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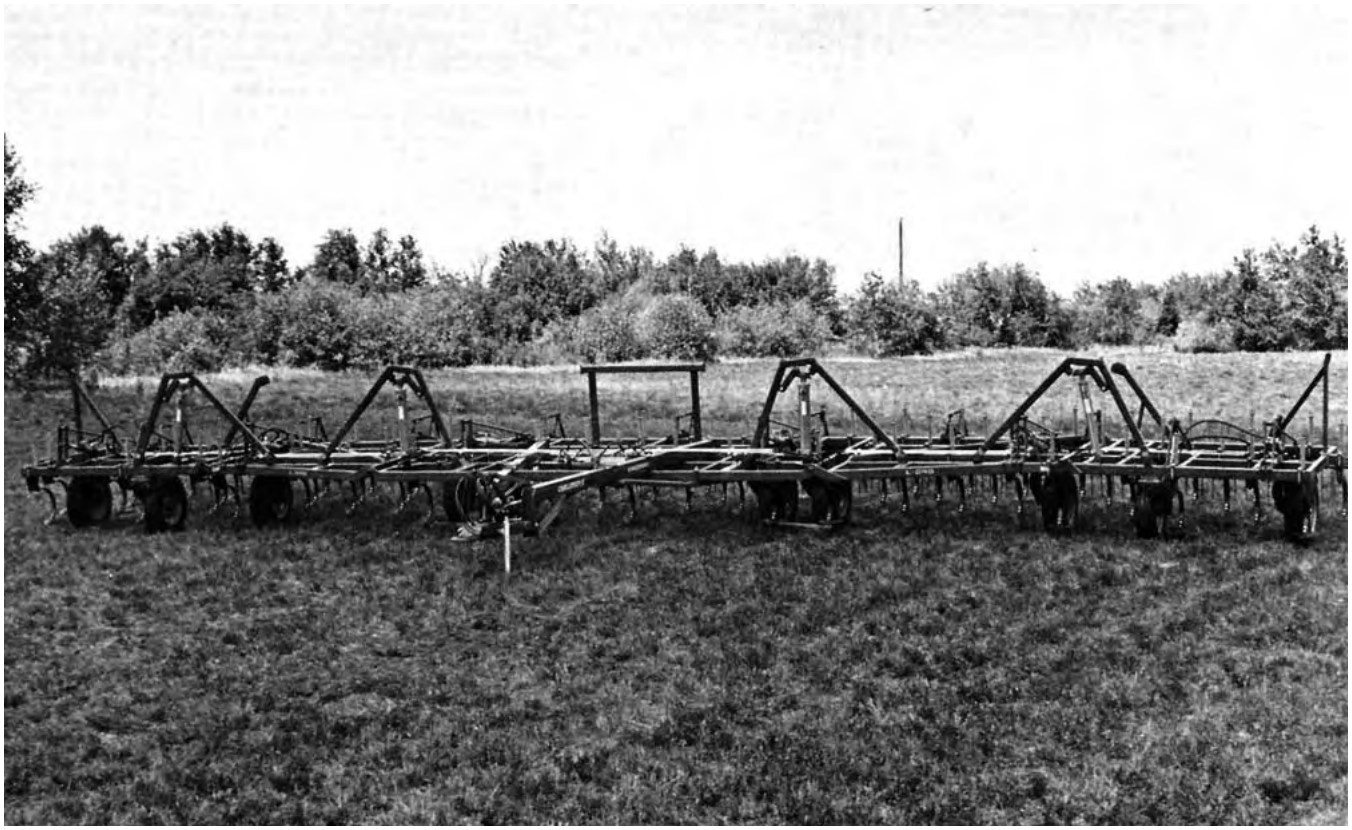

Morris L-249 (15.1 m) Field Cultivator

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

MORRIS L-249 FIELD CULTIVATOR

MANUFACTURER AND DISTRIBUTOR:

Morris Rod-Weeder Co. Ltd.
85 York Road
Yorkton, Saskatchewan
S3N 2X2

RETAIL PRICE:

$18,350.00 (December, 1981, f.o.b. Humboldt, 15.1 m width with optional mounted harrows).

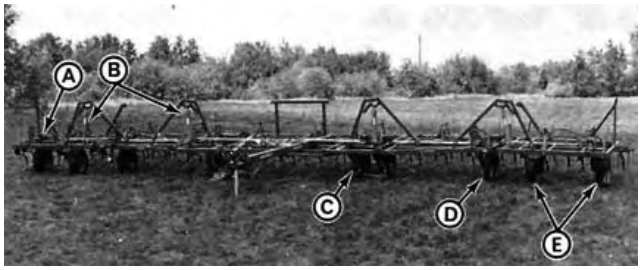

FIGURE 1. Morris L-249: (A) Depth Control Cylinders, (B) Wing Lift Cylinders, (C) Centre Wheels, (D) Primary Wing Wheels, (E) Secondary Wing Wheels.

SUMMARY AND CONCLUSIONS

Overall functional performance of the Morris L-249 was very good for seedbed preparation, and most herbicide incorporation, providing mounted finishing harrows were used. Its performance in second operation summerfallow was good with acceptable weed kill. Performance was reduced by uneven penetration in heavy secondary tillage. As with most light duty field cultivators the Morris L-249 was unsuitable for primary tillage and heavy trash conditions.

The spring trip shanks could lift 230 mm (9 in) to clear stones. As with most field cultivators, the shanks were quite flexible. When equipped with the recommended 47 degree sweeps, sweep pitch varied from 3 to 7 degrees over the normal secondary tillage draft range. With the 203 mm (8 in) spacing, the shanks began to trip at drafts greater than 6.3 kN/m (432 lb/ft). This occurred well above the secondary tillage draft range, indicating that the Morris L-249 shanks are well suited for secondary tillage operations.

Penetration was very good in most secondary tillage. In heavy secondary tillage, wing frame twisting caused the outer front sweeps to penetrate 50 mm (2 in) deeper than the outer rear sweeps. Wing frame twisting was greatly reduced when the manufacturer removed the inside secondary wing wheels and added stabilizer wheels to the front of the wing frames.

The Morris L-249 could clear moderately heavy trash, normally found in secondary tillage operations. The Morris L-249 buried less trash than most heavy duty cultivators. Skewing occurred only on hillsides or where soil hardness varied across the machine width. Weed kill was good in level, uniform fields. The mounted harrows were not sufficiently aggressive to break up lumps or to distribute heavy trash.

The Morris L-249 could be conveniently placed into transport position in less than five minutes. The 160 mm (6 in) sweep-to-ground clearance was adequate for normal transport. Because of its large transport width and height, transporting on public roads had to be done with extreme caution. The Morris L-249 was stable and towed well at normal transport speeds. The tires of the centre section were adequate to support the cultivator with mounted harrows, while transporting up to speeds of 32 km/h (20 mph). The 15.1 m (49.5 ft) wide test machine was 4 m (13.1 ft) high in transport, permitting safe transport under power lines in the three prairie provinces. A three section 11.3 m (37 ft) Morris field cultivator may be high enough to contact power lines.

The hitch jack and rigid hitch link made one man hitching easy. Adequate adjustment was provided for lateral levelling. Adequate fore-and-aft adjustment was obtained only after the manufacturer added stabilizer wheels to the front of the wing frames. The narrow hitch permitted normal turns.

Average draft for the 15.1 m (49.5 lt) wide test machine in light secondary tillage at 8 km/h (5 mph), varied from 12.1 kN (2720 lb) at 40 mm (1.5 in) depth to 32.2 kN (7464 lb) at 100 mm (4 in) depth. In heavy secondary tillage, at 8 km/h (5 mph), average draft varied from 19.6 to 43.8 kN (4406 to 9847 lb) over the same depth range.

In light secondary tillage, at 10 km/h (6.2 mph) and 75 mm (3 in) depth, a tractor with 129 kW (168 hp) maximum power take-off rating will have sufficient power reserve to operate the 15.1 m (49.5 ft) wide Morris L-249. In heavy secondary tillage at the same depth and speed, a 178 kW (231 hp) tractor is needed.

The Morris L-249 was equipped with depth control transport locks. No wing transport locks were required as the secondary wings rested firmly on the centre frame. A slow moving vehicle sign was not provided. A mounting bracket for the sign was located at the rear of the cultivator. The operator's manual was well written and clearly illustrated.

A few mechanical problems occurred during the 125 hours of field operation, none of which seriously affected cultivator performance. One shank broke, one shank bent and ten sweeps broke.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing stabilizer Wheels to improve penetration uniformity of the wing sections.
2. Modifying the mounted harrows to provide more aggressive action.
3. Protecting the sweep bolts from soil abrasion to allow easy removal.
4. Supplying a slow moving vehicle sign.
5. Working with the agricultural equipment industry to standardize hydraulic quick couplers and hydraulic hose fitting threads.
6. Working with the agricultural equipment industry to standardize shank and sweep stem angles and sweep fastener spacings and sizes.

Senior Engineer- G. E. Frehlich

Project Technologist- A. R. Boyden

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Stabilizer wheels will be offered as standard equipment for 1982 production Challengers, and as a kit for machines sold before 1982 that have problems with uneven penetration.
2. We will modify the carrier arm mounting brackets for the fall 1982 production of harrows to provide more aggressive action.
3. We have not had a great amount of customer complaints regarding protection for sweep bolts on the Challenger. No immediate changes are planned, but we will monitor the situation and make changes if required.
4. Our company presently supplies all our machines with a mounting bracket for a slow moving vehicle sign. We leave it up to the dealers to supply a sign to the farmer if requested. The sign will be provided as standard equipment if it becomes mandatory that farm machine companies must supply a slow moving vehicle sign with all equipment sold.
5. Our company agrees that standardization of hydraulic couplers and hose fitting threads would be helpful. The problem is to get the tractor manufacturers and equipment manufacturers to agree on one standard. We recommend the I.S.O. (International Standard Organization) standard, but presently use Pioneer couplers as we believe they are the most commonly used couplers.
6. We agree that standardization of shank and sweep stem angles and sweep fastener spacings and size would be beneficial. The problem again, is for all the farm machine companies to agree upon one standard. We recommend the
7. I.S.O. standard.

NOTE: This report has been prepared using SI units of measurement. A conversion table is given in APPENDIX III.

GENERAL DESCRIPTION

The Morris L-249 is a trailing, flexible, five section field cultivator suitable for light tillage such as seedbed preparation, herbicide incorporation and secondary summerfallow. Other models are available in widths ranging from 5.5 to 15.1 m (18 to 49 ft) with shank spacings of 203 mm (8 in) or 150 mm (6 in). The test machine was 15.1 m (49.5 ft) wide with a 5 m (16.4 ft) centre section, two 2.4 m (7.9 ft) primary wings, and two 2.4 (7.9 ft) secondary wings. It was equipped with 74 spring-trip shanks, laterally spaced at 203 mm (8 in) and arranged in four rows.

The frame is supported by ten wheels, two on each secondary wing, one on each primary wing, and two sets of dual wheels on the centre frame. A hydraulic flow divider, and two parallel sets of four hydraulic cylinders connected in series, control tillage depth. The wings fold into transport position with four hydraulic cylinders connected in parallel. A tractor with dual remote hydraulic controls is needed to operate the Morris L-249.

Detailed specifications are given in APPENDIX I and FIGURE 1 shows the location of major components.

SCOPE OF TEST

The Morris L-249 was operated in the field conditions shown in TABLE 1, for 125 hours, while cultivating about 1458 ha (3600 ac). It was evaluated for quality of work, ease of operation and adjustment, power requirements, safety and suitability of the operator's manual. Optional attached finishing harrows were used during the test.

TABLE 1. Operating Conditions.

FIELD CONDITIONS	HOURS	FIELD AREA (ha)
Soil Type		
- loam	82	982
- clay	12	145
- heavy clay	31	331
TOTAL	125	1458
Stony Phase		
- stone free	28	306
- occasional stones	35	406
- moderately stony	41	496
- very stony	21	248
TOTAL	125	1458

RESULTS AND DISCUSSION

QUALITY OF WORK

Shank Characteristics: There is a large variation in shank and sweep stem angles (FIGURE 2) on cultivators from different manufacturers. Sweeps and shanks must be matched to obtain sufficient sweep pitch to achieve and maintain penetration. Usually manufacturers recommend sweeps with a stem angle from 0 to 5 degrees less than the shank stem angle, to result in a slightly positive no-load sweep pitch.

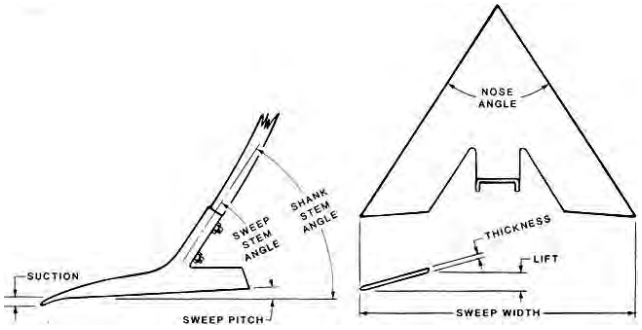

FIGURE 2. Shank and Sweep Terminology.

Sweep pitch increases in proportion to draft due to shank flexing and, depending on shank stiffness and trip-spring preload, may become excessive on some cultivators in normal tillage. A slightly positive sweep pitch results in uniform tillage depth and a smooth furrow bottom while excessive sweep pitch causes furrow bottom ridging, rapid sweep tip wear, and increased draft. Shanks which maintain a low, relatively constant sweep pitch, over the normal range. of tillage forces, are desirable.

The Morris L-249 was equipped with spring trip shank holders. Spring tension was adjustable. The Morris L-249 was used with 280 mm (11 in) McKay sweeps with a 47 degree stem angle, giving a no-load sweep pitch of 3 degrees.

FIGURE 3 shows pitch characteristics of the shank assemblies on the Morris L-249. The increase in pitch as draft increased resulted from shank flexing. Sweep pitch varied 4 degrees over the normal secondary tillage draft range at the manufacturer's recommended setting. When equipped with 47 degree sweeps, sweep pitch varied from 3 to 7 degrees over this draft range. Shank tripping occurred at a draft of 6.3 kN/m (432 lb/ft) and shank force decreased as tripping continued. Tripping occurred well above the secondary tillage draft range indicating that the Morris L-249 shank assemblies are well suited for secondary tillage.

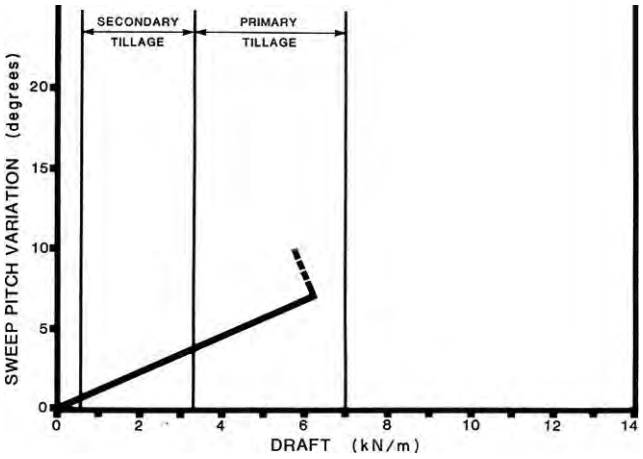

FIGURE 3. Sweep Pitch Variation over a Normal Range of Draft (203 mm Shank Spacing).

FIGURE 4 shows the lifting pattern when shanks encounter stones or field obstructions. Maximum lift height was 230 mm (9 in). One shank bent and ten sweeps broke during the 125 hour test period. The trip mechanisms gave good shank and sweep protection and these failures do not represent a serious problem.

Penetration: Penetration was very good in most secondary tillage. Penetration was slightly reduced in hard soil. As with most field cultivators, the Morris L-249 was not intended for primary tillage.

In light secondary tillage, penetration was uniform across the cultivator width. Penetration uniformity was greatly reduced in heavy secondary tillage as excessive wing frame twisting caused the outer front sweeps to penetrate 50 mm (2 in) deeper than the outer rear sweeps. Wing frame twisting was reduced and fore-and-aft penetration of the wing sections greatly improved after the manufacturer removed the inside secondary wing wheels and added stabilizer wheels to the front of the secondary wing frames (FIGURES 5 and 6).

The Morris L-249 followed gently rolling field contours well, maintaining uniform depth across its width. As with most wing cultivators, large variations in tillage depth occurred in fields with abrupt contour changes.

Plugging: The 203 mm (8 in) lateral shank spacing and 605 mm (24 in) sweep to frame clearance was suitable for moderate trash conditions normally found in secondary tillage operations. Plugging occurred occasionally at wheel locations in moderate trash and in most areas of the cultivator in heavy trash conditions.
The mounted finishing harrows could clear large amounts of trash.

Trash Burial and Field Surface: As with most field cultivators, the Morris L-249 buried less trash than most heavy duty cultivators. The mounted harrows effectively levelled slight ridges left by the cultivator, to produce a uniform seedbed (FIGURE 7). The harrow arm springs did not provide sufficient harrow pressure to effectively break up lumps or distribute large amounts of trash. It is recommended that the manufacturer modify the springs to provide more aggressive harrow action.

Furrow Bottom Ridging: The spring-trip shanks of the Morris L-249 held the sweeps very level in most secondary tillage. Furrow bottom ridging of 25 mm (1 in) occurred in hard soils due to increased sweep pitch.

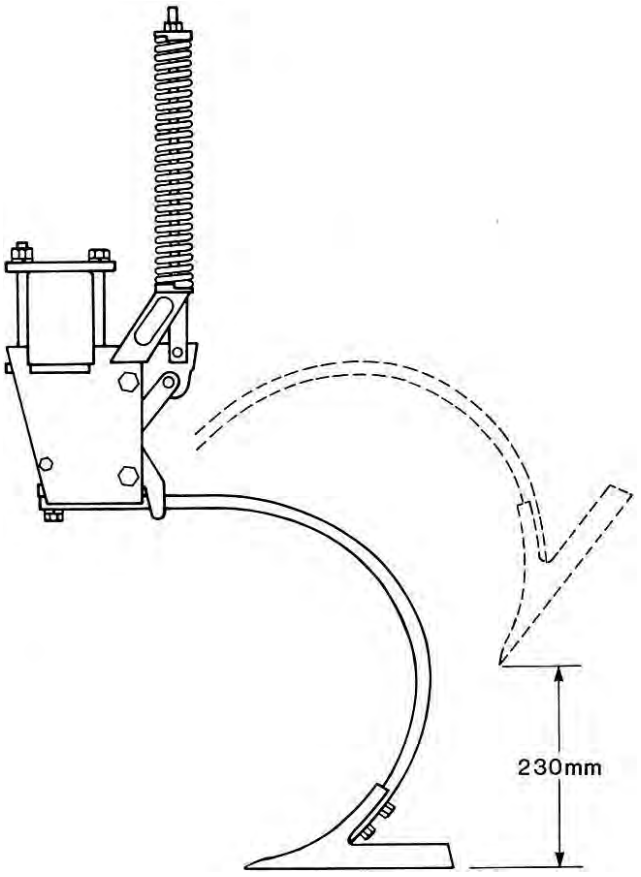

FIGURE 4. Shank Lifting Pattern.

FIGURE 5. Secondary Wing Wheel Positions Before Modifications.

Skewing and Stability: The Morris L-249 was stable and did not skew sideways in normal field conditions. The sweep pattern (FIGURE 8) was symmetrical and did not impose any side forces on the cultivator during normal tillage. As with most field cultivators, skewing occurred only on hillsides or where soil hardness varied across the machine width. With the 280 mm (11 in) sweeps, the cultivator had to skew more than 2.4 degrees for weed misses to occur.

Weed Kill: Weed kill was good, with the 280 mm (11 in) sweeps and 203 mm (8 in) shank spacing. Sweeps were positioned behind each wheel to uproot weeds in the tracks. The finishing harrows were effective in exposing weeds in light trash and non-lumpy conditions. The harrows were not sufficiently aggressive in breaking lumps and distributing heavy trash.

EASE QF OPERATION AND ADJUSTMENT

Transporting: The Morris L-249 was easily placed into transport position (FIGURE 9) by one person in less than five minutes. Transport locks were provided for the depth control wheels. Danger areas should be avoided when climbing on the machine to install these locks. Transport locks were not provided for the wings since the secondary wings folded to rest firmly on the cultivator centre section. Spacers on the harrow arms were positioned to raise the harrows for adequate transport clearance.

Transport width of the test machine was 7 m (23 ft) while the transport height was 4 m (13.1 ft). Care was needed when transporting on public roads, through gates, over bridges and beneath power and telephone lines.

The Morris L-249 towed well without sway at normal transport speeds. Sweep-to-ground clearance of 160 mm (6 in) and a wheel tread of 3.7 m (12.1 ft) usually provided adequate ground clearance.

Hitching: The hitch jack and rigid hitch link made one-man hitching easy. Hitch weight was positive in transport and field position with mounted harrows.

Hitch height could be easily adjusted over a 585 mm (23 in) range using the ratchet assembly (FIGURE 10). Adjustment was adequate to allow fore-and-aft frame levelling with all tractors used during testing.

FIGURE 6. Stabilizer Wheel Location.

FIGURE 7. Typical Seedbed Preparation.

Maneuverability: The hitch frame of the Morris L-249 was narrow, permitting normal turns without tractor wheel interference. The centre section dual wheels did not skid sideways in normal turns. There was a sufficient number of sweeps beyond the secondary wing wheels to allow moderate overlap without running a wheel on cultivated ground. Running all wheels on similar untilled soil maintains proper flotation and aids in uniform tillage depth.

Frame Levelling: Adequate lateral levelling adjustment was provided for the depth control wheels of the centre and wing sections. The threaded cylinder anchor rods could be adjusted at the rear of the cultivator to raise or lower the wheels.

The secondary wings could not be adequately levelled fore-and-aft until the manufacturer removed the inside secondary wing wheels and added stabilizer wheels to the front of the wing frames. These stabilizer wheels were easily adjusted for adequate fore-and-aft levelling. However, when the cultivator was raised out of the ground, the stabilizer wheels castored forward 180 degrees. The wheels would suddenly castor back to the original position when lowering the cultivator.

Tillage Depth: Tillage depth was controlled by a hydraulic flow divider and two parallel sets of four hydraulic cylinders connected in

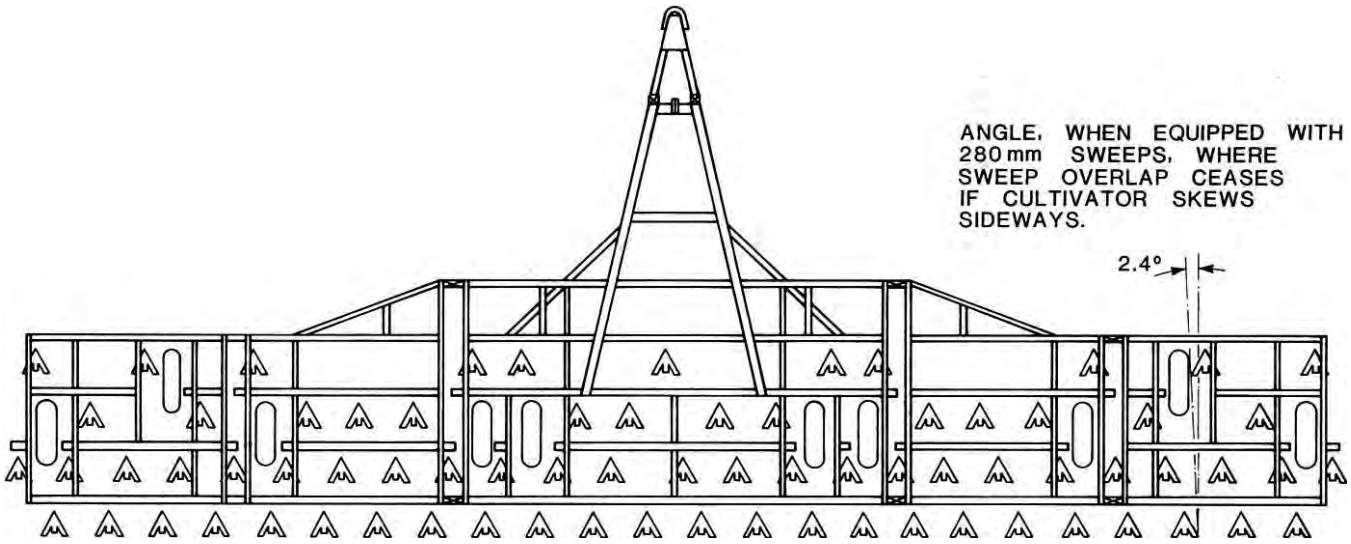

FIGURE 8. Sweep Pattern (203 mm Shank Spacing).

series. A hydraulic stop valve on the flow divider could be adjusted to set tillage depth. As is common with series hydraulic systems, to maintain the centre and wing sections at the same depth, periodic synchronization of the cylinders, by completely extending them to a fully raised position, was necessary.

Sweep Installation: It took one person about four and one-half hours to replace the 74 sweeps on the Morris L-249. The sweep bolts protruded beyond their nuts causing thread damage by soil abrasion, making bolt removal difficult. It is recommended that the sweep bolts be protected from abrasion to allow easy removal.

Shank Installation: A shank could be easily replaced in less than ten minutes by removing one bolt.

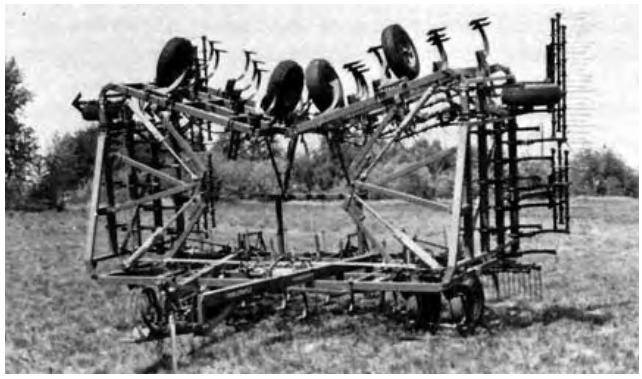

FIGURE 9. Transport Position.

FIGURE 10. Hitch Height Adjustment.

POWER REQUIREMENTS

Draft Characteristics: FIGURE 11 shows draft requirements for field cultivators in typical secondary tillage, at a speed of 8 km/h (5 mph). This figure gives average requirements based on tests of seven makes of field cultivators in three seasons and 14 different field conditions. Attempting to compare draft requirements of different makes of field cultivators usually is unrealistic. Draft requirements for the same cultivator, in the same field, may vary by as much as 30% in two different years, due to changes in soil conditions. Variation in soil conditions affect draft much more than variation in machine make, usually making it impossible to measure any significant draft differences between different makes of field cultivators.

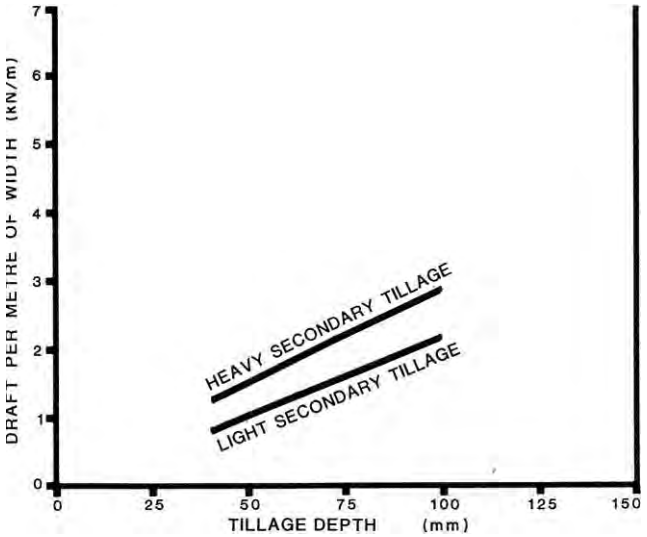

FIGURE 11. Average Draft Requirements for Field Cultivators at 8 km/h.

In light secondary tillage, such as herbicide incorporation or seedbed preparation, average draft per metre of width, at 8 km/h (5 mph), varied from 0.8 kN/m (55 lb/ft) at 40 mm (1.5 in) depth to 2.2 kN/m (151 lb/ft) at 100 mm (4 in) depth. For the 15.1 m (49.5 ft) wide test machine, this corresponds to a total draft ranging from about 12.1 to 33.2 kN (2720 to 7464 lb).

In heavy secondary tillage, such as firm summerfallow, average draft per metre of width, at 8 km/h (5 mph), varied from 1.3 kN/m (89 lb/ft) at 40 mm (1.5 in) depth to 2.9 kN/m (199 lb/ft) at 100 mm (4 in) depth, corresponding to a total variation from about 19.6 to 43.8 kN (4406 to 9847 lb) for the 15.1 m (49.5 ft) test machine.

Increasing speed by 1 km/h (0.6 mph) increased draft by 90 N/m (6 lb/ft). For the 15.1 m (49.5 ft) wide test machine, this represents a draft increase of about 1.4 kN (315 lb) for a 1 km/h (0.6 mph) speed increase.

Tractor Size: TABLES 2 and 3 show tractor sizes needed to operate the 15.1 m (49.5 ft) wide Morris L-249 in light and heavy secondary tillage. Tractor sizes have been adjusted to include tractive efficiency in loose soils and represent a tractor operating at 80% of maximum power on a level field. The sizes presented in the tables are the maximum power take-off rating, as determined by Nebraska tests or as presented by the tractor manufacturer.

Selected tractor sizes will have ample power reserve to operate the Morris L-249 in the stated conditions.

Tractor size may be determined by selecting the desired tillage depth and speed from the appropriate table. For example, in light secondary tillage at 75 m (3 in) depth and 10 km/h (6 mph), a 129 kW (168 hp) tractor is needed to operate the Morris L-249. In heavy secondary tillage at the same depth and speed, a 178 kW (231 hp) tractor is needed.

TABLE 2. Tractor Size (Maximum Power Take-off Rating, kW) to Operate the 15.1 m Wide Morris L-249 in Light Secondary Tillage.

DEPTH (mm)	SPEED (km/h)					
	7	8	9	10	11	12
40	37	47	58	71	84	99
50	49	61	73	87	102	119
75	78	94	111	129	148	169
100	107	127	148	171	194	219

TABLE 3. Tractor Size (Maximum Power Take-off Rating, kW) to Operate the 15.1 m Wide Morris L-249 in Heavy Secondary Tillage.

DEPTH (mm)	SPEED (km/h)					
	7	8	9	10	11	12
40	63	78	93	110	129	148
50	77	93	111	130	150	172
75	110	131	154	178	203	229
100	144	170	197	226	255	287

OPERATOR SAFETY

Extreme caution is needed in transporting most folding cultivators to avoid contacting power lines. Minimum power line heights vary in the three prairie provinces. In Saskatchewan, the energized line may be as low as 5.2 m (17 ft) over farm land or over secondary roads. In Alberta and Manitoba, the neutral ground wire may be as low as 4.8 m (16 ft) over farm land. In all three provinces, lines in farmyards may be as low as 4.6 m (15 ft).

Transport height of the 15.1 m (49.5 ft) wide five section test machine was 4 m (13.1 ft) permitting safe transport under prairie power lines. An 11.3 m (37 ft) three section Morris field cultivator may be high enough to contact some prairie power lines. The legal responsibility for safe passage under utility lines rests with the machinery operator and not with the power utility or machinery manufacturer. All provinces have regulations governing maximum permissible equipment heights on various types of public roads. If height limits are exceeded, the operator must contact power and telephone utilities before moving.

The test machine was 7 m (23 ft) wide in transport position, necessitating caution when transporting. A slow moving vehicle sign was not supplied, although a mounting bracket for a sign was provided. It is recommended that a slow moving vehicle sign be supplied as standard equipment.

Locks for the depth control were provided for safe transport. Danger areas should be avoided when climbing on the machine to install these locks. No wing transport locks were required as the secondary wings rested firmly on the centre frame.

The rigid hitch link allowed safe hitching by one person.

The four tires supporting the main frame were adequately sized for transporting the cultivator, with mounted harrows, at speeds up to 32 km/h (20 mph).

STANDARDIZATION

Hydraulics: During the test, considerable difficulty was encountered due to differences in hydraulic couplers on various tractors. The difficulty was in the lack of standardization both in couplers and in hose threads. More standardization is needed in this area.

Sweep Bolt Holes: The bolt hole size and Spacing on cultivator sweeps and shanks, as well as stem angles, should similarly be standardized to provide some degree of interchangeability of sweeps.

OPERATOR'S MANUAL

The operator's manual supplied instructions on set-up, operation, maintenance, and safety. It was well written and clearly illustrated.

DURABILITY RESULTS

TABLE 4 outlines the mechanical history of the Morris L-249 during 125 hours of field operation while tilling about 1458 ha (3600 ac). The intent of the test was evaluation of functional performance. The following mechanical problems represent those which occurred during functional testing. An extended durability evaluation was not conducted.

TABLE 4. Mechanical History

ITEM	OPERATING HOURS	EQUIVALENT FIELD AREA (ha)
Shank and Holder:		
- All of the trip mounting bolts were tightened at	40	470
- Several of the trips were adjusted to reduce free movement at	67	737
- A shank bent when tripping over a rock and was replaced at	40	470
- A shank broke when tripping over a rock and was replaced at	67	737
- Ten sweeps broke when tripping over rocks and were replaced at	67, 75, 83	737, 840, 930
Wheels:		
-A flat tire occurred while transporting at	32	390
-Secondary wing wheels were removed and stabilizer wheels added by the manufacturer at	69	775

DISCUSSION OF MECHANICAL PROBLEMS

SHANK AND HOLDER

Mounting Bolts: All of the trips came loose on the frame. The mounting bolts were tightened and did not loosen during the remainder of the test.

Trip Adjustments: The side to side free movement of the shanks was reduced by tightening the side plates on the trips. Rearward free movement was caused by pin connection wear and could not be eliminated.

Shanks: One shank bent and one shank broke while working in very stony conditions. The break occurred at the mounting bolt hole and was attributed to faulty material.

Sweeps: Ten sweeps broke in very rocky conditions. Since the sweeps were severely worn, these failures do not represent a serious problem.

WHEELS

Flat Tire: A flat tire occurred on the centre section while transporting on a narrow road. The tires were not overloaded.

APPENDIX I

SPECIFICATIONS
MAKE: Morris Field Cultivator
MODEL: L-249
SERIAL NUMBER: 452
MANUFACTURER: Morris Rod-Weeder Co. Ltd.
85 York Road
Yorkton, Saskatchewan S3N 2X2

	FIELD POSITION	TRANSPORT POSITION
DIMENSIONS:		
-- width	15,130 mm	6970 mm
-- length - with mounted harrows	7150 mm	7150 mm
-- height - with mounted harrows	1935 mm	4000 mm
-- maximum ground clearance	160 mm	160 mm
-- wheel tread	14,211 mm	3720 mm

SHANKS:	
-- number	74
-lateral spacing	203 mm
-- trash clearance (frame to sweep tip)	605 mm
-- number of shank rows	
-centre section	4
-wings	4
-- distance between rows	610 mm
-- shank cross section	15.5 x 45 mm
-- shank stem angle	50°
-- sweep hole spacing	40 mm
-- sweep bolt size	3/8 x 1-1/2 in
HITCH: vertical adjustment range	585 mm
DEPTH CONTROL:	hydraulic
FRAME:	
-- cross section	78 x 103 mm rectangular tubing, 6 and 5 mm thick
TIRES:	
-- centre section	4, 9.5L x 15, 8 ply
-- primary wings	2, 9.5L x 15, 6 ply
-- secondary wings	2, 9.5L x 15, 6 ply
	2, 7.6L x 15, 4 ply
NUMBER OF LUBRICATION POINTS:	168 grease fittings 10 wheel bearings
HYDRAULIC CYLINDERS:	
-- depth control	2, 90 x 203 mm
	2, 76 x 203 mm
	2, 64 x 203 mm
	2, 51 x 203 mm
-- wing lift	2, 102 x 610 mm
	2, 76 x 610 mm

WEIGHTS: (Without Harrows)	FIELD POSITION	TRANSPORT POSITION
-- right secondary wing wheels	415 kg	
-- right primary wing wheel	580 kg	
-- right centre wheels	945 kg	1875 kg
-- left centre wheels	955 kg	189"5 kg
-- left primary wing wheel	610 kg	
-- left secondary wing wheel	390 kg	
-- hitch	230 kg	355 kg
TOTAL	4125 kg	4125 kg

WEIGHTS: (With Mounted Harrows)	FIELD POSITION	TRANSPORT POSITION
-- right secondary wing wheels	465 kg	
-- right primary wing wheel	690 kg	
-- right centre wheels	1155 kg	2265 kg
-- left centre wheels	1155 kg	2280 kg
-- left primary wing wheels	705 kg	
-- left secondary wing wheels	475 kg	
-- hitch	85 kg	185 kg
TOTAL	4730 kg	4730 kg

OPTIONAL EQUIPMENT:
-- mounted finishing harrows
-- 150 mm (6 in) shank spacing
-- seven width options from 5.5 to 15.1 m

APPENDIX II

MACHINE RATINGS
The following rating scale is used in Machinery Institute Evaluation Reports:

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

APPENDIX III

CONVERSION TABLE

1 hectare (ha)	= 2.5 acre (ac)
1 kilometre/hour (km/h)	= 0.6 miles/hour (mph)
1 millimetre (mm)	= 0.04 inches (in)
1 metre (m)	= 3.3 feet (ft)
1 kilowatt (kW)	= 1.3 horsepower (hp)
1 kilogram (kg)	= 2.2 pounds mass (lb)
1 kilonewton (kN)	= 220 pounds force (lb)
1 kilonewton/metre (kN/m)	= 70 pounds force/foot (lb/ft)

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