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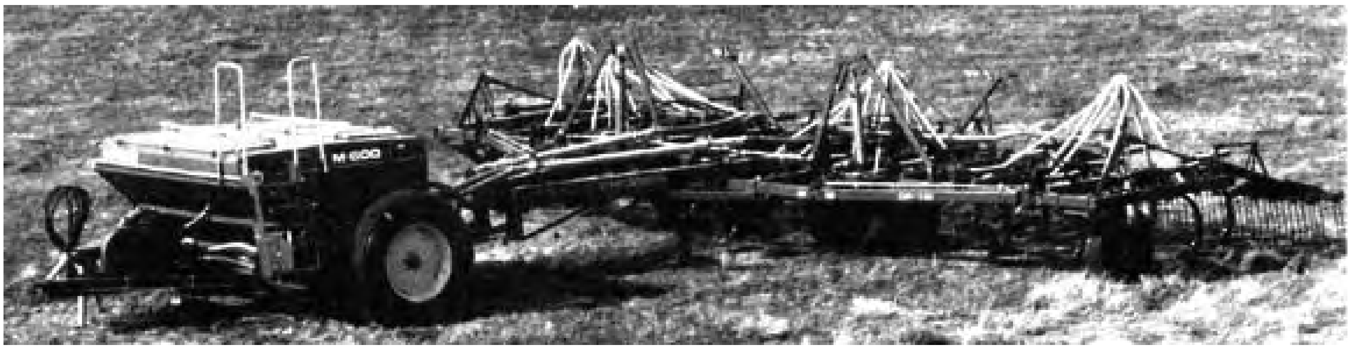

Morris M-600 Air Flow Seeder

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

MORRIS M-600 AIR FLOW SEEDER

MANUFACTURER AND DISTRIBUTOR:
Morris Rod Weeder Co. Ltd.
85 York Road
Yorkton, Saskatchewan
S3N 2X2

RETAIL PRICE: (February, 1982, f.o.b. Yorkton, Saskatchewan)

a. Morris M-600 air ow seeder complete with seed boots and distribution system to feed 31 shanks. $22,947.00
b. Morris CP-731 9.5 m (31 ft) heavy duty cultivator complete with attached harrows $13,907.00

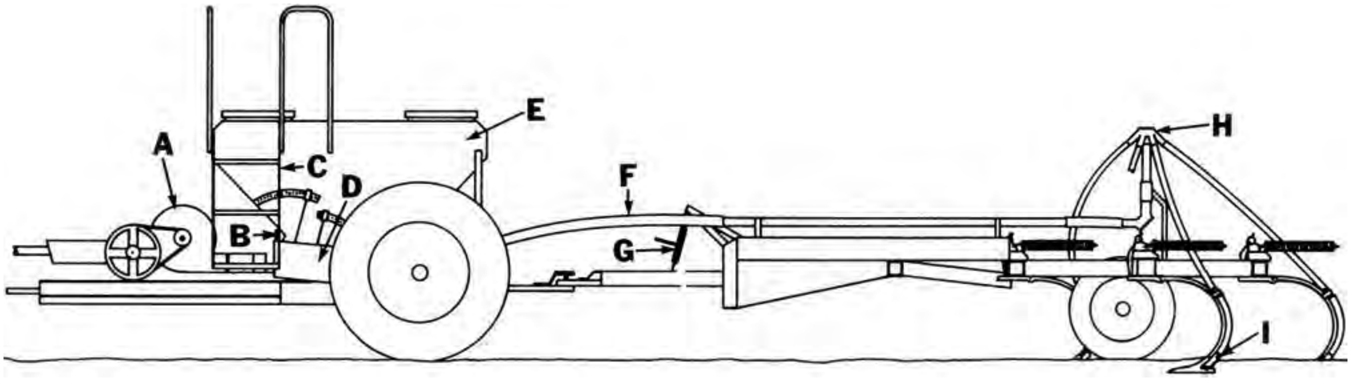

FIGURE 1. Morris M-600 Air Flow Seeder: (A) Fan, (B) Meter Operation indicator, (C) Ladder, (D) Metering System, (E) Tanks, (F) Primary Distribution Tube, (G) Hitch Height Turnbuckle, (H) Secondary Header, (I) Seed Boot.

SUMMARY AND CONCLUSIONS

Overall functional performance of the Morris M-600 air ow seeder was good in all seeding conditions. Performance was good when banding fertilizer at low application rates. When operated with the 9.5 m (31 ft) Morris CP-731 heavy duty cultivator, the Morris M-600 was suitable for seeding both in primary and in secondary eld conditions. The Morris was also suitable for banding fertilizer at application rates up to 172 kg/ha (153 lb/ac) at 9 km/h (5.5 mph). When equipped with an alternate larger fan, supplied by the manufacturer at the end of the evaluation, the Morris M-600 was capable of banding fertilizer at application rates up to 263 kg/ha (234 lb/ac) at 9 km/h (5.5 mph). Higher application rates were possible at reduced speeds.

Seed placement was good in most conditions. Variation in seed depth was slightly higher than with a conventional hoe drill when measured in the same elds under the same seeding conditions. The crop emerged in distinct rows with seed band widths ranging from 85 to 135 mm (3.3 to 5.3 in) behind each seed boot. With 305 mm (12 in) shank spacing, distance between rows varied from 170 to 220 mm (6.7 to 8.7 in). Row spacing and seed band width were usually wide enough to provide stubble support for most windrows, providing very light crops were not laid parallel to seeding rows. Maintaining good cultivator frame levelling and ensuring a seed depth of at least 50 mm (2 in) were critical in ensuring good emergence.

The manufacturer's metering calibrations were acceptable in barley, oats and fertilizer. The measured calibration was 22% higher than the manufacturer's rate for wheat and was over twice the manufacturer's rate for rapeseed at normal seeding rates. Distribution uniformity across the seeding width in wheat, barley, oats and rapeseed was acceptable at all normal seeding rates. Distribution uniformity was acceptable in fertilizer at rates up to 160 kg/ha (142 lb/ac).

Field bounce, eld slope and ground speed variation had little effect on metering rates. Travelling up a 10 degree slope caused a 10% increase in seeding rate and a 12% increase in fertilizing rate. Travelling down a 10 degree slope caused a 10% decrease in seeding rate and a 17% decrease in fertilizing rate, Distribution uniformity was only slightly affected by eld slope.

Seeding rate was easily adjusted. Tank and meter cleanout was inconvenient. Tank lling by hand was possible but was more convenient with a drill ll. Five grease ttings and two wheel bearings on the applicator required greasing.

The Morris M-600 with CP-731 cultivator could be placed in transport position in less than ve minutes. Operator visibility of the cultivator was unobstructed by the low pro le tanks.

Rate of work usually ranged from 7.6 to 9.5 ha/hr (19 to 24 ac/hr).

About 24 ha (58 ac) could be seeded before re lling both tanks when seeding wheat at a normal seeding rate.

Tractor size depended on eld conditions, seeding depth, ground speed, cultivator width, and soil nishing attachments. In light primary tillage, at 75 mm (3 in) depth and 8 km/h (5 mph), a 95 kW (128 hp) tractor was needed to operate the applicator-cultivator combination. In heavy primary tillage, at the same depth and speed, a 115 kW (154 hp) tractor was needed.

The operator's manual contained information on safety, adjustment, speci cations, maintenance and operation. A detailed parts list was also included.

Only minor mechanical problems occurred during evaluation.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Indicating in the operator's manual the actual seed densities used in preparation of the meter calibration charts.
2. Improving the metering calibration for rapeseed.
3. Modi cations to the' distribution system to improve distribution uniformity in fertilizer at high application rates.
4. Providing a higher output fan to permit the high fertilizer banding rates commonly used on the prairies.
5. Providing, as optional equipment, a monitoring system to monitor material ow.
6. Supplying a calibration setting so the area meter can be used for readout in SI units.
7. Improving access to seed and fertilizer metering shaft grease tting.
8. Supplying a slow moving vehicle sign as standard equipment.
9. Including accurate and complete meter calibration charts in the operator's manual.
10. Providing, as standard equipment, some means of supporting the primary distribution tubes on the cultivator.
11. Modi cations to metering chain drive tensioners to prevent chain loosening.

Senior Engineer: E. H. Wiens

Project Engineer: R. K. Allam

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Densities for the materials used to establish meter calibrations will be given in all future manuals and calibration charts.
2. Improved rapeseed metering calibrations will be provided in the future.

3. We are presently working on modifications to the distribution system which will improve distribution uniformity in fertilizer, as well as seed.
4. All future M-600 air seeders will be equipped with a new fan to permit higher fertilizer banding rates.
5. No optional monitoring system will be offered. We will leave it to individual farmers and dealers to purchase the system they desire.
6. A metric calibration setting chart is being prepared at the present time.
7. This recommendation has been noted and will be considered in future runs of the M-600 air seeder.
8. Presently, we supply a bracket for mounting a slow moving vehicle sign. However, supplying of the sign is left to the individual farmers and dealers. If it becomes mandatory by !aw that machinery companies supply a slow moving vehicle sign with each machine they sell, then we would comply with this recommendation.
9. New calibration charts will be included in future manuals.
10. Various mounting hardware packages for mounting air seeder hoses on Morris equipment will be made available.
11. A spring loaded, chain tightener is now available and a field changeover is presently underway, updating previously sold M-600 machines.

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

GENERAL DESCRIPTION

The Morris M-600 air flow seeder is a pneumatic seed and fertilizer applicator designed for use with varying makes and models of light, medium and heavy duty cultivators.

The cultivator is attached to the rear of the applicator with the standard cultivator hitch. The applicator is supported by two wheels, each on single axles.

Seed and fertilizer are pneumatically distributed from two tanks, through a network of tubes to seed boots attached to the rear of each cultivator shank. The applicator can be used for seeding, for combined seed and fertilizer application and for fertilizer banding.

Seed and fertilizer are metered, by pegged rollers which rotate inside seed cups mounted below the tanks. Metering is controlled by variable speed drives, chain driven from the left applicator wheel. Meters are controlled by an electric meter shutoff located in the tractor cab. A power take-off driven fan forces the metered material through the distribution system. The tanks are pressurized for positive metering of material. The distribution system consists of four primary tubes, each connected to one of four sets of pegged metering rollers across the machine width, feeding four secondary headers mounted on the cultivator. Three of the four sets of pegged rollers contained 9 rollers, each feeding a 9-port secondary header, while the fourth contained 5 pegged rollers feeding an 8-port header with 4 ports blocked. The ports are blocked in a symmetrical pattern, with each blocked port adjacent to an open port.

The test machine was used with a Morris CP-731 heavy duty cultivator. This cultivator was 9.5 m (31 ft) wide with a 4 m (13 ft) centre frame and two 2.7 m (9 ft) wing sections. It was equipped with 31 spring trip shanks, spaced at 305 mm (12 in) arranged in 3 rows. The cultivator was equipped with optional three-row mounted harrows.

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

SCOPE OF TEST

The Morris M-600 was operated in loam and clay soils in the field conditions shown in TABLE 1 for approximately 118 hours while processing about 615 ha (1520 ac). It was evaluated for quality and rate of work, ease of operation and adjustment, power requirements, safety and suitability of the operator's manual.

RESULTS AND DISCUSSION

QUALITY OF WORK

Metering Accuracy: The grain and fertilizer metering system was calibrated in the laboratory[1] and compared with the manufacturer's calibration. Since actual seed rates for certain settings depended on things such as seed size, density and moisture content, it is not possible for a manufacturer to present charts to include all the varieties of seed. Field calibration checks may be necessary for seed with properties differing from those used in establishing the manufacturer's charts. Research has, however, shown that small variations in seeding rates will not significantly affect grain crop yields.

TABLE 1. Operating Conditions.

CROP	FIELD TILLAGE CONDITIONS	STONE CONDITIONS	FIELD AREA (ha)	HOURS
Durum wheat on stubble	Secondary	Occasional stones	25	5
Durum wheat on summerfallow	Secondary	Occasional stones	70	13
Spring wheat on summerfallow	Secondary	Occasional stones	36	7
Spring wheat on stubble	Secondary	Occasional stones	30	6
Spring wheat on stubble	Primary	Stone free	135	26
Barley on stubble	Secondary	Occasional stones	70	12
Flax on summerfallow	Secondary	Occasional stones	10	2
Spring wheat on stubble	Primary	Occasional stones	100	20
Winter wheat on summerfallow	Secondary	Occasional stones	65	13
Winter wheat on stubble	Primary	Stone free	10	2
Banding fertilizer	Primary	Occasional stones	65	12
TOTAL			615	118

The metering calibration chart in the Morris M-600 operator's manual did not include a calibration for rapeseed. An updated metering calibration chart was received from the manufacturer at the end of the test and included a calibration for rapeseed as well as a more accurate calibration for barley and wheat. The seed densities used by the manufacturer for calibration were not given. It is recommended that they be included to permit the operator to compare seed densities to determine if field meter calibrations are necessary.

Calibration curves for wheat, barley and oats, using the rear meter, are given in FIGURES 2 to 4. PAMI's calibration curves are compared to the manufacturer's calibration curves. At a seeding rate of 80 kg/ha (70 lb/ac), measured rates were 22% higher than the manufacturer's calibration in wheat, 5% lower in barley, and 12% lower than the manufacturer's rate in oats.

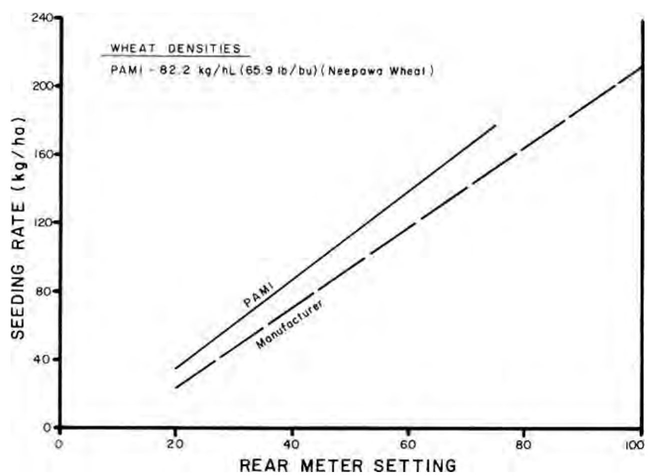

FIGURE 2. Metering Accuracy for the Rear Meter in Wheat.

At a seeding rate of 7 kg/ha (6.2 lb/ac) in rapeseed (FIGURE 5), the measured rate was over twice the manufacturer's indicated rate. At a seeding rate of 3 kg/ha (2.7 lb/ac), the measured rate was three times the manufacturer's indicated rate. It is recommended that the manufacturer's calibration for rapeseed be improved.

As is shown in FIGURE 6, the manufacturer's metering calibration for fertilizer, using the front meter, was accurate with little difference between measured and manufacturer's application rates.

The Morris M-600 metering calibrations were not identical for the front and rear meters due to differing meter variable drive box ratios. For the calibrations discussed above, the rear meter was

[1] T773, "Detailed Test Procedures for Grain Drills".

used for wheat, barley, oats and rapeseed, while the front meter was used for fertilizer. A tank partition cover plate could be removed to allow application of one material from both tanks using one meter.

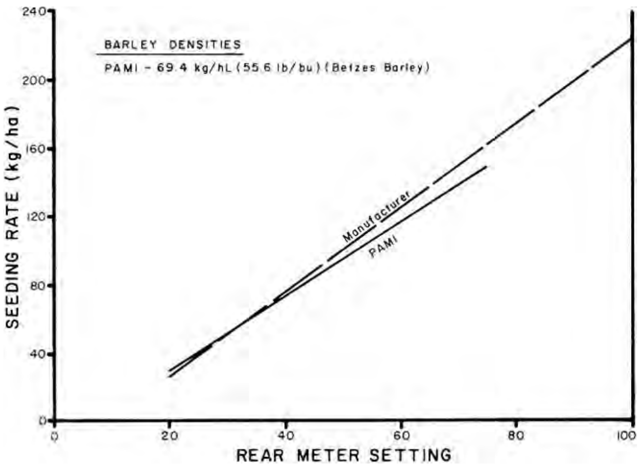

FIGURE 3. Metering Accuracy for the Rear Meter in Barley.

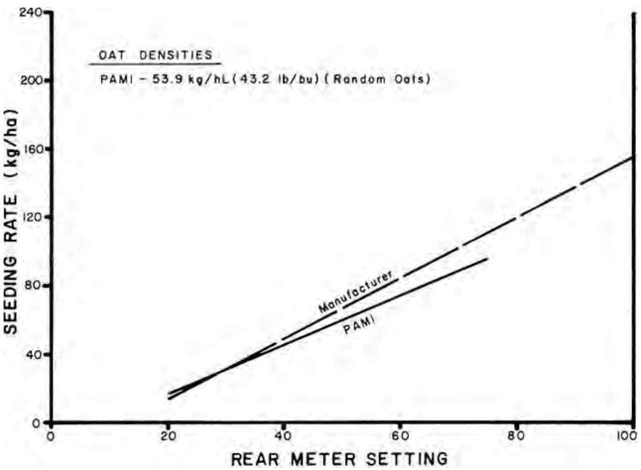

FIGURE 4. Metering Accuracy for the Rear Meter in Oats.

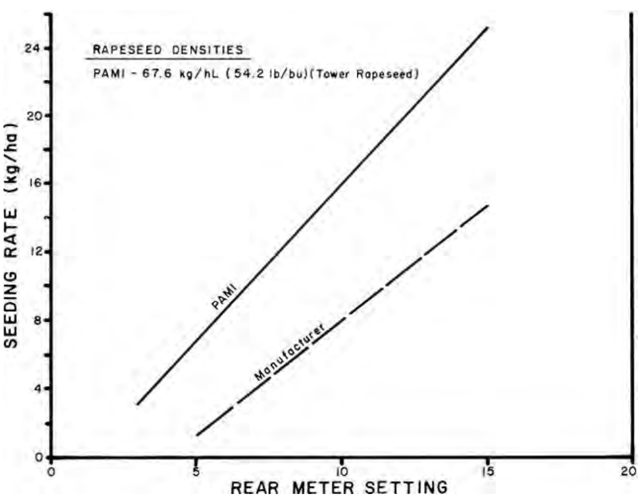

FIGURE 5. Metering Accuracy for the Rear Meter in Rapeseed.

Machine and eld variables such as eld bounce, side-slope and ground speed had little effect on metering rates. Travelling up a 10 degree slope caused a 10% increase in seeding rate and a 12% increase in fertilizing rate. Travelling down a 10 degree slope caused a 10% decrease in seeding rate and a 17% decrease in fertilizing rate. Although ground drive wheel slippage in soft elds is common with many ground driven applicators, no ground drive wheel slippage of the large diameter drive wheel was experienced with the Morris.

Distribution Uniformity: The pneumatic distribution system distributed seed uniformly from the metering system to the individual shank boots. FIGURE 7 gives seeding distribution uniformity for the Morris M-600 in wheat, barley and oats. Distribution was uniform over the full range of seeding rates. For example, at a seeding rate of 80 kg/ha (70 lb/ac) the coef cient of variation[2] (CV) was 5.5% in wheat, 6% in barley, and 6.5% in oats. Seeding distribution in rapeseed (FIGURE 8) was also uniform with CV's ranging from 10 to 15% over the full seeding range.

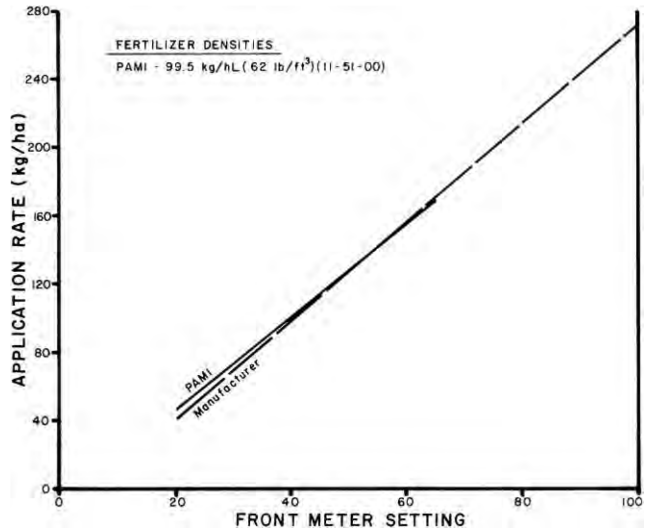

FIGURE 6. Metering Accuracy for the Front Meter in Fertilizer.

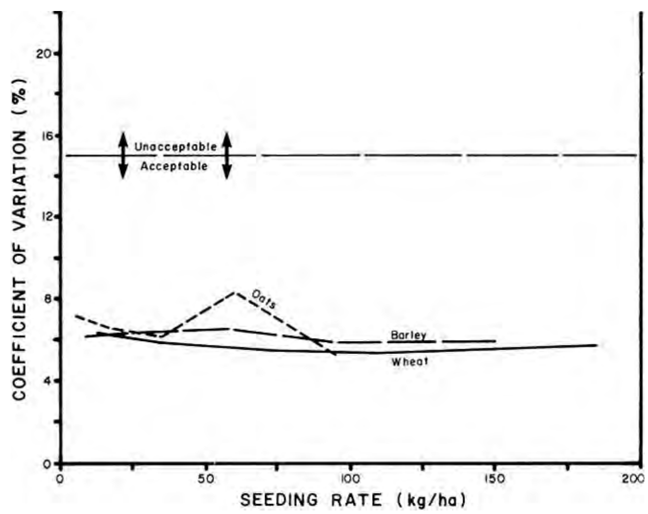

FIGURE 7. Seeding Uniformity in Cereal Grains at 9 km/h.

FIGURE 9 shows acceptable distribution uniformity in 11-51-00 fertilizer at rates up to 160 kg/ha (142 lb/ac). At higher rates, uniformity became unacceptable with CV's above 15%. All rates, shown in FIGURE 9, in excess of 172 kg/ha (153 lb/ac) were obtained using an alternate larger fan, supplied by the manufacturer at the end of the evaluation. It is recommended that the manufacturer consider modi cations to the distribution system to improve distribution uniformity at high application rates in fertilizer.

Distribution uniformity decreased at higher fertilizing rates due to the increased volume of seed being introduced into the constant volume of air supplied by the fan. Similarly, due to the air supply remaining constant regardless of forward speed or machine width, changes in distribution pattern uniformity could occur at different forward speeds or for different machine widths.

Seeding or fertilizing up or down a 10 degree slope or on a 10 degree side-slope had little effect on distribution uniformity.

Grain Damage: Grain damage by the metering and distribution system was well within acceptable limits for cereal grains and for rapeseed. For example, in dry Neepawa wheat at 11% moisture

[2]The coef cient of variation (CV) is the standard deviation of seeding rates from individual shanks expressed as a per cent of the average seeding rate. An accepted variation for seeding grain or applying fertilizer is a CV value not greater than 15%. If the CV is less than 15%, distribution is acceptably uniform, whereas if the CV is greater than 15%, the variation in application rate among individual shanks is excessive.

content, only 0.1% crackage occurred. In dry rapeseed with a moisture content of 7%, 0.6% crackage occurred.

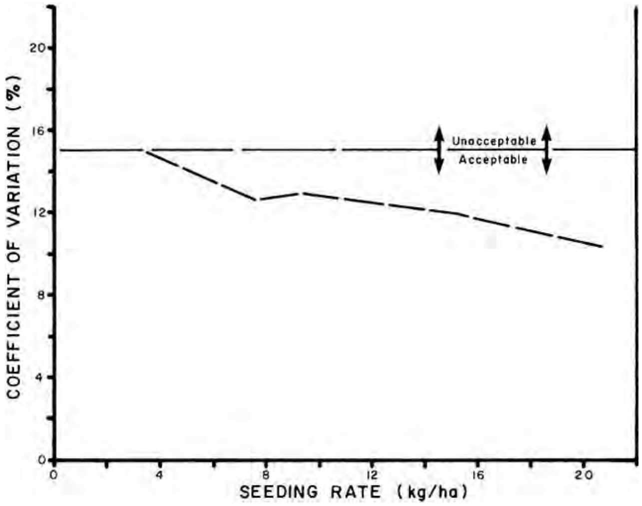

FIGURE 8. Seed Uniformity in Rapeseed at 9 km/h.

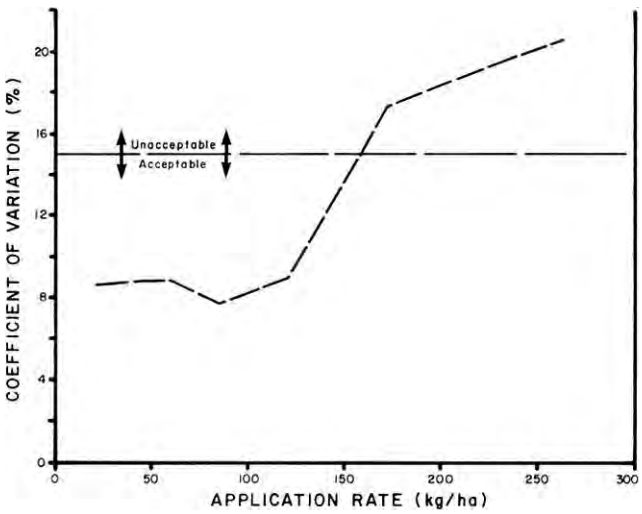

FIGURE 9. Distribution Uniformity in 11-51-00 Fertilizer at 9 km/h.

Seed Placement: Each seed boot consisted of a divider with two outlets (FIGURE 10) to spread the seed behind each cultivator sweep. However, the seed boot provided limited spreading behind each shank. In most fields it was possible to observe distinct rows ranging in band width from 85 to 135 mm (3.3 to 5.3 in) (FIGURE 11). With 305 mm (12 in) cultivator shank spacing, distances between rows varied from 170 mm (6.7 in) to 220 mm (8.7 in). This row spacing provided adequate windrow support providing light crops were laid across the rows rather than parallel to them.

Although seeds were usually placed on the furrow bottom at the working depth of each individual cultivator sweep, depth across the width of the machine varied due to cultivator frame geometry and non-uniform field surfaces. On level and gently rolling fields, vertical seed distribution was quite uniform. For example, at an average seeding depth of 60 mm (2.4 in), seeding depth across the width of the machine varied from 40 to 95 mm (1.6 to 3.7 in) with most of the seeds being placed within 15 mm (0.6 in) of the average cultivator sweep working depth. This compares to a vertical variation of from 12 to 15 mm (0.45 to 0.6 in) from average seeding depth for a hoe drill in similar conditions.

In fields with sharp hill crests or gullies, seed depth variation became much greater than for a hoe drill due to the greater distances between shank rows on a heavy duty cultivator than on a hoe drill.

Vertical seed distribution was not adversely affected by field tillage conditions. The shanks on the Morris CP-731 cultivator were sufficiently rigid to maintain a fairly uniform sweep pitch (FIGURE 13), with resultant uniform tillage depth, over a wide range of soil conditions.

Plant Emergence: As with most seeding implements, time and uniformity of plant emergence depended on seedbed preparation, soil moisture and seed placement. The Morris was used to seed in a number of fields with different types of seedbed preparation. Uniform emergence resulted as long machine settings were carefully adjusted to place seed in moist soil at the correct depth and providing loose seedbeds were packed after seeding. FIGURE 11 shows good wheat emergence when wheat was seeded into a pre-worked stubble field.

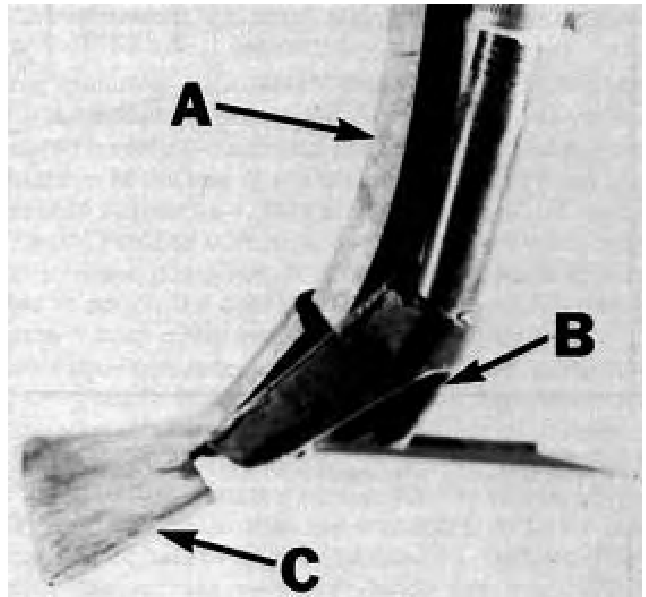

FIGURE 10. Morris Seed Boot: (A) Shank, (B) Seed Boot, (C) Sweep.

FIGURE 11. Uniform Wheat Emergence in Pre-worked Stubble (Upper: 25 days after Seeding, Lower: At Harvest).

Careful cultivator frame levelling was important in obtaining uniform emergence across the cultivator width. Due to the rigidity of heavy duty cultivator frames, improper sideways levelling and fore-and-aft levelling can both result in rows of shanks operating at different depths.

Seeding Depth: It is very important to seed deep enough to obtain uniform seed coverage. Correct cultivator adjustments for pneumatic seeding were best obtained by comparing the depth of seeds placed by several shanks across the cultivator width and from both the front and rear shank rows. This permitted accurate frame levelling to obtain uniform seed coverage. Seeding shallower than 50 mm (2 in) is not recommended for a heavy duty cultivator, due to poor seed coverage and generally poor cultivator performance at shallow tillage depths.

Frame levelling had to be checked and appropriate depth adjustments made when changing fields to ensure adequate, uniform seed coverage.

Soil Finishing: For this evaluation, the Morris CP-731 cultivator was equipped with optional three-row mounted harrows. Although the mounted harrows assisted in smoothing the soil surface and in breaking loose soil lumps, increased ground force for more aggressive harrow action would have been desirable for most field conditions encountered.

The Morris M-600 with CP-731 cultivator was not equipped with packers. Since it was considered essential to pack most fields seeded with the Morris M-600, a harrow-packer drawbar[3] equipped with five bar tine harrows and trailing steel coil packers was used as a follow-up operation. The harrow-packer combination served to further smooth and pack the seedbed, leaving packer ridges from 20 to 30 mm (0.8 to 1.2 in). To obtain a smooth, firm seedbed in dry conditions required packer drawbar operations in two directions. Care had to be used in moist conditions to avoid over packing the seedbed. FIGURE 12 shows a typical seedbed after seeding into stubble both before and after use of the harrow-packer drawbar.

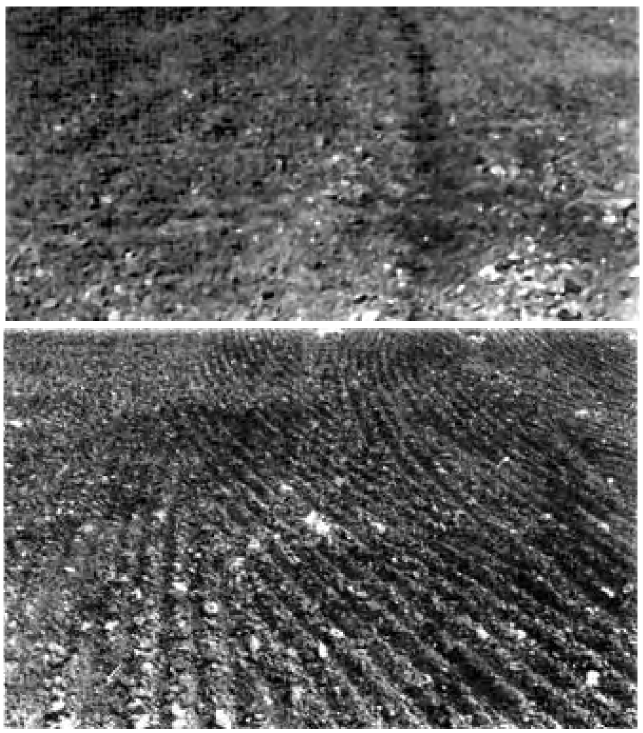

FIGURE 12. Morris Seedbed (Upper: Before Packing, Lower: After Packing).

Shank Characteristics: The Morris CP-731 cultivator was equipped with adjustable, spring trip shank holders. During the test, it was used with 405 mm (16 in) wide Edwards sweeps with 43 degree stem angles, giving a no-load sweep pitch of 4 degrees. These shanks were suitable for seeding since sweep pitch (FIGURE 13) varied only 4 degrees over the full range of draft normally expected for a heavy duty cultivator. This resulted in uniform tillage depth and a smooth furrow bottom over a wide range of soil conditions.

Shank tripping, with new shanks, occurred at drafts greater than 10.4 kN (728 lb/ft), which was well beyond the normal primary tillage draft range, indicating that the Morris CP-731 was suited for heavy primary tillage.

The shanks performed well in stony fields. Maximum lift height to clear obstructions was 206 mm (10.2 in).

Penetration: When equipped with 43 degree, 406 mm (16 in) sweeps, penetration was adequate in nearly all field conditions and it was easy to obtain correct seeding depth. Correct seeding depth could not be obtained in fields with very firm furrow bottoms. Penetration was uniform across the cultivator width provided all depth control linkages and hitch height were kept properly adjusted.

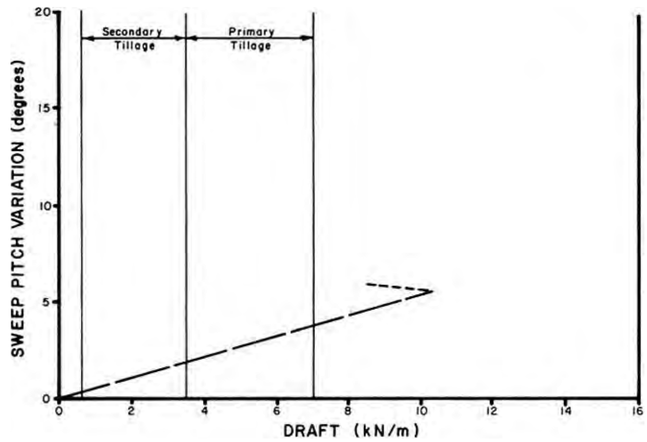

FIGURE 13. Sweep Pitch Variation over Normal Range of Draft (305 mm Shank Spacing).

The cultivator wheels were positioned so that each centre section wheel supported about 18% of the total cultivator weight while each wing wheel supported about 14%. In addition, each centre wheel supported about 16% of the total tillage suction force while each wing wheel supported about 19%. Cultivator or pneumatic seeder sinking was not a problem in moderately soft soils. Since the pneumatic seeder was not supported by the cultivator wheels, but was carried on its own wheels, it did not contribute to cultivator sinking in soft soils.

Trash Clearance: The Morris CP-731 cultivator had excellent trash clearance. In heavy, loose trash it was necessary to either raise the mounted tine harrows or release the tine angle adjustment to allow the trash to clear the harrows.

With the harrows correctly adjusted it was possible to operate in fields with a heavier trash cover than was possible with a conventional hoe drill.

Skewing and Stability: The Morris M-600 air flow seeder and CP-731 cultivator combination were very stable and sideways skewing occurred only in very hilly conditions. The cultivator shank pattern was symmetrical and did not impose any side forces on the cultivator during normal tillage. When equipped with 406 mm (16 in) sweeps, the cultivator had to skew more than 2.4 degrees to miss weeds. Throughout the evaluation period, in normal seeding conditions, skewing was never serious enough to cause weeds to be missed.

Weed Kill: Weed kill was very good when equipped with 406 mm (16 in) sweeps. The 305 mm (12 in) shank spacing resulted in 100 mm (4 in) sweep overlap. Considerable sweep wear could occur before weeds were missed. However, to ensure adequate sweep lift is maintained for proper seed placement, sweeps should be replaced before significant wear is evident.

Fertilizer Banding: The Morris M-600 could be used for two types of fertilizer application. It could be used for normal fertilizer application at seeding time by metering fertilizer from one tank and grain from the other and applying both through the same seed boots. When equipped with chisel points and alternate banding boots (FIGURE 14), it could also be used for fertilizer banding.

Banding is a relatively new method of fertilizer application on the Prairies. Experimental results suggest that placing fertilizer in compact bands, from 35 mm (1.5 in) below seed depth to twice seeding depth is desirable for fall fertilizer application. This required the use of chisel points to obtain sufficient depth and minimize soil disturbance and special boots to minimize fertilizer spreading.

The Morris M-600 worked well for fertilizer banding at low application rates. Fertilizer granules were placed in a band about 25 mm (1.0 in) wide. Vertical fertilizer distribution generally ranged from chisel tip depth to 10 mm (0.4 in) above chisel tip depth. Wider fertilizer bands were obtained in lumpy soil conditions and as the chisel points became worn.

The fan supplied on the Morris M-600 did not supply adequate air to allow the front metering system to be set for the maximum

[3]See Machinery Institute Evaluation Report 277.

rate while distributing 11-51-00 fertilizer. The air supply, at a rated fan speed of 4600 rpm, was adequate to apply 172 kg/ha (153 lb/ac) with the 9.5 m (31 ft) cultivator at 9 km/h (5.5 mph). At higher application rates, plugging of the distribution system occurred. Since fertilizer banding rates in excess of 172 kg/ha (153 lb/ac) are commonly used on the prairies, it is recommended that a higher output fan be provided.

A larger, alternate fan was supplied by the manufacturer after the eld evaluation had been completed. With this fan mounted on the Morris M-600 air ow seeder, fertilizer rates up to 263 kg/ha (234 lb/ac) were possible at 9 km/h (5.5 mph). Banding suitability at 9 km/h (5.5 mph) was reduced for application rates greater than 160 kg/ha (142 lb/ac) due to unacceptable distribution uniformity (FIGURE 9) at higher rates. Higher application rates with suitable distribution uniformity could be obtained by reducing forward speed. For example, the application rate could be increased to about 194 kg/ha (172 lb/ac) at 8 km/h (5 mph).

A tank divider door could be removed to allow fertilizer to be metered from both tanks through the front meter.

The Morris M-600 tanks and metering system were sealed against moisture entry. This eliminated any fertilizer caking problems. All unprotected metal surfaces should be cleaned and oiled periodically when applying fertilizer, to prevent corrosion.

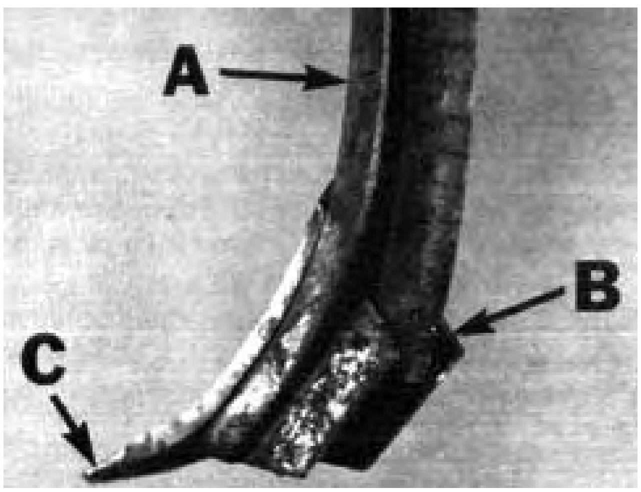

FIGURE 14. Morris Banding Boot: (A) Cultivator Shank, (B) Banding Boot, (C) Chisel Point.

EASE OF OPERATION

Dual Purpose Operation: The Morris M-600 could be detached from the cultivator by two men in about one-hour. The procedure included the removal of the primary distribution tubes, secondary headers and secondary hoses from the cultivator. This allowed the cultivator to be used as a dual purpose machine, both for seeding and seasonal tillage.

Hitching: The Morris M-600 was easily hitched to a tractor. Hitching convenience was increased by the fact that the hitch link remained horizontal when unhitched from the tractor. Hitching also required hook-up of four hydraulic lines with quick couplers and an electrical connector for the electric meter shut-off.

Filling: A drill ll or grain auger was needed to conveniently ll the applicator tanks. Because the ller openings were located only 1.6 m (5.2 ft) above the ground, hand lling was also possible. The large 600 x 300 mm (24 x 12 in) ller openings gave ample room for auger lling. The ller lids were mounted on hinges, which were easily lifted and were latched with a simple over centre lock. Closing the lids with the tanks full was dif cult because the lid guides had to be forced down into the material in the tanks in order to latch the lids. The lids were equipped with weather stripping for an airtight and moisture tight seal.

The front and rear tanks each held 1339 L (37 bu) for a total capacity of 2678 L (74 bu).

Visibility: Visibility of the cultivator was unobstructed by the low pro le applicator. This was considered a desirable feature of the Morris M-600.

Maneuverability: Because of the additional pivot point at the hitch between the applicator and the cultivator, the Morris M-600, when attached to the cultivator, was dif cult to manoeuvre while backing up.

Monitoring: The test machine was not supplied with a material ow monitoring system. An indicator, visible from the tractor cab, moved up and down on an eccentric drive to indicate the front meter was operating. Material ow through the distribution tubes was not monitored. Because plugging of the distribution system was dif cult to detect from the tractor seat, it is recommended that a ow monitoring system be made available as optional equipment.

Seed and Fertilizer Boots: Two seed boots plugged with wet soil while seeding around a low lying area. No fertilizer boot plugging problems were encountered while banding fertilizer.

Cleaning: Access to the discharge side of the pegged metering rollers was possible with full tanks, by removing two access doors behind the meters. Removal of these doors required the removal of 12 wing nuts.

Each tank was equipped with a cleanout door on the right hand end of both tanks. Collector placement below these doors was dif cult due to interference with the applicator wheel and the frame. Use of these end cleanout doors was inconvenient since all material in the tanks had to be moved to the right hand side. A vacuum cleaner was required for thorough cleaning of both tanks. Access to the tanks was possible through the ller openings.

Area Meter: The Morris M-600 was equipped with a mechanical area meter. Calibrations for various machine widths were given in the operator's manual for area readings displayed in acres. The operator's manual calibration, when used with the 9.5 m (31 ft) cultivator, gave readings about 9% low. A calibration check procedure was also outlined in the operator's manual and the necessary adjustments were easily made to obtain accurate area measurement. It is recommended that the manufacturer supply the meter calibration setting for area readout in SI units.

Transporting: A distinct advantage of cultivator mounted pneumatic seeders over conventional drills, is the ease with which relatively wide machines can be transported. The Morris applicator-cultivator assembly was easily placed in transport position (FIGURE 15) in less than ve minutes. Two hydraulic cylinders raised the cultivator wings to the upright position. The metering system was conveniently engaged and disengaged with an electrically operated lockout, controlled from the tractor seat. For long distance travel or travel at high speeds, the meter drive chain should be removed. This procedure was somewhat inconvenient due to poor access to the drive chain behind the meter drive chain safety shield. For short transport distances at slow speeds, the chain could be left on and the electrically controlled meter drive clutch disengaged.

The assembly towed well in transport position. Overall transport height and width were 3.9 m (12.8 ft) and 5.9 m (19.4 ft) respectively, requiring care when transporting on public roads.

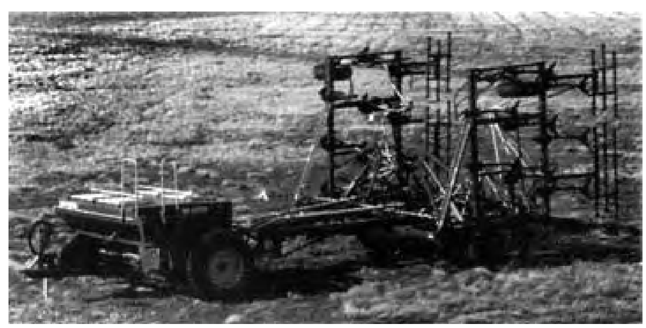

FIGURE 15. Transport Position.

EASE OF ADJUSTMENT

Lubrication: Six ttings on the applicator and 39 on the cultivator required servicing. Two wheels on the applicator and six on the cultivator required servicing. A servicing schedule was supplied in the operator's manual. Two ttings on the seed and fertilizer shaft were not supplied and access to them was inconvenient due to the meter drive shield. It is recommended that seed and fertilizer shaft tting access be improved.

Application Rate: Application rate was changed by adjusting the variable speed drive for seed and fertilizer as shown in FIGURE 16. The meter scale was adjustable from 0 to 100 in increments of one. The calibration charts in the operator's manual were not accurate for wheat and barley and no calibration was included for rapeseed. Improved calibrations for wheat and barley and a calibration for rapeseed, in both pounds per acre and kilograms per hectare, were supplied by the manufacturer at the end of the test.

The small scale divisions allowed relatively precise seeding rate adjustment. For example, in Tower rapeseed, each scale division changed seeding rate by only 1.8 kg/ha (1.6 lb/ac).

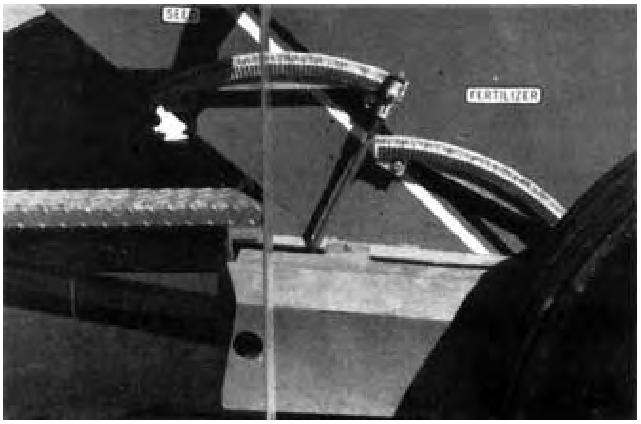

FIGURE 16. Application Rate Adjustment.

Depth Adjustment: Seeding depth was conveniently adjusted with the left wing master cylinder connected in series to the mainframe and right wing cylinders in a master-slave arrangement. An adjustable sleeve on the left wing depth cylinder could be used, without tools, to set maximum depth. As is common with series hydraulic systems, to maintain the centre and wing frames at the same height, periodic synchronization of the cylinders, by completely extending them to the fully raised position, was necessary. The Morris cultivator hitch was conveniently levelled with the hand operated turnbuckle provided. This adjustment could be made without tools and provided accurate fore-and-aft levelling in all conditions encountered. Since changing field conditions require frequent hitch height adjustments to maintain uniform seeding depth, this adjustment on the Morris M-600 was considered a desirable feature. Cultivator wing and mainframe lateral levelling was accomplished, using a wrench, by turning two threaded adjustment rods on each side of the mainframe and one on each wing frame.

RATE OF WORK

The Morris M-600 was operated at speeds of 5 to 10 km/h (3 to 6 mph). Overall best performance, in terms of weed kill and seed placement, was obtained at speeds of 8 to 10 km/h (5 to 6 mph), resulting in field work rates for the 9.5 m (31 ft) unit, ranging from 7.6 to 9.5 ha/hr (19 to 24 ac/hr). Using both tanks when seeding wheat at a rate of 85 kg/ha (75 lb/ac), about 24 ha (58 ac) could be seeded before refilling. Using only the rear tank, about 12 ha (30 ac) could be seeded before refilling. This compares to 13 to 22 ha (30 to 55 ac) between refills for most conventional drills of similar widths.

POWER REQUIREMENTS

Fan: The power requirement for the Morris M-600 fan, operating at the recommended power take-off speed of 1000 rpm and fan speed of 4600 rpm, was 4.3 kW (5.8 hp).

Draft Characteristics: Attempting to compare draft requirements of different makes of heavy duty 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 difference between makes of heavy duty cultivators. The power requirements given in TABLES 2 and 3 are based on average draft requirements of 15 makes of heavy duty cultivators in 56 different field conditions. Additional draft due to the applicator with full tanks and the mounted harrows has been included.

Tractor Size: TABLES 2 and 3 show tractor sizes needed to operate the Morris M-600 applicator, with the 9.5 (31 ft) CP-731 heavy duty cultivator, in light and heavy primary tillage. Tractor sizes have been adjusted to include tractive efficiency 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 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 primary tillage at 75 mm (3 in) depth and 8 km/h (5 mph), a 95 kW (128 hp) tractor is required to operate the seeding unit. In heavy tillage at the same depth and speed a 115 kW (154 hp) tractor is needed. Power tests with cultivators equipped with chisel points indicated that tractors suited for seeding in heavy primary tillage conditions will have ample power for banding fertilizer at depths up to 50 mm (2 in) greater than seeding depth.

TABLE 2. Tractor Size (Maximum Power Take-off Rating, kW) to Operate the Morris M-600 Applicator, with 9.5 m CP-731 Cultivator in Light Primary Tillage.

DEPTH (mm)	SPEED (km/h)					
	7	8	9	10	11	12
50	58	70	82	96	109	123
75	80	95	110	126	142	160
100	101	119	137	156	176	197
125	123	144	165	188	210	234

TABLE 3. Tractor Size (Maximum Power Take-off Rating, kW) to Operate the Morris M-600 Applicator, with 9.5 m CP-731 Cultivator in Heavy Primary Tillage.

DEPTH (mm)	SPEED (km/h)					
	7	8	9	10	11	12
50	56	65	77	89	100	115
75	98	115	133	151	169	189
100	142	164	188	212	237	263
125	185	214	244	274	305	337

OPERATOR SAFETY

The Morris M-600 tank access ladder was convenient and safe. A safety handrail was provided at the top of the ladder to gain access to the filler openings.

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 (15.7 ft) over farm land. In all three provinces, feeder lines in farmyards may be as low as 4.6 m (15 ft).

The Morris M-600 applicator with Morris CP-731 9.5 m (31 ft) cultivator was 3.9 m (12.2 ft) high in transport position, permitting safe transport under prairie power lines. However, caution should be observed if larger cultivators are used with the Morris M-600. 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 public roads. If height limits are exceeded, the operator must contact power and telephone utilities before moving.

The Morris M-600 with CP-731 cultivator was 6 m (19.4 ft) wide in transport position. This necessitated caution when towing on public roads, over bridges and through gates.

No slow moving vehicle sign was provided. It is recommended that a slow moving vehicle sign be provided as standard equipment.

Pins were provided to lock both the depth control cylinder and the wings in transport position. The Morris M-600 applicator with the CP-731 cultivator towed well at speeds up to 28 km/h (17 mph).

OPERATOR'S MANUAL

The operator's manual supplied with the Morris M-600 air flow seeder contained useful information on safety adjustments, assembly, specifications, maintenance and operation. A detailed parts list was also included in the operator's manual. The calibration charts in the operator's manual did not include a calibration for rapeseed or an accurate calibration for wheat or barley. A more accurate meter calibration chart for both Imperial and metric units was received from the manufacturer. It is recommended that the manufacturer include this new meter calibration chart in the operator's manual. A meter calibration chart printed on a decal which could be placed directly on the applicator would also be convenient for quick field reference.

DURABILITY RESULTS

TABLE 4 outlines the mechanical history of the Morris M-600 with Morris CP-731 heavy duty cultivator during 118 hours of field operation while processing about 615 ha (1520 ac). The intent of the test was evaluation of functional performance. An extended durability evaluation was not conducted.

TABLE 4. Mechanical History.

ITEM	OPERATING HOURS	EQUIVALENT FIELD AREA (ha)
ASSEMBLY		
-Three brackets were fabricated for supporting the primary distribution tubes at	beginning of test	
-The tank seals were repositioned for an air-tight seal at		
APPLICATOR		
-The fertilizer meter drive overload mechanism was replaced at	beginning of test	
-Manufacturer's changeovers were made at	beginning of test	
-The tank lid hold-down pins were repositioned to maintain placement in holders	throughout the test	
-The shear pin on the seed metering drive broke and was replaced at	40, 110	210, 575
-The rubber cushions in secondary headers were glued to the header caps at	45	235
-The meter drive clutch grease fitting was replaced with a 45 degree fitting for improved access at	60	315
-The tank partition brackets inside the tanks were rewelded at	65	340
-The fertilizer meter drive chain broke and was repaired at	65	340
-A seed boot tube was damaged and a hose end was pulled off by a large rock Both were repaired at	75	390
-The tank partition divider door was removed and refitted to prevent leakage between the tanks at	98	510
-The fertilizer meter variable drive box chain fell off and was replaced at	105	545
-Manufacturer's modifications were made at end of test -A hitch bolt was replaced at	115	600
CULTIVATOR		
-Both wing hydraulic cylinder seals were replaced at	85	445
-The left wing depth adjusting nut was lost and replaced at	85	445
-All sweeps were replaced at 87 453 -Additional adjustment holes were drilled in the harrow angle adjustment links at	100	520
-Chisel points and banding boots were installed at	106	550

DISCUSSION OF MECHANICAL PROBLEMS

ASSEMBLY

Support Brackets: Brackets were fabricated to support the primary distribution tubes on the cultivator and to prevent tube interference with the cultivator wheels (FIGURE 17) at the beginning of the test. It is recommended that some means of supporting the primary distribution tubes on the cultivator be supplied as standard equipment.

Tank Seals: The seals of both tank lids interfered with the tank cover screen edge, allowing air to leak from the pressurized tanks. The seals were repositioned to provide for an air tight tank.

APPLICATOR

Fertilizer Overload: The fertilizer meter drive overload mechanism mount was incorrectly manufactured, causing the drive to wobble while operating. This alternately tightened and loosened the drive chain as the meter rotated. The overload mechanism was replaced.

Tank Lid Pins: The tank lids were held down by swivel brackets with small rollers which locked under holders on the tanks. The rollers were held in the brackets by roll pins. These roll pins worked out of place frequently and were replaced by bolts.

Meter Drive Chains: The single bolt securing the meter drive chain idler sprocket was inadequate to keep the chains tight. Even with the bolts tight, the tensioner link swivelled around the retaining bolts. It is recommended that the manufacturer consider modifications to the chain tighteners to allow proper chain tension to be maintained.

Harrow Adjustment Links: Holes were drilled in the harrow adjustment links to allow two additional increments of harrow tine angle. These additional adjustment positions were required to allow heavy loose trash to clear the harrows while still maintaining some harrow action.

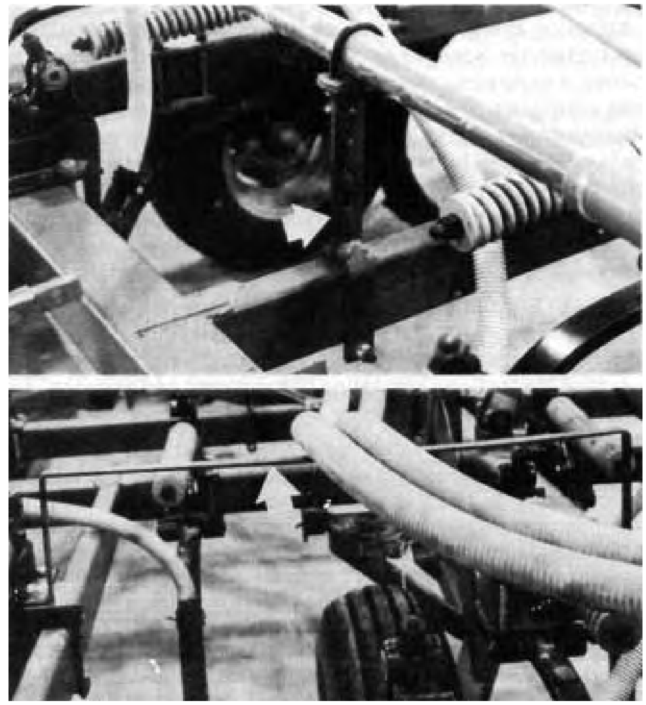

FIGURE 17. Fabricated Support Brackets.

Manufacturer's Changeovers: Manufacturer's changeovers performed during and after the evaluation period included meter drive modifications, fan gear box modification, tank lid hold-down roll pin changes and a new power take-off shaft.

APPENDIX I

SPECIFICATIONS

(A) AIR FLOW SEEDER

MAKE:	Morris Air Flow Seeder
MODEL:	M-600
SERIAL NUMBER:	80631
MANUFACTURER:	Morris Rod Weeder Co Ltd 85 York Road Yorkton, Saskatchewan S3N 2X2
DIMENSIONS:	
-width	3570 mm
-length	3790 mm
-height	2300 mm
-maximum ground clearance	250 mm
-wheel tread	3250 mm
METERING SYSTEM:	
-type	pegged rollers (pressurized tanks)
-number of meters	2
-drive	chain drive from applicator wheel
-adjustment	variable speed drive box
-transfer to openers	pneumatic conveyance through divider headers and plastic tubes
-shut off	electrically operated clutch
TANK CAPACITIES:	
-front	1339 L (37 bu)
-rear	1339 L (37 bu)
Total	2678 L (74 bu)
FAN:	
-type	straight blade centrifugal
-maximum operating speed	5000 rpm
-drive	power take off
WHEEL:	
-single wheels	1200 x 24, 6 ply
NUMBER OF LUBRICATION POINTS:	6 grease fittings 2 wheel bearings
HITCH:	
-vertical adjustment range	
-applicator	none
-cultivator	none

(B) CULTIVATOR

MAKE:	Morris
MODEL:	Magnum CP 731
SERIAL NUMBER:	81-81149
SHANKS:	
-number	31
-lateral spacing	305 mm
-trash clearance(sweep to frame)	610 mm
-number of shank rows	3
-distance between rows	
-extension to front	810 mm
-front to middle	865 and 810 mm
-rear to middle	755 and 810 mm
-shank cross section	25 x 50 mm
-shank stem angle	47 degrees
-sweep hole spacing	57 mm
-sweep bolt size	11 mm
HITCH:	
-vertical adjustment range	full range of adjustment with turnbuckle
DEPTH CONTROL:	hydraulic
FRAME:	
-cross section	100 x 100 mm
-thickness	6.4 mm
TIRES:	6, 95L x 15, 6 ply implement
NUMBER OF LUBRICATION POINTS:	39 grease fittings 6 wheel bearings
HYDRAULIC CYLINDERS:	
-depth control	4, 89 x 305 mm
-wing lift	2, 89 x 610 mm

OPTIONAL EQUIPMENT:
- -frame mounted 3 row spring tine harrows
- -4 width options ranging from 9.5 to 11.3 m

(C) OVERALL SPECIFICATIONS FOR APPLICATOR-CULTIVATOR ASSEMBLY

DIMENSIONS:	**FIELD POSITION**	**TRANSPORT POSITION**
-width	9900 mm	6000 mm
-length	10,900 mm	10,900 mm
-height	2300 mm	3850 mm
-maximum ground clearance	130 mm	130 mm
-wheel tread	8650 mm	3200 mm

WEIGHTS:	**TANKS EMPTY**	**TANKS FULL OF WHEAT**
APPLICATOR		
-hitch	350 kg	750 kg
-left wheel	700 kg	1540 kg
-right wheel	630 kg	1480 kg

CULTIVATOR (with attached harrows)	**FIELD POSITION**	**TRANSPORT POSITION**
-left mainframe wheels	1300 kg	1810 kg
-right mainframe wheels	1300 kg	1810 kg
-left wing wheel	510 kg	
-right wing wheel	510 kg	
Total, Tanks Empty	5300 kg	
Total, Tanks Full of Wheat	7390 kg	

APPENDIX II

MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

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

APPENDIX III

CONVERSION TABLE

1 hectare (ha)	= 2.5 acres (ac)
1 kilometre/hour (km/h)	= 0.6 miles/hour (mph)
1 meter (m)	= 3.3 feet (ft)
1 millimetre (mm)	= 0.04 inches (in)
1 kilowatt (kW)	= 1.3 horsepower (hp)
1 kilogram (kg)	= 2.2 pounds mass (lb)
1 newton (N)	= 0.22 pounds force (lb)
1 litre (L)	= 0.03 bushels (bu)
1 kilogram/hectare (kg/ha)	= 0.9 pounds/acre (lb/ac)
1 kilogram/hectolitre (kg/hL)	= 0.8 pounds/bushel (lb/bu)
1 kilonewton/metre (kN/m)	= 70 pounds force/foot (lb/ft)

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