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Evaluation Report 662

Phoenix Rotary Harrow

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

PHOENIX ROTARY HARROW

MANUFACTURER:
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RETAIL PRICE:
$13,500.00 [November, 1991, f.o.b. Humboldt, Saskatchewan, Model HT140, 36/47 ft (11/14 m) model].

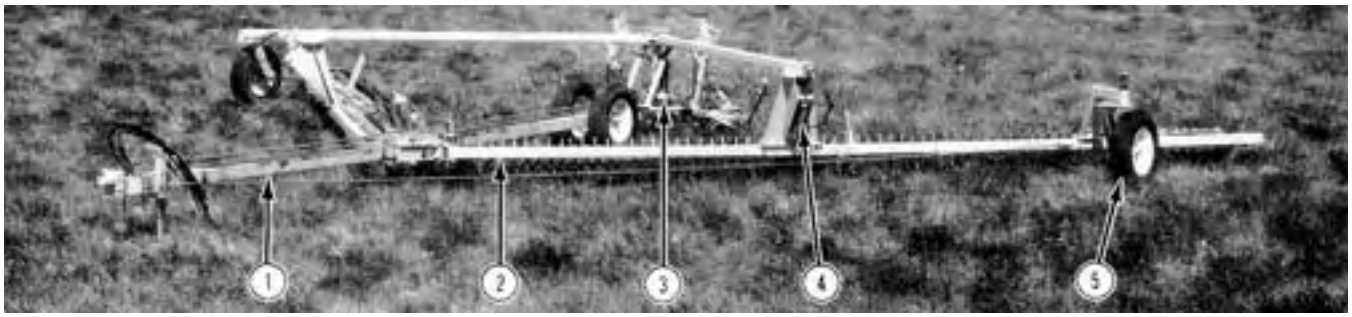

FIGURE 1. Phoenix Rotary Harrow Model HT140: 1) Hitch Frame. 2) Wing Frame, 3) Transport Motor Drive Location, 4) Tine Lift Cylinders, 5) Wing Wheels.

SUMMARY AND CONCLUSIONS

Quality of Work: The ability of the Phoenix rotary harrow for levelling the field surface was very good. Most of the trash was exposed in fallow conditions. In stubble, the surface was usually left level with some stubble uprooted when using the more aggressive harrow angles. Shallow incorporation of granular chemical was very good and the rotary harrow was capable of shallow incorporation in both summerfallow or stubble conditions. Proper trash management prior to chemical application was required for adequate chemical incorporation. Two passes at the maximum possible angle should be used to ensure best incorporation and mixing.

Straw spreading was fair. Piles or wads of straw left on the field surface were usually fluffed up and not spread. Trash retention of the harrow was very good. There was no reduction in trash coverage on the field surface due to the tillage action of the harrows. Trash clearance by the Phoenix rotary harrow was very good. However, green weeds or tough crop wrapped tightly at the three trailing tine bearing locations. Stone protection was good. Harrow tines that were bent were easily straightened with the supplied wrench. Weed killing ability of the Phoenix was good in loose and previously tilled soil where the harrow was effective in exposing weeds.

Stability of the rotary harrow was good. The centre rear section lifted off the ground while working over knolls, and forced the machine sideways while working through gullies.

Ease of Operation and Adjustment: Ease of transporting was fair. The harrow towed well at normal transport speeds. However, placing the unit into transport was time consuming and difficult at times. Ease of hitching was very good. However, the hitch pin fit too tightly to allow free vertical movement. Ease of maneuvering the rotary harrow in the field was very good. Sharp turns were done with the tines out of the ground. Ease of adjustment was very good. Permanent marks on the hitch pole and chains for harrow angle would make the adjustment more convenient. Tensioning the linked tines was easy with the supplied wrench. Ease of servicing was very good. All grease fittings were accessible in field or transport position.

Rate of Work: The harrow was operated at speeds ranging from 5 to 7.5 mph (8 to 12 km/h). The work rate also depended on the harrow angle used. Work rates varied from 19 to 35 ac/h (7.7 to 15.4 ha/h), for the harrow angles and speeds the harrow was operated at.

Power Requirements: A tractor with a maximum power take-off rating of 100 hp (75 kW) will have sufficient power to operate the Phoenix rotary harrow model HT140 on level ground.

Operator Safety: Normal safety precautions are required while operating the rotary harrow. However, there was no lock provided for the centre rear section when raised for transport, or the wing section tines when raised in field position. Also, there was no hitch safety chain, or slow moving vehicle sign or bracket provided.

Operator's Manual: The operator's manual was good. However, no information was provided for safety.

Mechanical History: The hitch link failed while operating in hilly conditions due to the tight hitch pin. Twenty harrow tines were straightened using the supplied wrench.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifying the tine bearing mounts to prevent wrapping of tough material.
2. Simplifying the method of placing the rotary harrow into transport.
3. Providing permanent marks on the hitch pole and chains for more convenient harrow angle adjustment.
4. Providing a transport lock for the centre rear tine section, and a lock for the wing section tines when raised in field position.
5. Providing a hitch safety chain, a slow moving vehicle sign or bracket, and safety information in the operator's manual.
6. Modifying the hitch link to provide vertical movement of the rotary harrow.

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Project Manager: G.E. Hultgreen
Project Technologist: A.R. Boyden

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. An anti-fouling device is available as optional equipment. A new bearing configuration that prevents wrapping is provided on new machines.
2. We are modifying the transport system. Other models are easier to put into transport.
3. Future machines will have permanent marks. We presently locate the angle positions with the owner at the time of purchase.
4. Transport locks will be provided.
5. A hitch safety chain and SMV sign will be provided. The operator's manual will have safety information added.
6. We will enlarge the hitch pinhole to allow this.

Manufacturer's Additional Comments

Other improvements are being made. For example, the centre section will float for better performance on rolling ground.

GENERAL DESCRIPTION

The Phoenix rotary harrow (FIGURE 1) is a light duty tillage machine having gangs of linked fingers or spokes that rotate over the field surface. The harrow can be used for levelling field surfaces before seeding or weeding summerfallow after tillage while maintaining trash on the field surface. It can also be used for shallow incorporation of preemergent chemical, or promoting weed growth for chemfallow or continuous cropping practices. In some conditions, the rotary harrow can also be used to break up large amounts of dry trash.

The angle of the harrow gangs can be adjusted from 25 to 45°. The rotary harrow is most aggressive at the higher angle. The test unit was a model HT140. The width of cut varied from 36.7 ft (11.2 m) at the 45° harrow angle to 47.3 ft (14.4 m) at the 25° angle. Four other models are available (see APPENDIX I).

SCOPE OF TEST

The machine evaluated by PAMI was configured as described in the General Description, FIGURE 1, and Specifications section of this report. The manufacturer may have produced different versions of this machine either before or after the PAMI tests. Therefore, when using this report, check to ensure the machine being considered is the same as the one evaluated in this report. If differences are found, PAMI or the manufacturer may be contacted to determine the effect of the changes on performance.

The Phoenix rotary harrow was operated in the conditions shown in TABLE 1 for 46 hours. During this time, measurements and observations were made to evaluate the harrow for quality of work, ease of operation and adjustment, rate of work, power requirements, operator safety, and suitability of the operator's manual.

TABLE 1. Operating Conditions

Field Conditions	Hours	Field Area	
		ac	ha
Summerfallow			
Loam	4	90	36
Stubble			
Loam	19	490	196
Sandy	8	195	78
Heavy Trash			
Loam	15	390	156
Total	46	1165	466

RESULTS AND DISCUSSION

QUALITY OF WORK

Levelling: The ability of the Phoenix rotary harrow for levelling the field surface was very good.

The soil finish in fallow conditions was usually very level. The rear centre harrow, when properly adjusted, was effective in levelling the ridge left between the main harrow sections. In dry and moist soil conditions while using harrow angles of 35° or more, the surface was fine, with most trash lying loosely on the soil surface (FIGURE 2).

FIGURE 2. Field Surface in Summerfallow.

In stubble conditions, the surface was usually level. However, larger furrows were left at the centre and outer ends when the tine bearings wrapped with tall green weeds. Some stubble was uprooted by the harrow at the higher angles of 40 and 45°. The amount of stubble uprooted was reduced by using lower angles of 25 to 35°.

otary harrows are more aggressive than tine harrows. This allows them to level better in severely ridged conditions. However, tine harrows will leave a slightly leveller finish in loose soil conditions.

Chemical Incorporation: Shallow incorporation of chemical was very good.

The Phoenix rotary harrow was capable of shallow incorporation in both summerfallow or stubble conditions. The best incorporation in summerfallow or stubble occurred at the 45° harrow angle. One pass with the rotary harrow covered approximately 90% of the chemical. However, to ensure better mixing of the chemical in the soil, a second pass at an angle to the previous pass is recommended.

Proper trash management prior to chemical application is required for adequate chemical incorporation. Decreasing the angle of the rotary harrow reduces the amount of incorporation on the first pass. The maximum harrow angle possible for trash clearance should always be used to ensure best incorporation and mixing of the chemical.

Straw Spreading: The ability of the Phoenix rotary harrow to spread straw was fair. Piles or wads of straw left on the field surface were usually fluffed up and only spread slightly, while using the most rigorous angle of 45°.

In wheat stubble, when set at the 45° harrow angle, chopped straw left by the combine was moved about 3 ft (0.9 m) when operated perpendicular to the direction of the previous combine operation. Harrowing the field a second time in the same direction moved the straw approximately another 4 ft (1.2 m) (FIGURE 3). In extremely heavy trash conditions, the trash was left evenly on the field surface after one pass. However, a second pass resulted in small straw bunches on the field surface (FIGURE 4).

FIGURE 3. Straw Spread (After Two Passes).

FIGURE 4. Hail Damaged Wheat (Second Pass).

Trash Retention: Trash retention of the harrow was very good.

There was no reduction in trash coverage due to the tillage action of the harrow. In tilled soil, where the trash was buried by a previous tillage operation, some of the trash was brought back to the surface. However, in loose soil, most of the trash was usually unanchored.

Trash Clearance: Trash clearance by the Phoenix rotary harrow was very good.

The rotary harrow was capable of clearing large amounts of dry straw or weeds. While operating in a hail damaged wheat crop, at a 40° angle, most of the straw was broken from the soil or stubble and

left lying loosely on the field surface. More stubble was uprooted by a second operation. The second pass however, created a slightly bunchy appearance on the field surface (FIGURE 4).

Some long straw or green weeds collected within the harrow tines. The straw or weeds were not usually tightly packed and did not greatly affect the machine's performance.

Green weeds and tough straw wrapped tightly at the three trailing tine bearing locations (FIGURE 5). The wrapped material required frequent removal in weedy or tough straw conditions. It is recommended that the manufacturer consider modifications to the tine bearing mounts to prevent wrapping of tough material.

FIGURE 5. Tough Material Wrapped at Bearings.

Stone Protection: Stone protection was good.
Very little damage occurred from rocks. Harrow tines that were bent by rocks, were easily straightened with the supplied wrench. Rocks easily cleared through the harrow tines as the linked tines flexed and prevented jamming.

Weed Kill: The weed killing ability of the Phoenix rotary harrow was good.

In loose and previously tilled soils, the harrow was effective in exposing weeds and leaving them on the field surface. The Phoenix rotary harrow was not effective in killing mature weeds in firm soil, such as summerfallow that had received significant rainfall, even when two passes were used with the harrows set at their maximum angle.

Skewing and Stability: The stability of the rotary harrow was good.

The machine did not skew on flat land. The opposed angle of the two main sections cancelled side forces. However, sideways skewing did occur in hilly conditions. This changed the angle of the harrow sections, reducing their aggressiveness on one side of the machine. Care is required on hillsides to ensure that adequate tillage occurs.

The centre rear harrow section lifted off of the ground while working over small knolls. Also, the machine was forced to skew sideways by the centre rear harrow section while working through small gullies. This occurred with the machine set at the maximum angle, and is less likely to occur at the shallower angles as the front to back distance between the tine sections is reduced.

EASE OF OPERATION AND ADJUSTMENT

Transporting: Ease of transporting was fair.

It took one man about 10 minutes to place the rotary harrow into transport (FIGURE 6). At times, it was difficult to wrap the lift chains around the harrow tines for lifting them into transport. Driving the harrow ahead slightly was required, as the wings were hydraulically folded back to ensure that they cleared their carry arms. The wings were then easily locked with the over centre catches using the supplied wrench. Storage pins were provided for the wing chains or they could be draped over the tines for short distances. The centre rear section did not have a transport lock system. It is recommended that the manufacturer consider providing a transport lock for the centre rear tine section. A minimum of two trips back to the machine were required for changing from field to transport position. It is recommended that the manufacturer consider simplifying the method of placing the rotary harrow into transport.

The rotary harrow towed well at normal transport speeds of 20 mph (32 km/h) when properly adjusted. The transport width was narrow enough to allow passage of on-coming traffic on most roadways.

The wing wheel castors had springs at the pivots to reduce wheel shimmy in transport. These springs were very loosely adjusted at the start of the test resulting in severe wheel shimmy on rough roads. Tightening the springs eliminated the wheel shimmy and improved transporting.

FIGURE 6. Transport Position.

Hitching: Ease of hitching was very good.

The hitch jack was suitably sized to handle the 1400 lb (635 kg) hitch load of the harrow in transport. The hitch link was solidly attached to the hitch pole making hitching convenient. Four hydraulic quick couplers required connection to the tractor hydraulic system.

Maneuverability: The ease of maneuvering the rotary harrow in the field was very good.

Sharp 180° turns were done with the harrow tines raised out of the ground. Wide turns with the harrow tines in the ground usually resulted in wasted time as the harrows were not effective while turning. Sharp turns with the tines in the ground caused a severe surface ridge and unnecessary stress on the linked tines.
Contact of the wing chain with the tractor rear tires only had to be avoided on very sharp turns. The machine could be backed up in field position.

Adjustments: Ease of adjustment was very good.

To adjust harrow angle, the butt plate was easily loosened with wrenches and slid along the hitch pole for the desired angle. The wing support chains were easily adjusted with the keyhole slots at the hitch.

The harrow angle locations for the butt plate were marked with a felt pen on the hitch pole in 5° increments from 25 to 45°. The appropriate chain links were also marked, making the adjustment very easy. It is recommended that the manufacturer consider providing permanent marks on the hitch pole and chains for easy harrow angle adjustment.

Turnbuckles located on one end of each of the harrow sections adjusted the tension of the linked tines. The adjustment was easy with the supplied wrench.

Servicing: Ease of servicing was very good.

There were 8 grease fittings that required grease every 10 to 12 hours. These included the harrow tine bearings and the wing wheel castors. The wing pivots and hitch tube slide required grease weekly. All grease fittings were easily accessible in field or transport position.

RATE OF WORK

The Phoenix rotary harrow was operated at speeds ranging from 5 to 7.5 mph (8 to 12 km/h). The harrow worked more aggressively at the higher speeds, causing more soil disturbance and greater trash break up.

The rate of work of the harrow depended on the harrow angle used. The cutting width of the machine was reduced from 47.3 to 36.7 ft (14.4 to 11.2 m) when the harrow angle was increased from 25 to 45°. At the 45° harrow angle work rate ranged from 19 to 29 ac/h (7.7 to 11.7 ha/ h) for the ground speeds used. At the 25° angle, the work rates ranged from 25 to 35 ac/h (10.1 to 15.4 ha/ h). For highest work rates, the Phoenix harrow should be operated at the least possible angle to obtain the desired results for soil disturbance and trash handling.

POWER REQUIREMENTS

Draft: Average draft for the Phoenix rotary harrow in a pre-

worked loam summerfallow field ranged from 2030 lb (9.0 kN) at a harrow angle of 25° and a ground speed of 4.5 mph (7.2 km/h) to 2890 lb (12.9 kN) at 45° and 7.5 mph (12.1 km/h).

Tractor Size: A tractor with a maximum power take-off rating of 100 hp (75 kW) will have sufficient power to operate the Phoenix rotary harrow model HT140 on level ground at 7.5 mph (12.1 km/h). This tractor size has been adjusted to include tractive efficiency.

OPERATOR SAFETY

Normal safety precautions are required while operating the Phoenix rotary harrow.

However, there was no transport lock for the centre rear section or a lock provided for the tines of the wing sections when raised in field position. There was no hitch safety chain or slow moving vehicle sign or bracket provided. Safety information was not included in the operator's manual. It is recommended that the manufacturer consider providing a transport lock for the centre rear tine section and a lock for the wing section tines when raised in field position. It is also recommended that the manufacturer consider supplying a hitch safety chain, a slow moving vehicle sign or a bracket, and safety information in the operator's manual.

OPERATOR'S MANUAL

The operator's manual was good.

It provided the essential information for servicing, adjustment, operation, and transport. No information was provided for safety. It is recommended that the manufacturer consider providing safety information in the operator's manual.

MECHANICAL HISTORY

The intent of this test was the evaluation of functional performance. Extended durability testing was not conducted. However, the following mechanical problems occurred during the test.

Hitch Link: The hitch link failed while operating in hilly conditions. The hitch pin fit too tightly to allow free vertical movement of the rotary harrow. It is recommended that the manufacturer consider modifying the hitch link to provide vertical movement.

Tines: Twenty harrow tines were straightened. The wrench supplied was also used for straightening the tines. The wrench worked well as the tines straightened easily.

APPENDIX I
SPECIFICATIONS

MAKE:	Phoenix rotary harrow	
MODEL:	HT140	
DISTRIBUTOR:	Phoenix Rotary Spike Harrows Ltd. Suite 900 10665 Jasper Avenue Edmonton, Alberta T5J 3S9 Phone: (403) 425-2633 FAX: (403) 421-8400	
DIMENSIONS:	**Field Position**	**Transport Position**
-- width		14.2 ft (4.3 m)
-at 250	51.1 ft (15.6 m)	
-at 450	41.1 ft (12.5 m)	
-- width of cut		
-at 250	47.3 ft (14.4 m)	
-at 450	36.7 ft (11.2 m)	
-- length (at 45°)	41.2 ft (12.6 m)	41.2 ft (12.6 m)
-- height	5.1 ft (1.6 m)	5.1 ft (1.6 m)
-- -minimum ground clearance	8 in (203 mm)	8 in (203 mm)
-- wheel tread (at 45°)	35.7 ft (10.9 m)	13 ft (4.0 m)
HARROWS:		
-- type	interlocking rotary tines	
-- number of sections	3	
-- rows of tines	8	
-- tine spacing	4.5 in (114 mm)	
-- outside diameter	19.5 in (495 mm)	
-- tine diameter	0.75 in (19 mm)	
HITCH:		
-- vertical adjustment range	12 in (305 mm)	
FRAME:		
-- main frame	5 in (127 mm) square tubing	
-- wing frame	4 in (102 mm) square tubing	
TIRES:	4, 7.50 - 16, 8-ply	
WEIGHTS: (in transport position)		
-- right wing wheel	1090 lb (494 kg)	
-- right centre wheel	1220 lb (553 kg)	
-- left centre wheel	1250 lb (567 kg)	
-- left wing wheel	1040 lb (472 kg)	
-- hitch	1410 lb (640 kg)	
TOTAL	6010 lb (2726 kg)	
SERVICING:		
-- grease fittings	12	
-- wheel bearings	4	
OPTIONAL EQUIPMENT:		
-- models and widths available		
-HT080	22/27 ft (6.7/8.2 m)	
-HT110	27/34 ft (8.2/10.2 m)	
-HT140	36/47 ft (11.0/14.3 m)	
-HT170	44/58 ft (13.6/17.7 m)	
-HT190	52/67 ft (15.8/20.4 m)	
-- other models available	3 point hitch models; rotary tine attachments for cultivators and seed drills; vertical folding wing models	

APPENDIX II
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent	Fair
Very Good	Poor
Good	Unsatisfactory

SUMMARY CHART
PHOENIX ROTARY HARROW

RETAIL PRICE	$13,500.00 [November, 1991, f.o.b. Humboldt, Saskatchewan, Model HT140, 36/47 ft (11/14 m) model]
QUALITY OF WORK	
Levelling	**Very Good;** usually level in stubble conditions
Chemical Incorporation	**Very Good;** suitable for shallow incorporation in summerfallow or stubble conditions
Straw Spreading	**Fair;** piles or wads of straw were fluffed up and only spread slightly
Trash Retention	**Very Good;** did not reduce trash on the field surface
Trash Clearance	**Very Good;** cleared large amounts of dry trash; some wrapping at three tine bearing locations
Stone Protection	**Good;** bent harrow tines were easily straightened
Weed Kill	**Good;** in loose previously tilled soil; reduced in firm soil
Skewing and Stability	**Good;** stable on level ground; the centre rear section lifted off the ground while working over knolls
EASE OF OPERATION AND ADJUSTMENT	
Transporting	**Fair;** placing into transport was time-consuming and difficult at times
Hitching	**Very Good;** hitch link rigid
Maneuverability	**Very Good;** sharp turns were done with the tines out of the ground
Adjustment	**Very Good;** wrench supplied
Servicing	**Very Good;** all grease fittings were accessible in field or transport position
RATE OF WORK	
Speed	5 to 7.5 mph (8 to 12 km/h)
Work Rate	19 to 35 ac/h (7.7 to 15.4 ha/h) depending on harrow angle and speed
POWER REQUIREMENTS	100 hp (75 kW) at 7.5 mph (12.1 km/h) on level ground; angle had little effect
OPERATOR SAFETY	Normal safety precautions; no transport lock for the centre rear tines or wing section tines in field position
OPERATOR'S MANUAL	**Good;** essential information provided; no safety information provided
MECHANICAL HISTORY	Hitch link failed in hilly conditions due to the tight hitch pin

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