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Evaluation Report 297

Leon S-45 Air Seeder

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

LEON S-45 AIR SEEDER

MANUFACTURER AND DISTRIBUTOR:

Leon's Manufacturing Co. Ltd.
135 York Road East
Yorkton, Saskatchewan
S3N 2X3

RETAIL PRICE: (March 1983, f.o.b. Yorkton, Saskatchewan).

(a) Leon S-45 air seeder complete with seed boots and distribution system to feed 36 shanks. $24,383.00

(b) Leon 36 ft (11 m) Vulcan CP-737 heavy duty cultivator complete with attached harrows. $17,598.00

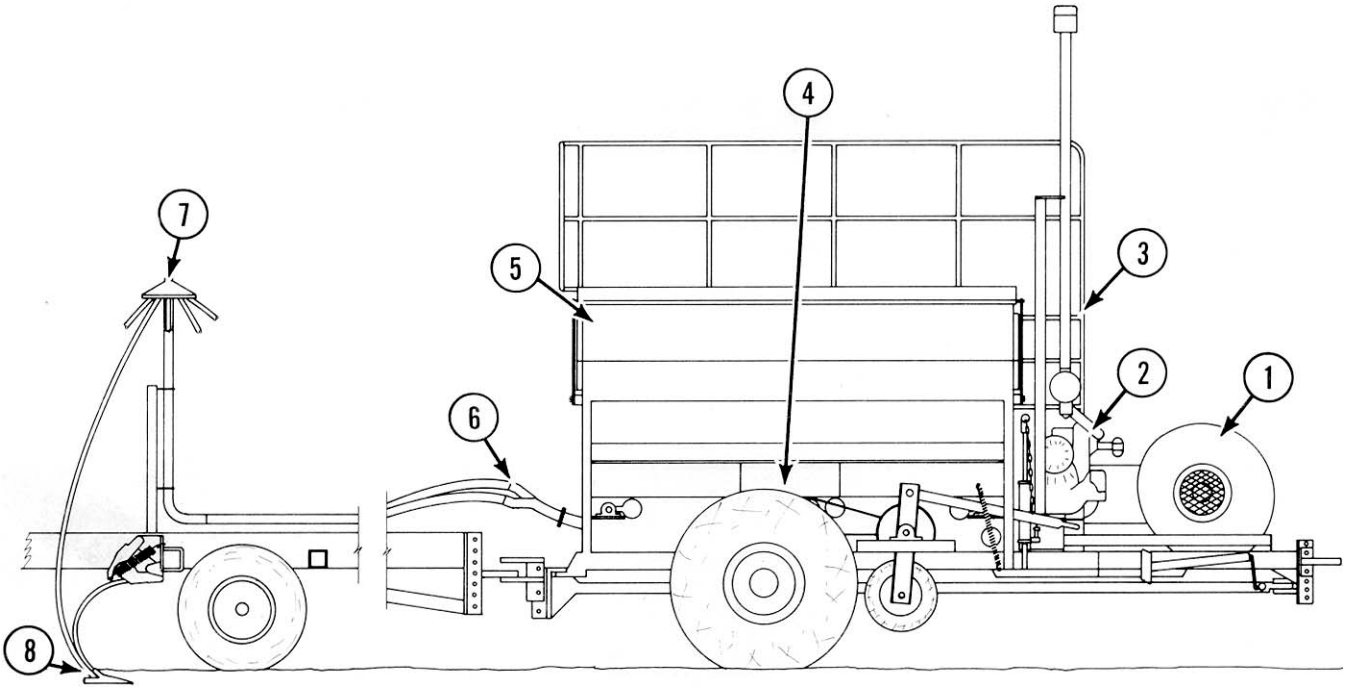

FIGURE 1. Leon S-45 Air Seeder: (1) Fan, (2) Fan Engine, (3) Ladder, (4) Metering System and Air Lock, (5) Tanks, (6) Primary Header, (7) Secondary Header, (8) Seed Boot.

SUMMARY AND CONCLUSIONS

Overall Performance: Performance of the Leon S-45 air seeder was good in all seeding conditions. Performance was very good when banding fertilizer. When operated with the 36 ft (11 m) Leon CP-737 heavy duty cultivator, the Leon S-45 was suitable for seeding and fertilizer banding in both primary and secondary field conditions. The Leon S-45 was suitable for banding fertilizer at application rates up to 300 lb/ac (337 kg/ha) at 5.5 mph (9 km/h).

Meter Calibrations: The manufacturer's metering system calibration charts were inaccurate in wheat, barley, oats, and fertilizer. The manufacturer's calibration chart for canola was fairly accurate at high seeding rates and no manufacturer's calibration chart was provided for lower rates.

Distribution Uniformity: Distribution uniformity across the seeding width, when seeding on level ground, was acceptable in wheat, barley, and oats. Distribution uniformity in fertilizer was acceptable at rates up to 300 lb/ac (340 kg/ha). Distribution uniformity was unacceptable when seeding canola.

Effect of Field Variables: Field bounce, slope and forward speed all had only a small effect on metering rates. Travelling up and down field slopes only slightly affected the distribution pattern. Field side slopes, however, had a large effect on distribution uniformity due to reduced dividing effectiveness on the primary header when operating on a sideslope.

Grain Damage: Grain damage by the metering and distribution system was within acceptable limits at normal fan speeds.

Seed Placement and Emergence: Seed placement was good in most conditions. Variation in seed depth was similar to a conventional hoe drill when measured in the same fields under the same conditions. Row spacing and seed band width behind each seed boot provided adequate windrow support providing light windrows were not laid parallel to the seeding rows. Good cultivator frame levelling was critical to obtain a uniform seeding depth and subsequent good crop emergence.

Ease of Adjustment and Operation: Seeding rate was easily adjusted. Tank and meter cleanout convenience was fair. Tank filling required the use of a drill fill or auger. Nineteen grease fittings and two wheel bearings on the applicator required greasing.

Operator visibility of the cultivator was obstructed by the tanks.

The Leon S-45 with Leon CP-737 cultivator could be placed in transport position in less than five minutes.

Rate of Work: The rate of work usually ranged from 22 to 26 ac/hr (8.9 to 10.5 ha/hr). About 82 ac (33.2 ha) could be seeded before refilling both tanks when seeding wheat at a normal seeding rate. Using only the larger rear tank, 46 ac (18.6 ha) could be seeded before refilling.

Power Requirements: Tractor size depended on soil conditions, seeding depth, ground speed, cultivator width, and soil finishing attachments. In light primary tillage, at 3 in (75 mm) depth, and 5 mph (8 km/h), a 143 hp (107 kW) tractor was needed to operate the air seeder-cultivator combination. In heavy primary tillage, at the same depth and speed, a 179 hp (134 kW) tractor was needed.

Safety: Operator care was required when operating the fan engine controls to avoid contact with the engine exhaust. The Leon S-45 was otherwise safe to operate providing normal safety precautions were observed.

Operator's Manual: The operator's manual contained useful information on safety, adjustment, assembly, maintenance and operation. Also included were useful sections on checking distribution uniformity and metering accuracy in the field.

Mechanical Problems: A number of mechanical problems occurred during the evaluation. Problems included failure of a main distribution tube connection and failure of a fan bearing.

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 charts for wheat, barley, oats and fertilizer.
3. Expanding the meter calibration chart for canola.
4. Modifications to the distribution system to improve distribution uniformity in canola.
5. Modifications to the distribution system to improve distribution in all materials when operating on sideslopes.
6. Modifications to prevent cultivator skewing in heavy conditions.
7. Modifying the tank lid to reduce the force required to open and close the lid.
8. Including a servicing schedule in the operator's manual.
9. Including a meter calibration chart in both Imperial and SI (metric) units, in the operator's manual as well as on the machine.
10. Providing protection around the fan engine exhaust, throttle and shutoff for improved operator safety.
11. Providing an improved method of draining engine oil to prevent oil spillage.
12. Modifications to prevent trash build-up on the fan inlet screen.
13. Improving quality control of monitoring system components to prevent failures due to poor assembly.

Senior Engineer: E. H. Wiens

Project Engineer: R. K. Allam

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1, 2 & 3 Leon's Mfg. Co. Ltd. agrees with PAMI's statement that actual seeding rates depend on several variables such as seed size, density, and moisture content and it is not possible to provide charts to include all the varieties of seed. The owners manual clearly states that the charts are approximate and meant as a guideline only, and explains an application rate calibration procedure using the actual seed in question. The S-45 easily lends itself to actual field calibration and we have found that most operators prefer this procedure. When so calibrated the application rate is very accurate and we are surprised that this recommended procedure was not mentioned in the report. However, in view of your findings we will investigate the charts in question and implement possible changes.

4. From the seeding rate graph provided, it appears that the primary distribution to the 6 secondary outlets is acceptably uniform, and any variation in distribution occurs in the secondary heads and headstands. In view of your findings we will investigate modifications in this area to provide increased air turbulence for more even distribution.
5. We feel that the apparent problem on sidehills occurs when the seed makes the drop from the conveyor belts to the rotary airlock, and that this would tend to be exaggerated by laboratory conditions as opposed to field conditions. In view of your findings we will investigate this problem and implement any modifications required in this area.
6. We have found the Vulcan Chisel Plow series to be very stable and resistant to side skew. However, we would feel that removing a shank from one end could result in the skew encountered in heavy draft conditions. Normally all 37 shanks would be left on the unit for seeding, and the last shank would provide an allowance for one foot of overlap when operating.
7. We feel that the large lid provided is necessary for easy auger alignment and filling. The lid is spring assisted for opening and closing, and is to some extent adjustable by tightening or loosening the springs. It is necessary, however, for the lid to be closed with enough force to prevent it coming open when the seeder is operating in a rough field. We will investigate the use of a latch to lock the lid shut and allow for easier opening and closing.
8. The owners manual for the S-45 provides information on engine service, frequency of oil changes, air filter service and frequency, valve adjustment and frequency, belt adjustment and frequency, a list of replacement parts and a list of engine service depots. It also includes information on greasing of blower bearings, and includes recommended lubricants for various conditions. The Chisel Plow Owners Manual includes information on lubrication points and frequency, maintainance, and storage. We will investigate combining all the information into one chart for easier reference.
9. All 1982 units included an application rate chart in Imperial units as a decal on the machine. However, we stress on the chart that it is meant as a guideline only and the application rate calibration procedure should be used for exact calibration. Therefore, we do not feel the S.I. measurements are required. The application rate procedure can be used in either Imperial or S.I. figures and information is provided for both systems.
10. We will investigate either providing shielding in this area or re-locating the controls away from the engine exhaust.
11. We will investigate providing a drain hole through the engine mount plate to allow the oil to fall through.
12. We will investigate a ducted screening system to eliminate this problem.
13. The monitor system tested was replaced in 1982 with a newer version from a different supplier which has been much more satisfactory.

MANUFACTURER'S ADDITIONAL COMMENT

We would like to further comment that since the introduction of the Leon S-45 Air Seeder with the Diesel Engine, which was tested by PAMI, we have developed and now also offer an S-45 P.T.O. Model (1000 R.P.M.) as an option.

GENERAL DESCRIPTION

The Leon S-45 air seeder is a pneumatic seed and fertilizer applicator designed for use with varying makes and models of cultivators.

The cultivator is attached to the rear of the applicator with the standard cultivator hitch. The applicator is supported by two wheels on a single axle.

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 from the front and rear tanks by varying the gate openings above conveyor belts. Metered material passes through an air lock before entering the airstream. The conveyor belts and air lock are driven by a meter drive wheel which engages and runs off of the right applicator wheel. An air cooled diesel engine powered fan, forces the metered material through the distribution system. The distribution system consists of a six-port primary header on the applicator feeding six, six-port secondary headers mounted on the cultivator frame. Tubes from the secondary headers connect to the seed boots.

The test machine was used with a Leon Vulcan CP-737 heavy duty cultivator with one shank removed to accommodate 36 outlets. This cultivator was 36 ft (11.0 m) wide with a 14 ft

(4.3 m) centre frame and two 11.5 ft (3.5 m) wing sections. It was equipped with 36 spring trip shanks, spaced at 12 in (305 mm), arranged in four rows. The cultivator was equippped with optional three-row mounted harrows. A tractor with two remote hydraulic controls was required to operate the Leon S-45 air seeder with the Leon CP-737 cultivator.

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

SCOPE OF TEST

The Leon S-45 air seeder was operated in loam and clay soils in the field conditions shown in TABLE 1 for approximately 150 hours while processing about 2400 ac (972 ha). It was evaluated for quality and rate of work, ease of operation and adjustment, power requirements, safety and suitability of the operator's manual.

TABLE 1. Operating Conditions

CROP	FIELD TILLAGE CONDITIONS	STONE CONDITIONS	FIELD AREA ac	(ha)	HOURS
Spring wheat on stubble	Primary	Occasional stones	400	(162)	25
Spring wheat on stubble	Secondary	Occasional stones	685	(277)	44
Spring wheat on summerfallow	Secondary	Occasional stones	320	(130)	20
Winter wheat on summerfallow	Secondary	Stone free	430	(174)	27
Banding fertilizer	Secondary	Occasional stones	350	(142)	22
Banding fertilizer	Primary	Occasional stones	215	(87)	12
Total			2400	(972)	150

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 seeding 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.

The Leon S-45 had high and low range meter drive sprockets. All evaluation work was performed with the meter drive sprockets in the low range position. The low range sprockets provided adequate meter rate adjustments for all materials used during the test.

The seed densities used by the manufacturer for meter 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, oats and fertilizer are given in FIGURES 2 to 5. PAMI's calibration curves are compared to curves based on the manufacturer's calibration charts. Considerable differences were found between the manufacturer's and PAMI's calibrations. For example, at a seeding rate of 60 lb/ac (67 kg/ha), PAMI's measured rates were 50% higher than the manufacturer's calibration in wheat and 95% higher than the manufacturer's calibration in barley. At a seeding rate of 45 lb/ac (50 kg/ha), the measured rate was 100% higher than the manufacturer's indicated rate in oats. At an application rate of 26 lb/ac (29 kg/ha), PAMI's measured rate in 11-51-00 fertilizer was 73% higher than the manufacturer's indicated rate while at an application rate of 103 lb/ac (116 kg/ha) the measured rate was 41% higher than the manufacturer's indicated rate. It is recommended that the manufacturer provide improved metering calibration charts for wheat, barley, oats and fertilizer.

[1]Detailed Test Procedures for Air Seeders.

The calibration curves for canola are given in FIGURE 6. The manufacturer's meter calibration chart for canola did not include rates below 7.4 lb/ac (8.3 kg/ha). At application rates from 7.4 to 12.5 lb/ac (8.3 to 14.0 kg/ha) the manufacturer's calibration for canola was fairly accurate. It is recommended that the manufacturer provide an expanded chart for lower application rates in canola.

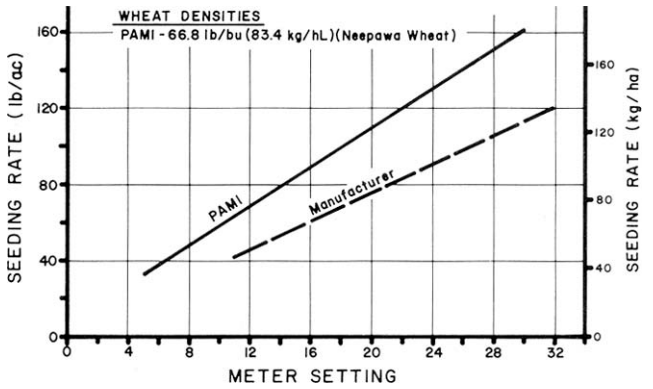

FIGURE 2. Metering Accuracy in Wheat.

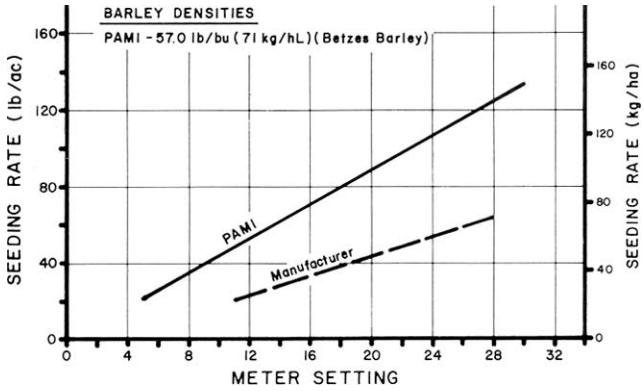

FIGURE 3. Metering Accuracy in Barley.

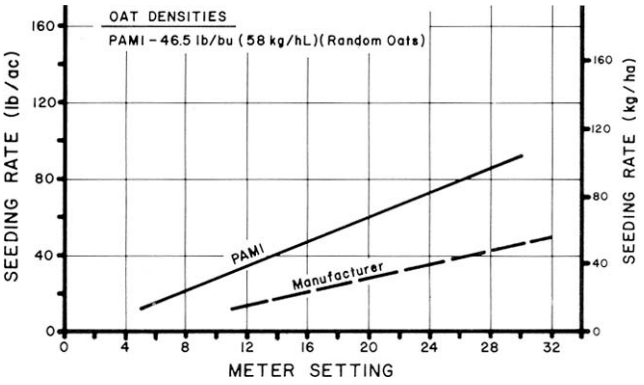

FIGURE 4. Metering Accuracy in Oats.

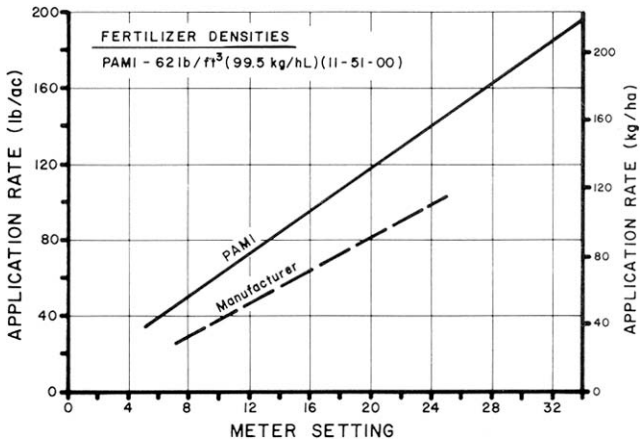

FIGURE 5. Metering Accuracy in Fertilizer.

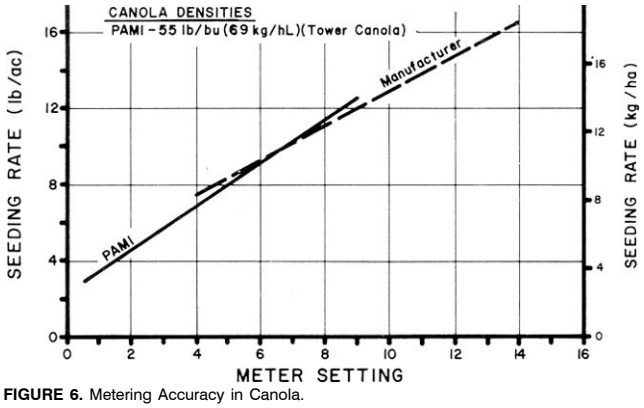

FIGURE 6. Metering Accuracy in Canola.

Operating on slopes had only a minor effect on metering rates. For example, when operating on a 10 degree side hill the metering rate changed by up to 6% with wheat or fertilizer. An increase in ground speed from 3 to 7.5 mph (5 to 12 km/h) decreased the metering rate by up to 8% for wheat or fertilizer. No meter drive wheel slippage with the Leon S-45 occurred. Field bounce had little effect on metering rates.

Distribution Uniformity: FIGURE 7 gives seeding distribution uniformity for the Leon S-45 in wheat, barley and oats. Distribution was uniform over the full range of seeding rates at a fan speed of 3000 rpm. For example, at a seeding rate of 75 lb/ac (85 kg/ha), the coefficient of variation[2] (CV) was 6% for wheat and barley and 9% for oats. FIGURE 8 shows a typical seeding distribution pattern obtained in wheat at a seeding rate of 75 lb/ac (85 kg/ha). The application rate from each shank across the width of the air seeder varied from 66 to 86 lb/ac (74 to 97 kg/ha). This resulted in acceptable distribution uniformity with a CV of 6%.

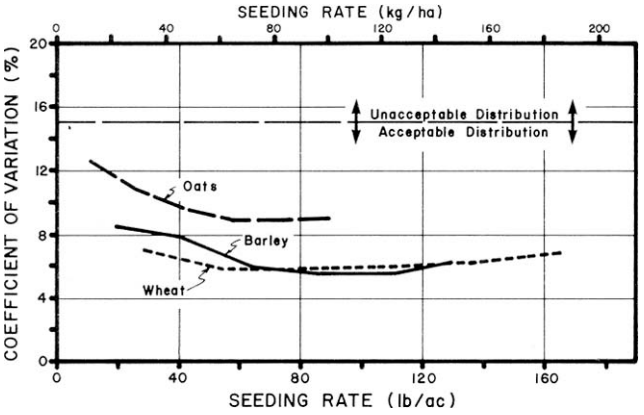

FIGURE 7. Distribution Uniformity in Cereal Grains Over a Range of Seeding Rates at 5.5 mph (9 km/h) at a Fan Speed of 3000 rpm.

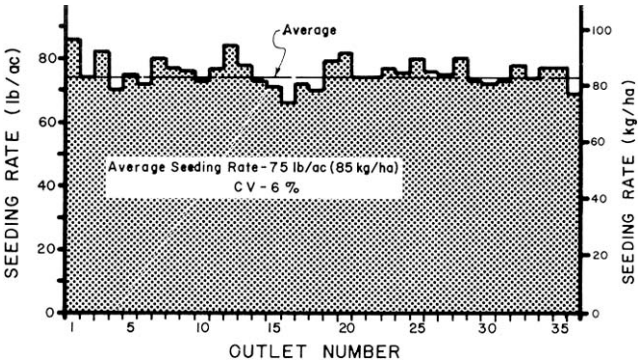

FIGURE 8. Distribution Uniformity Pattern in Wheat at 75 lb/ac (85 kg/ha) at a Fan Speed of 3000 rpm.

[2]The coefficient of variation (CV) is the standard deviation of seeding rates from individual shanks expressed as a percent 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.

FIGURE 9 shows a typical distribution pattern obtained in canola at a seeding rate of 9 lb/ac (10 kg/ha) at a fan speed of 2000 rpm. The application rate across the width of the air seeder varied from 6 to 15 lb/ac (7 to 17 kg/ha) which resulted in unacceptable distribution uniformity with a CV of 23%. Although decreasing the fan speed to 1500 rpm resulted in the CV decreasing by about 2%, canola distribution patterns were unacceptable over the full range of fan speeds and metering rates, with CV's ranging from 21 to 26% (FIGURE 10). It is recommended that modifications be made to the distribution system to improve distribution uniformity in canola.

Distribution uniformity in 11-51-00 fertilizer was acceptable at fan speeds of 3000 and 3400 rpm for metering rates up to 300 lb/ac (337 kg/ha), with CV's ranging from 9 to 14% (FIGURE 11). At higher rates uniformity became unacceptable with CV's from 16 to 18%.

Changes in distribution pattern uniformity could occur at different forward speeds or for different machine widths due to different volumes of material being introduced into the constant volume of air supplied by the fan.

Changes in fan speed had only a small effect on distribution patterns. Operating up or down a 10 degree slope also had only a small effect on distribution uniformity. However, when operating on a 10 degree sideslope, the distribution uniformity became unacceptable when applying seed or fertilizer. For example, on level ground the CV obtained in wheat at a seeding rate of 75 lb/ac (85 kg/ha) was 6% (FIGURE 8) while on a 10 degree sideslope, the CV increased to 25% (FIGURE 12). This large increase in CV was due to reduced dividing effectiveness of the primary header when operating on a sideslope. A similar increase in CV was obtained when applying fertilizer on a 10 degree sideslope. It is recommended that modifications be made to the Leon distribution system to improve distribution uniformity in all materials when operating on sideslopes.

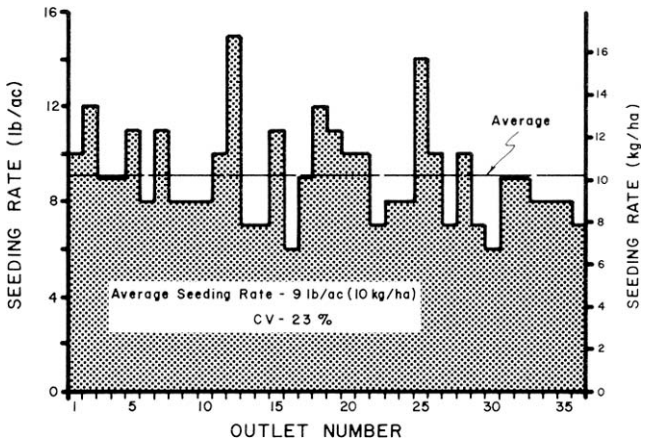

FIGURE 9. Distribution Uniformity Pattern in Canola at 9 lb/ac (10 kg/ha) at a Fan Speed of 2000 rpm.

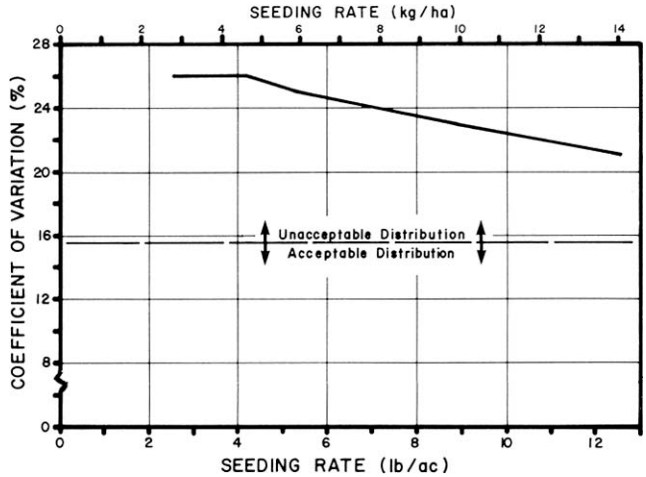

FIGURE 10. Distribution Uniformity in Canola Over a Range of Seeding Rates at 5.5 mph (9 km/h) at a Fan Speed of 2000 rpm.

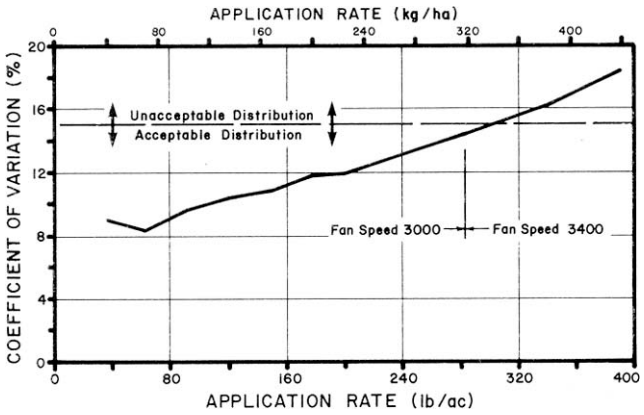

FIGURE 11. Distribution Uniformity in Fertilizer Over a Range of Application Rates at 5.5 mph (9 km/h) at Two Fan Speeds.

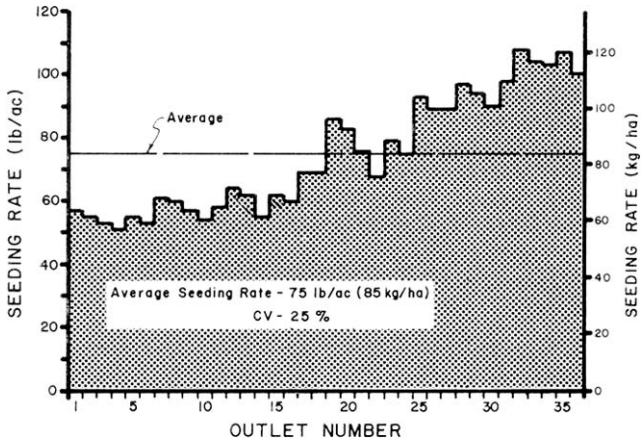

FIGURE 12. Distribution Uniformity Pattern in Wheat at 75 lb/ac (85 kg/ha) on a 10 Degree Sideslope at a Fan Speed of 3000 rpm.

Grain Damage: Grain damage by the metering and distribution system was within acceptable limits for cereal grains and canola at fan speeds below 3000 and 2500 rpm, respectively. For example, in dry Neepawa wheat at 11% moisture content and a fan speed of 3000 rpm, only 0.5% crackage occurred. In dry canola, with a moisture content of 7%, crackage at a fan speed of 2500 rpm was 1.0%. Reducing fan speed to 2000 rpm reduced canola crackage to 0.1%.

Seed Placement: Each seed boot was equipped with a V-shaped spreader (FIGURE 13) 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 3 to 5 in (75 to 127 mm) (FIGURE 14). With 12 in (305 mm) cultivator shank spacing, distances between rows varied from 7 to 9 in (178 to 229 mm). This row spacing provided adequate windrow support providing light crops were laid across the rows rather than parallel to them.

Although most seeds were 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 2.2 in (55 mm), seeding depth across the width of the machine varied from 1.4 to 3.7 in (35 to 95 mm) with most of the seeds being placed within 0.6 in (15 mm) of the average cultivator sweep working depth. This compares to seed being placed from 0.5 to 0.6 in (12 to 15 mm) 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.

Seed placement was not adversely affected by field tillage conditions. The shanks on the Leon CP-737 cultivator were sufficiently rigid to maintain a fairly uniform sweep pitch (FIGURE 16), with resultant uniform tillage depth, over a wide range of tillaqe conditions.

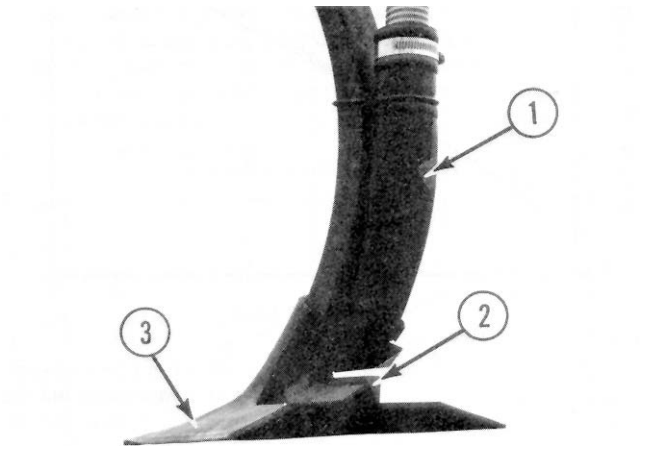

FIGURE 13. Leon Seed Boot: (1) Seed Boot, (2) V-shaped Spreader, (3) Sweep.

Plant Emergence: As with most seeding implements, time and uniformity of plant emergence depended on seedbed preparation, soil moisture and seed placement. The Leon S-45 was used to seed in a number of fields with different types of seedbed preparation. Uniform emergence resulted as long as machine settings were carefully adjusted to place seed in moist soil at the correct depth and providing loose seedbeds were packed after seeding. FIGURE 14 shows good wheat emergence when wheat was seeded into a pre-worked stubble field.

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.

FIGURE 14. Uniform Wheat Emergence in Pre-worked Stubble (Upper: 25 Days After Seeding, Lower: At Harvest).

Seeding Depth: It is very important to seed deep enough to obtain uniform seed coverage. Correct cultivator adjustments for air 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 2 in (50 mm) 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 Leon CP-737 cultivator was equipped with optional three-row mounted harrows. The mounted harrows were effective in smoothing the soil surface and in breaking soil lumps. The harrows also increased weed kill by loosening weeds.

The Leon S-45 with CP-737 cultivator was not equipped with packers. Since it was considered essential to pack most fields seeded with the Leon, 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 1.0 to 1.2 in (25 to 30 mm). 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 overpacking the seedbed. FIGURE 15 shows a typical seedbed after seeding into stubble, both before and after use of the packer drawbar.

FIGURE 15. Leon Seedbed. (Upper: Before Packing, Lower: After Packing).

Shank Characteristics: The Leon CP-737 cultivator was equipped with spring-trip shank holders. During the evaluation, it was used with 16 in (406 mm) wide McKay sweeps with a 50 degree stem angle, giving a no-load sweep pitch of 1 degree. These shanks were very suitable for seeding since sweep pitch (FIGURE 16) varied only 4 degrees over the full range of draft (drawbar pull) 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.

The shank trip began to release and shank force decreased at drafts greater than 753 lb/ft (11 kN/m). Tripping occurred well beyond the normal primary tillage draft range, indicating the Leon CP-737 was well suited for heavy primary tillage.

The shanks performed well in stony fields. Maximum lift height to clear obstructions was 10.2 in (258 mm).

Penetration: When equipped with 50 degree, 16 in (406 mm) sweeps, penetration was very good in most field conditions and it was easy to obtain correct seeding depth. Correct seeding depth could not be obtained in hard conditions such as dry, baked slough bottoms or in fields with abnormally hard furrow bottoms. Penetration was uniform across the cultivator width provided all depth control linkages and hitch height were kept properly adjusted.

[3]See Machinery Institute Reports No. 277 and 304.

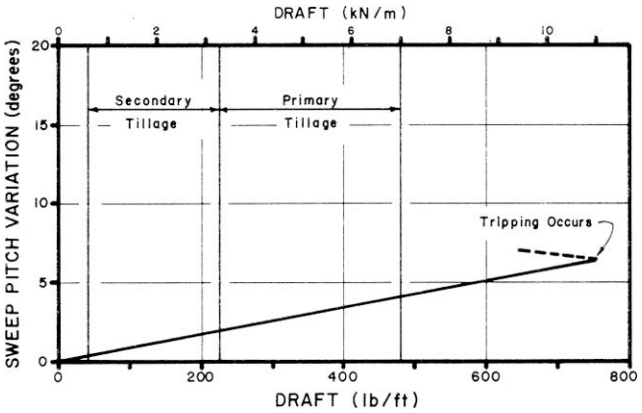

FIGURE 16. Sweep Pitch Variation over a Normal Range of Draft with 12 in (305 mm) Shank Spacing.

The cultivator wheels were positioned so that each centre section wheel supported about 15% of the total cultivator weight while each wing wheel supported about 10%. In addition, each centre wheel supported about 13% of the total suction force while each wing wheel supported about 12%. Cultivator or air seeder sinking was not a problem in moderately soft soils. Since the air 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 Leon CP-737 cultivator had very good trash clearance. In heavy, loose trash it was necessary to either raise the mounted harrows or release the tine angle adjustment to allow trash to clear the harrows.

With the harrows properly 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 Leon air seeder and CP-737 cultivator combination was usually stable. However, sideways skewing occurred in some conditions. The cultivator shank pattern was not symmetrical due to the removal of the outermost left shank, made necessary to accommodate 36 air seeder openings on a 37 shank cultivator. When equipped with 16 in (406 mm) sweeps, the cultivator had to skew more than 2.5 degrees to miss weeds. In heavy draft areas, such as those encountered in primary field conditions, the cultivator would tend to skew sideways from 2 to 5 degrees. This would allow weeds to be missed when seeding in some conditions. It is recommended that the manufacturer consider modifications to prevent cultivator skewing in heavy draft (drawbar pull) conditions.

Reasonable care had to be observed on steep hillsides due to the high centre of gravity of the applicator, especially with full grain and fertilizer tanks.

Weed Kill: Weed kill, in conditions other than those described above, was very good when equipped with 16 in (406 mm) sweeps. The 12 in (305 mm) shank spacing resulted in 4 in (100 mm) 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 Leon S-45 could be used for two types of fertilizer applications. 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 with the V-shaped seed boot spreaders removed (FIGURE 17), 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 1.5 in (35 mm) below seed depth to twice seeding depth is desirable for fall fertilizer application. This requires the use of chisel points to obtain sufficient depth and minimize soil disturbance and special boots to minimize fertilizer spreading.

The Leon S-45 worked well for fertilizer banding. Fertilizer granules were placed in a band about 1 in (25 mm) wide. Vertical fertilizer distribution generally ranged from chisel tip depth to 0.4 in (10 mm) above chisel tip depth. Wider fertilizer bands were obtained in lumpy soil conditions and as the chisel points became worn.

The Leon S-45 fan provided adequate air to allow both front and rear meters to be opened fully while distributing 11-51-00 fertilizer with the meter drive sprockets in low range. When using both meters, at a maximum fan speed of 3400 rpm, a maximum rate of 392 lb/ac (440 kg/ha) was possible with the 36 ft (11 m) cultivator at 5.5 mph (9 km/h). When using the front or rear tank only, fertilizer rates of 196 lb/ac (220 kg/ha) were possible. With the meter drive sprockets i n high range, at the same ground speed, a maximum application rate of only 225 lb/ac (255 kg/ha) was possible due to air lock plugging at the higher air lock speed.

Banding suitability at 5.5 mph (9 km/h) was reduced for application rates greater than 300 lb/ac (337 kg/ha) due to unacceptable distribution uniformity at higher rates. Higher application rates, with acceptable distribution uniformity, could be obtained by reducing ground speed. For example, the application rate could be increased from 300 to 340 lb/ac (337 to 382 kg/ha) by decreasing forward speed from 5.5 to 5 mph (9 to 8 km/h).

When exposed to driving rain, some moisture entered the tanks, causing fertilizer to cake. The metering system should be checked after rainfall for any caking of fertilizer to avoid errors in application rates. To prevent corrosion, all unprotected components should be cleaned and oiled periodically when applying fertilizer.

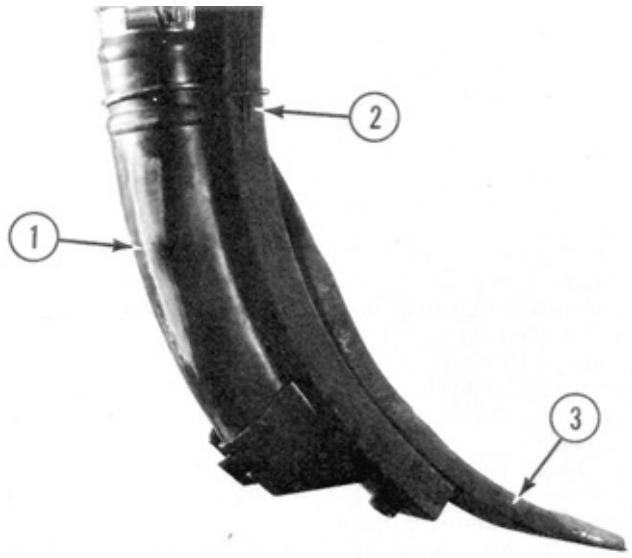

FIGURE 17. Leon Banding Boot: (1) Banding Boot, (2) Cultivator Shank, (3) Chisel Point.

EASE OF OPERATION

Dual Purpose Operation: The Leon S-45 could be detached from the cultivator by two men in about one hour. The secondary headers and hoses had to be removed from the cultivator, allowing the cultivator to be used as a dual purpose machine, both for seeding and seasonal tillage.

Hitching: The Leon S-45 air seeder 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 coupler for the electronic monitoring system.

Filling: A drill fill or grain auger was needed to fill the applicator tanks. Because the filler openings were located 6.7 ft (2.0 m) above the ground, hand filling was difficult as it necessitated carrying the grain or fertilizer up the access ladder. The large 23 x 43 in (584 x 1092 mm) front tank opening and 71 x 43 in (1800 x 1092 mm) rear tank opening gave ample room for auger filling. The filler lid was mounted on over-centre hinges (FIGURE 18), requiring a force of about 65 lb (290 N) to push the lid open (over centre) and about 135 lb (600 N) to close the lid. The considerable force required to open and close the filler lid was inconvenient for some operators. The lid was not equipped with weather stripping to prevent moisture entry. It is recommended that the manufacturer consider reducing the tank lid opening and closing force requirement.

The front tank held 46 bu (1673 L) while the rear tank held 60 bu (2182 L).

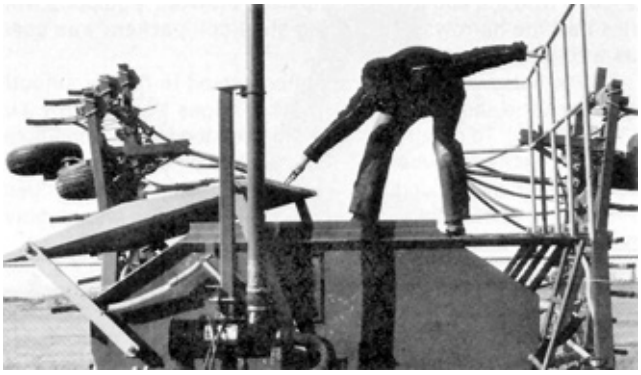

FIGURE 18. Operator Closing Tank Lid.

Visibility: Visibility of the cultivator mainframe section was obstructed by the tanks. Care had to be observed when operating the Leon S-45 to detect possible problems such as mainframe plugging.

Maneuverability: Because of the additional pivot point at the hitch between the applicator and the cultivator, the Leon S-45 air seeder, when attached to the cultivator, was difficult to maneuver while backing up.

Monitoring: The Leon S-45 air seeder was supplied with an electronic material flow sensor system and area meter. The monitoring system was easy to use. The flow sensors monitored material flow at each secondary header location. Therefore, primary tube blockage or metering stoppage was easily identified from the operator station. Although the monitoring system was convenient, individual secondary header outlet tube blockage could go unnoticed due to the location of the monitoring sensors. The Leon S-45 monitoring system required operator care to maintain correct wire placement along the seeder and the cultivator and to avoid wire damage.

Seed and Fertilizer Boots: The Leon seed and fertilizer boots tended to plug in wet conditions encountered around low lying field areas. When operating in wet conditions it was necessary to periodically check for plugged seed boots because the monitoring system did not detect individual seed boot blockage.

Cleaning: Both front and rear meters were accessbile without emptying the tank. Tank side cleanout doors were provided for both tanks. However, the tanks did not emply completely and required material to be moved to the cleanout door. Because the cleanout doors were located about 2 in (51 mm) above the bottom of the tanks, a vacuum cleaner was required for thorough cleaning. Access to the tanks was possible through the tank filler openings by removal of the tank opening screens. The screens could be removed without tools.

Area Meter: The Leon S-45 air seeder was equipped with an electronic area meter. The meter could easily be calibrated to measure area in either acres or hectares. When adjusted according to the manufacturer's setting for hectares, the area meter read about 7% high and when adjusted for readout in acres the meter read about 11% high.

Transporting: A distinct advantage of cultivator mounted air seeders over conventional drills is the ease with which relatively wide machines can be transported. The Leon S-45 and Leon CP-373 cultivator were easily placed in transport position (FIGURE 19) in less than five minutes. Two hydraulic cylinders raised the cultivator wings to the upright position. The meter drive wheel lift cylinder was connected with the cultivator lift

cylinders and was automatically disengaged when the cultivator was raised.

The assembly towed well in transport position. Overall transport height and width were 14.4 ft (4.4 m) and 21.8 ft (6.6 m), respectively, requiring care when travelling on public roads.

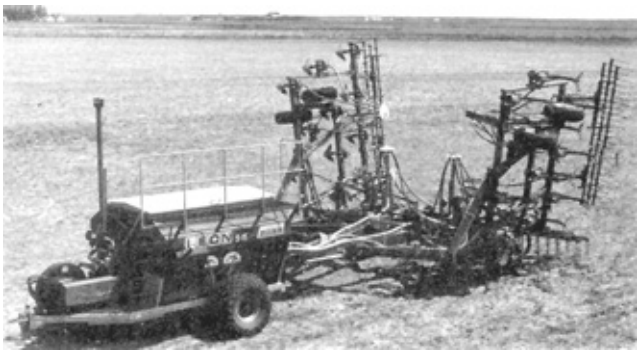

FIGURE 19. Transport Position.

EASE OF ADJUSTMENT

Lubrication: Lubrication was convenient with good access to all grease fittings. Nineteen fittings on the applicator and four on the cultivator required servicing. Two wheels on the applicator and eight on the cultivator required servicing. A servicing schedule was not supplied in the operator's manual. It is recommended that a servicing schedule be included in the operator's manual.

Engine Servicing: The engine was positioned for convenient access. The recommended oil change interval for the engine was 100 hours. The oil drain was located above the flat engine mount surface (FIGURE 21). When draining the engine oil there was no means of catching the oil and preventing oil spillage. It is recommended that the manufacturer consider modifications to provide for convenient draining and collecting of oil from the fan engine.

Engine fuel consumption was about 0.45 gal/hr (2.04 L/hr). The engine could run about 26 hours on one filling of the 11.7 gal (53 L) tank.

Application Rate: Application rate for both tanks was easily changed by loosening a lock bolt and adjusting a lever for the amount of gate opening above the conveyor belts (FIGURE 20). An adaptor with a small opening could be bolted in place to provide a finer adjustment for small grains such as canola. The gate opening adjustment was calibrated in increments of 0.5 from 1 to 34. Calibration charts, in pounds per acre, were given on a separate typewritten sheet. Adjusting for precise seeding rates was easy due to relatively small scale divisions. For example, in Tower canola with the adaptor bolted in place, each 0.5 scale increment changed the seeding rate by only 0.6 lb/ac (0.7 kg/ha).

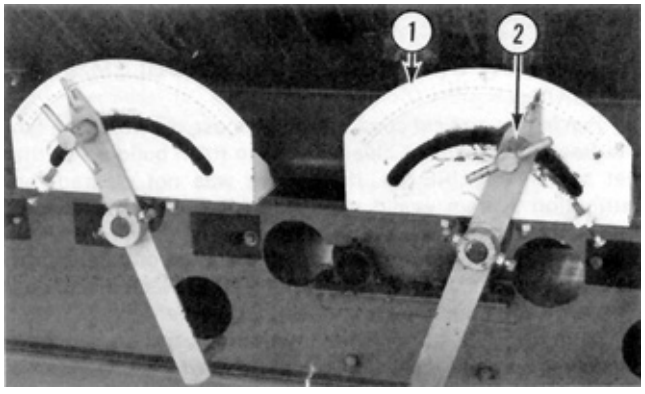

FIGURE 20. Application Rate Adjustment: (1) Gate Opening Indicator, (2) Lock Bolt.

Depth Adjustment: Seeding depth was conveniently adjusted with the right wing master cylinder connected in series to the mainframe and left wing cylinder in a master-slave arrangement. An adjustable sleeve on the right wing depth cylinder could be used to set maximum depth. A wrench was needed to position the depth stop. 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 Leon cultivator was levelled by positioning the hitch stop bolts in one of five positions. The cultivator hitch on the rear of the applicator could also be placed in one of two positions. The applicator hitch height could be adjusted by placing the hitch link in one of six positions. Cultivator wing and mainframe levelling was accomplished, using a wrench, by turning threaded connectors on each depth cylinder linkage. Levelling adjustments were adequate to suit all field conditions encountered throughout the evaluation.

RATE OF WORK

The Leon S-45 was operated at speeds ranging from 3 to 6 mph (5 to 10 km/h). Overall best performance in terms of weed kill and seed placement was obtained at speeds of 5 to 6 mph (8 to 10 km/h). This resulted in field work rates for the 36 ft (11 m) unit ranging from 22 to 26 ac/hr (8.9 to 10.5 ha/hr). Using both tanks when seeding wheat at a rate of 75 lb/ac (85 kg/ha), about 82 ac (33.2 ha) could be seeded before refilling. Using only the larger rear tank, about 46 ac (18.6 ha) could be seeded before refilling. This compares to 41 to 62 ac (16.6 to 25.1 ha) between refills for most conventional drills of similar widths.

POWER REQUIREMENTS

Draft Characteristics: Attempting to compare draft (drawbar pull) 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. Variations 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 Leon S-45 applicator with full tanks and the mounted harrows has been included.

Tractor Size: TABLES 2 and 3 show tractor sizes needed to operate the Leon S-45 applicator and Leon CP-737 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 3 in (75 mm) depth and 5 mph (8 km/h), a 143 hp (107 kW) tractor is required to operate the seeding unit. In heavy tillage at the same depth and speed a 179 hp (134 kW) 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 2 in (50 mm) greater than seeding depth.

TABLE 2. Tractor Size (Maximum Power Take-off Rating, hp (kW)) to Operate the Leon S-45 Applicator, with 36 ft (11 m) Leon CP-737 Cultivator in Light Primary Tillage.

DEPTH		SPEED mph (km/h)							
in	(mm)	4	(6.4)	5	(8)	6	(9.6)	7	(11.2)
2	(50)	77	(57)	104	(78)	136	(101)	170	(127)
3	(75)	108	(81)	143	(107)	182	(136)	224	(167)
4	(102)	139	(104)	182	(136)	229	(171)	279	(208)
5	(127)	170	(127)	221	(165)	275	(205)	333	(248)

TABLE 3. Tractor Size (Maximum Power Take-off Rating, hp (kW)) to Operate the Leon S-45 Applicator, with 36 ft (11 m) Leon CP-737 Cultivator in Heavy Primary Tillage.

DEPTH		SPEED mph (km/h)							
in	(mm)	4	(6.4)	5	(8)	6	(9.6)	7	(11.2)
2	(50)	74	(55)	100	(75)	130	(97)	162	(121)
3	(75)	137	(102)	179	(134)	224	(167)	272	(203)
4	(102)	200	(149)	257	(192)	318	(237)	382	(285)
5	(127)	262	(195)	337	(251)	413	(308)	492	(367))

OPERATOR SAFETY

The Leon tank access ladder was convenient and safe. A safety handrail was provided beside the access ladder and along the upper walkway.

The fan engine fuel shut-off was located on the side of the engine (FIGURE 21). After prolonged periods of use, the shut-off became very hot and difficult to operate without some form of insulation between the operator's hand and the engine. The engine exhaust system was also located so that the operator had to reach under the exhaust to operate the engine throttle and shut-off. It is recommended that modifications be made to provide protection around the engine shut-off, throttle and exhaust for improved operator safety.

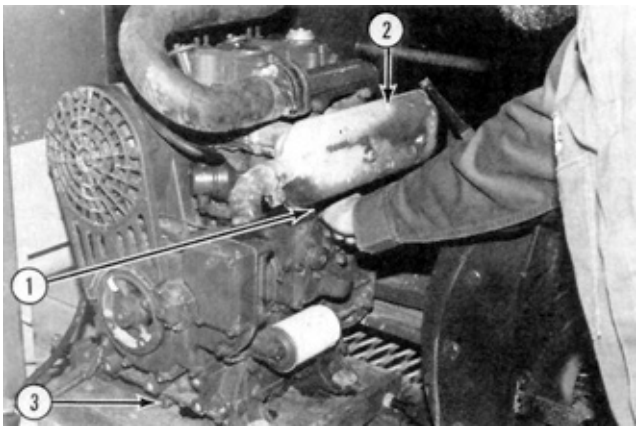

FIGURE 21. (1) Engine Throttle and Shut-off, (2) Exhaust, (3) Oil Drain Plug.

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 17 ft (5.2 m) over farm land or over secondary roads. In Alberta and Manitoba, the neutral ground wire may be as low at 15.7 ft (4.8 m) over farm land or over secondary roads. In all three provinces, feeder lines in farmyards may be as low as 15 ft (4.6 m).

The Leon S-45 applicator with Leon 36 ft (11 m) CP-737 cultivator was 14.4 ft (4.4 m) high in transport position, permitting safe transport under prairie power lines. However, larger models of cultivators may be high enough to contact prairie power lines. The legal responsibility for safe passage under utility lines rests with the machinery operator and not with the power utility or the 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 Leon S-45 with Leon CP-737 cultivator was 21.8 ft (6.6 m) wide in transport position. This necessitated caution when towing on public roads, over bridges and through gates.

A slow moving vehicle sign was provided on the rear of the applicator for transport. Pins were provided to lock the cultivator wings in transport position. Two mainframe depth cylinder stops could be placed around the cylinder shafts to lock the cultivator in the raised position.

The Leon S-45 applicator with Leon CP-737 cultivator, towed well at speeds up to 17 mph (28 km/h).

Total engine and fan noise level at the tractor hitch point was about 95 dbA. This increased the operator station noise level in most modern tractor cabs by only 2.2 dbA. For example in one tractor cab, operator station noise level was 74.0 dbA with only the tractor operating and 76.2 dbA with the tractor and pneumatic applicator operating. Suitable ear protectors should be worn if the tractor is not equipped with an appropriate cab.

OPERATOR'S MANUAL

The operator's manual for the Leon S-45 air seeder contained useful information on safety, maintenance, assembly and operation. The manual also included a useful section on application rate calibration and on testing distribution uniformity. A detailed parts list was also included. No metering calibration chart was included in the operator's manual. A calibration chart, in pounds per acre, was printed on a separate typewritten sheet. It is recommended that the manufacturer consider supplying a meter calibration chart, in both Imperial and SI (metric) units, in the operator's manual as well as on the machine for easy field reference.

DURABILITY RESULTS

TABLE 4 outlines the mechanical history of the Leon S-45 air seeder with Leon CP-737cultivator during 150 hours of field operation while processing about 2400 ac (972 ha). 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 ac	FIELD AREA (ha)
APPLICATOR			
- The fan motor voltage regulator was replaced at	beginning of test		
- The fan air inlet collected loose trash	throughout the test		
- The flow monitoring system ceased functioning correctly due to a faulty switch at	13. 15	200, 240	(81, 97)
- A loose fuel line on the fan engine was tightened at	24	385	(156)
- A seed boot plugged with moist soil at	24, 125. 130, 142	385, 2000, 2080, 2270	(156. 810 842, 919)
- Two broken main distribution tube bolts were replaced at	24	385	(156)
- The metering conveyor belt alignment was adjusted at	31, 50 110	500, 800 1775	(202, 324 719)
- The monitoring system stopped working due to two faulty sensors. The sensors were replaced at	67	1070	(433)
- The distribution system plugged with seed and fertilizer due to a plugged fan inlet at	67	1070	(433)
- A meter drive engagement hydraulic cylinder fitting was replaced due to leakage at	78	1250	(506)
- The fan speed readout on the monitoring system ceased functioning due to a poor connection. The connection was repaired at	90	1440	(583)
- The main distribution tube connection to the air lock broke. The tube and air lock were replaced at	108	1730	(700)
- The outer bearing on the fan shaft failed and was replaced at	142	2270	(919)
- Two fertilizer boot lower brackets bent due to rock damage and were straightened at	144. 148	2300, 2370	(931, 960)
CULTIVATOR			
The master depth cylinder was replaced due to leaking seals at	85	1200	(486)
- All sweeps were replaced at	89	1425	(577)
- One cultivator hitch bolt fell out and was replaced at	92	1470	(595)
- Chisel points and banding boots were installed at	116	1835	(743)

DISCUSSION OF MECHANICAL PROBLEMS

APPLICATOR

Fan Inlet: In field conditions with loose dry trash, the fan inlet frequently required cleaning due to trash build-up on the inlet screen (FIGURE 22). If the inlet was not cleared the distribution system would plug after prolonged use due to restricted air flow. The amount of material build-up on the fan inlet could probably be reduced by installation of a delfector. It is recommended that the manufacturer consider modifications to prevent trash buildup on the fan inlet screen.

Monitoring System: The monitoring system stopped functioning correctly due to a poorly assembled electrical switch on the control box which fell apart after a short period of field use. The switch on a replacement control box also fell apart for the same reason. It is recommended that the manufacturer ensure correct assembly of monitoring components to prevent monitoring system failures.

Main Distribution Tube: The main distribution tube was connected to the air lock by a number of spot welds. These welds

broke loose allowing metered material to blow out around the broken connection and onto the ground. The air lock and tube was replaced and no more problems were encountered throughout the remainder of the evaluation period.

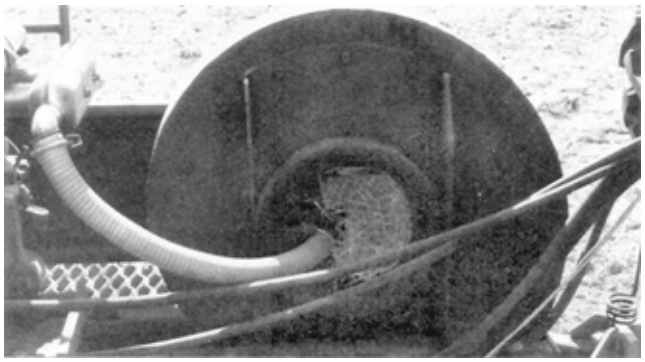

FIGURE 22. Fan Inlet Plugged with Trash.

APPENDIX I

SPECIFICATIONS

(A) AIR SEEDER

MAKE:	Leon Air Seeder
MODEL:	S-45
SERIAL NUMBER:	81-1011
MANUFACTURER:	Leon's Manufacturing Co. Ltd. 135 York Road East Yorkton, Saskatchewan S3N 2X3
DIMENSIONS:	
- width	8.2 ft (2500 mm)
- length	12.0 ft (3658 mm)
- height	9.4 ft (2865 mm)
- maximum ground clearance	1.0 ft (305 mm)
- wheel tread	6.8 ft (2073 mm)
METERING SYSTEM:	
- type	slide door over conveyor
- number of meters	2
- drive	chain from meter drive wheel off right applicator wheel
- adjustment	vary gate opening above conveyor belt two conveyor speed ranges
- airstream loading	air lock
- transfer to openers	pneumatic conveyance through divider headers and hoses
TANK CAPACITIES:	
- front	46 bu (1673 L)
- rear	60 bu (2182 L)
Total	106 bu (3855 L)
FAN:	
- type	straight blade centrifugal
- make	Chicago Blower
- model	2T-15-16
- maximum operating speed	3400 rpm
- drive	triple V-belt
ENGINE:	
- make	Lombardini Air Cooled 4-Stroke Diesel
- model	L20
- serial number	1938276
- power rating	18 hp (13.2 kW) at 2200 rpm
- starting system	12-volt electric
- fuel tank capacity	11.7 gal (53 L)
WHEELS:	
- single wheels	2, 18.4 x 26, 10-ply
NUMBER OF LUBRICATION POINTS:	19 grease fittings 2 wheel bearings
HITCH:	
- vertical adjustment range	
- applicator	9-1/4 in (235 mm), 6 positions
- cultivator	8 in (203 mm), 2 positions

(B) CULTIVATOR

MAKE:	Leon Heavy Duty Cultivator
MODEL:	CP-737
SERIAL NUMBER:	7171-108
MANUFACTURER:	Leon's Manufacturing Co. Ltd. 135 York Road East Yorkton, Saskatchewan S3N 2X3
SHANKS:	
- number	36
- lateral spacing	12 in (305 mm)
- trash clearance (sweep to frame)	24.6 in (625 mm)
- number of shank rows	4
- distance between rows	18, 32, 40 in (457, 813, 1016 mm)
- shank cross section	1 in x 2 in (25 x 50 mm)
- shank stem angle	51 degrees
- sweep hole spacing	2-1/4 in (57 mm)
- sweep bolt size	7/16 in (11 mm)
HITCH:	
- vertical adjustment range	9.8 in (249 mm), 5 positions
DEPTH CONTROL:	hydraulic
FRAME:	
- cross section	4 x 4 in (102 x 102 mm)
- thickness	1/4 in (6.4 mm)
TIRES:	8, 9.5L - 15, 8-ply
NUMBER OF LUBRICATION POINTS:	four
HYDRAULIC CYLINDERS:	
- main depth control	1, 4 x 8.5 in (102 x 216 mm) 1, 4 x 7.75 in (102 x 197 mm)
- wing frame cylinders	1, 4.5 x 7.5 in (114 x 190 mm) 1, 3.5 x 9 in (89 x 229 mm)
- wing lift	2, 4 x 24 in (102 x 610 mm)

OPTIONAL EQUIPMENT:

- frame mounted 3-row spring tine harrows
- four width options ranging from 31 to 37 ft (9.4 to 11.3 m)

(C) OVERALL SPECIFICATIONS FOR APPLICATOR-CULTIVATOR ASSEMBLY

DIMENSIONS:	**FIELD POSITION**	**TRANSPORT POSITION**
- width	37.0 ft (11,278mm)	21.8 ft (6645 mm)
- length	38.5 ft (11,735 mm)	38.5 ft (11,735 mm)
- height	12.0 ft (3658 mm)	14.4 ft (4389 mm)
- maximum ground clearance	5.0 in (127 mm)	5.0 in (127 mm)
- wheel tread	30.6 ft (9327 mm)	10.4 ft (3170 mm)
- effective seeding width	36.0 ft (19,973 mm)	

WEIGHTS:	**TANKS EMPTY**	**TANKS FULL OF WHEAT**
APPLICATOR		
- hitch	1290 lb (586 kg)	1870 lb (850 kg)
- left wheel	2000 lb (909 kg)	4820 lb (2191 kg)
- right wheel	2040 lb (927 kg)	4730 lb (2150 kg)
CULTIVATOR (WITH ATTACHED HARROWS)	**FIELD POSITION**	**TRANSPORT POSITION**
- left centre tandem wheels	3300 lb (1500 kg)	5000 lb (2273 kg)
- right centre tandem wheels	3150 lb (1432 kg)	5250 lb (2386 kg)
- left wing tandem wheels	1900 lb (864 KG)	
- right wing tandem wheels	1900 lb (864 kg)	
Total, Tanks Empty	15,580 lb (7802 kg)	
Total, Tanks Full of Wheat		21,670 lb (9850 kg)

APPENDIX II

MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

excellent
very good
good
fair
poor
unsatisfactory

APPENDIX III

CONVERSION TABLE

acres (ac) x 0.40	= hectares (ha)
miles/hour (mph) x 1.61	= kilometres/hour (km/h)
inches (in) x 25.4	= millimetres (mm)
feet (ft) x 0.305	= metres (m)
horsepower (hp) x 0.75	= kilowatts (kW)
pounds (lb) x 0.45	= kilograms (kg)
pounds force (lb) x 4.45	= newtons (N)
bushels (bu) x 36.4	= litres (L)
pounds/bushel (lb/bu) x 1.25	= kilograms/hectolitre (kg/hL)
pounds force/foot (lb/ft) x 0.015	= kilonewtons/metre (kN/m)

ALBERTA FARM MACHINERY RESEARCH CENTRE
3000 College Drive South
Lethbridge, Alberta, Canada T1K 1L6
Telephone: (403) 329-1212
FAX: (403) 329-5562
http://www.agric.gov.ab.ca/navigation/engineering/afmrc/index.html

Prairie Agricultural Machinery Institute
Head Office: P.O. Box 1900, Humboldt, Saskatchewan, Canada S0K 2A0
Telephone: (306) 682-2555

Test Stations:
P.O. Box 1060
Portage la Prairie, Manitoba, Canada R1N 3C5
Telephone: (204) 239-5445
Fax: (204) 239-7124

P.O. Box 1150
Humboldt, Saskatchewan, Canada S0K 2A0
Telephone: (306) 682-5033
Fax: (306) 682-5080