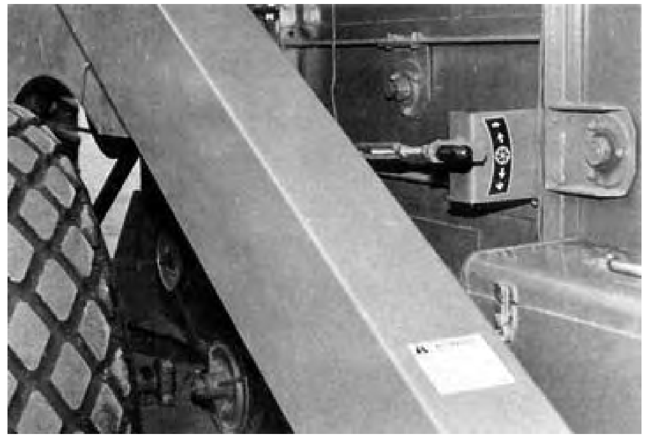

FIGURE 11. Fan Speed Adjustment.

Suitable shoe settings in rapeseed were with the chaffer one-quarter open, with minimum fan speed, with optional fan doors two-thirds open and with the windboards set to direct the air blast to the rear of the shoe. Total dockage in rapeseed varied from 1 to 3% when properly adjusted.

As is common with most combines, the windrow should be fed centred on the feeder housing. Shoe loss in rapeseed became signi cant if the windrow was fed on one side of the feeder housing. Similarily, shoe loss increased noticeably when combining on side slopes greater than 3°, due to non-uniform shoe loading.

Header Adjustments: The White 8650 was evaluated only with a pickup attachment for windrowed crops. Straight combining attachments were not evaluated. To remove the header, the hitch jack had to be repositioned to the rear of the combine to prevent the combine from tipping rearward. The table could be removed from the feeder by one man in about 15 minutes. The complete header and feeder assembly could also be removed from the combine, taking two men about 10. minutes. Header removal was facilitated by use of a header jack, which was permanently installed under the rear of the feeder housing. The header had to be completely lowered with the front of the header rmly supported before the header jack was extended to prevent damage to the feeder housing. It is recommended that the manufacturer consider modifying the header jack support to eliminate possible deformation of the feeder house bottom.

The table auger was easy to adjust both vertically and horizontally while the feeder conveyor was also easy to adjust.

Slip Clutches: Individual slip clutches protected the table auger and feeder conveyor.

RATE OF WORK

Average Workrates: TABLE 3 presents the average workrates for the White 8650, at acceptable loss levels, in all crops harvested during the test. Average workrates are affected by crop conditions in a speci c year and should not be used for comparing combines tested in different years. In some crops, workrates were reduced by bunchy and sunken windrows, rough ground, irregular shaped elds, and driving the combine empty to unload grain at a central location. During the 1977 harvest average workrates varied from 5.9 t/h (273 bu/h) in 3.1 t/ha (58 bu/ac) Betzes barley to 3.3 t/h (145 bu/h) in 1.1 t/ha (31 bu/ac) Tower rapeseed.

TABLE 3. Average Workrates

		Average Yield		Average Speed		Average Workrate			
Crop	Variety	t/ha	bu/ac	km/h	mph	ha/h	ac/h	t/h	bu/h
Wheat	Neepawa	2.8	42	3.4	2.1	1.5	3.8	4.4	160
Barley	Betzes	3.1	58	4.0	2.5	1.9	4.7	5.9	273
Barley	Fergus	1.9	35	4.3	2.7	2.0	5.0	3.8	174
Barley	Bonanza	3.3	61	3.2	2.0	1.7	4.2	5.7	260
Barley	Conquest	3.6	65	3.2	2.0	1.6	3.8	5.4	248
Barley	Klondike	2.2	42	4.0	2.5	2.6	6.4	5.9	270
Rapeseed	Tower	1.7	31	3.8	2.4	1.9	4.7	3.3	145

Maximum Feedrate: The workrates given in TABLE 3 represent average workrates at acceptable loss levels. The tractor had ample power to achieve much higher workrates in nearly all crops. In most crops the maximum acceptable feedrate was limited by grain loss, while in light crops the maximum feedrate was limited by pickup performance and in heavy bunchy rapeseed and damp grain crops, maximum feedrate was limited by plugging of the table auger and feeder conveyor.

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

MOG Feedrate, MOG/G Ratio and Percent Loss: 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 straw and chaff being processed and the quantity of grain being processed.

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.

The weight of grain or seed passing through a combine per unit time is called the Grain Feedrate. The ratio of MOG Feedrate to Grain Feedrate, which is abbreviated as MOG/G gives an indication of how dif cult a certain crop is to separate. For example, if a certain combine is used in two wheat elds 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 2.25.

Grain losses from a combine are of two main types, unthreshed grain still in the head and threshed grain or seed, which is discharged with the straw or chaff. Unthreshed grain is called cylinder loss. Free grain in the straw and chaff is called separator loss and consists of shoe loss and straw 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.

Capacity of the White 8650: TABLE 4 presents capacity results for the White 8650 in four different crops. MOG Feedrates for a 3% total grain loss varied from 9.70 t/h (356 lb/min) in a eld of 3.28 t/ha (49 bu/ac) Neepawa wheat to 7.60 t/h (279 lb/min) in a eld of 3.14 t/ha (58 bu/ac) Betzes barley. In rapeseed the total loss at all feedrates was above 3% as the fan blast was too great, resulting in excessive shoe loss. Addition of optional fan doors reduced shoe loss to an acceptable level.

GRAIN LOSS CHARACTERISTICS

The grain loss characteristics for the White 8650, in the four crops described in TABLE 4 are presented in FIGURES 12 to 15.

Walker Loss: As is common with most combines, walker loss was the most signi cant factor limiting capacity in all grain crops. Cylinder loss and shoe loss usually were insigni cant in comparison to walker loss. A reduction in free grain loss over the straw walkers would have enabled much higher combining rates especially in dif cult-to-separate crops such as barley.

An optional second one piece curtain was available for installation behind the rst curtain if dif culty was experienced retaining straw on the walkers. This curtain was installed in bunchy non-uniform crops to prevent the back beater from discharging straw to the rear of the walkers.

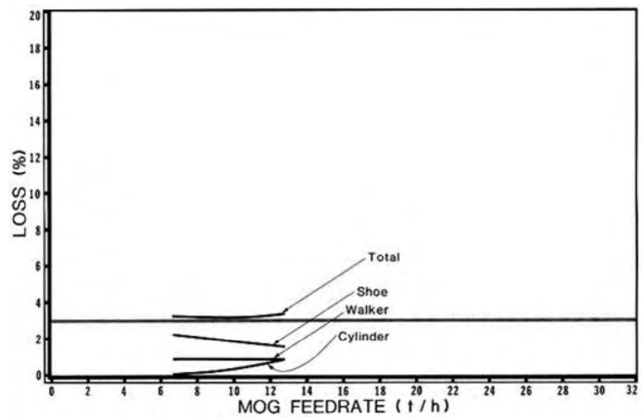

FIGURE 12. Grain Loss in Tower Rapeseed Before Installation of Optional Fan Doors.

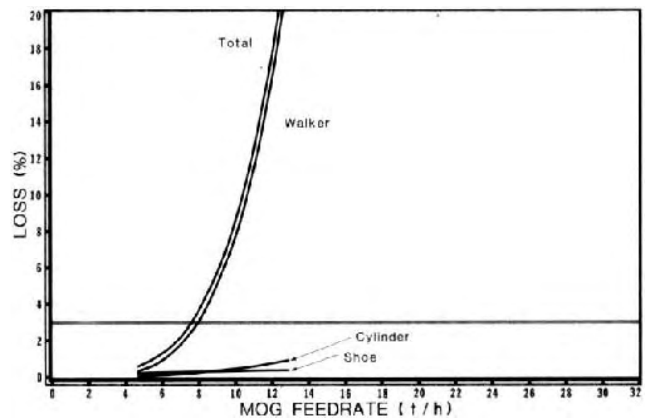

FIGURE 13. Grain Loss in Betzes Barley.

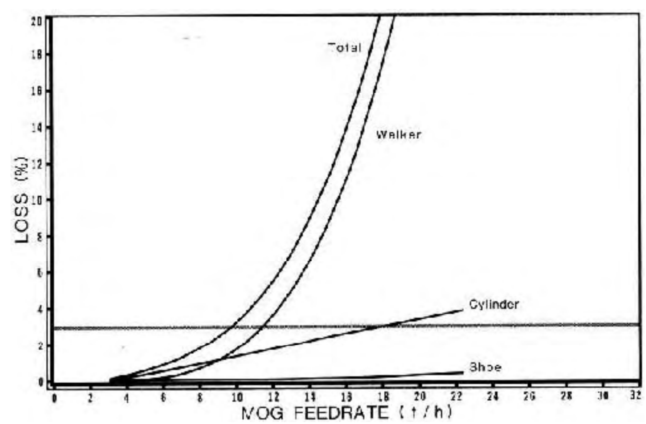

FIGURE 14. Grain Loss in Neepawa Wheat.

Shoe Loss: Shoe loss rarely limited combine capacity in grain crops. In rapeseed (FIGURE 12) shoe loss limited combine capacity since the airflow at the minimum fan speed setting was too great. The addition of optional fan doors reduced shoe loss to less than 1% in rapeseed.

Cylinder Loss: Cylinder loss was low in most dry and well matured crops. In difficult-to-thresh crops, cylinder and concave

TABLE 4. Capacity at a Total Grain Loss of 3% of Yield.

Crop Conditions									Capacity Results						
		Width of Cut		Crop Yield		Grain Moist.ure			MOG Feedrate		Grain Feedrate		Ground Speed		
Crop	Variety	m	ft	t/ha	bu/ac	Straw %	Grain %	MOG/G	t/h	lb/min	t/h	bu/h	km/h	mph	Loss Curve
Rapeseed[1]	Tower	4.9	16	2.33	42	16.6	12.0	1.84							Fig. 12
Barley-	Betzes	4.9	16	3.14	58	17.1	15.9	1.02	7.60	279	7.45	342	4.8	3.0	Fig 13 & 16
Wheat	Neepawa	6.1	20	3.28	49	11.9	14.3	0.87	9.70	356	11.15	410	5.6	3.5	Fig 14 & 17
Barley	Bonanza	7.3	24	4.12	77	29.9	13.9	1.07	7.75	284	7.25	333	2.4	1.5	Fig 15 & 18

[1]Total loss greater than 3% of yield. Run conducted before installation of optional fan doors.

adjustments were important and cylinder loss could make a significant contribution to total loss. In most hard-to-thresh grains such as Neepawa wheat, accepting a cylinder loss of 1 to 2% was necessary to avoid higher losses through cracking.

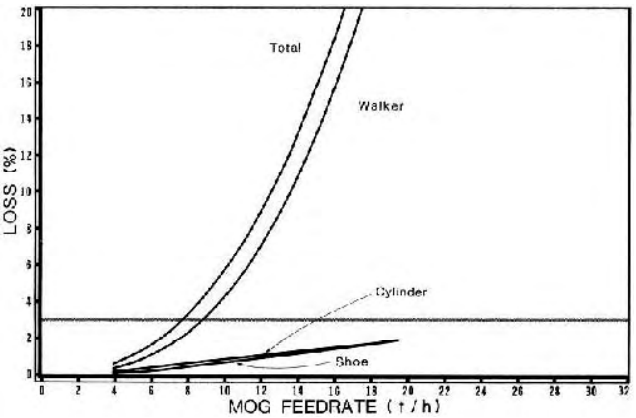

FIGURE 15. Grain Loss in Bonanza Barley.

Body Loss: Slight grain leakage occurred from the junction between the feeder housing and the combine body, but was insignificant.

Comparison to Reference Combine: Comparing combine capacities is complex because crop and growing conditions influence combine performance with the result that slightly different capacity characteristics can be expected every year. As an aid in determining relative combine capacities, PAMI uses a reference combine. This combine is operated alongside test combines whenever capacity measurements are made. This permits the comparison of loss characteristics of every test combine to those of the reference combine, independent of crop conditions. The reference combine used by PAMI is commonly accepted in the prairie provinces and is described in PAMI evaluation report E0576C. See APPENDIX III for PAMI reference combine capacity results.

FIGURES 16 to 18 compare the total grain losses of the White 8650 and the PAMI reference combine in three of the crops described in TABLE 4. The shaded areas on the figures are 95% confidence belts. If the shaded areas overlap, the loss characteristics of the two combines are not significantly different whereas if the shaded areas do not overlap, the losses are significantly different. The capacity of the White 8650 was similar to the capacity of the reference combine and usually had similar grain losses when operating at the same feedrate.

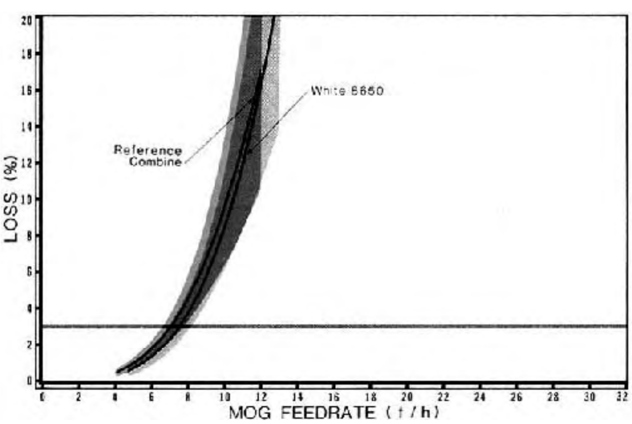

FIGURE 16. Total Grain Losses in Betzes Barley.

POWER REQUIREMENTS

The manufacturer recommended a minimum tractor size of 75 kW (100 hp). This tractor size was suitable for normal crops, however when using a straw chopper in damp crops on soft or hilly fields, a minimum tractor size of about 90 kW (120 hp) was needed.

Power consumption was measured in two fields. When operating at a 3% total grain loss, power input (FIGURE 19) was 30 kW (40 hp) in wheat and 21 kW (28 hp) in barley.

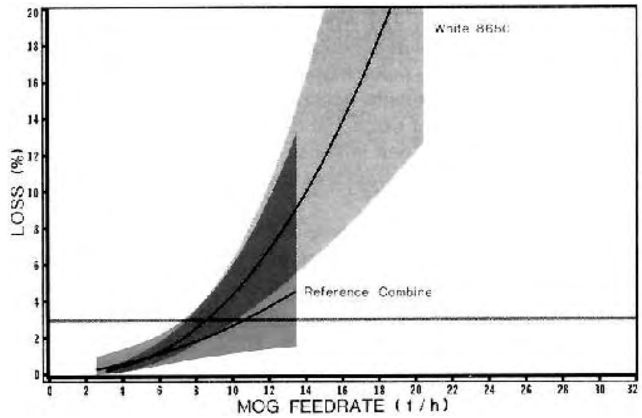

FIGURE 17. Total Grain Losses in Neepawa Wheat.

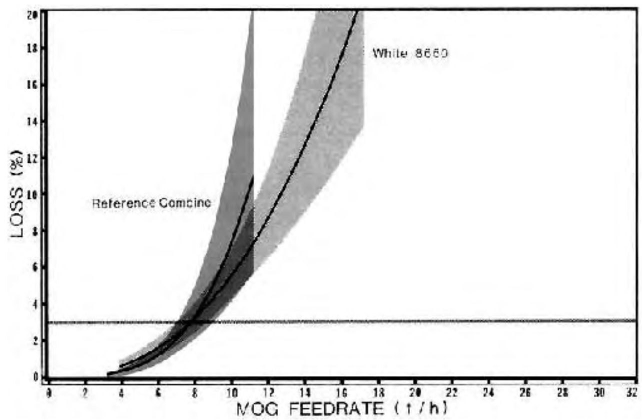

FIGURE 18. Total Grain Losses in Bonanza Barley.

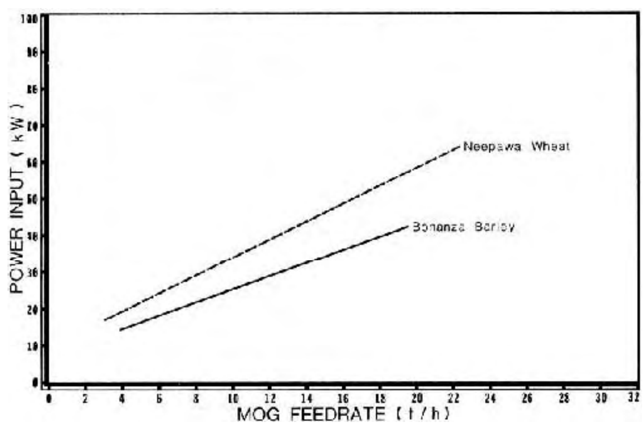

FIGURE 19. Power Input in Neepawa Wheat end Bonanza Barley.

OPERATOR SAFETY

The operator's manual for the combine and header emphasized operator safety.

The White 8650 had adequate warning decals, and was equipped with a slow-moving-vehicle sign, warning lights and reflectors for road transport.

Shielding provided good protection from most moving parts. All shields were easy to remove and install. The support post for the cylinder drive chain shielding made changing the cylinder sprocket difficult.

The White 8650 was equipped with a header lock and its proper use was emphasized in the operator's manual.

The hitch jack was safe and easy to use. An optional second jack was available to place at the rear of the combine to prevent the combine from tipping rearward when the header was removed. A hitch safety chain was not supplied with the White 8650. It is recommended that the manufacturer provide a hitch safety chain as standard equipment.

If recommended safety procedures were followed, all servicing and adjustment could be safely performed. A fire extinguisher should be carried on the combine or tractor at all times.

OPERATOR'S MANUAL

The operator's manual was clearly written, well illustrated and contained much useful information on servicing, adjustments, and suggested settings.

DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the White 8650 during 114 hours of operation while combining about 201 ha (496 ac). The intent of the test was evaluation of functional performance. The following failures represent those, which occurred during functional testing. An extended durability evaluation was not conducted.

TABLE 5. Mechanical History

Item	Operating Hours	Field Area ha	(ac)
Power Shaft			
-The centre power shaft universal joint bearings failed and the front power shaft assembly was replaced at	103	179	(442)
-The rear power shaft universal joint bearings failed and the joint assembly was replaced at	113	200	(494)
-Two intermediate wood alignment blocks shattered, the front support bearing failed and the power shaft twisted. All components were replaced at	113	200	(494)
Header			
-The header jack support deformed at the bottom of the feeder housing and was straightened and reinforced at	Beginning of test		
-The roll pin securing the feeder conveyor drive hub sheared under load and the drive hub seized on the shaft. A new keyed feeder shaft and corresponding drive hub were installed at	End of Test		
-The header jackshaft coupling moved and had to be repositioned and secured with a spacer at	91	158	(390)
-The feeder slip clutch jaws had worn necessitating replacement at	93	163	(403)
Drives			
-The main drive belt jumped one groove to the left on the driven sheave and was repositioned at	16	30	(74)
-The driven pickup pulley shifted to the right and was repositioned at	24	45	(111)
-The right straw chopper jackshaft bearing failed and was replaced at	29	57	(140)
-The cylinder drive chain was worn requiring replacement at	96	168	(415)
-The unloading auger jackshaft drive sprocket seized on the shaft as a key had not been installed. The sprocket was aligned and secured at	End of test		
Miscellaneous			
-The power take-off speed sensing disc loosened, striking the magnetic pickup, and was repositioned at	50	91	(225)
-Four deformed feeder slats were straightened at	59	106	(262)

DISCUSSION OF MECHANICAL PROBLEMS

Power Shaft: No cause was determined for power shaft failures. The White 8650 was powered with a tractor equipped with non-feathering hydraulically actuated clutch, which quickly starts and/or stops the power take-off. The shaft had been deformed under power and not from combine shutdown. It is recommended that the manufacturer modify the power take-off shaft to reduce driveline failures.

Header: The roll pin securing the feeder conveyor drive hub sheared during shock loading due to slip clutch release. Fragments of the roll pin caught under the hub and seized it to the shaft. To remedy this problem, the manufacturer supplied a keyed feeder shaft and corresponding drive hub. It is recommended that the manufacturer modify the feeder conveyor drive to eliminate roll pin failure.

Cylinder Drive Chain: The cylinder drive chain required early replacement possibly due to its circuitous path. It is recommended that the manufacturer consider modifications to reduce chain wear.

APPENDIX I
SPECIFICATIONS

MAKE:	White Pull-Type Combine
MODEL:	8650
SERIAL NUMBER:	Header 702140, Combine Body L20359
MANUFACTURER:	White Farm Equipment Brantford, Ontario
WINDROW PICKUP:	
--type	belt
--pickup width	3048 mm (120 in)
--number of belts	5
--teeth per belt	48
--type of teeth	nylon
--number of rollers	2
--height control	castor wheels and support chains
--speed control	crank adjusted variable pitch sheave
--belt speed range	1.1 to 1.8 m/s (210 to 340 ft/min)
HEADER:	
--type	off-set
--width	3960 mm (13 ft)
--auger diameter	508 mm (20 in)
--feeder conveyor	3 roller chains, undershot slatted conveyor
--conveyor speed	2.24 m/s (442 ft/min)
--range of picking height	-215 to 1524 mm (-8.5 to 60 in)
--number of lift cylinders	1
--options	rear stand, feeder stand, high speed auger sprocket, auger flighting extensions, stone guards
CYLINDER:	
--type	rasp bar
--number of bars	8
--diameter	550 mm (21.65 in)
--width	1132 mm (44.57 in)
--drive	chain
--speeds (standard)	1040 and 942 rpm
--speeds (optional)	815, 670, 520, and 470 rpm
--stripper bar	13 mm (0.50 in) fabric belting
--option	cylinder blanks
CYLINDER BEATER:	
--type	drum with 4 triangular bats
--diameter	385 mm (15.16 in)
--speed	670 rpm
CONCAVE:	
--type	bar and wire grate
--number of bars	13
--configuration	12 intervals with 9.5 mm (0.37 in) wires and 17 mm (0.67 in) spaces
--area	0.55 m² (853 in²)
--concave grate extension area	0.22 m² (333 in²)
--transition grate area	0.22 m² (333 in²)
--wrap	101 degrees
--grain delivery to shoe	grain pan
STRAW WALKERS:	
--type	rotary, formed metal
--number	5
--length	3250 mm (128 in)
--width of body	1156 mm (45.51 in)
--separating area	3.76 m² (5823 in²)
--crank throw	102 mm (4 in)
--speed	205 rpm
--grain delivery to shoe	one piece oscillating grain pan
--risers	standard, 2 per walker
--options	second retarding curtain
SHOE:	
--type	single action
--speed	330 rpm
--chaffer sieve	adjustable lip, 1.46 m² (2270 in²) with 50 mm (1.97 in) throw
--clean grain sieve	adjustable lip, 1.20 m² (1860 in²) with 50 mm (1.97 in) throw
--options	chaffer sieves, cleaning sieves, side hill attachment
CLEANING FAN:	
--type	5 blade undershot
--diameter	610 mm (24 in)
--width	950 mm (37.40 in)
--drive	crank controlled variable pitch belt
--speed range (standard)	450 to 660 rpm (small driving sheave) 580 to 850 rpm (large driving sheave)
--speed range (optional)	535 to 1050 rpm
--options	fan screen, fan doors, second windboard
ELEVATORS:	
--type	roller chain with rubber flights and top delivery
--clean grain (top drive)	207 x 245 mm (8.15 x 9.65 in)
--tailings (top drive)	155 x 242 mm (6.10 x 9.53 in)

GRAIN TANK:

--capacity	5.3 m^3 (147 bu)
--unloading time	87 s

STRAW CHOPPER:

--type	rotor with 27 freely swinging hammers
--speed	2790 rpm
--options	straw spreader

NUMBER OF CHAIN DRIVES: 8

NUMBER OF BELT DRIVES: 12

NUMBER OF PRELUBRICATED BEARINGS: 95

LUBRICATION POINTS:

--10 h lubrication	15
--50 h lubrication	9

CLUTCHS:

--header	electromagnetic
--unloading auger	electromagnetic

TIRES:

--right	18.4 x 26, 10-ply
--left	18.4 x 26, 6-ply

OVERALL DIMENSIONS:

--wheel tread	2667 mm (105 in)
--transport height	3465 mm (136 in)
--transport length	10,135 mm (399 in)
--transport width	4572 mm (180 in)
--field height	3465 mm (136 in)
--field length	10,110 mm (398 in)
--field width	7620 mm (300 in)
--unloader discharge height	3277 mm (129 in)
--unloader clearance height	2870 mm (113 in)
--unloader reach	1550 mm (61 in)

WEIGHT: (with empty grain tank and hitch in field position)

--right wheel	2860 kg (6310 lb)
--left wheel	2150 kg (4740 lb)
--hitch	530 kg (1170 lb)
TOTAL	5540 kg (12220 lb)

APPENDIX II
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations, for the capacity results shown in FIGURES 12 to 15, are presented in TABLE 6. In the regressions, C = cylinder loss in percent of yield, S = shoe loss in percent of yield, W = straw walker loss in percent of yield, F = The MOG feedrate in t/h, while $\ln$ is the natural logarithm. Sample size refers to the number of loss collections. Limits of the regressions may be obtained from FIGURES 12 to 15 while crop conditions are presented in TABLE 4.

TABLE 6. Regression Equations

Crop - Variety	Fig. No.	Regression Equations	Simple Correlation Coefficient	Sample Size
Rapeseed - Tower	12	$C = 0.94 - 0.003F$ $S = 3.01 - 0.11F$ $\ln W = -9.03 + 3.52 \ln F$	0.09 0.70 0.94	7
Barley - Betzes	13	$\ln C = -6.37 + 2.44 \ln F$ $S = 0.09 + 0.02F$ $\ln W = -7.44 + 4.12 \ln F$	0.89 0.59 0.97	8
Wheat - Neeawa	14	$C = -.059 + 0.20F$ $S = -0.01 + 0.02F$ $\ln W = -8.25 + 3.84 \ln F$	0.98 0.76 0.96	9
Barley - Bonanza	15	$C = -0.37 + 0.11F$ $S = -0.51 + 0.12F$ $\ln W = -4.90 + 2.76 \ln F$	0.93 0.96 0.97	9

APPENDIX III
PAMI REFERENCE COMBINE CAPACITY RESULTS

TABLE 7 and FIGURES 20 and 21 present capacity results for the PAMI reference combine in wheat and barley crops harvested in 1976 and 1977.

In 1976, after a warm and dry growing season, capacity tests were conducted in crops harvested soon after windrowing, with the windrows receiving little or no rain. In 1977, after a cool and moist growing season, tests were conducted in crops harvested long after windrowing and subjected to many wetting and drying cycles.

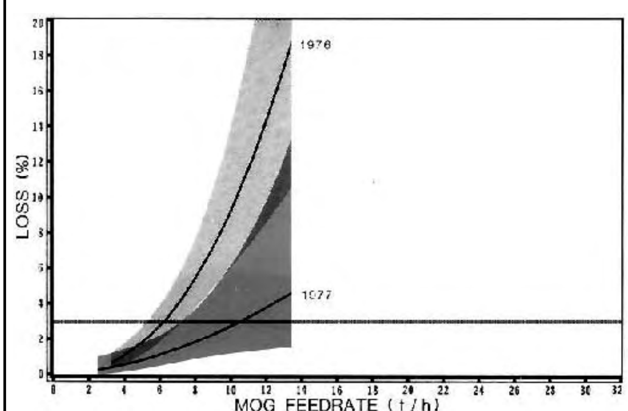

FIGURE 20. Total Grain Losses for the PAMI Reference Combine in Neepawa Wheat.

FIGURE 20 shows large capacity differences in Neepawa wheat for the two years. Although straw and grain moisture contents were similar the MOG/G ratios, growing conditions and windrow maturities were quite different. Much lower cylinder losses resulted from the easier threshability of the 1977 Neepawa wheat crop, and lower straw walker losses resulted from the lower MOG/G ratio.

FIGURE 21 also shows differences in capacities in Bonanza barley. Grain moisture contents were similar but MOG/G ratios were different. Growing conditions and windrow maturities also were quite different in the two years. The high straw moisture content of the 1977 Bonanza barley crop was not indicative of the physical properties of the straw, which was green but not damp. This resulted in less straw breakup that is common for barley at low straw moisture contents which, in combination with the lower MOG/G ratio, resulted in lower straw walker losses.

These results show that a reference combine is important in determining the effects of crop variables and in comparing capacity results of combines evaluated in different growing seasons.

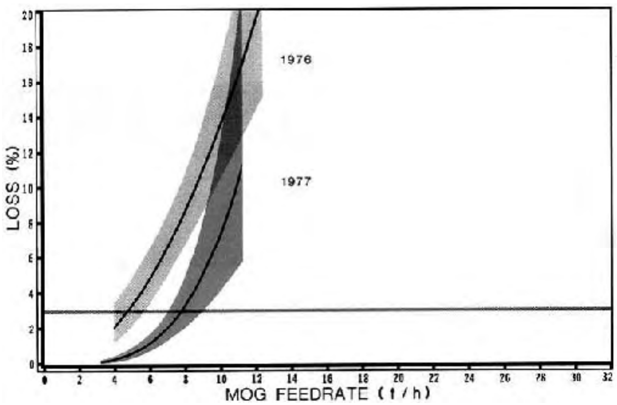

FIGURE 21. Total Grain Losses for the PAMI Reference Combine in Bonanza Barley.

TABLE 7. Capacity of the PAMI Reference Combine at a Total Grain Loss of 3% of Yield.

	Crop Conditions									Capacity Results						
			Width of Cut		Crop Yield		Grain Moist.ure			MOG Feedrate		Grain Feedrate		Ground Speed		
Year	Crop	Variety	m	ft	t/ha	bu/ac	Straw %	Grain %	MOG/G	t/h	lb/min	t/h	bu/h	km/h	mph	Loss Curve
1977	Barley	Betzes	4.9	16	3.35	82	17.2	15.9	0.92	7.10	261	7.70	354	4.7	2.9	
	Wheat	Neepawa	5.1	20	3.97	59	13.4	14.6	0.79	11.10	408	14.05	516	5.8	3.8	Fig. 20
	Barley	Bonanza	7.3	24	4.74	86	25.7	14.6	0.84	7.90	290	9.40	432	2.7	1.7	Fig. 21
1976	Wheat	Neepawa	5.5	16	2.78	41	dry to tough	14.7	1.29	7.1	281	5.5	202	3.6	2.3	Fig. 20
	Barley	Bonanza	7.2	24	3.18	60	dry to tough	14.6	0.96	4.6	178	5.0	230	2.2	1.4	Fig 21

APPENDIX IV
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

(a) excellent
(b) very good
(c) good
(d) fair
(e) poor
(f) unsatisfactory

APPENDIX V
METRIC UNITS

In keeping with the Canadian metric conversion program, this report has been prepared in SI units. For comparative purposes, the following conversions may be used:

1 kilometre/hour (km/h)	= 0.62 miles/hour (mph)
1 hectare (ha)	= 2.47 acres (ac)
1 kilogram (kg)	= 2.2 pounds (lb)
1 tonne (t)	= 2 204.6 pounds (lb)
1 tonne/hectare (t/ha)	= 0.45 ton/acre (ton/ac)
1 tonne/hour (t/h)	= 36.75 pounds/minute (lb/min)
1000 millimetres (mm) = 1 metre (m)	= 39.37 inches (in)
1 kilowatt (kW)	= 1.34 horsepower (hp)
1 litre/hour (L/h)	= 0.22 Imperial gallons/hour (gal/h)

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