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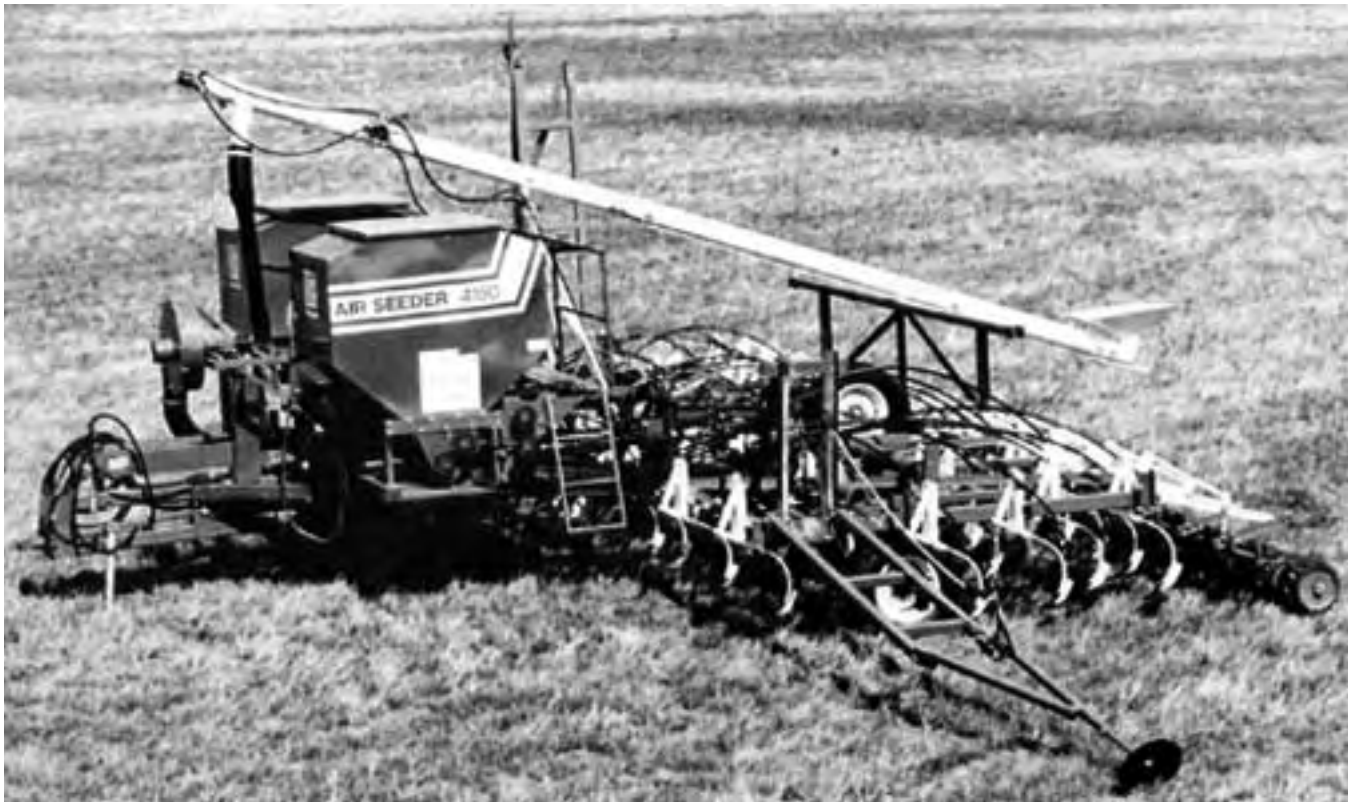
Evaluation Report 220



Wil-Rich 4150 Air Seeder

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

WIL-RICH 41 50 AIR SEEDER

MANUFACTURER AND DISTRIBUTOR:

Wil-Rich, Inc.
P.O. Box 1013Wahpeton, North Dakota 58075
U.S.A.

RETAIL PRICE: (January, 1981, f.o.b. Lethbridge)

a. Wil-Rich Model 4150 eld cultivator air seeder complete with 27-foot cultivator, air seeder, 3-bar harrow (12" teeth) and tires	$20,554.00
b. Auger ll option for above	$1,114.88
c. Marker option for above	$1,442.18
d. Packer wheel option in lieu of 3-bar harrow	$2,192.58

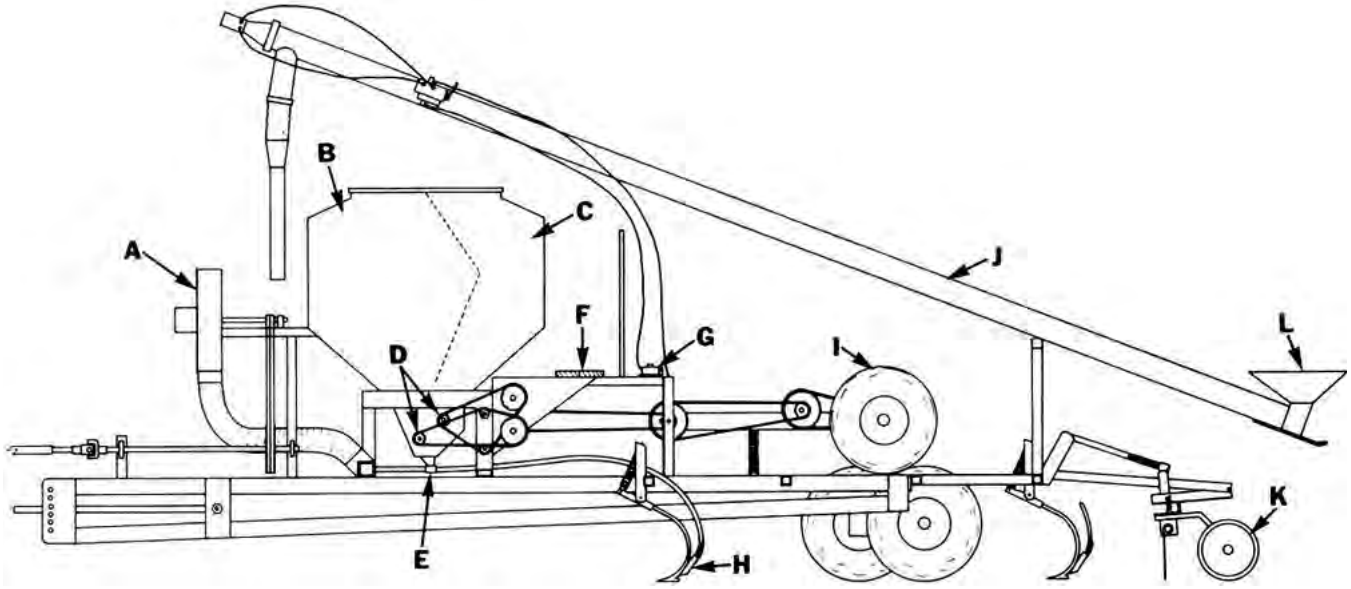


FIGURE 1. Wil-Rich 4150 Air Seeder: (A) Fan, (B) Grain Tank Compartment, (C) Fertilizer Tank Compartment, (D) Metering Rollers, (E) Divider Cups, (F) Tank Access Walkway, (G) Hydraulic Control Valves, (H) Seed Boot, (I) Meter Drive Wheel, (J) Filler Auger, (K) Packers, (L) Hopper.

SUMMARY AND CONCLUSIONS

Overall functional performance of the Wil-Rich 4150 air seeder with 8.4 m (27.4 ft) eld cultivator was very good in all secondary seeding conditions. Seeding or banding fertilizer in primary eld conditions is not recommended due to the light duty characteristics of the Wil-Rich eld cultivator. The air seeder, if mounted on a heavy duty cultivator, would be suitable for banding fertilizer at application rates up to about 300 kg/ha (270 lb/ac).

Seed placement was good in most pre-worked elds. Variation in seed depth depended on depth of tillage and was similar to seed depth variation with a conventional hoe drill when seeding at 50 mm (2 in). Seed depth variation increased slightly when seeding at depths of 50 to 75 mm (2 to 3 in). The 40 to 70 mm (1.6 to 2.8 in) seed band width, with 180 mm (7 in) shank spacing, provided good windrow support in all conditions. Good cultivator frame levelling was critical in obtaining a uniform seed depth and subsequent good emergence.

The manufacturer's metering system calibrations were fairly accurate in wheat, barley, oats, rapeseed and fertilizer. The Wil-Rich 4150 gave very uniform seed and fertilizer distribution across the machine width at all application rates.

Level of material in the tanks, eld bounce and slope all had little effect on metering rates or on distribution uniformity. Increasing ground speed, slightly reduced the fertilizer metering rate.

Seeding rate adjustment was inconvenient and required about 10 minutes with wrenches. Tank and meter cleanout was inconvenient. Tank lling was convenient when using the optional ller auger. Twenty-nine grease ttings on the applicator required greasing every other day while 47 ttings on the packer wheels required daily greasing.

The Wil-Rich 4150 with 8.4 m (27.4 ft) Wil-Rich eld cultivator and mounted packers could be placed in transport position in less than ve minutes.

Rate of work usually ranged from 6.5 to 8.1 ha/hr (16 to 20 ac/hr). About 26 ha (65 ac) could be seeded before re lling all compartments on both tanks when seeding wheat at a normal seeding rate.

Tractor size depended on soil conditions, seeding depth, cultivator width and soil nishing attachments. In light secondary tillage, at a 75 mm (3 in) depth and 8 km/h (5 mph), an 81 kW (109 hp) tractor was needed to operate the applicator-cultivator-packer combination. In heavy secondary tillage, at the same depth and speed, a 106 kW (142 hp) tractor was needed.

The optional marker was very convenient for aligning the seeder on subsequent rounds. Marker operation convenience was reduced due to poor lowering characteristics, marker pan bearing failure and marker arm shear bolt failure.

The operator's manual contained useful information on safety, adjustment, maintenance and operation. A number of minor mechanical problems occurred during evaluation.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modi cations to the metering system to allow lower seeding rates in rapeseed.
2. Providing, as optional equipment, a monitoring system to monitor material ow.
3. Providing cleanout doors for convenient cleanout of the rear tank compartment.
4. Supplying meter calibrations and land area measurement in SI units.
5. Modi cations to the marker system to improve lowering characteristics.
6. Modi cations to the power take-off safety shield to provide improved access to the grease ttings.
7. Providing a slow moving vehicle sign as standard equipment.
8. Providing an improved method of attaching the seed boot tubes to the seed boot brackets,
9. Providing improved marker pan bearings and larger outer marker section shear bolts.
10. Providing improved packer axle bushings and access to bushing grease ttings.

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THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. An optional sprocket is now available which decreases seed rate by 50%. This sprocket can be used for very low seed or herbicide rates, as well as solid seeded sun owers.
2. Material ow monitoring equipment which can be adapted to the air seeder is presently available from several agricultural electronics manufacturers.
3. Improved accessibility to the rear tank compartment is under consideration.
4. Meter calibration in SI units are available on request. Owners manuals supplied with the acre meters describe proper procedures for calibration in SI units.
5. The restrictors in the marker circuit are sized to prevent excessive speed of operation on all tractors. Once all mechanical explanations for slow operation of markers (i.e. interference between marker and mounting bracket) have been ruled out, restrictor size can be increased slightly to improve operating characteristics. A cutting torch tip cleaner is recommended to keep from getting the hole too large.
6. Recent redesign of the power take-off system to improve operating characteristics include access to all grease ttings.
7. Consideration will be given to providing slow moving vehicle sign brackets.
8. Revised mounting clips along with improved assembly instructions have nearly eliminated problems with tube to bracket mounting,
9. Marker section shear bolts have been enlarged. Marker discs with pan bearings have been 100% replaced both in the eld and on new production with a new design which utilizes a hub and spindle assembly and bolt-on marker disc.
10. Packer sections have been 100% replaced both in the eld and on new production with a new design utilizing agricultural quality triple-sealed roller bearings to replace the bushings. Lubrication is no longer required.

MANUFACTURER'S ADDITIONAL COMMENTS

The metering panel has been redesigned. High and low range drive shafts are now both available externally to facilitate quicker changeover.

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

GENERAL DESCRIPTION

The Wil-Rich 4150 is a pneumatic seed and fertilizer applicator designed for use with several models of Wil-Rich cultivators. The air seeder components mount directly on the cultivator frame. Seed and fertilizer are pneumatically distributed from two tanks, each with two separate compartments, through a network of tubes to seed boots attached to the rear of each cultivator shank. The applicator can be used for seeding or combined seed and fertilizer application.

Seed and fertilizer are metered through rubber metering rollers mounted below each tank compartment, while a power take-off driven fan forces the metered material through the distribution system. The distribution system consists of plastic divider cups, mounted below the metering rollers, connected to each shank seed boot by individual distribution tubes. The tank compartment divider can be removed and a diverter plate installed to enable metering of only one material.

The applicator components were mounted on a Wil-Rich model 13 FCW 8.4 m (27.4 ft) eld cultivator with a 4.0 m (13 ft) centre frame and two 2.2 m (7.2 ft) wing sections. It was equipped with 47 spring cushioned shanks, spaced at 180 mm (7 in), arranged in four rows. The air seeder was equipped with Optional mounted packers, optional ller auger, and optional markers and an electronic area meter.

Detailed speci cations for the complete air seeder are given in Appendix I while FIGURE 1 shows the location of major components.

SCOPE OF TEST

The Wil-Rich 4150 was operated in light loam soils in the eld conditions shown in TABLE 1 for approximately 178 hours while seeding about 1035 ha (2556 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.

TABLE 1. Operating Conditions

CROP	FIELD TILLAGE CONDITIONS	STONE CONDITIONS	FIELD AREA (ha)	HOURS
Durum wheat on summerfallow	Secondary	Moderately stony	40	7
Durum wheat on stubble	Secondary	Occasional stones	35	6
Spring wheat on summerfallow	Secondary	Occasional stones	125	22
Spring wheat on stubble	Secondary	Occasional stones	125	22
Winter wheat on summerfallow	Secondary	Stone free	8	2
Flax on stubble	Secondary	Stone free	150	26
Flax on summerfallow	Secondary	Occasional stones	95	16
Mustard on summerfallow	Secondary	Occasional stones	225	36
Barley on summerfallow	Secondary	Occasional stones	60	10
Barley on stubble	Secondary	Occasional stones	170	30
Rapeseed on summerfallow	Secondary	Stone free	2	1
TOTAL			1035	178

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 indicated in the manufacturer's charts. Research has, however, shown that small variations in seeding rates will not signi cantly affect grain crop yields.

The metering rollers on the front tank compartments were for metering seeds and were made of a softer rubber material than the rear metering rollers, which were designed for metering fertilizer. The difference in roller material resulted in a difference between front and rear meter calibrations. Therefore, the metering systems could not be used interchangeably for one material without using different sprocket ratios for each set of metering rollers.

Two metering ranges were available. Calibration curves in high range for wheat, barley, and oats, using the front metering rollers, are given in FIGURES 2 to 4. At a seeding rate of 80 kg/ha (70 lb/ac), actual rates were 19% lower than indicated in wheat, 5% higher than indicated in barley and 14% lower than indicated in oats.

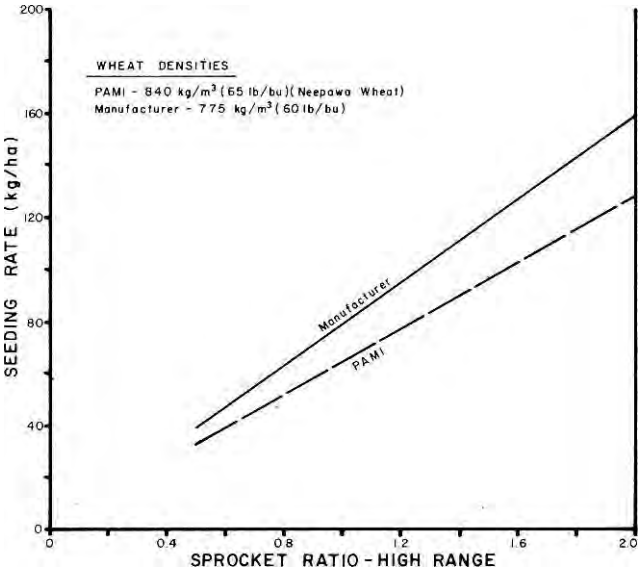

FIGURE 2. Metering Accuracy in Wheat - High Range.

FIGURE 5 shows the calibration curves while metering rapeseed, using the front metering rollers, in low range. At a seeding rate of 7 kg/ha (6.2 lb/ac), the actual rate was 7% higher than

[1]PAMI T773 "Detailed Test Procedures for Grain Drill"

indicated. The minimum obtainable seeding rate in rapeseed was about 4 kg/ha (3.6 lb/ac). At this setting, the actual rate was 20% higher than indicated.

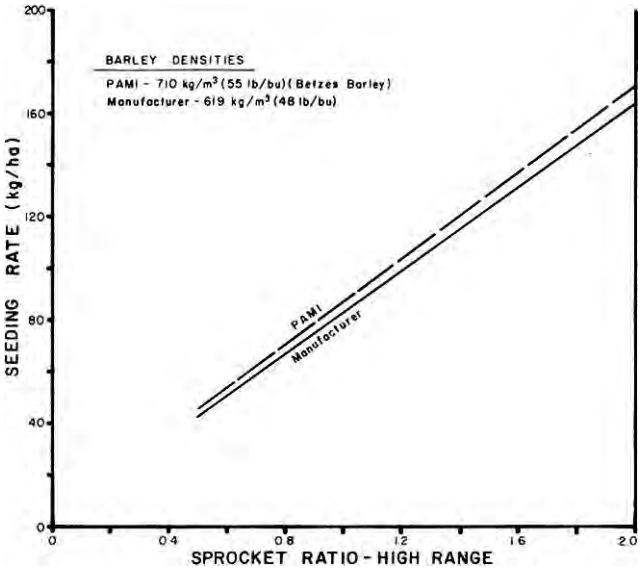

FIGURE 3. Metering Accuracy in Barley - High Range.

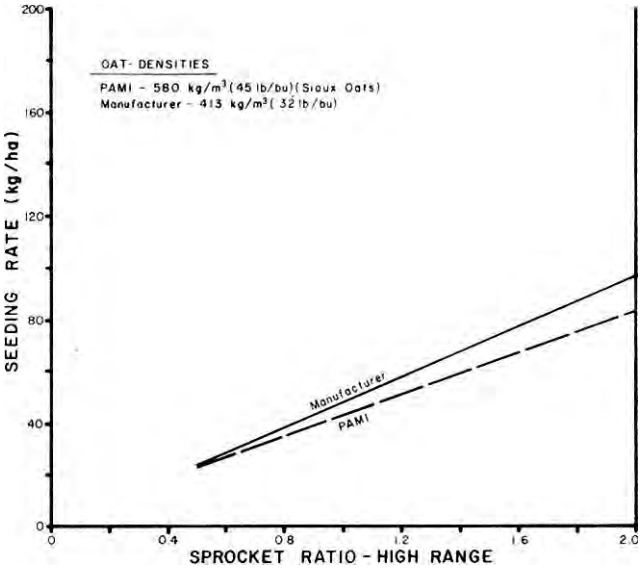

FIGURE 4. Metering Accuracy in Oats - High Range.

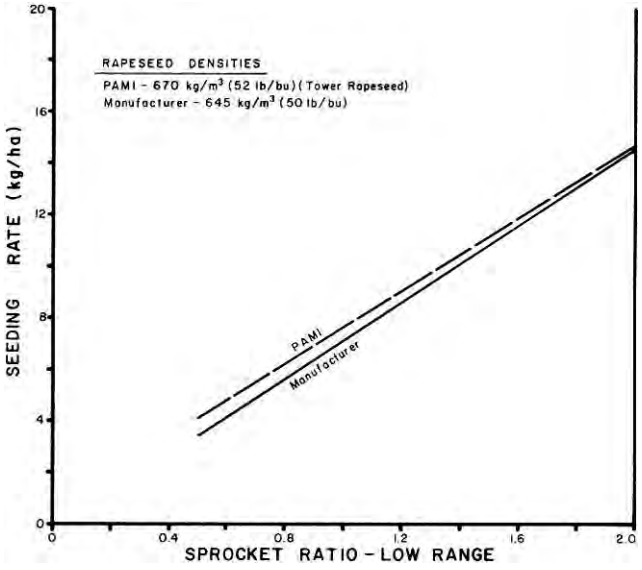

FIGURE 5. Metering Accuracy in Rapeseed - Low Range.

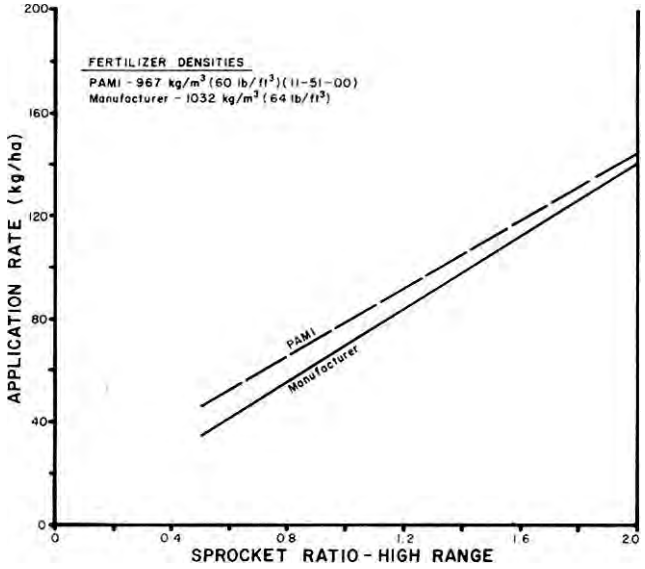

FIGURE 6. Metering Accuracy in Fertilizer - High Range.

Since low seeding rates are commonly required for rapeseed, it is As is shown in FIGURE 6, actual fertilizer application rates, in recommended that the manufacturer consider modi cations to allow high range, using the rear metering rollers, varied from 30% high at seeding rates lower than 4 kg/ha (3.6 lb/ac). Low application rates to 3% high at high application rates.

Level of grain or fertilizer in the tanks, eld slope and eld vibration all had little effect on application rate. Increasing ground speed from 4.8 km/h (3 mph) to 12 km/h (7.5 mph) decreased application rate with fertilizer by 6.5%. Changes in ground speed had little effect when metering wheat. The metering rolls were ground driven. Meter drive wheel slippage was insigni cant in soft elds.

Seed Distribution Uniformity: Metered material was divided into individual seed cups for each cultivator shank as it fell from the rollers. Therefore, distribution uniformity was determined before material entered the air stream. FIGURE 7 gives seeding distribution uniformity for the Wil-Rich 4150 in wheat, barley and oats. Distribution was very 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 4.4% in wheat and barley and 5.1% in oats. Seeding distribution in rapeseed was very uniform with a CV of 3% at all seeding rates.

FIGURE 8 shows distribution uniformity in 11-51-00 fertilizer with a CV ranging from 6.2 to 9.3% over the complete range of application rates.

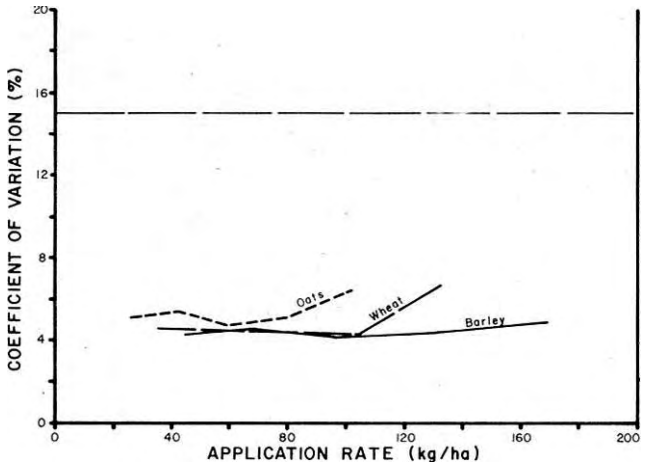

FIGURE 7. Seeding Uniformity in Cereal Grains at 8 km/h.

[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.

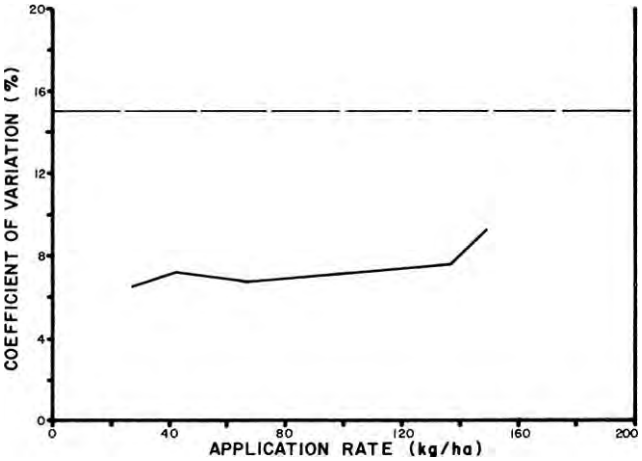

FIGURE 8. Seeding Uniformity in 11-51-00 Fertilizer at 8 km/h

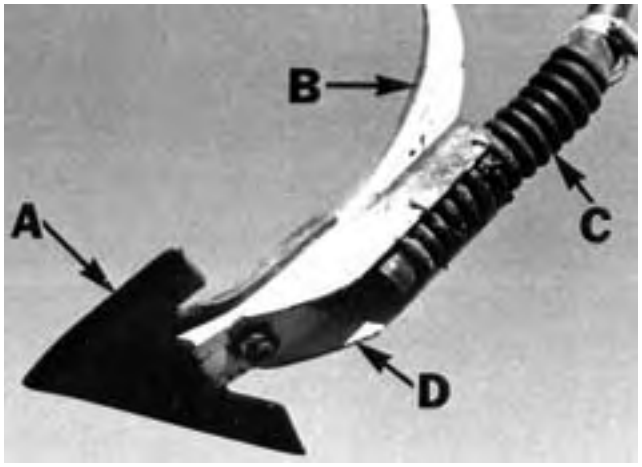

FIGURE 9. Wil-Rich Seed Boot: (A) Sweep, (B) Shank, (C) Seed Boot, (D) Boot Attachment.

Grain Damage: Grain damage by the metering and distribution system was well within acceptable limits. For example, in dry Neepawa wheat at 10.5% moisture content, only 0.2% crackage occurred.

Seed Placement: The Wil-Rich seed boot (FIGURE 9) provided very little spreading behind the cultivator sweep. Plants emerged in distinct rows in band widths ranging from 40 to 70 mm (1.6 to 2.8 in) (FIGURE 11). With the 180 mm (7 in) cultivator shank spacing, distances between rows varied from 110 to 140 mm (4.3 to 5.5 in). This row spacing provided adequate windrow support in all conditions.

Vertical seed distribution depended on eld tillage conditions. The light duty shanks on the Wil-Rich eld cultivator were not suf ciently rigid to maintain a uniform sweep pitch throughout the full range of soil forces encountered in all secondary tillage conditions. Normal secondary tillage forces frequently exceeded shank spring preload at tillage depths greater than 50 mm (2 in) (FIGURE 13). On level and gently rolling elds, when seeding in secondary tillage conditions at less than a 50 mm (2 in) depth, most seeds were placed within 12 mm (0.5 in) of the working depth of the bottom of the cultivator sweep. When seeding in secondary tillage conditions at depths between 50 to 75 mm (2 to 3 in), most seeds were placed within 18 mm (0.7 in) of the working depth. In elds 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 eld cultivator than on a hoe drill.

A broadcast bracket (FIGURE 10) was available to broadcast seeds, granular chemicals or fertilizer on top of the ground. A small plot of rapeseed was seeded using the broadcast brackets. At a tillage depth of 50 mm (2 in), seeds were scattered across the width at depths ranging from 0 to 45 mm (0 to 1.8 in). Seeds which fell behind the shanks were placed deeper than those beside the shanks. This method of seeding is not recommended in dry conditions.

Plant Emergence: As with most seeding implements, time and uniformity of plant emergence depended on seedbed preparation, soil moisture and seed placement. The Wil-Rich was used to seed in a number of elds with different types of seedbed preparation. In all instances, uniform emergence resulted as long as the seed was placed in moist soil and the soil was packed after seeding. FIGURE 11 shows good wheat emergence when wheat was seeded into pre-worked summerfallow.

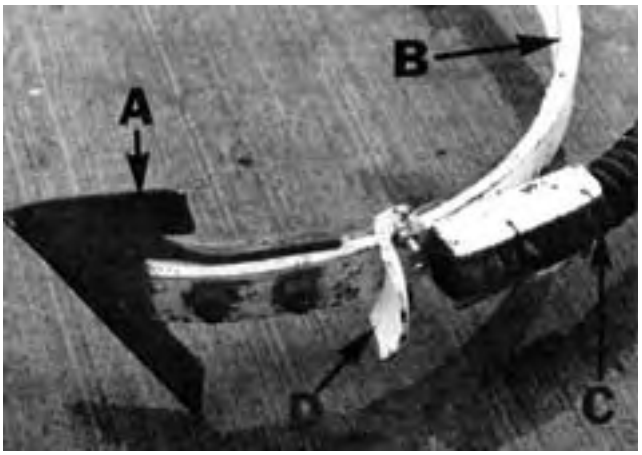

FIGURE 10. Wil-Rich Broadcast Bracket: (A) Sweep, (B) Shank, (C) Seed Boot, (D) Spreader.

Careful cultivator frame levelling was important in obtaining uniform emergence across the cultivator width. Improper sideways levelling and fore-and-aft levelling can result in rows of shanks operating at different depths.

Seeding Depth: It was 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 25 mm (1 in) is not recommended for a eld cultivator, due to poor seed coverage and generally poor cultivator performance at shallow tillage depths.

FIGURE 11. Wheat Emergence (Upper: 30 Days after Seeding, Lower: 78 Days after Seeding).

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

Soil Finishing: Tests were conducted with both optional three row mounted harrows and with optional mounted packers. The mounted harrows were effective in smoothing the soil surface and in breaking soil lumps. The harrows also increased weed kill by loosening weeds. Both the ground pressure and tine angle were adjustable to suit varying conditions.

The Wil-Rich mounted packers, when substituted for the mounted harrows, were effective in compacting the soil and levelling the surface, leaving packer ridges from 25 to 50 mm (1.0 to 2.0 in). FIGURE 12 shows a typical seedbed after seeding into summerfallow. The single row of tine harrows located in front of the packers were less effective than the three-row mounted harrows. The harrows were adjustable for height and tine angle. The packers could be adjusted to obtain a ground pressure comparable to steel spiral packers.

FIGURE 12. Typical Seedbed into Summerfallow (Left: Unseeded, Right: Seeded, Far Left: Marker Trail).

Shank Characteristics: The Wil-Rich eld cultivator was equipped with adjustable spring cushioned shank holders. During the evaluation it was used with 190 mm (7.5 in) wide Wil-Rich sweeps with a stem angle of 47 degrees, giving a no-load sweep pitch of 5 degrees. Sweep pitch (FIGURE 13) varied 12 degrees over the range of draft normally expected in secondary tillage conditions.

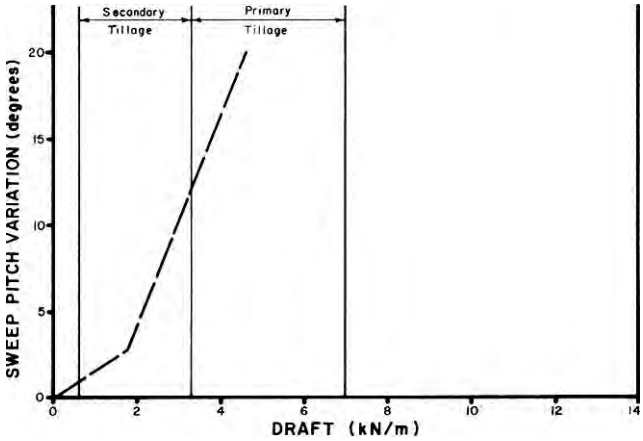

FIGURE 13. Sweep Pitch Variation over a Normal Range of Draft (180 mm Shank Spacing).

Cushioning spring preload was exceeded at drafts greater than 1.8 kN/m (125 lb/ft), occurring midway in the range of normal secondary tillage. This shows that the Wil-Rich eld cultivator is suitable only for light secondary tillage. In heavy secondary tillage, sweep pitch became excessive, resulting in non-uniform tillage depth and furrow bottom ridging.

The shanks performed well in stony elds. Maximum lift height to clear obstructions was 330 mm (13 in).

Penetration: When equipped with 47 degree, 190 mm (7.5 in) sweeps, penetration was very good in secondary tillage. However, due to light shanks and increased sweep pitch at higher draft, use of the Wil-Rich eld cultivator is not recommended for heavy secondary or primary tillage. Penetration was uniform across the cultivator width, provided all depth control linkages and hitch height were kept properly adjusted.

With full tanks, cultivator wheels were positioned so that each centre wheel supported about 15% of the total weight while each wing wheel supported about 9%. In addition, each centre wheel supported about 15% of the total tillage suction force while each wing wheel supported 20%. Cultivator wheel sinking was not a problem in moderately soft soils because over half of the increased cultivator weight due to full applicator tanks was transferred to the tractor hitch rather than to the mainframe cultivator wheels. A tractor with dual rear tires is recommended for good distribution of hitch weight when seeding with full tanks.

Trash Clearance: The Wil-Rich 4150, equipped with the packers, plugged in heavy, loose trash unless the tine angle adjustment was released to allow trash to clear the single row of tine harrows. In medium to heavy trash, plugging would usually occur rst in front of the single row of tine harrows and occasionally between the shanks in the rear row. With the harrows correctly adjusted it was possible to operate in elds with a heavier trash cover than was possible with a conventional hoe drill.

Skewing and Stability: The Wil-Rich 8.4 m (27 ft) eld cultivator with 4150 applicator was 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 190 mm (7.5 in) sweeps, skewing more than 0.3 degrees would result in weeds being missed.

Because of the small skew angle, weeds could be missed on steep hillsides.

Weed Kill: Weed kill was fair to good when equipped with 190 mm (7.5 in) sweeps. The 178 mm (7 in) spacing resulted in only a 13 mm (0.5 in) sweep overlap. Only a minimum amount of wear could occur before weeds were missed. In conditions where a good weed kill is required, a wider sweep is recommended. Using sweeps wider than 220 mm (9 in) in width is not recommended due to sweep interference with adjacent seed row placement.

Fertilizer Banding: Due to shank cushioning spring preload being exceeded midway in the range of normal secondary tillage (FIGURE 13), the Wil-Rich air seeder, mounted on the eld cultivator, would be suitable for fertilizer banding only in light secondary tillage. Since fertilizer banding is usually a primary tillage operation, no evaluation was attempted. The Wil-Rich air seeder mounted on a heavy duty cultivator, however, would be capable of fertilizer banding. When using both compartments in each tank and both metering systems, application rates of about 300 kg/ha (270 lb/ac) with an 8.4 m (27.4 ft) cultivator at ground speeds up to 10.5 km/h (6.5 mph) would be possible. Fertilizer banding rates in excess of 300 kg/ha (270 lb/ac) are commonly recommended.

EASE OF OPERATION

Dual Purpose Operation: The Wil-Rich 4150 air seeder could be removed from the eld cultivator by two men in about four hours. This required a front end loader or overhead hoist for removing the applicator tanks, power take-off drive assembly, fan, distribution tubes and meter drive wheel assembly. These components could be removed as one unit by the removal of seven frame clamps. This allowed the cultivator to be used as a dual purpose machine both for seeding and seasonal tillage.

Hitching: The Wil-Rich 4150 was easily hitched to a tractor. Hitching convenience was reduced by the fact that the front portion of the hitch bar link was not supported by the cultivator hitch frame when unhooked from the tractor. The hitch bar link had to be held up while backing the tractor to the implement. Hitching also required power take-off hook-up, an electrical connector hook-up for the acre monitor and hook-up of four hydraulic lines with quick couplers.

Packers: Attaching the Wil-Rich packers on the Wil-Rich 13 FCW eld cultivator required removal of the Wil-Rich mounted harrows. Attachment of the packers was simple and was clearly outlined in the operator's manual. Both height and tine angle were adjustable on the single row of spring tine harrows supplied with the Wil-Rich packers. Changing harrow height and tine angle was inconvenient and required wrenches. Packer ground pressure could be altered b y adjusting the compression springs.

Filling: The optional 150 mm (6 in) ller auger supplied with the Wil-Rich 4150 was convenient for lling the applicator tanks. The hydraulically driven auger was activated by a two-position

valve located behind the tanks. The direction of auger rotation was controlled by a three-position-valve located on the upper end of the auger. This valve could be reached from the access walkway located behind the tanks.

The auger could be manually swung rearward on its pivot mounting so that the hopper was positioned on the ground, behind the cultivator, for convenient truck access. The safety screen covering the auger hopper restricted the ow of some grains, slightly reducing auger capacity. The hopper could be removed for cleanout by loosening two bolts.

The large 420 x 953 mm (16.5 x 37.5 in) grain and fertilizer tank openings gave ample room for auger lling with the directional spout supplied on the auger. Because the ller openings were located 2.4 m (7.8 ft) above the ground, hand lling would be dif cult since it would require carrying the grain or fertilizer up the access ladder. The ller lids were hinged and could be latched with rubber tie down straps. The lids were not equipped with weather stripping to prevent moisture entry.

Each front tank compartment held 916 L (26 bu) for a total of 1832 L (52 bu) while each rear tank compartment held 564 L (16 bu) for a total of 1128 L (32 bu). When all tanks were used for grain, total capacity was 2960 L (84 bu).

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

Distribution Tubes: The individual distribution tubes, running from the meter, divider cups located under the metering system near the front of the machine, back to each of the 47 shanks, resulted in a somewhat cluttered arrangement. Operator precaution was required to ensure all tubes remained in place and were not damaged by eld obstructions or crimped when the wings were raised into transport position.

Monitoring and Control System: The test machine was equipped with an electronic area meter. The read-out was mounted in the tractor cab while a magnetic pickup monitored meter drive wheel revolutions.

No ow monitoring or fan speed monitoring system was supplied on the Wil-Rich 4150. When seeding in dust free conditions, material ow was visible, from the tractor cab, as it fell from the meter rollers into the distribution cups. However, when seeding in dusty conditions, or when lighting was poor, material ow was not visible from the tractor cab. It is recommended that a monitoring device be provided for convenient material ow monitoring in all eld conditions.

Cleaning: Access to the meter rollers required emptying of the tanks. A tank cleanout door was provided for the front tanks but not for the rear tanks. If all the tanks were used for one material with the tank dividers removed, the front cleanout door could be used for all tanks. Because the cleanout door was located about 125 mm (5 in) above the meter rollers, a vacuum cleaner was required for thorough cleaning. Access into the tanks was possible through the tank ller openings. It is recommended that the manufacturer consider providing cleanout doors for convenient rear tank cleanout when the tank dividers are in place.

Area Meter: An accurate electronic area meter was supplied with the Wil-Rich 4150. The area meter was accurate and recorded the nearest tenth acre up to 10,000 acres. Although no calibration for area covered in SI units was given in the operator's manual, the area meter could easily be calibrated to record area covered in SI units simply by providing the appropriate calibration setting for the read-out unit. It is recommended that calibrations for area readout in SI units be provided in the operator's manual.

Transporting: A distinct advantage of cultivator mounted pneumatic seeders over conventional drills is the ease with which relatively wide machines can be transported. The Wil-Rich applicator-packer assembly was placed in transport position (FIGURE 14) in about ve minutes. Before the wings could be raised, the tractor had to be dismounted to properly position the two-way valves located behind the applicator tank. Two hydraulic cylinders raised the cultivator wings to the upright position. The packers were conveniently transported since they were directly mounted to the cultivator frame. The meter drive wheel was raised automatically when the cultivator was raised with the depth control cylinder. The depth control had a mechanical lock-up for safe transport.

The assembly towed well in transport position. Overall transport width was 5.7 m (18.6 ft), requiring care when travelling on public roads.

FIGURE 14. Transport Position.

Markers: The Wil-Rich 4150 was equipped with hydraulically controlled markers on each cultivator wing. The easily distinguished mark (FIGURE 12) provided for convenient operator alignment of the seeder on subsequent rounds, thereby reducing misses and overlaps.

Both markers were operated from one tractor remote outlet by single acting hydraulic cylinders equipped with restrictor valves for controlled raising and lowering. When one marker was lowered, the other marker was lifted up. The markers raised automatically when the cultivator was lifted out of the ground. Both markers could be locked up with a lock-out pin.

Problems were encountered throughout the evaluation with the markers because they tended to remain in the raised position when the remote was activated to lower them. Often, marker lowering would have to be initiated by dismounting the tractor and pulling the marker arms out of the hold up bracket. Due to the restrictor in each marker hydraulic line, the markers would lower very slowly, even after the marker was over-centered. It is recommended that the manufacturer consider modi cations to the marker system to improve lowering characteristics.

EAST OF ADJUSTMENT

Lubrication: One grease tting on each of the 47 packer wheels required daily greasing. The six cultivator wheels and the meter drive wheel required twice seasonal greasing while 29 other grease ttings required greasing every other day. Both the front (FIGURE 15) and rear grease tting on the power take-off shaft could not be reached without removal or modi cation of the power take-off shield. It is recommended that the manufacturer modify the power take-off safety shield for improved access to power take-off shaft grease ttings.

FIGURE 15. Poor Access to Grease Fittings behind Power Take-off Shield.

Application Rate: Application rate was adjusted by changing meter roller speeds with different sprocket combinations (FIGURE 16). Changing sprockets required the use of wrenches and in some cases, varying lengths of chain. Usually, application rate could be changed in less than ten minutes. Calibration charts, in pounds per acre, were located on the applicator tanks as well as in the operator's manual. In addition to changing sprocket combinations, a high or low range could be selected by interchanging two sprockets located

on the inside of the meter sprocket selection panel and below the access ladder (FIGURE 17). Changing ranges was dif cult due to poor accessibility.

Precise seeding rates were not always obtainable with the Wil-Rich 4150. For example, depending on the sprocket combination used, the change in application rate for wheat could vary from 2.3 to 15.7 kg/ha (2 to 14 lb/ac) in high range.

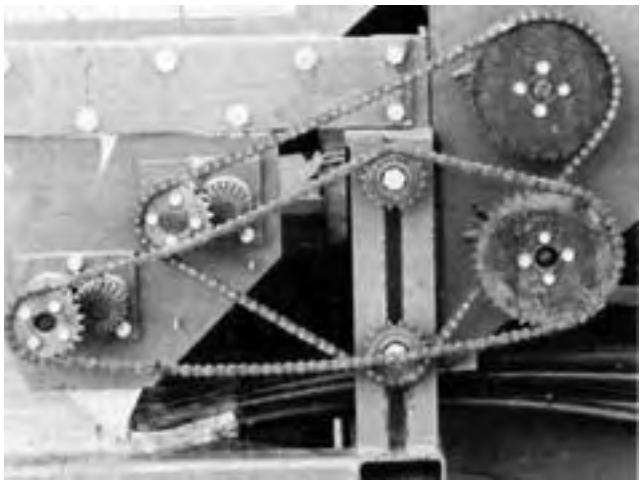

FIGURE 16. Application Rate Adjustment Sprockets.

FIGURE 17. Poor Accessibility of High-Low Range Sprockets.

Depth Adjustment: Seeding depth was conveniently adjusted with a single hydraulic cylinder. Each set of wheels was connected to the depth cylinder by a rockshaft. A threaded depth stop collar could be adjusted, without wrenches, to set maximum depth.

The cultivator frame was levelled by positioning the hitch link in one of seven positions and by adjusting rockshaft turnbuckle connections between the mainframe and each wing. Adjustment of these turnbuckles was dif cult due to the awkward location of the turnbuckles (FIGURE 18).

FIGURE 18. Awkward Location of Wing Adjustment Turnbuckles.

RATE OF WORK

The Wil-Rich 4150 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 eld work rates for the 8.4 m (27.4 ft) unit, ranging from 6.5 to 8.1 ha/hr (16 to 20 ac/hr). In loose soil conditions, reductions in forward speed were required due to excessive soil movement around the sweeps. Using both tanks, when seeding wheat at a rate of 85 kg/ha (75 lb/ac), about 26 ha (65 ac) could be seeded before re lling. Using only the front tanks, about 16 ha (40 ac) could be seeded before re lling. This compares to 12 to 18 ha (30 to 45 ac) between re lls for most conventional drills of similar width.

POWER REQUIREMENTS

Fan: The power requirement of the Wil-Rich 4150 fan, operating at the recommended power take-off speed of 1000 rpm and fan speed of 3750 rpm, was 6.8 kW (9.1 hp).

Draft Characteristics: Attempting to compare draft requirements of different makes of eld cultivators usually is unrealistic. Draft requirements for the same cultivator, in the same eld, 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 signi cant draft difference between makes of eld cultivators. The power requirements given in TABLES 2 and 3 are based on average draft requirements of 6 makes of eld cultivators in two seasons and 12 different eld conditions. Additional draft due to the air seeder with full tanks and mounted packers has been included.

TABLE 2. Tractor Size (Maximum Power Take-off Rating, kW) to Operate the Wil-Rich 4150 Air Seeder with 8.4 m Field Cultivator and Packers in Light Secondary Tillage.

DEPTH (mm)	SPEED (km/h)					
	7	8	9	10	11	12
40	48	57	66	76	86	98
50	54	64	74	85	96	108
75	70	81	94	120	120	136
100	85	99	114	145	145	161

TABLE 3. Tractor Size (Maximum Power Take-off Rating, kW) to Operate the Wil-Rich 4150 Air Seeder with 8.4 m Field Cultivator and Packers in Heavy Secondary Tillage.

DEPTH (mm)	SPEED (km/h)					
	7	8	9	10	11	12
40	64	75	87	100	114	128
50	72	84	97	111	126	141
75	91	106	122	138	156	174
100	110	128	146	165	185	206

Tractor Size: TABLES 2 and 3 show tractor sizes needed to operate the Wil-Rich 4150 air seeder mounted on an 8.4 m (27.4 ft) Wil-Rich eld cultivator with attached packers in light and heavy secondary tillage. Power requirements for the power take-off driven fan have also been included. Tractor sizes have been adjusted to include tractive ef ciency and represent a tractor operating at 80% of maximum power on a level eld. The sizes presented in the tables are the maximum power take-off rating as determined by Nebraska tests or as presented by the tractor manufacturers. 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 secondary tillage at 75 mm (3 in) depth and 8 km/h (5 mph), an 81 kW (109 hp) tractor is required to operate the seeding unit. In heavy tillage, at the same depth and speed, a 106 kW (142 hp) tractor is needed.

OPERATOR SAFETY

The ladders to the tank access walkway were considered to be safe. A safety hand rail was located along the access walkway.

The hopper on the Wil-Rich ller auger was covered with a screen. This screen prevented foreign objects from entering the tanks and was also considered a good safety feature.

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 Wil-Rich 4150 air seeder with 8.4 m (27.4 ft) cultivator was 3.5 m (11.5 ft) in transport position, permitting safe transport under prairie power lines. The Wil-Rich 4150 applicator with 12.6 m (41.4 ft) Wil-Rich eld cultivator is 4.4 m (14.5 ft) high in transport position which also permits safe transport under prairie power lines.

The Wil-Rich 4150 with 8.4 m (27.4 ft) cultivator was 5.7 m (18.5 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 Wil-Rich 4150 air seeder with 8.4 m (27.4 ft) cultivator towed well at speeds up to 28 km/h (17 mph).

OPERATOR'S MANUAL

The operator's manual for the Wil-Rich 4150 air seeder contained useful information on safety, adjustments, maintenance and operation. Calibration charts and a detailed parts list were also included. A metric calibration chart was not included. It is recommended that the manufacturer consider providing metric meter calibrations.

DURABILITY RESULTS

TABLE 4 outlines the mechanical history of the Wil-Rich 4150 air seeder, eld cultivator and mounted packers during 178 hours of operation while seeding about 1035 ha (2556 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)
APPLICATOR		
-The "Air Seeder 4150" decals were replaced at	beginning of test	
-The fan was aligned within the housing and air leaks were caulked at	beginning of test	
-A distribution line crimped and was replaced at	12, 45, 116	70, 260, 675
-The wire clips holding the seed boots were lost and replaced with wire	throughout the test	
-The meters plugged with lumps of wet grain at	87	505
-Straw blocked a few seed cups at	50, 110	290, 640
-The power take-off constant velocity U-joint failed and was replaced at	143	830
CULTIVATOR		
-All the shovels were replaced at	168	975
MARKERS		
-The right marker bolts failed and were replaced at	12, 55	70, 320
-The right marker pan bearing failed and was replaced at	75, 120	435, 695
-The right marker arm was twisted and straightened at	75	435
-The left marker pan bearing failed and was replaced at	140	610
PACKERS		
-The packer arm guides on one packer section broke off due to poor welds	throughout the test	
-A packer wheel fell off and was replaced at	55	320
-The packer axle bushings were worn out at	end of test	320

DISCUSSION OF MECHANICAL PROBLEMS

Seed Boots: Many of the wire clips holding the seed boots to the seed boot bracket were lost throughout the evaluation. The wire clips were considered too light and were replaced with wire (FIGURE 9). It is recommended that the manufacturer consider an improved fastener for the seed boot tubes.

MARKERS

Pan Bearings: Both the right and left marker pan bearings failed and were replaced during the evaluation. It is recommended that the manufacturer consider providing improved marker pan bearings.

Shear Bolts: The 9.5 mm (3/8 in) shear bolts fastening the outer marker section to the inner arm were of insuf cient strength to withstand continued eld service and were replaced by 11 mm (7/16 in) bolts. It is recommended that the manufacturer consider providing larger outer marker section shear bolts.

PACKERS

Bushings: The grease ttings on the packer wheels were recessed, making it impossible to use a conventional grease gun. Daily greasing throughout the evaluation was accomplished by grinding the end of a grease gun to accommodate the recessed ttings. In spite of daily greasing, most of the bronze bushings were worn out and required replacing at the end of the test. It is recommended that the manufacturer consider improvements to the packer bearings to increase service life and to modify the grease ttings for improved accessibility.

APPENDIX I

SPECIFICATIONS
(A) AIR SEEDER

MAKE:	Wil-Rich Air Seeder
MODEL:	4150
MANUFACTURER:	Wil-Rich, Inc. P.O. Box 1013 Wahpeton, North Dakota 58075
METERING SYSTEM:	
-type	soft rubber roller
-number of meters	2
-drive chain	drive from ground drive
-adjustment	
-high range	sprocket selection
-low range	sprocket selection
TANK CAPACITIES:	
-front section	2, 916 L (26 bu)
-rear section	2, 564 L (16 bu)
Total	960 L (84 bu)
FAN:	
-type	backward curved centrifugal
-maximum operating speed	3750 rpm
-drive	tractor power take-off
NUMBER OF LUBRICATION POINTS:	15 grease fittings, 2 day service 1 wheel bearing, twice seasonally

OPTIONAL EQUIPMENT:
-hydraulic drive filler auger*
-right and left hydraulically controlled markers*
-gas engine fan drive
-tractor front mounted fan
-tractor mounted power take-off drive fan
-cultivator mounted power take-off drive fan*
-cultivator frame mounted packers with single row tine harrows
* Supplied on test machine.

(B) CULTIVATOR

MAKE:	Wil-Rich Field Cultivator
MODEL:	13 FCW
SERIAL NO.:	9062
MANUFACTURER:	Wil-Rich, Inc. P.O. Box 1013 Wahpeton, North Dakota 58075
SHANKS:	
-number	47
-lateral spacing	180 mm
-trash clearance (sweep to frame)	600 mm
-number of shank rows	4
-distance between rows	varies from 405 mm to 815 mm across cultivator width
-shank cross section	15 x 45mm
-shank stem angle	52°
-sweep hole spacing	45 mm
-sweep bolt size	11 mm
HITCH:	
-vertical adjustment range	250 mm in 7 positions
DEPTH CONTROL:	hydraulic
FRAME:	
-cross section	65 mm square tubing, 4.8 mm thickness
TIRES:	4, 9.5L x 15, 8-ply, implement 2, 9.5L x 15, 6-ply, implement
NUMBER OF LUBRICATION POINTS:	14 grease fittings, 2 day servicing 6 wheel bearings, twice seasonally
HYDRAULIC CYLINDERS:	
-main depth control	1, 127 x 203 mm
-wing lift	2, 100 x 610 mm
-markers	2, 64 x 203 mm

OPTIONAL EQUIPMENT:
-width options in the three section model varying from 6.1 to 14,5 m
-frame mounted 3-row spring tine harrows

(C) PACKERS WITH SINGLE ROW SPRING TINE HARROWS

MAKE:	Wil-Rich Frame Mounted Semi-Pneumatic Packers
MANUFACTURER:	Wil-Rich, Inc. P.O. Box 1013 Wahpeton, North Dakota 58075
NUMBER OF SECTIONS:	4
SECTION WIDTH:	2.134 mm
PACKER WHEEL DIAMETER:	330 mm
LUBRICATION POINTS:	47 grease fittings, 10 hr. service
OBSTRUCTION CLEARANCE:	305 mm*
WEIGHTS:	230 kg per section
HARROW HEIGHT ADJUSTMENT:	115 mm in 7 settings

* Measured at cultivator working depth of 76 mm at maximum packer force setting,

(D) OVER ALL SPECIFICATIONS FOR AIRSEEDER-CULTIVATOR-PACKER ASSEMBLY

DIMENSIONS:	**FIELD POSITION**	**TRANSPORT POSITION**
-overall width	8331 mm	5664 mm
-overall length	8434 mm	8434mm
-overall height (c/w auger)	3480 mm	3480mm
-ground clearance	185 mm	185 mm
-wheel tread	7264 mm	3023mm
WEIGHTS: (Tanks Empty)		
-hitch	400 kg	540 kg
-left centre tandem wheels	1720 kg	2310 kg
-right centre tandem wheels	1810 kg	2150 kg
-left wing wheel	850 kg	
-right wing wheel	820 kg	
Total	5000 kg	5000 kg
(Tanks Full of Wheat)		
- hitch	1700 kg	1850 kg
-left centre tandem wheels	2200 kg	2850 kg
-right centre tandem wheels	2050 kg	2600 kg
-left wing wheel	700 kg	
-right wing wheel	850 kg	
Total	7300 kg	7300 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 metre (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 (lb)
1 newton (N)	= 0.2 pounds force (lb)
1 litre (L)	= 0.03 bushels (bu)
1 kilogram/hectare (kg/ha)	= 0.9 pounds/acre (lb/ac)
1 kilogram/cubic metre (kg/m^3)	= 0.08 pounds/bushel (lb/bu)
1 kilonewton/metre (kN/m)	= 70 pounds force/foot (lb/ft)

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