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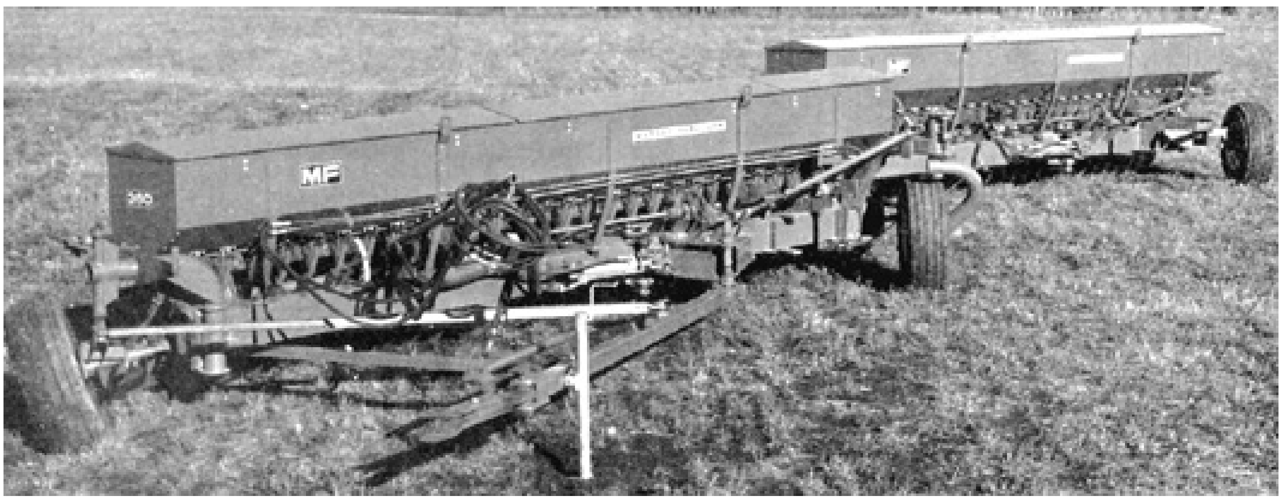

Massey Ferguson 360 Wide Level Disk Harrow

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

MASSEY FERGUSON
360 WIDE LEVEL DISK HARROWS

MANUFACTURER:
Massey Ferguson Industries Limited
915 King Street West
Toronto, Canada
M6K 1E3

DISTRIBUTOR:
Massey Ferguson Industries Limited
2330 - 34 South Railway Street
Regina, Saskatchewan
S4P 0B6

RETAIL PRICE:
$16,760.00 (December, 1980, f.o.b. Humboldt. Two, 4.6 m wide piggyback hitched units with rear furrow wheel weights, disk scraper attachment, rapeseed kit and hydraulic extension tubes.)

SUMMARY AND CONCLUSIONS

Overall functional performance of the Massey Ferguson 360 wide level disk harrow was *good.* Penetration was *very good* when seeding into summerfatlow or moist stubble and *fair* when seeding into dry compacted stubble. Ability to cut through surface trash was *good* in firm soils and *fair* in soft soils. Heay surface trash prevented proper penetration in all fields and lead to plugging in soft, moist fields.

Seed placement and seed coverage were *good.* In stony fields, rocks occasionally lodged between disks. The disk gangs rode freely over buried rocks and obstructions with little damage. The optional disk scrapers reduced the amount of soil clinging to the disks but did not prevent plugging in wet clay soils. Stability was *good* except when operating on steep hills. Stability was slightly affected by changes in ground speed, soil hardness and tillage depth.

The accuracy of the seed metering system was *very good* in barley, wheat and oats and *fair* in rapeseed. The seeding rate for rapeseed varied considerably with changes in seed properties and seed treatments. The variation in seeding rates among seed runs was very low in wheat, oats and barley, but was quite high in rapeseed. Seeding rates were not affected by field roughness, field slope, ground speed or depth of grain in the seed box.

Overall performance of the fertilizer attachment was *fair.* Variation of the application rates among runs was acceptable and the application rate was not affected by field roughness, ground speed or level of fertilizer in the fertilizer box. Application rate was significantly affected by field slope and increased 190% when seeding down a 15° slope.

Both the seed and fertilizer rates were difficult to adjust. The seed and fertilizer boxes were convenient to refill and clean, but moisture entered the boxes in heavy rains. Daily lubrication took from 20 to 25 minutes. All lubrication points were readily accessible.

The Massey Ferguson 360 could be placed into full transport position in fifteen minutes and into semi-transport position in five minutes. Overall width in full transport position was suitable for safe transport on all secondary roads whereas the overall width in semi-transport position was much wider, making passing difficult on most secondary roads. The MF 360 towed well at speeds up to 32 km/hr (20 mph). The MF 360 should not be transported at road speeds with full grain and fertilizer boxes, as the rear and centre furrow wheel loads exceeded the Tire and Rim Association's maximum ratings by 72% and 114% respectively. No tire overload occurred when transporting with empty boxes.

Average draft for the 9.2 m (30 ft) wide test machine, in primary tillage, at 8 km/h (5 mph), varied from 20.2 kN (4450 lb) at 50 mm (2 in) depth to 32.2 kN (7100 lb) at 90 mm (3.5 in) depth.

In primary tillage, at 8.0 km/h (5 mph) and 75 mm (3 in) depth, a tractor with 97 kW (130 hp) maximum power take-off rating will have sufficient power reserve to operate the 9.2 m (30 ft) wide Massey Ferguson 360.

The operator's manual was complete, well written and well illustrated. The Massey Ferguson 360 was safe to operate if normal safety procedures were followed.

No serious mechanical problems occurred during functional testing.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifying the seed cup inserts to reduce the large variations in the seeding rates obtained when seeding rapeseed with different physical properties.
2. Including in the operator's manual, information on the use and installation of the seed cup inserts and the stow speed grain drive attachment.

Chief Engineer - E.O. Nyborg
Senior Engineer - J.D. MacAulay
Project Engineer - G.E. Frehlich

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. We will investigate the seed rate variations in rapeseed and will re-calibrate and revise the rate charts where required.
2. The additional information will be included in the next printing of the operator's manual.

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

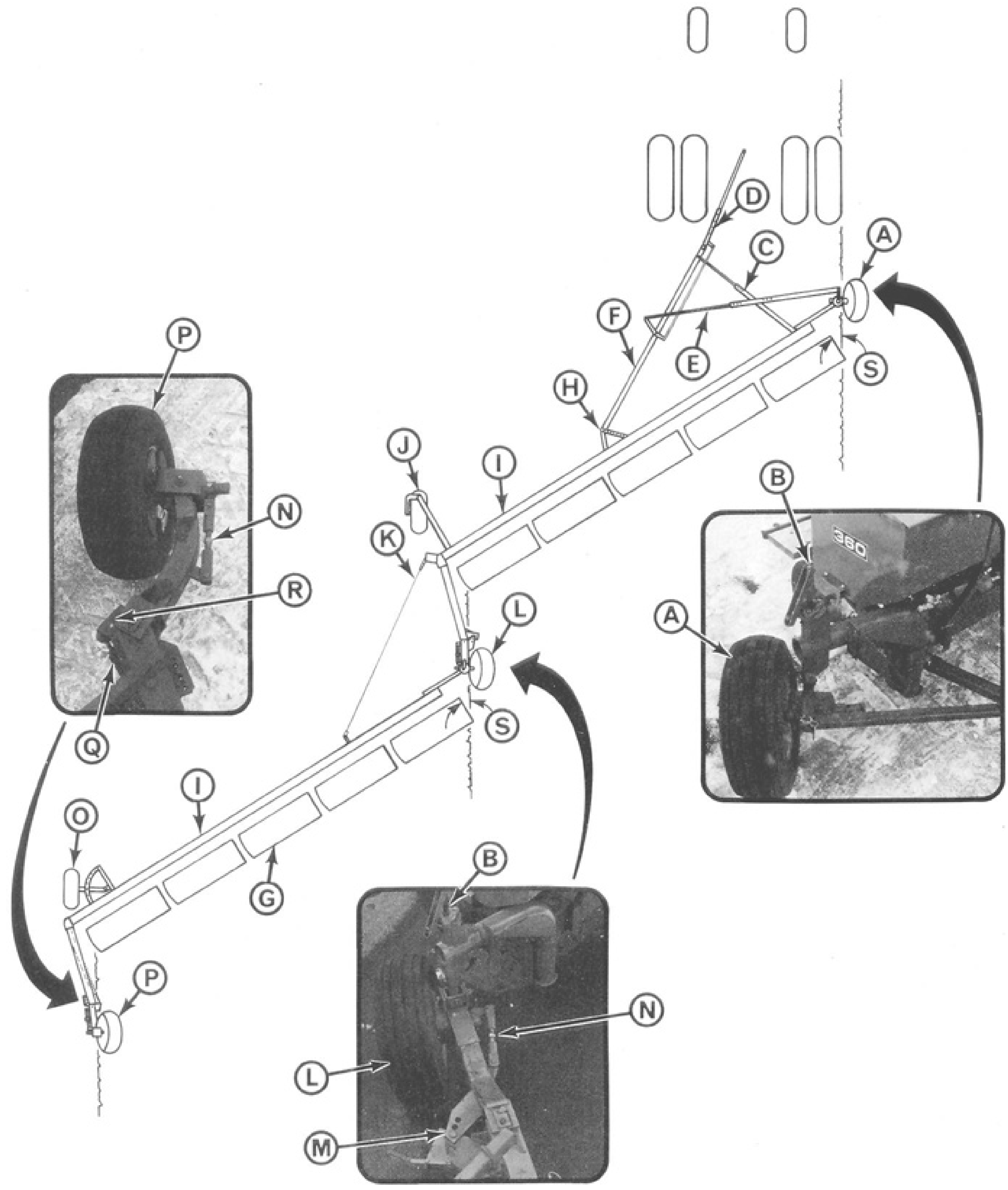

FIGURE 1. Massey Ferguson 360: (A) Front Furrow Wheel, (B) Frame Levelling Screws, (C) Hitch Brace, (D) Front Hitch, (E) Steering Link, (F) Main Hitch, (G) Disk Gangs, (H) Vertical Hitch Post, (I) Main Frame, (J) Castering Land Wheel, (D) Hitch Cable, (L) Centre Furrow Wheel, (M) Wheel Lock and Width of Cut Adjustment, (N) Lead Adjustment Turnbuckle, (O) Arcuate Land Wheel, (P) Rear Furrow Wheel, (Q) Rear Furrow Wheel Control Spring, (R) Width of Cut Adjustment, (S) Disk Angle.

GENERAL DISCRIPTION

The Massey Ferguson 360 is a 9.2 m (30 ft) wide one-way disk harrow consisting of two 4.6 m (15 ft) sections hitched in piggyback configuration. Each section has five independent disk gangs, each containing six 508 mm (20 in) diameter disks spaced at 178 mm (7 in). Disk penetration is controlled with a hydraulic cylinder on each section and compression springs on each gang. Width of cut is adjustable from 8.2 to 9.5 m (27 to 31 ft).

The Massey Ferguson 360 is equipped with seeding and fertilizing attachments as standard equipment. The two grain boxes have a total capacity of 1790 L (50 bu) while the fertilizer boxes hold about 1120 kg (2480 lb) of granular fertilizer. Seed is metered by internally fluted, double run feed cups and fertilizer is metered by flexible wire augers on a circular feed shaft. Seed and fertilizer are delivered through common drop tubes to seed boots adjacent to each disk.

The test machine was equipped with optional disk scrapers, rear furrow wheel weights, seed cup inserts for rapeseed, and hydraulic extension tubes.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Massey Ferguson 360 was operated in the conditions shown in TABLE 1 for 95 hours while tilling 500 ha (1250 ac). It was evaluated for quality of work, ease of operation, ease of adjustment, power requirements, operator safety and suitability of the operator's manual. Of the total operating time, 33 hours were spent in seeding. In addition, the seed and fertilizer systems were calibrated in the laboratory. Packers were not used during the seeding trials.

TABLE 1. Operating Conditions

FIELD CONDITIONS	HOURS	FIELD AREA (ha)
Soil Type		
- silty loam	41	168
- fine sandy loam	6	26
- loam	25	164
- clay	23	142
TOTAL	95	500
Stoney Phase		
- stone free	75	360
- moderately stony	15	108
- very stony	5	32
TOTAL	95	500

RESULTS AND DISCUSSION

QUALITY OF WORK

Penetration: Penetration was very good when seeding into summerfallow or into moist stubble and was fair when seeding into dry compacted stubble. Both the grain and fertilizer boxes had to be full to provide adequate penetration in hard dry soils. The optional rear furrow wheel weights were needed in most conditions. In addition, in hard dry soil, filling all tires with calcium chloride solution improved penetration.

The disks effectively cut through moderate amounts of surface trash when tilling firm soils. In soft soils, trash was turned without being cut. In very heavy trash, disk penetration was non-uniform regardless of the soil conditions. Penetration in trashy fields was improved by sharpening the disks and by increasing the disk angle.

As is characteristic of most large disk harrows, penetration was uneven in rough, undulating fields. The long frame and triangular wheel configuration caused irregular penetration at the bottom of steep ravines or gullies. To improve penetration in rough, undulating fields, the depth setting of each disk harrow had to be individually controlled hydraulically from the tractor.

Penetration and seeding depth were controlled by one hydraulic cylinder for each disk harrow and by compression springs on each disk gang (FIGURE 2). When the disk harrows were properly adjusted, adequate penetration was obtained when the spring force adjustment nuts were set so as to slightly clear the swivels. Operating with too much clearance between the nuts and swivels caused uneven penetration in fields of varying soil hardness as the disk gangs penetrated too deeply in the soft or loose areas of the field.

The vertical force needed to lift a disk gang out of the soil could be adjusted from 100 to 2400 N (22 to 480 lb). Adjusting the springs to provide a lift force from 1400 to 1500 N (280 to 300 lb) was adequate for most field conditions.

Seed Placement: Seed placement was good in most field conditions. At speeds up to 8 km/h (5 mph), seeds were placed near the bottom of each furrow and uniformly covered with soil. Higher speeds caused some seed scattering. In very trashy fields, seeds were placed amidst the trash if the disks failed to cut through it. If the trash was cut by the disks, the seeds were placed on the soil at the furrow bottom, and covered by a loose mixture of soil and trash. As is characteristic of all disk harrows, soil was not compacted firmly about the seeds. It is important that packers be used after seeding, especially in dry, loose or trashy soils, to aid seed germination and plant growth. Seed placement in rough, undulating fields was variable. In the bottom of steep ravines or gullies, seed was placed on the soil surface as the disks were unable to follow sharp variations in ground contour.

For one setting of the hydraulic cylinder, the seeding depth ranged from 36 to 96 mm (1.4 to 3.8 inches). Such large seeding depth variations are characteristic of disk harrows and are mainly due to variations in soil density. The seeding depth was not significantly affected by ground speed.

Stability: All one-way disk harrows have a characteristically large side draft which changes with changing field conditions. As a result, some sideways movement relative to the tractor, and changes in the disk angle or width of cut occur in non-uniform or undulating fields.

Stability of the Massey Ferguson 360 was good in most field conditions, provided the optional rear furrow wheel weights were used. Stability can be improved by adding calcium chloride to the tires, by operating at reduced speeds, by reducing the tillage depth and by increasing the disk angle. In non-uniform level fields, width of cut varied up to 150 mm (6 in) and sideways movement of up to 250 mm (10 in) occurred due to variations in soil hardness. When operating on side slopes up to 8°, the width of cut varied up to 550 mm (22 in) and sideways movement of up to 600 mm (24 in) occurred. When operating down slopes of 8° to 15°, width of cut varied by as much as 1000 mm (39 in) with the rear wheel leaving the furrow (FIGURE 4). The disk harrows were much more stable when tilling uphill or on a hillside sloping down to the right than when tilling downhill or on a hillside sloping down to the left.

Ridging: The Massey Ferguson 360 usually produced an even seedbed with a uniform soil surface (FIGURE 5), providing it was properly adjusted and the tractor driven at a steady speed and a consistent distance from the furrow. Slight ridging occurred on right turns, or on hillsides.

Seed Emergence: Seed emergence was uniform (FIGURES 6 & 7) in all fields with sufficient moisture and nutrient reserves. Emergence was delayed in dry fields. Skips or unseeded strips were evident only on steep hillsides or where the operator had failed to drive with the front wheel in the furrow.

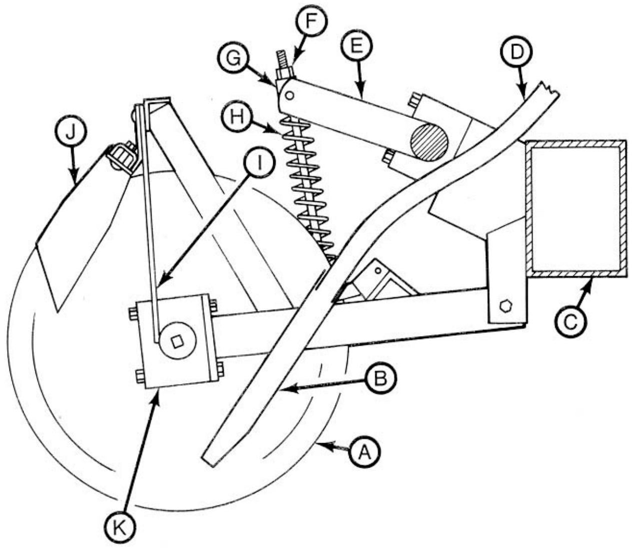

FIGURE 2. Disk Gang: (A) Disk, (B) Seed Boot, (C) Main Frame, (D) Seed Tube, (E) Lift Arm, (F) Spring Force Adjustment Nut, (G) Swivel, (H) Spring, (I) Rock Deflector, (J) Scraper, (K) Gang Bearing Block.

FIGURE 4. Rear Furrow Wheel Leaving the Furrow when Operating Downhill.

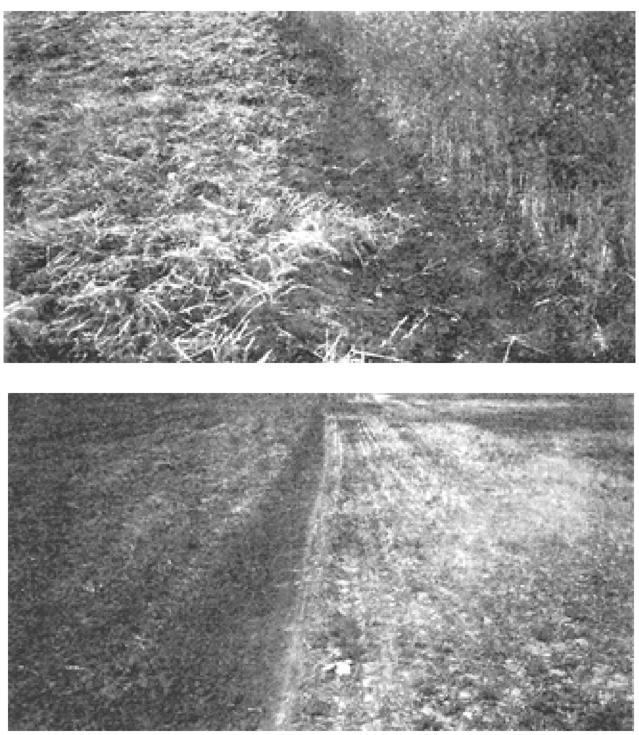

FIGURE 3. Soil Surface after Seeding into Stubble: (Top: Heavy Trash Cover, Bottom: Light Trash Cover).

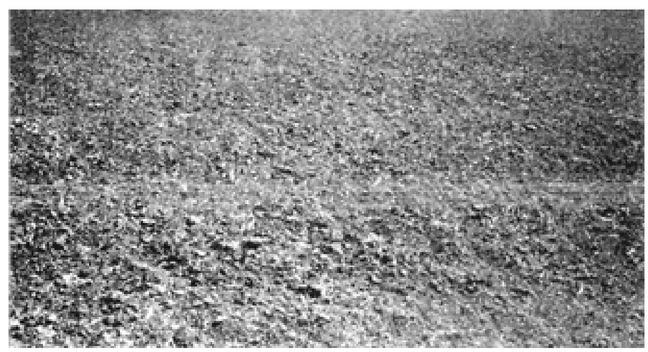

FIGURE 5. Uniform Soil Surface after Tilling.

FIGURE 6. Neepewa Wheat 33 Days after Seeding Into Stubble. Moisture Conditions were Average.

Metering Accuracy: The grain and fertilizer metering systems (FIGURE 8) were calibrated in the laboratory, using a standard procedure[1] and were compared with the manufacturer's calibrations.

Since the actual application rates for certain settings depend on factors such as the size, density, moisture content of seeds and fertilizer particles and on the width of cut, it is not practical for a manufacturer to present charts to include all possible variations. Research has shown, however, that small variations in seed or fertilizer application rates will not significantly affect grain crop yields.

Seed Metering System: Large seeds such as oats are metered through the right side of the seed cup while smaller seeds, such as wheat and barley, are metered through either the right or left side of the seed cup, depending upon the desired seeding rate. Rapeseed is sown through the left side of the seed cup with the special seed cup inserts installed.

Seed metering system accuracy was very good in wheat, barley and oats and was fair in rapeseed. The manufacturer's calibration charts for wheat, barley and oats were accurate when using standard density seed. The manufacturer's calibration for rapeseed (FIGURE 9) was inaccurate, indicating nearly twice the actual seeding rate. Large differences in the seeding rates also occurred between rapeseed that had been treated with Vitavax and untreated rapeseed. These dif. ferences are attributed to the flow properties of seed through the seed cup inserts that are used for all small seeds. It is recommended that the manufacturer consider modifications to the seed cup inserts to reduce the effect of seed properties on the seeding rates of small seeds.

Field roughness, depth of seed in the grain box, variation in field slope or ground speed did not affect the seeding rate for either large or small seeds.

The coefficient of variation[2] (CV) is commonly used to describe the variation of the application rate among individual seed cups. An accepted variation for grain or fertilizer application is a CV value not greater than 15%. If the CV is less than 15%, seeding is acceptable whereas if the CV is much greater than 15%, the variation among individual seed cups is excessive.

For wheat, oats and barley, seeding was very uniform. For example, when seeding wheat at 90 kg/ha (81 lb/ac), the CV was 4%. When seeding rapeseed at a rate of 9.5 kg/ha (8.6 lb/ac), the CV was 13%.

FIGURE 7. Klages Barley 34 Days after Seeding into Stubble. Moisture Conditions were Average.

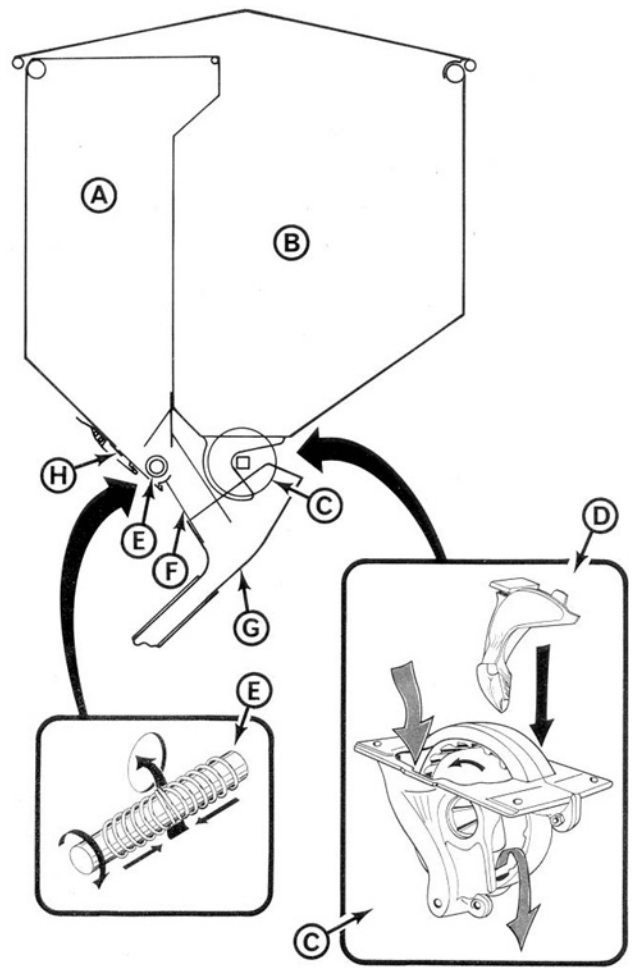

FIGURE 8. Seed and Fertilizer Metering Systems: (A) Fertilizer Box, (B) Grain Box, (C) Internally Fluted Double Run Seed Cup, (D) Seed Cup Insert, (E) Wire Fertilizer Auger, (F) Fertilizer Spout, (G) Grain and Fertilizer Drop Tube, (H) Fertilizer Cleanout Panel.

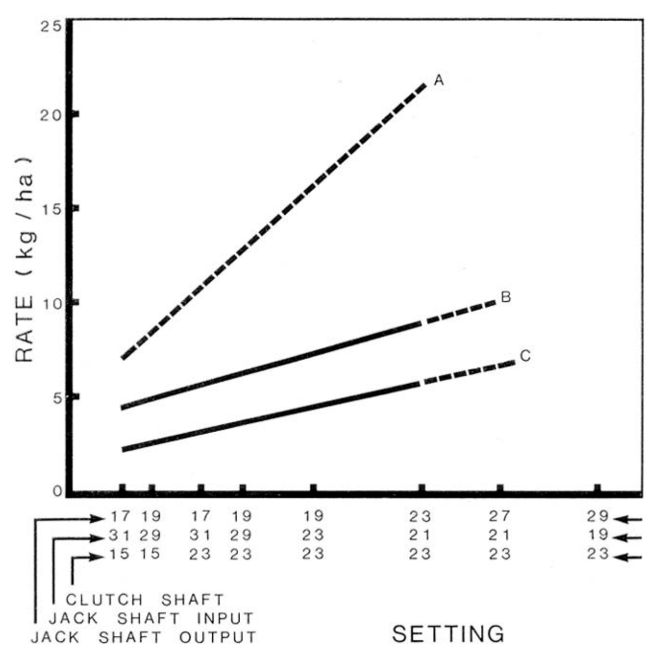

FIGURE 9. Rapeseed Calibration with Normal Speed Grain Drive: (A) Manufacturer's Calibration 625 kg/m³ Seed Density, (B) Untreated Regent Rapeseed 612 kg/m³ Seed Density and (C) Treated Regent Rapeseed 598 kg/m³ Seed Density.

[1] PAMI T792-R79, Detailed Test Procedures for Disker Seeders.

[2] The coefficient of variation is the standard deviation of application rates from individual seed cups expressed as a percent of the mean application rate.

Fertilizer Metering System: Fertilizer metering accuracy was good. Comparison of the manufacturer's calibrations with the actual application rate for 11-48-0 fertilizer having a density of 886 kg/m³ (55 lb/ft³) showed actual application rates 10% less than indicated. This difference is probably due to the variation in the size and density of fertilizer used in the two calibrations. The density of the fertilizer used by the manufacturer was not indicated in the operator's manual.

The variation in the fertilizing rate from one run to another was acceptable. For example, when distributing 11-48-0 fertilizer at a rate of 58 kg/ha (52 lb/ac), the coefficient of variation among individual feed cups was 9.5%.

The fertilizer application rate was not significantly affected by level of fertilizer in the box or by ground speed. It was, however, significantly affected by field slope. FIGURE 10 shows the variation in application rates obtained when fertilizing uphill, downhill and on level ground. The application rate at one setting varied from 33 kg/ha (30 lb/ac) when seeding up a 15° slope to 139 kg/ha (125 lb/ac) when seeding down a 15° slope. The application rate on level ground was 48 kg/ha (43 lb/ac). Application rate was only slightly affected by machine side slope.

Machine vibrations in rough fields caused an insignificant increase in application rate.

Grass Seeding: TABLE 2 presents PAMI calibration charts for sowing alfalfa and ryegrass through the seed box. These charts are presented for operator information only, since these calibrations were not given in the operator's manual. The alfalfa calibration was obtained by seeding through the left side of the seed. cup with the seed cup inserts installed. The ryegrass calibration was obtained by seeding through the right side of the seed cup without the seed cup inserts.

TABLE 2. Alfalfa and Ryegrass Calibrations.

CLUTCH SHAFT	JACK SHAFT INPUT	JACK SHAFT OUTPUT	ALFALFA[1] (kg/ha)	RYEGRASS[2] (kg/ha)
17	31	15	6.0	6.8
17	29	15	6.2	7.2
19	29	15	6.7	8.0
19	25	15	7.1	9.2
17	31	23	7.5	10.0
17	29	23	7.7	11.0
19	29	23	8.1	12.0
19	27	23	8.5	12.4
19	25	23	9.0	13.8
19	23	23	9.2	15.0
19	21	23	9.4	16.3
21	21	23	9.8	18.0
23	21	23	10.2	19.7

1. Alfalfa seeded through the left side of the seed cups with the seed cup inserts. Alfalfa density 759 kg/m³ (60. 7 lb/bu).

2 Ryegrass seeded through the right side of the seed cups without the seed cup inserts. Ryegrass density 252 kg/m³ (20.2 lb/bu).

EASE OF OPERATION

Wet Fields: Mud buildup on the disks and loose trash occasionally caused disk plugging in wet fields. Plugging occurred more readily in heavy trash areas where bunched straw was pushed ahead of the gangs.

The rock deflectors reduced plugging, but did not prevent mud from clinging to the disks (FIGURE 11). Optional disk scrapers reduced the mud buildup in moist soils, but did not completely prevent plugging in wet soils. As is common with most one-way disk harrows, plugging occurred more readily at reduced widths of cut.

Stony Fields: Small, 180 to 230 mm (7 to 9 in) diameter rocks sometimes lodged between adjacent disks in stony fields. The rock deflectors eliminated lodging of most rocks except for those that wedged tightly between the disks, and jammed against the rock deflectors to stop gang rotation.

The spring loaded disk gangs could lift a maximum of 180 mm (7 in) to clear rocks and other obstructions. Disk gang force at maximum trip clearance was about 2400 N (480 lb). As the force on the disk gang is increased by adjusting the gang spring, the trip clearance is reduced. In normal operating conditions, the disks rode smoothly over rocks and other obstructions without serious damage.

Trashy Fields: Heavy surface trash caused poor disk penetration, poor seed placement and occasional plugging. Plugging occurred when loose clumps of straw and trash were pushed ahead of the disk gangs. Plugging due to trash was more frequent in wet fields than in firm dry fields.

Filling: The 230 mm (9 in) wide walkway at the rear of the disk harrows and the wide opening lids made filling with grain and fertilizer safe and convenient. One lid covered both the fertilizer and the grain compartments and an interior fertilizer cover prevented the grain and fertilizer from being mixed when filling. The large lids could be reversed to permit filling from the front or rear. The Massey Ferguson 360 was capable of carrying 1790 L (50 bu) of grain and 1120 kg (2460 lb) of fertilizer. Grain and fertilizer level indicators were not provided on the machine.

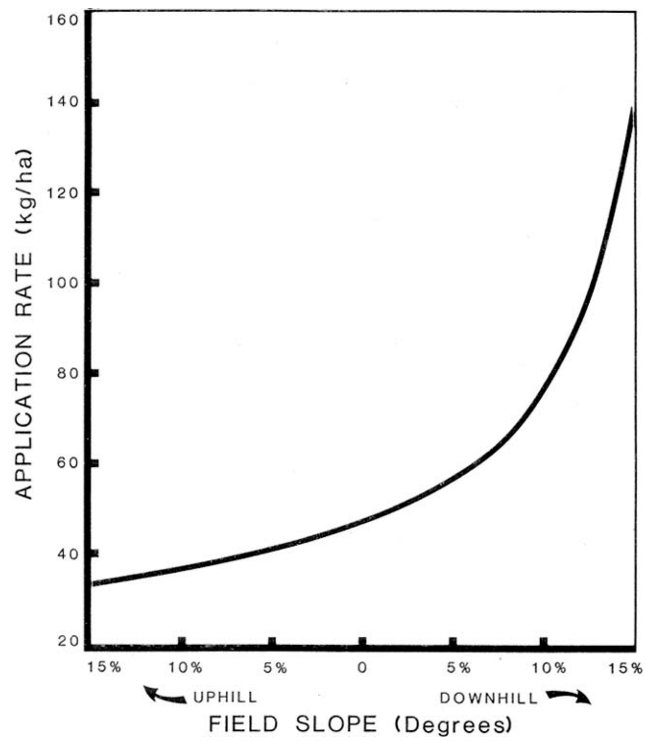

FIGURE 10. Variation in Fertilizer Application Rate with Change in Fore-and-Aft Slope While Applying 11-48-0 Fertilizer at the 17-29-19-31 Setting.

FIGURE 11. Mud Buildup on Disks when Operating in Wet Fields.

Moisture: The grain and fertilizer boxes were adequately sealed to prevent leakage into the boxes in light rains, but some moisture entered in heavy rains. If the disk harrows are allowed to stand out in the rain, the fertilizer shaft should be checked before operation to ensure that it Is free to rotate and that the fertilizer has not caked.

Cleaning: A vacuum cleaner was needed for thorough cleaning of the grain boxes. The seed cup covers at the bottom of the grain box made it difficult to scoop the grain out of the boxes. The fertilizer boxes were easily cleaned by removing bottom drop out panels, which were equipped with quick release latches. Visibility into the grain and fertilizer boxes was very good.

Acrerneter: The Massey Ferguson 360 was equipped with an acremeter that recorded the nearest tenth acre up to 10 000 acres. The accuracy of the acremeter depended on the width of cut. At a nominal 9.2 m (30 ft) width, the acremeter was accurate to within 7%. A metric counter was not available.

Turning: Sharp left turns were easily made (FIGURE 12). Tilled corners were smooth and could easily be covered by two passes when finishing the field. When a left turn was being made, the sudden tightening of the hitch cable pulled the front disk harrow about 300 mm (12 in) to the left.

Right turns had to be made with caution due to interference between the tractor wheel and the lead disk harrow. When making right turns, the angle of cut increased considerably and it was important that the gangs be raised to reduce draft and prevent possible disk damage in stony fields.

Transporting: The Massey Ferguson 360 could be safely transported at speeds up to 25 km/hr (15 mph) when in full transport position, providing the seed and fertilizer boxes were empty. It could be put into full transport position by one man in about 15 minutes. A jack was usually needed to place the front and rear furrow wheels in the upright position. It was very difficult for one man to lift the heavy hitch onto its transport holder. Transport width was narrow enough to allow most vehicles to pass on secondary roads (FIGURE 13).

The Massey Ferguson 360 could be placed into semi-transport position by one person in about 5 minutes. It was difficult to transport in this position, because the overall width of the machine and the tractor (FIGURE 14) made travel along some roads very precarious and the passing of vehicles difficult. Interference between the tractor tire and the hitch brace made it difficult to make right turns when in semi-transport position (FIGURE 15). The semi-transport width could be reduced and the tractor tire clearance increased by adjusting the land wheel and the steering link on the lead harrow.

EASE OF ADJUSTMENT

Width of Cut: The width of cut was adjustable from 8.2 to 9.5 m (27 to 31 ft) depending upon soil conditions, operating depth and ground speed. The width of cut was adjusted by adjusting the angle between the main frame and the centre and rear furrow wheel sub frames, setting the lead of the arcuate land wheel and furrow wheels and lengthening or shortening the hitch cable to make the two harrows parallel. All adjustments were quickly and easily made and were adequate to provide the desired range of cutting widths.

FIGURE 12. Disk Harrows Midway Through a Left Turn.

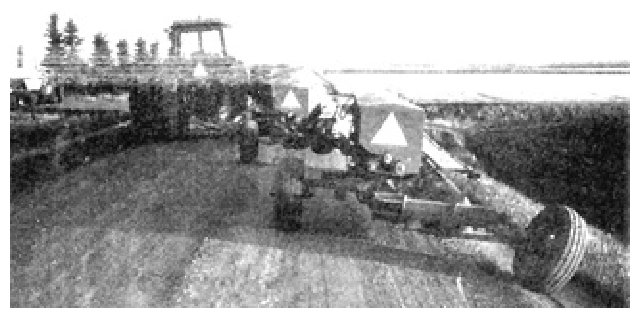

FIGURE 14. Semi-Transport Position.

FIGURE 13. Full Transport Position.

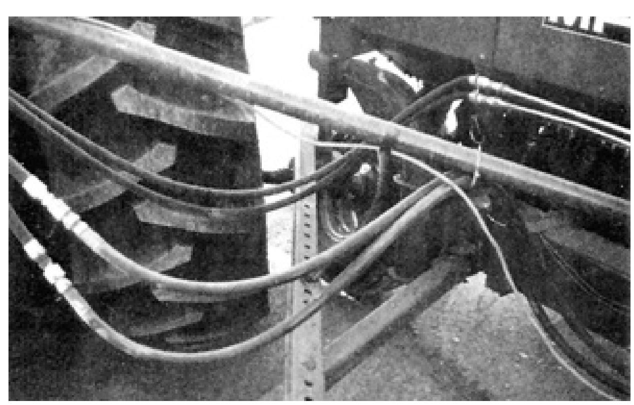

FIGURE 15. Limited Clearance Between Tractor Tire and Hitch Brace in Semi-Transport Position.

Tillage Depth: The depth of tillage was determined by the position of the hydraulic cylinder on each harrow and by the amount of spring compression on each disk gang. The hydraulic cylinders were easily adjusted from the tractor. A hydraulic cylinder equipped with an adjustable stop aided in setting the desired depth.

Individual harrow frames were easily levelled with levelling screws at the front of each harrow.

Each harrow was equipped with an indicator showing the hydraulic cylinder position. The indicators were beneficial for initial cylinder settings, but were difficult to see from the tractor while operating in the field.

Lubrication: Fifty-nine pressure grease fittings required greasing every 10 hours of operation. All drive chains required oiling every 10 hours and the seed cups required lubrication with diesel fuel every 20 hours. The wheel bearings are to be cleaned and repacked with grease each season. Daily lubrication took from 20 to 25 minutes. All lubrication points were readily accessible.

Seeding and Fertilizing Rates: Seeding and fertilizing rates were difficult to adjust. A combination of three sprockets was used for the grain drive and four sprockets for the fertilizer drive. Changing the seeding and fertilizing rates consisted of loosening the chain idler pulleys, removing one or two chains, exchanging sprockets and replacing the chains. The seeding rate was also adjusted by covering the left or right side of the seed cups. Seed cup inserts were required for seeding small seeds such as rapeseed or alfalfa. It required considerable time to remove or replace the seed covers when switching from one side of the seed cup to another, or when installing the seed cup inserts.

POWER REQUIREMENTS

Draft Characteristics: FIGURE 16 shows draft requirements for one-way disk harrows in typical primary tillage at a speed of 8 km/hr (5 mph). This figure gives average requirements based on tests of nine machines in 27 different field conditions.

It is impossible to make meaningful comparisons of the draft requirements of different makes of one-way disk harrows. Draft requirements for the same one-way disk harrows, 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 one-way disk harrows. The difficulty in accurately measuring and controlling the depth of tillage, which directly affects draft requirement, further complicates direct draft comparisons.

In primary tillage, average draft at 8 km/h (5 mph), varied from 2.2 kN/m (147 lb/ft) of width at 50 mm (2 in) depth to 3.5 kN/m (235 lb/ft) of width at 90 mm (3.5 in) depth. This represents a total draft from 20.2 to 32.2 kN (4500 to 7000 lb) for the 9.2 m (30 ft) test machine.

Increasing speed by 1 km/h, increased draft by about 134 N/m of width (a draft increase of 14 lb/ft of width for a 1 mph speed increase). For the 9.2 m (30 ft) wide test machine, this represents a draft increase of 1.23 kN for a 1 km/h speed increase (430 lb for a 1 mph speed increase).

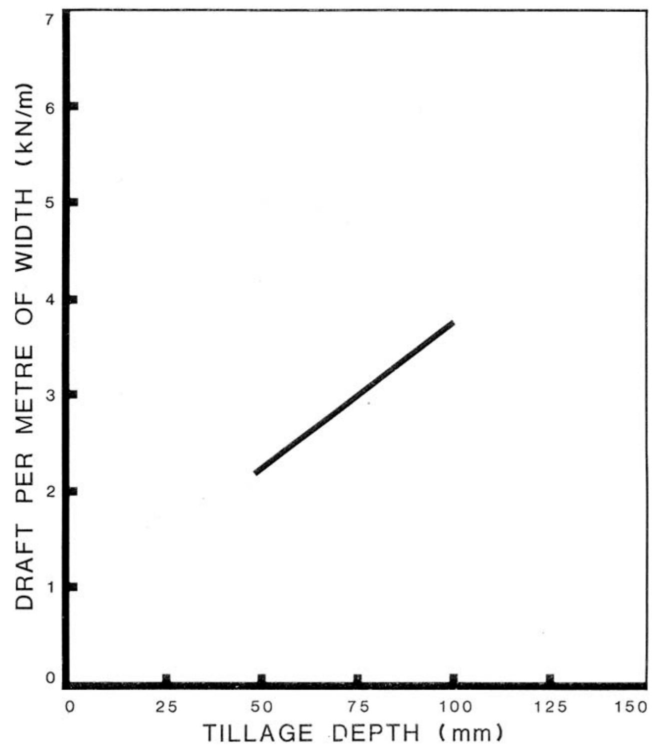

FIGURE 16. Average Draft Requirements for One-Way Disk Harrows at 8 km/h.

Tractor Size: TABLE 3 shows tractor power ratings needed to operate the 9.2 m (30 ft) wide Massey Ferguson 360 in primary tillage. Tractor power requirements have been adjusted to include tractive efficiency and are based on the tractor operating at 80% of maximum power on a level field. The tractor sizes presented in the table are the maximum power take-off rating, as determined by Nebraska tests or as presented by the tractor manufacturer. Tractors selected according to this table will have ample power reserve to operate the Massey Ferguson 360 in primary tillage.

Tractor size may be determined from TABLE 3 by selecting the desired tillage depth and speed. For example, at a depth of 75 mm (3 in) and a speed of 8.0 km/h (5 mph), a 97 kW (130 hp) tractor is needed to operate the Massey Ferguson 360.

TABLE 3. Tractor Size (Maximum Power Take-off Rating, kW) to Operate the 9.2 m wide Massey Ferguson 360 in Primary Tillage.

DEPTH mm	SPEED (km/h) 5	6	7	8	9	10
50	37	48	59	72	68	101
75	53	66	81	97	114	132
89	61	77	93	111	130	149
100	68	85	103	122	142	164

OPERATOR SAFETY

The Massey Ferguson 360 was safe to operate if normal safety precautions were observed.

The front furrow wheel and centre furrow wheel loads exceeded the Tire and Rim Association maximum rating for 11L x 15, 6 ply Implement tires by 46% and 81% respectively when operating in the field with full grain and fertilizer boxes. The overload became negligible as box levels lowered. The same tires were overloaded by 72% and 114% respectively, when transporting with full boxes at speeds above 16 km/h (10 mph). There was no tire overload when transported with empty boxes.

Each disk harrow was equipped with a slow moving vehicle sign that was readily visible when transporting.

OPERATOR'S MANUAL

The operator's manual was very well written and illustrated, and presented useful information on operation and maintenance of the machine. The operator's manual contained several errors in referencing to illustrations and did not include information on the installation or use of the rapeseed seed cup inserts or the slow speed grain drive. It is recommended that the manufacturer include information on the installation and use of these attachments in the operator's manual.

DURABILITY RESULTS

The Massey Ferguson 360 was operated for 95 hours while tilling about 500 ha (1250 ac). The intent of the test was to evaluate the functional performance of the machine, and an extended durability evaluation was not conducted. TABLE 4 outlines the mechanical problems that occurred during the functional testing.

TABLE 4. Mechanical History

ITEM	OPERATING HOURS	EQUIVALENT FIELD AREA (ha)
- The clamps on the hydraulic hose support came loose and were tightened at	38, 47, 64	152, 194, 293
- Two rock deflectors and two seed boots were bent at	85	435
- Fourteen disks were bent and one disk was broken	during the test	

DISCUSSION OF MECHANICAL PROBLEMS

Disks: The disk damage occurred during 40 hours of operation in stony fields. The majority had knicks on the edges and were still suitable for resharpening.

APPENDIX I

SPECIFICATIONS

MAKE: Massey Ferguson Wide Level Disk Harrow

MODEL: 360

SERIAL NUMBER:

- front harrow	1752 002867
- rear harrow	1752 002896

HITCH CONFIGURATION

- number of harrows	2
- hitch type	piggyback

OVERALL DIMENSIONS:

	FIELD	SEMI-TRANSPORT	TRANSPORT
- height	1440 mm	1440 mm	1440 mm
- width	9400 mm	2360 mm	3900 mm
- ground clearance	184 mm	184 mm	184 mm
- nominal seeding width		9145 mm	

SEED METERING SYSTEM:

- type	double run feed cups with internally fluted feed wheels.
. drive	sprocket and chain drive from land wheel.
- adjustment	changing speed of feed-shaft by interchanging sprockets.
- transfer to openers	rubber hose to metal spring loaded boots mounted on the disk gangs.

FERTILIZER METERING SYSTEM:

- type	wire augers on round horizontal shaft,
- drive	sprocket and chain drive from land wheel.
- adjustment	changing speed of feed-shaft by interchanging sprockets.
- transfer to openers	plastic hoses to top of the grain drop tubes.

DISK GANGS:

- number of disks per harrow	30
- number of gangs per harrow	5
- number of disks per gang	6
- disk diameter	503 mm
- disk thickness	4.5 mm (22 gauge)
- disk concavity	64 mm
- disk spacing	178 mm

TIRES:

- number	5
- size	11L x 15, 6 ply

GRAIN AND FERTILIZER BOX CAPACITIES:

- grain box capacity	1790 L
- fertilizer box capacity	1120 kg

WEIGHT:

	BOXES EMPTY	BOXES FULL
- weight on front furrow wheel	996 kg	644 kg
- weight on front land wheel	682 kg	118kg
- weight on centre furrow wheel	1246 kg	038 kg
- weight on rear land wheel	290 kg	590 kg
- weight on rear furrow wheel	850 kg	246 kg
TOTAL WEIGHT	4064 kg	

LUBRICATION POINTS:

- 59 pressure grease fittings	10h
- 8 drive chains	10h
- 60 seed cups	20h
- wheel bearings	seasonal

NUMBER OF CHAIN DRIVES:	8
NUMBER OF HYDRAULIC LIFTS:	2
NUMBER OF SEALED BEARINGS:	37

APPENDIX II

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 III

CONVERSION TABLE

1 kilometre/hour (km/h)	= 0.6 miles/hour (mph)
1 metre (m)	= 3.3 feet (ft)
1 millimetre (mm)	= 0.04 inches (in)
1 kilogram (kg)	= 2.2 pounds mass (lb)
1 kilowatt (kW)	= 1.3 horsepower (hp)
1 hectare (ha)	= 2.5 acres (ac)
1 litre (L)	= 0.03 bushels (bu)
1 newton (N)	= 0.2 pounds force (lb)
1 kilonewton (kN)	= 220 pounds force (lb)
1 kilogram/hectare (kg/ha)	= 0.9 pounds/acre (lb/ac)

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