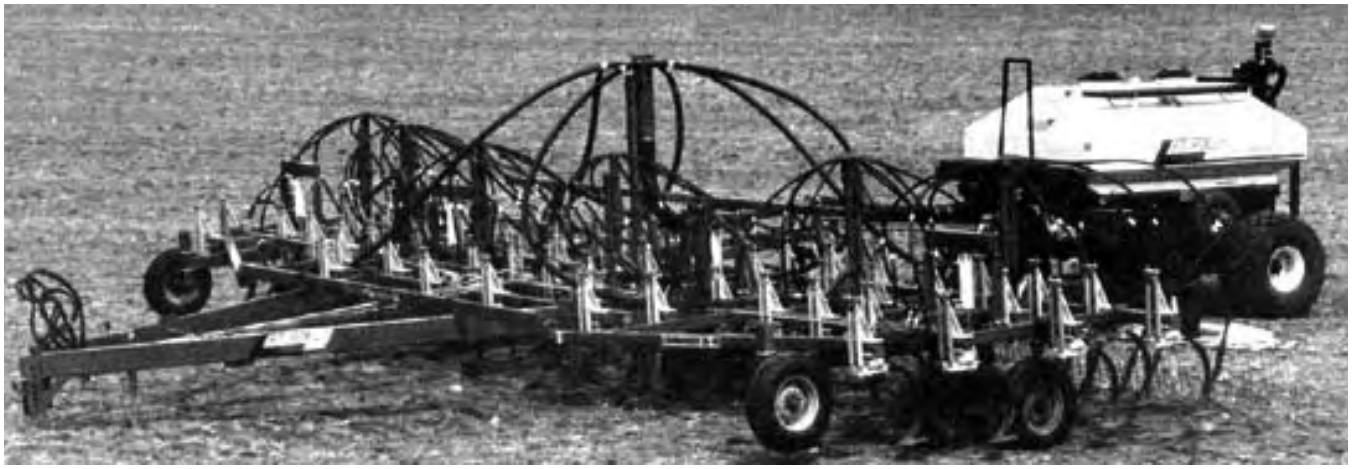
Printed: March, 1983
Tested at: Lethbridge
ISSN 0383-3445

Evaluation Report 298



Bourgault Model 138D Air Seeder

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

BOURGAULT MODEL 138D AIR SEEDER

MANUFACTURER AND DISTRIBUTOR

Bourgault Industries Ltd.
P.O. Box 130
St. Brieux, Saskatchewan
S0K 3V0

RETAIL PRICE: (March, 1983, f.o.b. Lethbridge, Alberta).

a. Bourgault Model 138D air seeder complete with seed boots and distribution system to feed 60 shanks $24,969.00
b. Bourgault Model 36-40 Commander 40 ft (12.2 m) intermediate duty cultivator complete with attached harrows $18,305.00

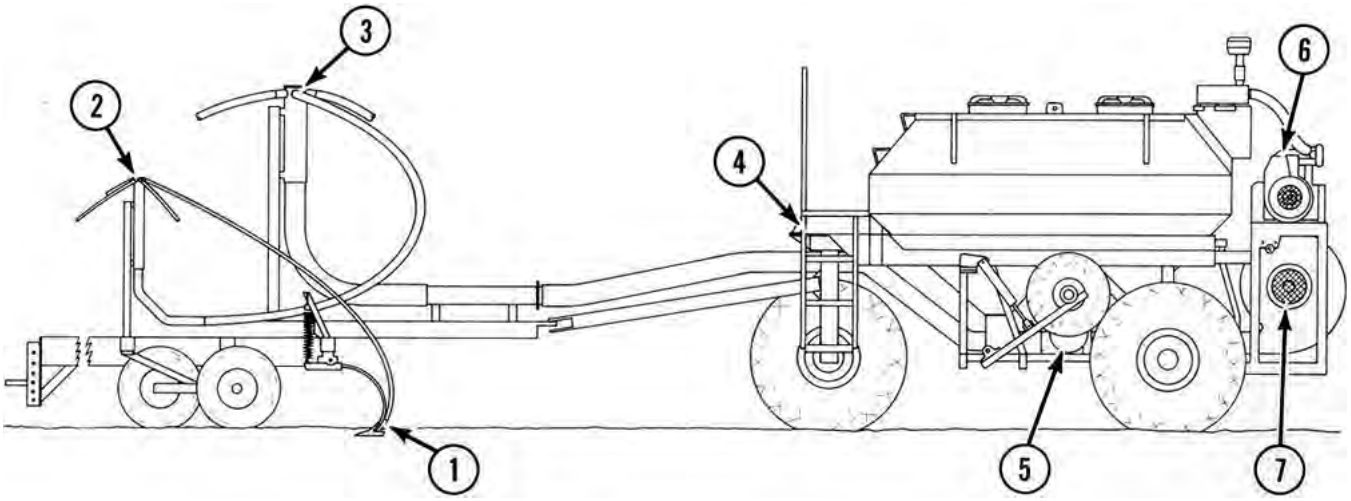


FIGURE 1. Bourgault Model 138D Air Seeder: (1) Seed Boot, (2) Secondary Header, (3) Primary Header, (4) Tank Access Ladder, (5) Metering System, (6) Engine, (7) Fan.

SUMMARY AND CONCLUSIONS

Overall Performance: Performance of the Bourgault Model 138D air seeder was very good for seeding and fertilizer banding in secondary and light primary field conditions. Suitability for seeding and banding fertilizer was reduced in heavy primary tillage due to the light shank spring characteristics of the Bourgault Model 36-40 Commander intermediate duty cultivator, The Bourgault 138D was suitable for banding fertilizer in secondary and light primary field conditions at application rates up to 215 lb/ac (242 kg/ha).

Meter Calibrations: The manufacturer's metering system calibrations were accurate in wheat and barley and fairly accurate in oats, canola and 11-51-00 fertilizer.

Distribution Uniformity: Distribution uniformity across the seeding width was acceptable in all materials used throughout the test. Effect of Field Variables: Field bounce had little effect on metering rates. Field slope and ground speed had only a small effect on metering rates. Distribution uniformity was only slightly affected by field slope.

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

Seed Placement: 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 seeding conditions. Row spacing and seed band width behind each seed boot provided ample stubble for good windrow support. Good cultivator frame levelling was critical in obtaining a uniform seed depth and subsequent good crop emergence.

Ease of Adjustment and Operation: Seeding rate was easily adjusted. Tank and meter cleanout convenience was good. Tank filling required the use of a drill fill or auger. Thirteen grease fittings and three wheel bearings on the applicator required greasing.
Since the applicator was towed behind the cultivator, operator visibility of the cultivator was not obstructed by the tanks. The Bourgault 138D with Bourgault 36-40 cultivator could be placed in transport position in less than five minutes.

Rate of Work: The rate of work usually ranged from 24 to 30 ac/hr (9.7 to 12.2 ha/hr). About 96 ac (39 ha) could be seeded before refilling both tanks when seeding wheat at a normal seeding rate. Using only the larger front tank, 53 ac (21 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 a 3 in (75 mm) depth and 5 mph (8 km/h), a 163 hp (122 kW) tractor was needed to operate the applicator-cultivator combination. In heavy primary tillage, at the same depth and speed, a 200 hp (149 kW) tractor was needed.

Safety: The cultivator tires were overloaded by about 20% in transport position. The Bourgault 138D 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, specifications, operation, lubrication and maintenance. A detailed parts list was also included.

Mechanical Problems: Only minor mechanical problems occurred during the evaluation.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing, as optional equipment, a monitoring system to monitor material flow.
2. Supplying a slow moving vehicle sign as standard equipment.
3. Providing in the operator's manual, equations to permit calculating the area covered in SI (metric) units in addition to the equations already provided to calculate area covered in Imperial units.
4. Providing meter calibration charts in SI (metric) units in addition to those *already provided in Imperial units.*

Senior Engineer: E. H. Wiens

Project Engineer: R. K. Allam

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Bourgault is presently testing prototype flow monitoring equipment to offer as optional equipment.
2. Bourgault is now providing a slow moving sign-holder bracket as standard equipment.
3. & 4. The Fall, 1983 operator's manual now includes both metric (SI) and Imperial units.

GENERAL DESCRIPTION

The Bourgault Model 138D air seeder is a pneumatic seed and fertilizer applicator designed for use with varying models of

Bourgault intermediate duty cultivators.

The applicator is hitched to the rear of the cultivator. The applicator is supported by one steering wheel at the front and two trailing wheels at the rear.

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 or fertilizers are metered through two variable speed metering augers mounted below the tanks. The meters are driven by a meter drive wheel, which engages and runs off of the left 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 feeding six, ten-port secondary headers, all of which are mounted on the cultivator frame. Tubes from the secondary headers connect to the seed boots.

The test machine was used with a Bourgault Model 36-40 Commander intermediate duty cultivator. This cultivator was 40 ft (12.2 m) wide, with a 17 ft (5.2 m) centre frame and two, 11.5 ft (3.5 m) wing sections. It was equipped with 60 spring cushioned shanks, spaced at 8 in (203 mm), arranged in four rows. The cultivator was equipped with optional three-row mounted harrows. A tractor with three remote hydraulic controls was required to operate the Bourgault Model 138D air seeder with the Bourgault Model 36-40 cultivator.

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

SCOPE OF TEST

The Bourgault Model 138D air seeder was operated in loam and clay soils in the field conditions shown in TABLE 1 for approximately 125 hours while processing about 2300 ac (930 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	FIELD AREA ha	HOURS
Spring wheat on stubble	Primary	Occasional stones	885	358	48
Spring wheat on stubble	Secondary	Stone free	285	115	15
Spring wheat on summerfallow	Secondary	Occasional stones	100	40	6
Winter wheat on summerfallow	Secondary	Stone free	470	190	25
Winter wheat on stubble	Secondary	Occasional stones	160	65	9
Banding fertilizer	Secondary	Occasional stones	400	162	22
TOTAL			2300	930	125

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 significantly affect grain crop yields.

The Bourgault 138D had four sprocket combinations which could be used to obtain each of four meter auger speed ranges for the rear tank. Sprocket combination I was used for cereal grains or fertilizer application while sprocket combinations 2 to 4 were for small seeds such as canola. The front tank had only one sprocket combination for use in metering cereal grains or fertilizer.

Calibration curves for wheat, barley, oats, canola and fertilizer are given in FIGURES 2 to 6. PAMI's calibration curves are compared to the manufacturer's calibration curves. At a seeding rate of 75 lb/ac (85 kg/ha), PAMI's measured rates were similar to the manufacturer's calibration in wheat and barley and 12% lower than the manufacturer's calibration in oats. At a seeding rate of 6 lb/ac (6.7 kg/ha), PAMI's measured rate was 22% lower than the manufacturer's rate in canola. At an application rate of 45 lb/ac (50 kg/ha), PAMI's measured rate in 11-51-00 fertilizer was 27% lower than the manufacturer's indicated rate while at an application rate of 130 lb/ac (146 kg/ha) the measured rate was 19% lower than the manufacturer's indicated rate.

Operating up and down 10 degree hills had only a small effect on metering rates while operating on 10 degree side slopes changed metering rate in fertilizer and wheat by up to 14%.

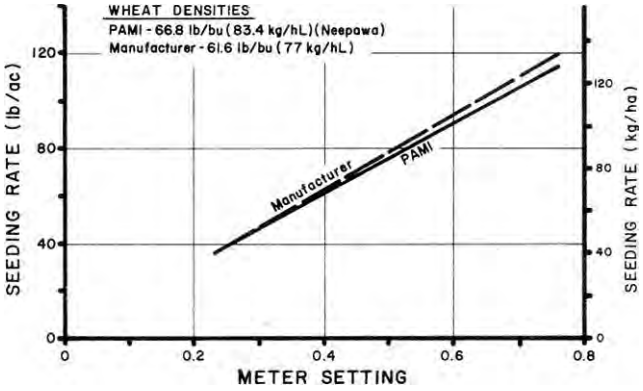


FIGURE 2. Metering Accuracy in Wheat.

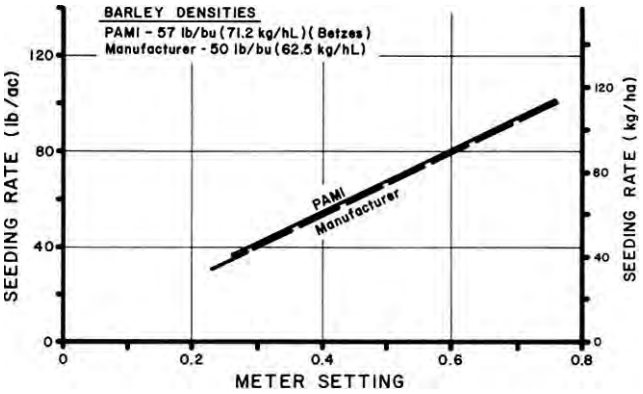


FIGURE 3. Metering Accuracy in Barley.

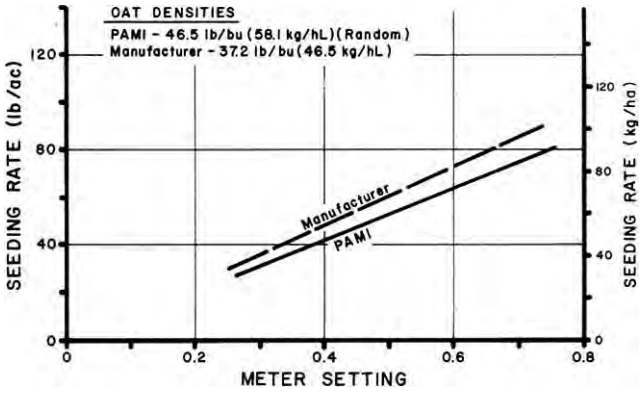


FIGURE 4. Metering Accuracy in Oats.

Distribution Uniformity: FIGURE 7 gives seeding distribution uniformity for the Bourgault 138D in wheat, barley and oats. Distribution was uniform over the full range of seeding rates for wheat, barley and oats at a fan speed of 3500 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 4% for oats. FIGURE 8 shows a typical seeding distribution pattern obtained in wheat at a seeding rate of 80 lb/ac (89 kg/ha) at a fan speed of 3500 rpm. The application rate from each shank across the width of the air seeder

[1]Detailed Test Procedures for Air Seeders.

[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.

varied from 72 to 92 lb/ac (81 to 103 kg/ha). This resulted in an acceptable distribution uniformity with a CV of 6%.

FIGURE 9 shows a typical distribution pattern obtained in canola at a seeding rate of 8 lb/ac (9 kg/ha) at a fan speed of 3000 rpm. The application rate across the width of the air seeder varied from 6 to 10 lb/ac (7 to 11 kg/ha), which resulted in acceptable distribution uniformity with a CV of 12%. Distribution uniformity was acceptable over the full range of canola seeding rates with CV's ranging from 10 to 14% (FIGURE 10).

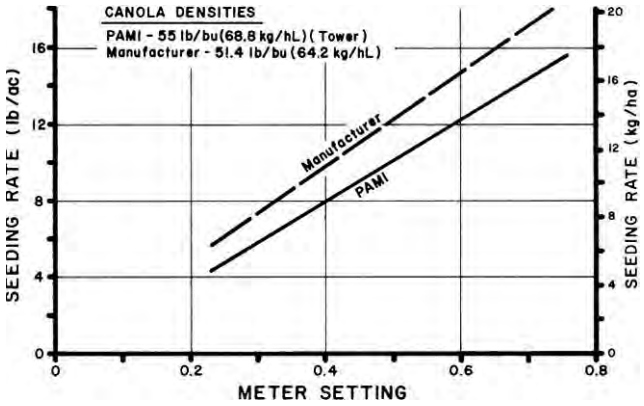


FIGURE 5. Metering Accuracy in Canola.

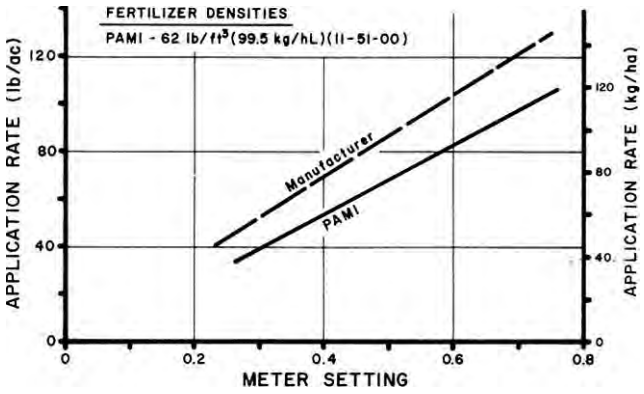


FIGURE 6. Metering Accuracy in Fertilizer.

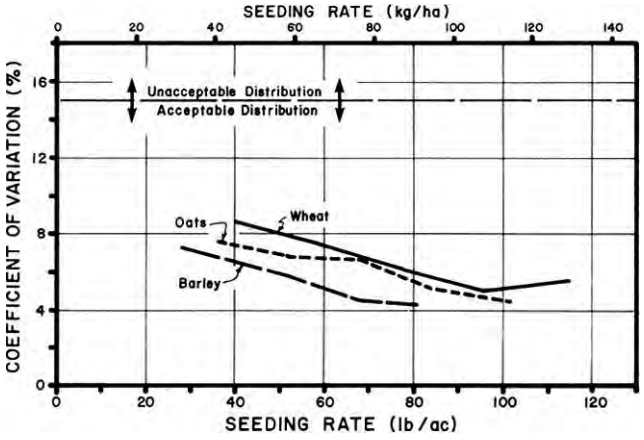


FIGURE 7. Distribution Uniformity in Cereal Grains Over a Range of Seeding Rates at 55 mph (9 km/h) at a Fan Speed of 3500 rpm.

Distribution uniformity in 11-51-00 fertilizer was acceptable at fan speeds of 3500 and 4300 rpm, for metering rates up to 215 lb/ac (241 kg/ha), with CV's ranging from 6to 14% (FIGURE 11).

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 and operation in hilly terrain had only a small effect on distribution uniformity.

Grain Damage: Grain damage by the metering and distribution system was within acceptable limits for cereal grains at a fan speed of 3500 rpm or lower. For example, in dry Neepawa wheat at 11% moisture content and a fan speed of 3500 rpm, only 0.5% crackage occurred. In dry canola with a moisture content of 7%, crackage at a fan speed of 3000 rpm was 5.0%. Reducing fan speed to 2500 and 2000 rpm reduced canola damage to 1.3 and 0.7%, respectively. Due to excessive canola damage at higher fan speeds, it is suggested that a maximum fan speed of 2500 rpm be recommended for canola.

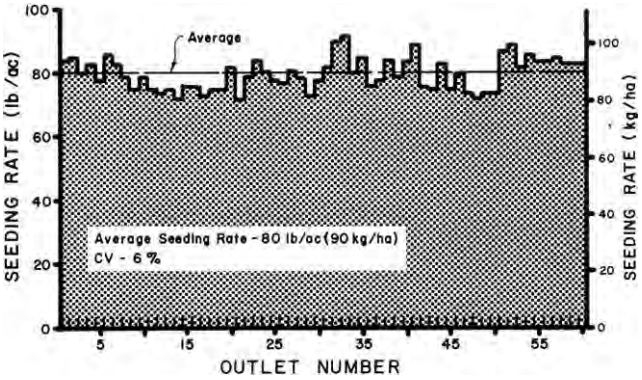


FIGURE 8. Distribution Uniformity Pattern in Wheat at 80 lb/ac (90 kg/ha) at a Fan Speed of 3500 rpm.

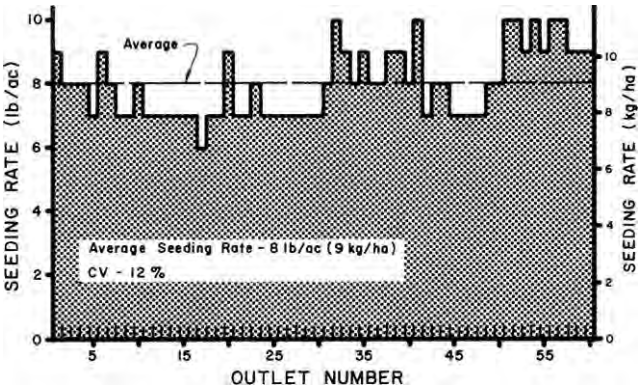


FIGURE 9. Distribution Uniformity Pattern in Canola at 8 lb/ac (9 kg/ha) at a Fan Speed of 3000 rpm.

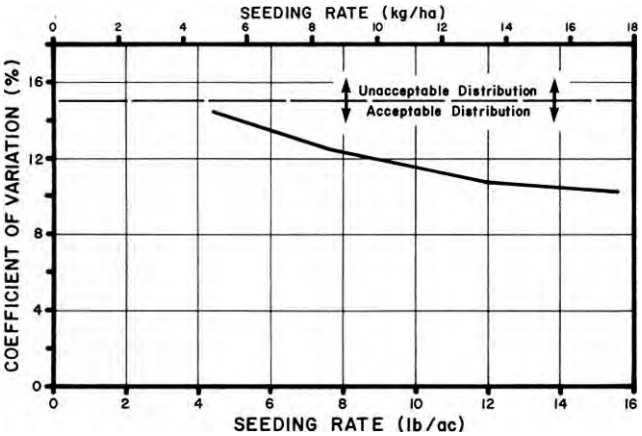


FIGURE 10. Distribution Uniformity in Canola over a Range of Seeding Rates at 55 mph (9 km/h) at a Fan Speed of 3000 rpm.

Seed Placement: The Bourgault seed boot (FIGURE 12) provided very little spreading behind the cultivator sweep. Plants emerged in distinct rows in band widths ranging from 1.3 to 2.8 in (33 to 70 mm) (FIGURE 13). With 8 in (203 mm) cultivator shank spacing, distances between rows varied from 5.2 to 6.7 in (132 to 170 mm). This row spacing provided adequate windrow support in all conditions.

Variation in seed depth depended on field tillage conditions. Although seed placement was adequate in all secondary field conditions, the intermediate duty shanks on the Bourgault Commander 36-40 were not sufficiently rigid to maintain a uniform sweep pitch throughout the full range of soil forces encountered in all primary tillage conditions (FIGURE 15).

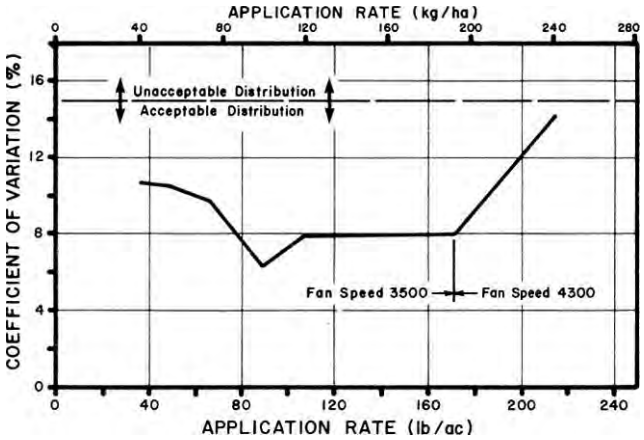


FIGURE 11. Distribution Uniformity in Fertilizer over a Range of Application Rates at 55 mph (9 km/h) at Two Fan Speeds.

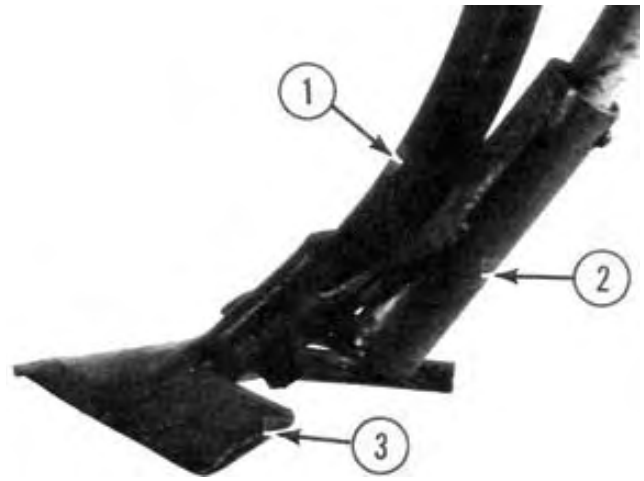


FIGURE 12. Bourgault Seed Boot: (1) Shank, (2) Seed Boot, (3) Sweep.

Although seeds were usually placed on the furrow bottom at the working depth of each individual cultivator sweep, depth across the width of the machine varied due to cultivator frame geometry and non-uniform field surfaces. On level and gently rolling fields, when seeding in secondary or light primary field conditions, variation in seed depth was quite uniform. For example, at an average seeding depth of 2 in (50 mm), seeding depth across the width of the machine varied from 1.0 to 3.2 in (25 to 80 ram) with most of the seeds placed within 0.5 in (13 mm) of the average cultivator working depth. This compares to most 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 cultivator than on a hoe drill.

In heavy primary tillage conditions, seed depth variation increased due to soil forces exceeding the shank spring preload setting. Therefore, seeding in heavy primary tillage conditions with an air seeder and the Bourgault 36-40 Commander intermediate duty cultivator is not recommended.

Plant Emergence: As with most seeding implements, time and uniformity of plant emergence depended on seedbed preparation, soil moisture and seed placement. The Bourgault 138D 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 13 shows good wheat emergence when wheat was seeded directly in summerfallow as the first spring operation.

With the applicator being towed behind the cultivator, the applicator wheels packed the seedbed firmly in the wheel tracks. The applicator wheels did not over pack the seedbed in normal seeding conditions encountered during the test.

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

FIGURE 13. Uniform Wheat Emergence in Summerfallow. (Upper: 29 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 1.5 in (38 mm) is not recommended for an intermediate 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 Bourgault 36-40 Commander 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 Bourgault 138D with Bourgault 36-40 Commander cultivator was not equipped with packers. Since it was considered essential to pack most fields seeded with the Bourgault, 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 over packing the seedbed. FIGURE 14 shows a typical seedbed after seeding into stubble, both before and after use of the harrow packer drawbar.

Shank Characteristics: The Bourgault 36-40 Commander cultivator was equipped with adjustable spring cushioned shank holders. During the evaluation it was used with 10 in (254 mm) wide sweeps with a 47 degree stem angle, giving a no-load sweep pitch of 4 degrees. Sweep pitch (FIGURE 15) varied 2.5 degrees over the range of draft (drawbar pull) normally encountered in secondary field conditions.

Cushioning spring preload was exceeded at drafts greater than 300 lb/ft (4.4 kN/m), occurring midway in the range of normal primary tillage. This shows that the Bourgault intermediate duty cultivator is suitable for secondary tillage and for light primary tillage. In heavy

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

primary tillage, sweep pitch became excessive resulting in non-uniform seeding depth and furrow bottom ridging.

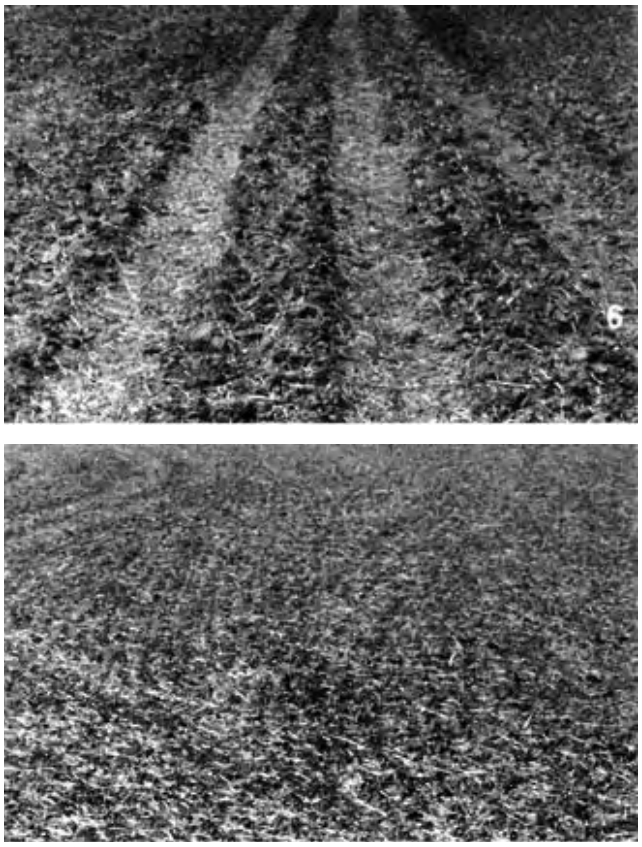


FIGURE 14. Bourgault 138D Seedbed. (Left: Before Packing, Right: After Packing.)

The shanks performed well in stony fields. Maximum lift height to clear obstructions was 11.8 in (300 mm).

Penetration: When equipped with 47 degree, 10 in (254 mm) sweeps, penetration was very good in nearly all field conditions and it was easy to obtain correct seeding depth. However, due to increased sweep pitch at higher draft, use of the Bourgault 36-40 Commander cultivator is not recommended for heavy primary tillage. Penetration was uniform across the cultivator width, provided all depth control linkages and hitch height were kept properly adjusted.

The cultivator wheels were positioned so that each centre section wheel supported about 16% of the total cultivator weight while each wing wheel supported about 9%. In addition, each centre wheel supported about 15% of the total suction force while each wing wheel supported about 10%. 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.

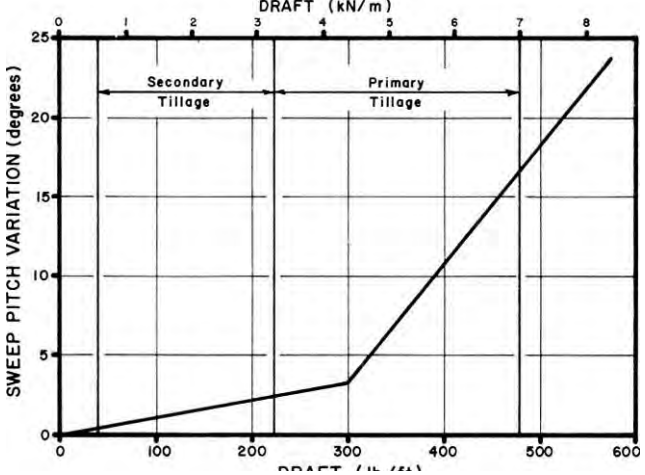


FIGURE 15. Sweep Pitch Variation over a Normal Range of Draft with 8 in (203 mm) Shank Spacing.

Trash Clearance: The Bourgault Commander 36-40 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 heavier trash cover than was possible with a conventional hoe drill.

Skewing and Stability: The Bourgault air seeder and Commander 36-40 cultivator combination were very stable and sideways skewing occurred only in very hilly conditions. The cultivator shank pattern was symmetrical and did not impose any side forces on the cultivator during normal tillage. When equipped with 10 in (254 mm) sweeps, the cultivator had to skew more than 1.3 degrees to miss weeds. Throughout the evaluation period, in normal seeding conditions, skewing was never serious enough to cause weeds to be missed.

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 was very good when equipped with 10 in (254 mm) sweeps. The 8 in (203 mm) shank spacing resulted in 2 in (50 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 Bourgault 138D 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 (FIGURE 16), the Bourgault could also be used for fertilizer banding. No special banding boots were required. The seed boots, since they did not spread the fertilizer behind the chisel points, also served as banding boots.

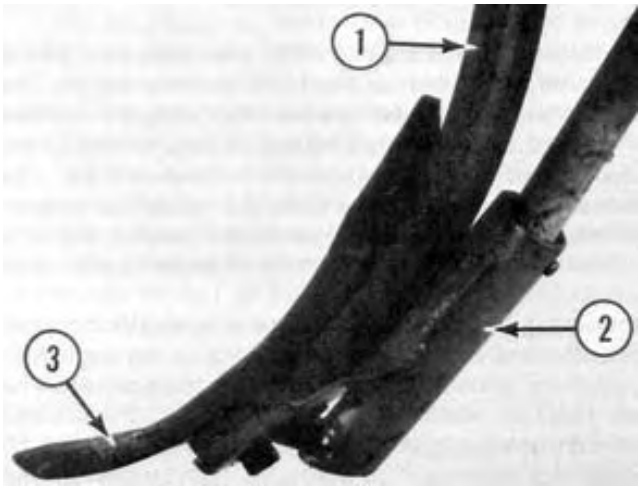


FIGURE 16. Bourgault Banding Boot: (1) Cultivator Shank, (2) Banding Boot, (3) Chisel Point.

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 banding boots to minimize fertilizer spreading.

Due to the intermediate duty characteristics of the Bourgault 36-40 Commander shanks, banding suitability of the unit was restricted to use in secondary and light primary field conditions. The Bourgault 138D worked well for fertilizer banding in these conditions. 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 fan provided adequate air to allow both meters to be fully opened while distributing 11-51-00 fertilizer. When using both tanks, the air supply at a maximum fan speed of 4300 rpm was adequate to apply 215 lb/ac (242 kg/ha) with the 40 ft (12.2 m) cultivator at 5.5 mph (9 km/h). When using the rear or front tank only, fertilizer

rates of 108 lb/ac (121 kg/ha) were possible.

The Bourgault 138D tanks and metering system were sealed against moisture entry. This eliminated fertilizer caking problems due to rainfall. All unprotected metal surfaces should be cleaned and oiled periodically when applying fertilizer to prevent corrosion.

EASE OF OPERATION

Dual Purpose Operation: The applicator, since it towed behind, could be detached in less than 15 minutes, providing the headers and hoses were left on the cultivator, allowing the cultivator to be used as a dual purpose machine, for both seeding and seasonal tillage. If all headers and hoses were removed from the cultivator, it took two men about two hours to detach the applicator from the cultivator. A hoist or front end loader was required to remove the primary header stand from the cultivator.

Hitching: The Bourgault 138D was easily hitched to a tractor. Hitching convenience was increased by the fact that the hitch link could be held in a horizontal position with a pin when unhitched from the tractor. Hitching also required hook-up of six 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 8 ft (2.4 m) above the ground, hand filling was difficult as it necessitated carrying the grain or fertilizer up the access ladder. To reduce spilling when filling with-an auger, the relatively small 9.5 in (240 mm) diameter openings required the use of a directional spout. The filler lids were hinged and were latched by a simple hinged friction lock. The lids were equipped with a rubber gasket for an airtight and moisture tight seal.

The front tank held 70 bu (2548 L) while the rear tank held 57 bu (2075 L).

Visibility: Since the applicator towed behind, visibility of the cultivator was unobstructed by the applicator. This was considered a desirable feature of the Bourgault 138D air seeder.

Maneuverability: The applicator-cultivator combination manoeuvred well in the forward direction. Because the three-wheeled air seeder pulled behind the cultivator had a swivel front wheel for steering, the cultivator-air seeder combination could only be backed up a very short distance.

Monitoring: The test machine was not supplied with a material flow monitoring system. Two warning lights for meter operation and a fan speed digital readout were included in an electronic monitor console which was placed in the tractor cab. Because plugging of the distribution system was difficult to detect from the tractor seat, it is recommended that a flow monitoring system be made available as optional equipment.

Seed and Fertilizer Boots: Only one seed boot plugged with wet soil while seeding in moist conditions. No boot plugging problems were encountered while banding fertilizer.

Cleaning: Access to the metering augers was not possible without emptying the tanks. Each tank was equipped with a cleanout spout and door. Collection of material from the meter cleanout was convenient. Since the cleanout spouts were located about 1.25 in (32 mm) above the augers, a vacuum cleaner was needed for thorough cleaning of both tanks. Access into the tanks was possible by removal of the tank filler cover assembly.

Area Meter: The Bourgault 138D was equipped with a meter drive shaft revolution counter for area measurement. The operator's manual gave equations for calculating the number of acres covered, based on starting and ending readings from the revolution counter, for various machine widths. The calculations, when used with the 40 ft (12.2 m) cultivator, gave area readings about 7% low. It is recommended that the manufacturer also supply equations for calculating area in SI (metric) units.

Transporting: A distinct advantage of cultivator mounted pneumatic seeders over conventional drills is the ease with which relatively wide machines can be transported. The Bourgault 138D air seeder and Bourgault 36-40 Commander cultivator were easily placed in transport position (FIGURE 17) in less than five minutes. Two hydraulic cylinders raised the cultivator wings to the upright position. The meter drive was conveniently engaged and disengaged hydraulically from the tractor seat.

The assembly towed well in transport position. Overall transport height and width were 14.8 ft (4.5 m) and 24.6 ft (7.5 m) respectively, requiring care when travelling on public roads.

FIGURE 17. Transport Position.

EASE OF ADJUSTMENT

Lubrication: Lubrication was convenient with good access to all grease fittings. Thirteen fittings on the applicator and twelve on the cultivator required servicing. Three wheels on the applicator and ten on the cultivator required servicing. A servicing schedule was supplied 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. Engine fuel consumption was about 0.45 gal/hr (2.1 L/hr). The engine could run about 31 hours on one filling of the 14 gal (64 L) tank.

Application Rate: One meter drive sprocket combination was available on the front tank and four sprocket combinations were available on the rear tank. Three of the four combinations, on the rear tank, were for low application rates commonly required for seeding crops such as canola or alfalfa. A metering chart for each sprocket combination gave gear box settings for the metering rate desired. Application rates, for a particular drive sprocket combination, were easily changed by removing a spring clip and turning a hand crank on the variable drive gear box. Gear box settings were divided in scale increments of 0.1 from 0.23 to 0.76 (FIGURE 18). The gear box setting could easily be adjusted to the nearest 0.05 scale increment.

Calibration charts, in pounds per acre, were shown in both the operator's manual and on a decal on the air seeder.

The metering scale allowed relatively precise seeding rate adjustment. For example, changing the meter setting by 0.05 in Tower canola changed seeding rate by only 1.1 lb/ac (1.2 kg/ha).

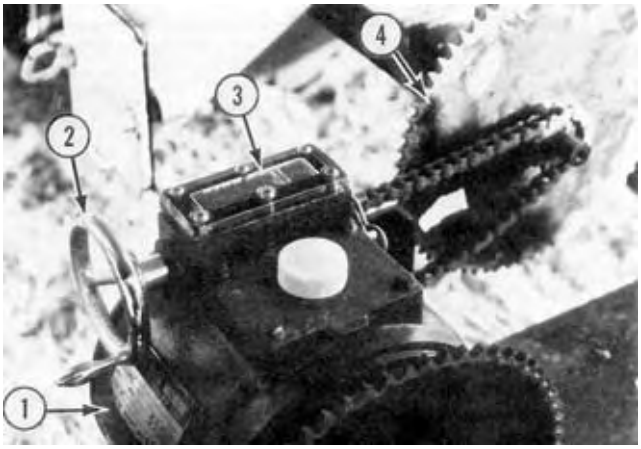


FIGURE 18. Application Rate Adjustment: (1) Gear Box, (2) Hand Crank, (3) Scale, (4) Sprockets.

Depth Adjustment: Seeding depth was conveniently adjusted with the left mainframe master cylinder connected in series to the right mainframe and wing cylinders in a master-slave arrangement. An adjustable sleeve on the master cylinder could be used to set maximum depth. As is common with series hydraulic systems, to maintain the centre and wing frames at the same height, periodic synchronization of the cylinders by completely extending them to the fully raised position was necessary.

The Bourgault cultivator frame was levelled from front to back by positioning the hitch stop bolts in one of nine positions and from

side to side by adjusting threaded connectors on each depth cylinder. These adjustments required the use of tools. Cultivator levelling adjustments were adequate to suit all field conditions encountered throughout the evaluation.

RATE OF WORK

The Bourgault 138D 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), resulting in field work rates for the 40 ft (12.2 m) unit ranging from 24 to 30 ac/hr (9.7 to 12.2 ha/hr). Using both tanks, when seeding wheat at a rate of 75 lb/ac (85 kg/ha), about 96 ac (39 ha) could be seeded before refilling. Using only the larger front tank, about 53 ac (21 ha) could be seeded before refilling. This compares to 45 to 70 ac (18 to 28 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 intermediate 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 intermediate duty cultivators. The power requirements given in TABLES 2, 3 and 4 are based on average draft requirements of 16 makes of cultivators in 52 different field conditions. Additional draft due to the Bourgault 138D applicator with full tanks and cultivator attached harrows has been included.

Tractor Size: TABLES 2 to 4 show tractor sizes needed to operate the Bourgault 138D air seeder and Bourgault 36-40 intermediate duty cultivator in light and heavy secondary tillage as well as in 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 secondary tillage at 3 in (75 mm) depth and 5 mph (8 km/h), a 115 hp (86 kW) tractor is needed to operate the seeding unit. In heavy secondary or light primary tillage at the same depth and speed, a 163 hp (122 kW) tractor is needed, while in heavy primary tillage a 200 hp (149 kW) tractor is required.

TABLE 2. Tractor Size (Maximum power Take-off Rating, hp (kW) to Operate the Bourgault 138D Air Seeder, with 40 ft (12.2 m) Bourgault 36-40 Cultivator in Light Secondary Tillage.

DEPTH		SPEED mph (km/h)							
in	(mm)	4	(6.4)	5	(8)	6	(9.6)	7	(11.2)
2	(50)	57	(43)	80	(60)	106	(79)	136	(101)
3	(75)	91	(68)	115	(86)	148	(110)	185	(138)
4	(102)	120	(90)	151	(113)	191	(142)	235	(175)

TABLE 3. Tractor Size (Maximum Power Take-off Rating, hp (kW)) to Operate the Bourgault 138D Air Seeder, with 40 ft (12.2 m) Bourgault 36-40 Cultivator in Heavy Secondary or Light Primary Tillage.

DEPTH		SPEED mph (km/h)							
in	(mm)	4	(6.4)	5	(8)	6	(9.6)	7	(11.2)
2	(50)	88	(66)	120	(90)	155	(116)	194	(145)
3	(75)	123	(92)	163	(122)	207	(154)	254	(189)
4	(102)	157	(117)	206	(154)	258	(192)	315	(235)

TABLE 4. Tractor Size (Maximum Power Take-off Rating, hp (kW)) to Operate the Bourgault 138D Air Seeder, with 40 ft (12.2 m) Bourgault 36-40 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)	84	(63)	113	(84)	146	(109)	182	(136)
3	(75)	154	(115)	200	(149)	251	(187)	304	(227)
4	(102)	224	(167)	288	(215)	356	(266)	426	(318)

OPERATOR SAFETY

The Bourgault 138D air seeder tank access ladder was convenient and safe. A safety handrail was provided beside the access ladder.

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 17 ft (5.2 m) over farm land or over secondary roads. In Alberta and Manitoba, the neutral ground wire may be as low as 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 Bourgault 138D air seeder with Bourgault 40 ft (12.2 m) cultivator was 14.8 ft (4.5 m) high in transport position, permitting safe transport under prairie power lines. On the other hand, transport height with the 50 ft (15.2 m) wide model of the same cultivator is 17.8 ft (5.4 m), which is high enough for contact with many 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 machine 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 Bourgault 138D with Bourgault 36-40 cultivator was 24.6 ft (7.5 m) wide in transport position. This necessitated caution when towing on public roads, over bridges and through gates.

A slow moving vehicle sign was not provided on the rear of the applicator for transport. It is recommended that the manufacturer consider supplying a slow moving vehicle sign as standard equipment. Pins were provided to lock the cultivator wings in transport position. The depth cylinder could be locked in the raised position with the depth adjusting sleeve.

The Bourgault air seeder with Bourgault 36-40 cultivator, towed well at speeds up to 17 mph (28 km/h).

Centre section tire loads on the cultivator in transport position exceeded the Tire and Rim Association maximum load rating for 9.5L-14, 6-ply tires by about 20%.

The Bourgault 138D air seeder was pulled behind the cultivator and the fan engine was located at the rear of the applicator. Due to the remote fan engine location, the operator station noise level in most modern tractor cabs was virtually unaffected by fan or fan engine noise with no significant increase in operator station noise level with the fan engine running.

OPERATOR'S MANUAL

The operator's manual for the Bourgault 138D air seeder contained useful information on safety, assembly, adjustment, specifications, maintenance and operation. A detailed parts list was also included. Calibration charts, calibrated in pounds per acre, were included in the operator's manual and on a decal on the machine. It is recommended that the manufacturer also supply meter calibration charts in SI (metric) units.

DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the Bourgault 138D air seeder during 125 hours of operation while processing about 2300 ac (930 ha). The intent of the test was evaluation of functional performance. An extended durability evaluation was not conducted.

TABLE 5. Mechanical History.

ITEM	OPERATING HOURS	EQUIVALENT FIELD AREA ac (ha)	
APPLICATOR			
-The front metering rate adjustment crank fell off due to a loose set screw. The crank was replaced at	17	315	(128)
-The front tank filler lid hinge bracket broke and was welded at	70	1290	(522)
-One distribution hose pulled out of a seed boot due to shank tripping at	75	1380	(559)
-The hitch pin between the applicator and the cultivator fell out due to the upper clip breaking off at	105	1930	(781)
CULTIVATOR			
-All the sweeps were replaced at	80	1475	(597)
-Chisel points for fertilizer banding were installed at	103	1900	(769)

APPENDIX I

SPECIFICATIONS

[A) AIR SEEDER

MAKE:	Bourgault Air Seeder
MODEL:	138D
SERIAL NUMBER:	1170
MANUFACTURER:	Bourgault Industries Ltd P.O. Box 130 St. Brieux, Saskatchewan S0K 3V0

DIMENSIONS:

-width	8.9 ft (2713 mm)
-length	20.2 ft (6157 mm)
-height	9.3 ft (2835 mm)
-maximum ground clearance	1.2 ft (366 mm)
-wheel tread	7.2 ft (2195 mm)
-wheel base	8.6 ft (2621 mm)

METERING SYSTEM:

-type	auger
-number of meters	2
-drive	chain drive from meter wheel off applicator wheel
-adjustment	variable gear box in addition to sprocket combinations
-air stream loading	pressurized tanks
-transfer to openers	pneumatic conveyance through divider headers and plastic tubes

TANK CAPACITIES:

-front	70 bu (2548 L)
-rear	57 bu (2075 L)
Total	127 bu (4623 L)

FAN:

-type	straight blade centrifugal
-maximum operating speed	4300 rpm
-drive	triple V belt from air cooled diesel engine

ENGINE:

-make	Wisconsin
-model	WD2 1000
-serial number	095464215
-power rating	170 hp (13 kW) at 2200 rpm
-starting system	12 volt electric
-fuel tank capacity	14 gal (64 L)

WHEELS:

-single wheels	3, 21.5L-161, 6-ply rating
-meter drive wheel	1, 20 x 11.00-8 NHS, 2-ply rating

NUMBER OF LUBRICATION POINTS: 13 grease fittings
3 wheel bearings

OPTIONAL EQUIPMENT:
- -diesel engine fan drive*
- -hydraulic fan drive from tractor remote
- -meter drive variable gear boxes*
- -meter drive quick change sprocket assembly

*Supplied on test machine

(B) CULTIVATOR

MAKE:	Bourgault Intermediate Duty Cultivator
MODEL:	36-40 Commander
MANUFACTURER:	Bourgault Industries Ltd P.O. Box 130 St. Brieux, Saskatchewan S0K 3V0

SHANKS:

-number	60
-lateral spacing	8 in (203 mm)
-trash clearance (sweep to frame)	27 in (686 mm)
-number of shank rows	4
-distance between rows	29 in (737 mm)
-shank cross section	3/4 x 2 in (19 x 50 mm)
-shank stem angle	43 degrees
-sweep hole spacing	1-3/4 in (44 mm)
-sweep bolt size	7/16 in (11 mm)

HITCH:

-vertical adjustment range	14 in (356 mm), in 9 positions

DEPTH CONTROL: h ydraulic

FRAME:

-cross section	35 in (89 mm) square tubing
-thickness	3/16 in (48 mm)

TIRES: 4, 9.5L 14, 6-ply
6, 7.5L 14, 4-ply

NUMBER OF LUBRICATION POINTS: 12 grease fittings
10 wheel bearings

HYDRAULIC CYLINDERS:

-depth control	1, 41/4 x 8 in (108 x 203 mm) 1, 4 x 8 in (102 x 203 mm) 1, 3-3/4 x 8 in (95 x 203 mm) 1, 3-1/2 x 8 in (89 x 203 mm)
-wing lift	2, 4 x 18 in (102 x 459 mm)

OPTIONAL EQUIPMENT:
- -four width options ranging from 36 to 40 ft (11 to 122 m)
- -frame mounted three row spring tine harrows

(C) OVERALL SPECIFICA33ONS FOR APPLICATOR-CULTIVATOR ASSEMBLY

DIMENSIONS:	**FIELD POSITION**	**TRANSPORT POSITION**
-width	40.3 ft (12,283 mm)	24.6 ft (7498 mm)
-length	46.3 ft (14,112 mm)	46.3 ft (14,112 mm)
-height	9.3 ft (2835 mm)	14.8 ft (4511 mm)
-maximum ground clearance	7.0 in (178 mm)	7.0 in (178 mm)
-wheel tread	35.0 ft (10,668 mm)	14.8 ft (4511 mm)
-effective seeding width	40.0 ft (12,192 mm)	

WEIGHTS:	**TANKS EMPTY**	**TANKS FULL OF WHEAT**
APPLICATOR		
-front wheel	1385 lb (630 kg)	3955 lb (1798 kg)
-left wheel	1725 lb (785 kg)	4295 lb (1952 kg)
-right wheel	1690 lb (768 kg)	4145 lb (1884 kg)

CULTIVATOR (with attached harrows)	**FIELD POSITION**	**TRANSPORT POSITION**
-hitch	520 lb (236 kg)	680 lb (309 kg)
-left centre tandem wheels	3450 lb (1568 kg)	5265 lb (2393 kg)
-right centre tandem wheels	3400 lb (1545 kg)	5125 lb (2330 kg)
-left wing tandem wheels	1875 lb (852 kg)	
-right wing tandem wheels	1825 lb (830 kg)	
Total, Tanks Empty	15,870 lb (7214 kg)	
Total, Tanks Full of Wheat		23,465 lb (10,666 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