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Evaluation Report 577

Summers Model 9FS3421 Skid Mounted Field Sprayer

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

SUMMERS MODEL 9FS3421 SKID MOUNTED FIELD SRPAYER

MANUFACTURER:
Summers Manufacturing Co. Inc.
Devils Lake, ND 58348

DISTRIBUTOR:
Summer Distributing and Sales
#6 Hwy. N. and Sherwood Road
P.O. Box 4602
Regina, Saskatchewan

RETAIL PRICE:
$5,400.00 (July, 1988, f.o.b. Lethbridge, Alberta).

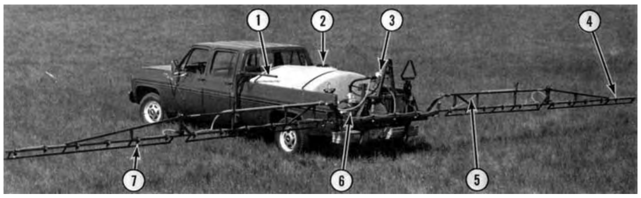

FIGURE 1. Summers Model 9FS3421 Skid Mounted Field Sprayer: (1) Remote Control Swing Arm, (2) Filler Opening, (3) Regulating and Solenoid Valves, (4) Boom Breakaway Assembly, (5) Spray Boom Inlet Hose, (6) Gasoline Motor and Pump, (7) Nozzle Assembly.

SUMMARY AND CONCLUSIONS

Rate of Work: Operating at average speeds of 10 and 16 mph (16 and 26 km/h) resulted in instantaneous work rates of 58 and 94 ac/h (23 and 38 ha/h) respectively. At an application rate of 9.8 gal/ac (110 L/ha), about 31 ac (13 ha) could be sprayed with a full spray tank.

Quality of Work: Application rate depended on forward speed, nozzle size and pressure. The Delavan LF4-80° nylon nozzles supplied, delivered 9.8 gal/ac (110 L/ha) at an average forward speed of 10 mph (16 km/h) and nozzle pressure of 40 psi (276 kPa). However, forward speed was difficult to keep constant and varied from 7 to 12 mph (11 to 19 km/h), resulting in the application rate varying from 14 to 8 gal/ac (157 to 90 L/ha).

Nozzle calibration was very good. The delivery rate of the new LF4-80° nylon nozzles was the same as specified by the nozzle manufacturer. Delivery of the used LF4-80° nylon nozzles increased about 2% after 67 hours of use. Variability among individual nozzle deliveries was low when new and used.

Nozzle spray distribution patterns were very good. The spray distribution patterns were very uniform above 21 psi (145 kPa) with the LF4-80° nozzles. Spray drift was good. The high capacity LF4-80° nozzles produced coarse spray droplets and could operate at a 13.5 in (345 mm) nozzle height that helped minimize spray drift.

The pressure gauge was very good. The pressure gauge was accurate and reliable. Pressure losses were fair. Pressure losses from the control valves to the nozzles were significant, resulting in application rates varying from 9.2 to 10 gal/ac (103 to 112 L/ha) at the outer and center boom nozzles, respectively, using the Delavan LF4-80° nozzle tips.

The strainers were very good in that the 50 mesh strainers and the use of large sized nozzle tips prevented nozzle plugging. Boom stability was good. The boom swing assembly and the truck suspension system reduced boom bounce. Reduced boom movement improved spray distribution patterns.

Ease of Operation and Adjustment: Ease of adjusting application rate was good and required the operator to select nozzle size, pressure and forward speed. The operator was required to calibrate truck forward speed. Keeping the truck's forward speed constant and watching the speedometer and path of travel for long periods of time was difficult.

Ease of controlling flow to the booms and nozzle pressure was good. The sprayer was equipped with a Raven remote control system. Flow to the spray booms was easily controlled by the solenoid valves. Nozzle pressure was adjusted by the butterfly valve. The valve was difficult to adjust until the operator gained experience.

The sprayer was compact and maneuverability with the truck was very good both in field and transport position. Turning quickly in field position was easy because the boom swing assembly prevented the boom ends from striking the ground. Ease of placing the booms in transport or field position was good. The booms were light and took one man about two minutes to fold or unfold. The outer end booms were awkward to fold or unfold and care had to be exercised.

Ease of nozzle adjustment was fair. Nozzle angle could not be adjusted. The nozzle height adjustment assembly binded, making it difficult and unsafe to adjust nozzle height. Nozzle height could be adjusted from about 21 to 34 in (533 to 864 mm) in field conditions. Nozzle height range varied depending on field conditions, amount of fluid in the spray tank and truck size. The quick-disconnect and self-aligning nozzle caps made nozzle changing quick and easy.

Ease of tank filling was good using a nurse tank with an auxiliary pump. The spray tank filler opening was not easily accessible. Ease of inducting chemical was fair. Care had to be exercised lifting the chemical containers and climbing on the truck box or spray tank.

Ease of installing the Summers sprayer on a truck was very good. The sprayer was light and the dismount jack was convenient to use.

Ease of cleaning was fair. Removing the nozzle caps for nozzle and strainer cleaning was quick and easy, however, removing the strainers was inconvenient and messy. Cleaning the main line strainer was easy.

Ease of draining was poor. The fluid drained on the truck and the spray tank could not be completely drained. Ease of servicing was good. The motor oil was inconvenient to check and change.

Pump Performance: Pump capacity was good and adequate to supply to Delavan LF4-80° nozzle tips. The pump could deliver about 15 gpm/min (1.13 L/s) at a 40 psi (276 kPa) nozzle pressure. This was adequate to apply 15 gal/ac (169 L/ha) at 10 mph (16 km/h).

Engine and Fuel Consumption: The motor performance was very good. The motor had ample power to run the centrifugal pump. Average fuel consumption was 0.35 gal/h (1.6 L/h).

Operator Safety: Care had to be exercised when adjusting nozzle height, adding chemical and placing the outer end booms in field or transport position.

Operator's Manual: The operator's manual was very good and provided useful illustrations and information on sprayer assembly, operation and parts.

Mechanical History: The first Briggs and Stratton motor stopped operating frequently and backfired frequently in the dusty conditions encountered. It was replaced and the second motor ran smoothly throughout the rest of the test.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifying the plumbing system to equalize the nozzle pressure at each boom section.
2. Modifying the filler opening to make it easily accessible.
3. Modifying the method of inducting chemical into the spray tank to make it easier and safer to use.
4. Improving spray tank draining.

Station Manager: R. P. Atkins
Project Engineer: L. Papworth

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. The sprayer tested was plumbed so the operator could spray with the center section only while the booms were folded for transport. If this feature is not important to the operator, all boom sections can be plumbed the same width equalizing nozzle pressure.
2. Our tank manufacturer recommends that the filler opening be

positioned at the tank center. This feature eliminates lid leakage on uneven ground and side hills.
3. A fifteen gallon mix and fill tank is available as an option. This option allows the operator to add chemical at the truck bed height. Chemical can also be measured with this tank and inducted directly into the spray tank.
4. Volume and depth of the tank sump was kept at a minimum to reduce total tank height. Current tank height allows the operator an unobstructed view out of the rear window of the truck.

GENERAL DESCRIPTION

The Summers Model 9FS3421 is a skid mount, boom-type field sprayer equipped with a 5 hp (3.8 kW) gasoline motor that directly drives the centrifugal pump. The low profile 305 gal (1387 L) plastic tank is equipped with hydraulic agitation, fluid level indicator and filler opening. The self-swing booms mount to the back of the spray tank frame, fold back for transport and have a self-returning breakaway system. The spray boom has 29 varispace quick TeeJet nozzle assemblies with diaphragm check valves, spaced at 20 in (508 mm) giving a spraying width of 48.3 ft (14.7 m). Nozzle height and spacing are adjustable and nozzle angle is constant.

The Summers Model 9FS3421 is equipped with a remote control that mounts on a swing arm. The remote control contains a pressure gauge and control switches to operate the pressure regulating and boom solenoid valves.

FIGURE 1 shows the location of the sprayer's major components, while detailed specifications are given in Appendix I.

SCOPE OF TEST

The Summers Model 9FS3421 was operated for 78 hours in conditions shown in TABLES 1 and 2, while spraying about 1765 ac (715 ha). It was evaluated for rate of work, quality of work, ease of operation and adjustment, pump performance, operator safety and suitability of the operator's manual.

During the test, Delavan flat fan LF4-80° nylon nozzle tips supplied with the sprayer and Lurmark flat fan 03-Fl10 nylon nozzle tips were used for 67 and 11 hours, respectively.

TABLE 1. Operating Conditions.

Chemical Applied	Crop	Hours	Speed		Field Area	
			mph	km/h	ac	ha
2, 4-D	Duram	11.0	11	18	292	115
2, 4-D	Duram	9.3	16	26	197	80
2, 4-D/Avenge	Wheat	5.2	10	16	158	64
Sabre/Poast	Flax	7.0	10	16	108	44
Tordon 202C	Soft Wheat/Barley	5.5	10	16	136	55
Glean	Duram	3.0	10	16	73	30
Lorox-L-MCPA	Wheat	12.5	10	16	306	124
Round-up/Rustler	Grassland	4.0	10	16	43	17
Dyvel	Various	14.0	10	16	402	163
Decis	Duram	2.5	10	16	50	20
Transport	–	4.0	62	100	–	–
Total		78.0			1765	715

TABLE 2. Field Conditions

Topography	Hours	Field Area	
		ac	ha
Level	21	367	149
Undulating	32	800	324
Rolling	20	437	177
Hilly	5	161	65
Total	78	1765	715

RESULTS AND DISCUSSIONS

RATE OF WORK

During field testing, the Summers sprayer was operated at average speeds of 10 and 16 mph (16 and 26 km/h), resulting in instantaneous workrates of 58 and 94 ac/h (23 and 38 ha/h), respectively. Actual workrates were less, depending on operator skill and reloading time. The quick folding of the booms and high speed transport made tank refilling from a central location quick. With a full spray tank, about 31 ac (13 ha) could be sprayed at 9.8 gal/ac (110 L/ha) before refilling.

QUALITY OF WORK

Application Rate: Application rate depended on truck speed, nozzle size and pressure. The Delavan LF4-80° nozzles supplied with the Summers sprayer delivered 9.8 gal/ac (110 L/ha) at an average forward speed of 10 mph (16 km/h) and a nozzle pressure of 40 psi (276 kPa). Changes in forward speed or nozzle pressure resulted in different application rates as shown in FIGURE 2. Keeping forward speed constant with a truck, particularly at the low speeds, was difficult. For example, at a desired speed of 10 mph (16 km/h), actual forward speed varied from 7 to 12 mph (11 to 19 km/h) in flat to undulating field conditions. At a nozzle pressure of 40 psi (276 kPa), the corresponding application rate varied from 16 to 8 gal/ac (157 to 90 L/ha), when the forward speed changed from 7 to 13 mph (11 to 19 km/h). To ensure uniform application rates it is recommended that the desired speed be kept constant using application rate control monitors.

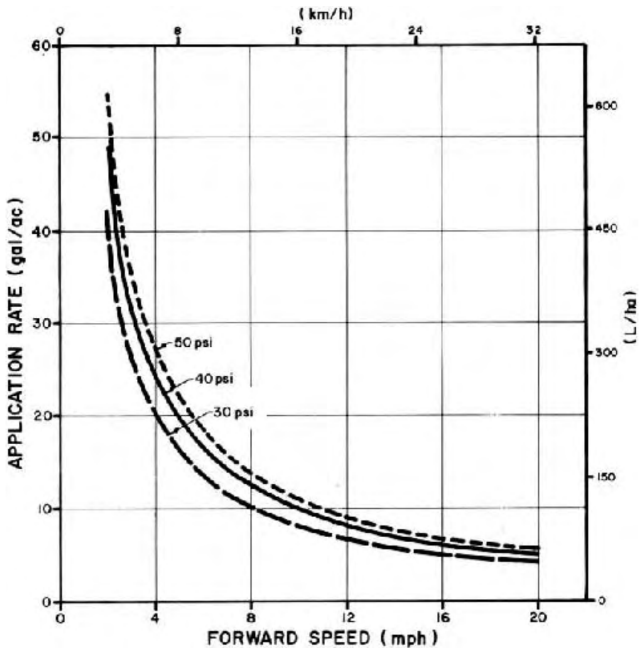

FIGURE 2. Application Rates at Various Forward Speeds and Pressures Using Delavan LF4-80° Nozzles.

Nozzle Calibration: Nozzle calibration was very good. FIGURE 3 shows the average delivery of Delevan LF4-80° and Lurmark 03-F110 nylon nozzles at various pressures. Measured delivery of the LF4-80° nylon nozzles agreed with Delavan rated output. The delivery of the 03-Fl10 nylon nozzles was about 2% greater than specified by Lurmark.

Nozzle wear was very good in that the delivery rate of used LF4-80° nylon nozzle tips increased by only 2% after 67 hours of field use. Some researchers indicate that a nozzle needs replacement once delivery has increased by more than 10%. Nozzle wear depends on the type of chemicals sprayed and water cleanliness.

Variability among individual nozzle deliveries for both the Delavan LF4-80° and Lurmark 03-F110 nylon nozzles was low and rated as very good. A low coefficient of variation (CV)[1] indicates similar delivery rates for all nozzles, while a high CV indicates larger variability among individual nozzle deliveries. The CV of nozzle deliveries of Delavan LF4-80° and Lurmark 03-F110 nozzles was 0.9 and 1.9%, respectively, when new.

Distribution Patterns: Nozzle spray distribution patterns were very good. FIGURES 4 and 5 show spray distribution patterns along the boom with Delavan LF4-80° nylon nozzles when operated at an 18 in (457 mm) nozzle height. The coefficient of variation (CV)[2] at 15 psi (100 kPa) (FIGURE 4) was 22.4%, with application rates along the boom varying from 4.2 to 8.9 gal/ac (47 to 101 L/ha) at

[1]The coefficient of variation (CV) is the standard deviation of delivery rates for ten nozzles expressed as a percent of the mean delivery rate.

10 mph (16.1 km/h). High spray concentrations occurred below each nozzle with inadequate coverage between nozzles. At 44 psi (300 kPa) (FIGURE 5) the distribution pattern improved considerably, reducing the CV to 4.8%. Application rate along the boom varied from 9.0 to 11.6 gal/ac (100 to 130 L/ha) at 10 mph.

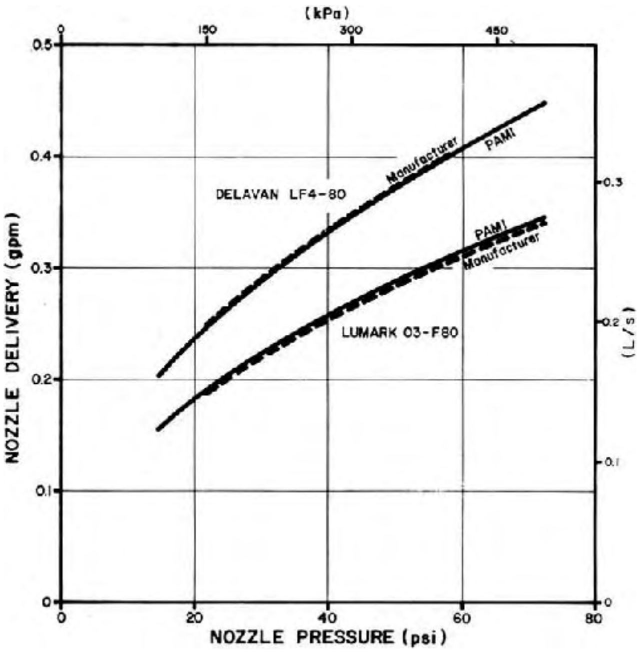

FIGURE 3. Average Delivery Rates for Delavan LF4-80° and Lurmark 03-F110 Nylon Nozzles.

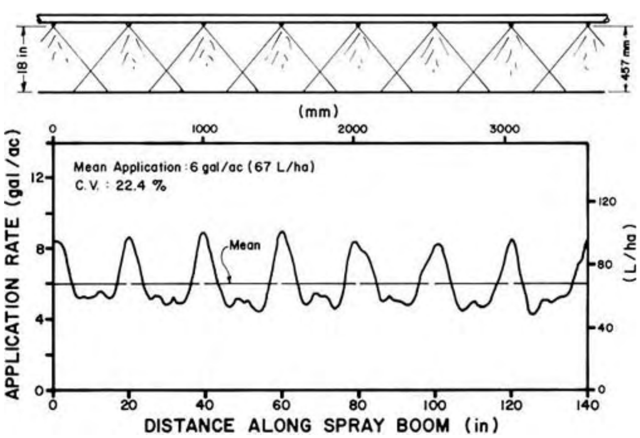

FIGURE 4. Typical Distribution Pattern Along the Boom at 15 psi (100 kPa) with Delavan Flat Fan LF4-80° Nylon Nozzles, at an 18 in (457 mm) Nozzle Height and at 10 mph (16.1 km/h).

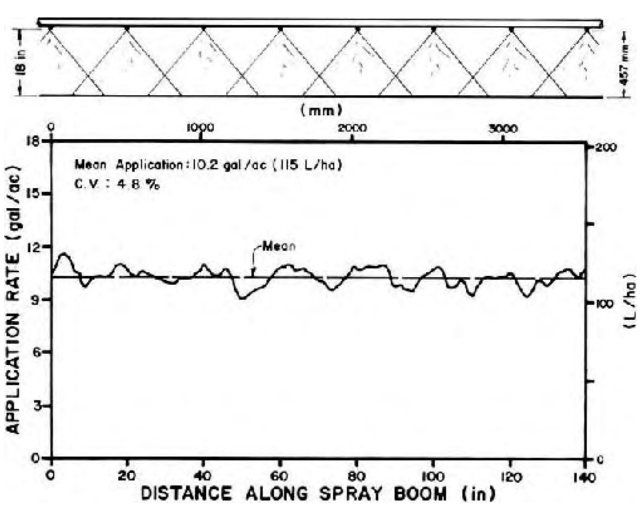

FIGURE 5. Typical Distribution Pattern Along the Boom at 44 psi (300 kPa) with Delavan Flat Fan LF4-80° Nylon Nozzles, at an 18 in (457 mm) Nozzle Height and at 10 mph (16.1 km/h).

Distribution Pattern Uniformity: FIGURE 6 shows how nozzle pressure affected spray pattern uniformity for the Delavan LF4-80° and Lurmark 03-Fl10 nylon nozzles. The coefficient of variation (CV) was used to express spray distribution pattern uniformity. The high capacity Delavan flat fan LF4-80° nozzles produced acceptable spray distribution patterns at pressures above 19 psi (131 kPa) and very uniform patterns at pressures above 21 psi (145 kPa). After 67 hours of field use, there was no significant change in spray pattern uniformity.

The lower capacity Lurmark flat fan 03-Fl10 nozzles produced acceptable spray distribution patterns at pressures above 27.6 psi (190 kPa) and could not produce very uniform patterns at any pressure.

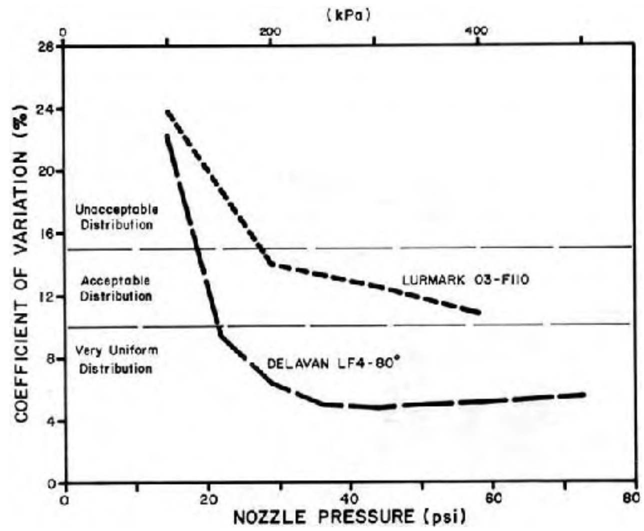

FIGURE 6. Spray Pattern Uniformity for Delavan LF4-80° and Lurmark 03-Fl10 Flat Fan Nylon Nozzles Operated at an 18 in (457 mm) Nozzle Height.

Spray Drift: There were no tests conducted to evaluate spray drift but work by the Saskatchewan Research Council[3] indicates that off-swath drift from 8002 TeeJet flat fan nozzles operated at 30 psi (207 kPa) and 18 in (457 mm) height was generally below 1% of the emitted material in 13 mph (21 km/h) winds. The nozzles used were rated as good in that the low drift was attributed to the nozzles high capacity, coarse droplets and low nozzle height operation. The higher capacity Delavan LF4-80° flat fan nozzles used on the Summers sprayer produced more coarse spray droplets than the 8002 TeeJet nozzles. In addition, the LF4-80° nozzles could be operated at nozzle heights as low as 13.6 in (345 mm) in suitable field conditions, and still produce acceptable spray distribution patterns.

The Lurmark 03-F110 flat fan nozzles were also high capacity nozzles that produced coarse spray droplets, and therefore were effective in reducing spray drift.

Pressure Losses in Plumbing System: Pressures in the plumbing system were measured at the pump, the control valves and each boom section using different sized nozzles, including the Delavan LF4-80° nozzle tips. The remote control console pressure gauge measured the pressure at the control valves.

When using Delavan LF4-80° nozzles, pressure loss from the boom control valves to the nozzles was significant and was rated as fair. Pressure varied from 2 to 6 psi (14 to 41 kPa), depending on the boom section and nozzle position on the boom. The pressure loss was greatest at the outer boom end nozzles. Higher pressure losses occurred when using large nozzles.

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[2]The coefficient of variation (CV) is the standard deviation of application rates for successive 0.63 in (16 mm) sections along the boom expressed as a percent of the mean application rate. The lower the CV, the more uniform is the spray coverage. A CV below 10% indicates very uniform coverage while a CV above 15% indicates inadequate uniformity. The CV's above were determined in stationary laboratory tests. In the field, CV's may differ due to boom vibration and wind. Different chemicals vary as to the acceptable range of application rates. For example, 2,4-D solutions have a fairly wide acceptable range while other chemicals may have a narrow range.

[3]Maybank, J; Yoshida, K; Shewchuk, S.R., "Comparison of Swath Deposit and Drift Characteristics of Ground Rig and Aircraft Herbicide Spray Systems" (Report of the 1975 Field Trials, Saskatchewan Research Council Report No. P76-1, January, 1976, p. 16).

This pressure loss increased nozzle delivery rate variability from a CV of 0.9 to 2.3%. With the control console pressure gauge set at 40 psi (276 kPa), application rate along the width of the boom varied from 9.2 gal/ac (103 L/ha) at the outer end boom nozzles to 10 gal/ac (112 L/ha) at the centre boom nozzles. It is recommended the manufacturer modify the plumbing system to equalize the nozzle pressure across the entire boom width.

The remote control pressure gauge was rated as very good in that it was reliable and accurate throughout the test.

Use of Optional Nozzles: The quick TeeJet nozzle assemblies (FIGURE 7) accepted flat fan, flood or cone nozzle tips.

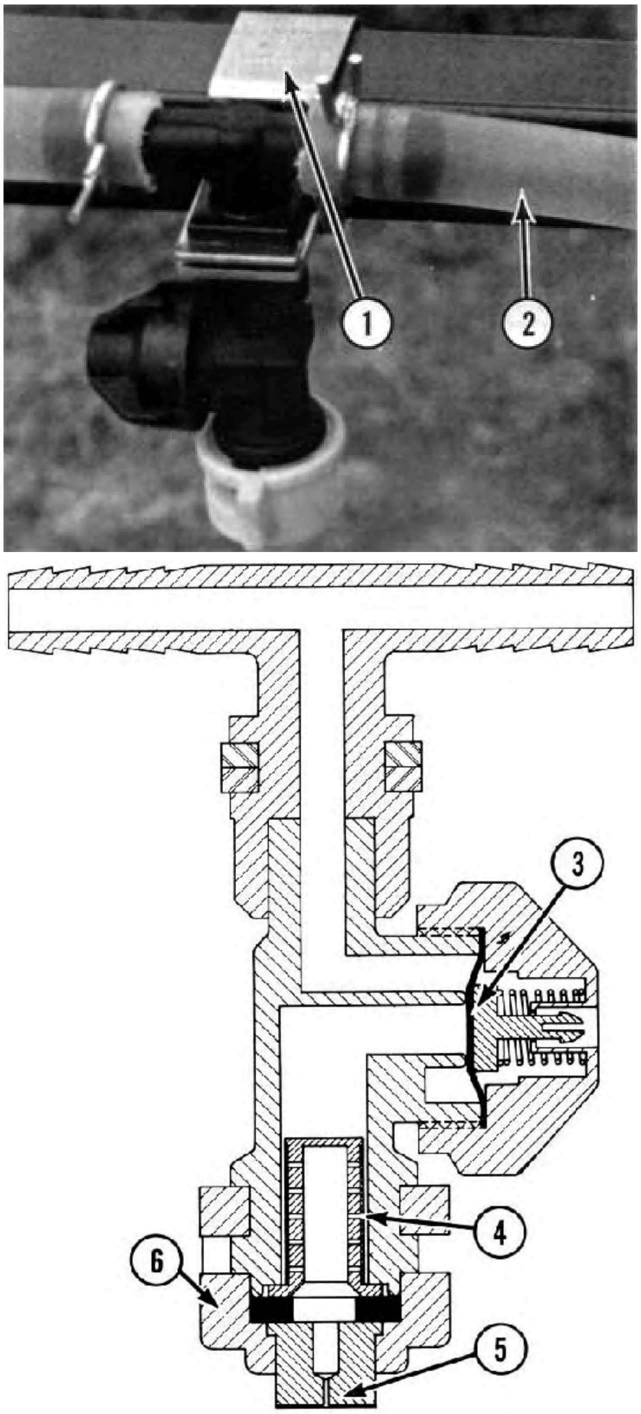

FIGURE 7. Quick Tee Jet Nozzle Assembly: (1) Vari-Clamp, (2) Spray Boom Hose, (3) Diaphragm Check-Valve, (4) Strainer, (5) Nozzle Tip, (6) Quick-Disconnect and Self-Aligning Nozzle Cap.

System Strainers: The tank filler opening was not equipped with a strainer. The pump outlet hose and nozzles were equipped with 50 mesh strainers. The strainers were very good in that they effectively prevented the Delavan LF4-80° and Lurmark 03-F110 nozzle tips from plugging.

Boom Stability: Boom stability was rated as good. Field observations indicated that the booms remained relatively stable in the field conditions encountered (TABLE 2) during the test. The boom rail construction, boom swing assembly and truck suspension systems reduced boom bounce on rough fields. However, the boom ends still moved up and down, which typifies cantilever type boom systems, causing variations in nozzle heights along the boom. The moderate variations in nozzle heights did not significantly deteriorate spray distribution patterns using Delavan LF4-80° nozzle tips. As shown in FIGURE 8, the LF4-80° nozzle tips produced acceptable spray distribution patterns above 13.6 in (345 mm) nozzle heights.

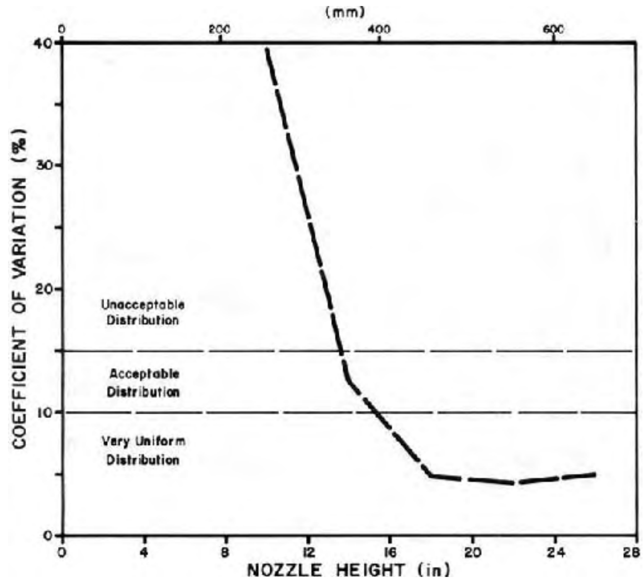

FIGURE 8. Spray Pattern Uniformity Using Delavan LF4-80° Nozzles at 44 psi (300 kPa) when Operating at Various Nozzle Heights.

Soil Compaction and Crop Damage: The Summers skid mount sprayer was mounted on a 3/4 ton pick-up truck. The truck travelled over about 2.4% of the total field area sprayed. The average soil contact pressure and tire track width was 47 psi (324 kPa) and 7 in (178 mm), respectively, with a full spray tank. For comparative purposes, the average soil contact pressure was 38 psi (262 kPa) without the sprayer. Some crop damage was observed because the crop was usually lower and thinner in the truck tire tracks.

EASE OF OPERATION AND ADJUSTMENT

Application Rate: Adjusting the application rate was rated as good and was done by changing forward speed, nozzle size or pressure. The operator's manual provided good information on selecting nozzle size, pressure and forward speed to obtain the desired application rates.

The quick TeeJet nozzle assemblies made changing nozzles easy. Nozzle pressure was adjusted by the remote control system and remained constant once adjusted. With new nozzle tips, no nozzle calibrations were needed, however a visual check should be made of spray patterns before spraying.

Due to truck tire slippage and fluctuating speedometer readings at low truck speeds, it is recommended that truck forward speed be calibrated with the sprayer tank half full of water. Each change in forward speed should be calibrated.

Application rate accuracy was dependant on the operator's ability to keep the truck's forward speed constant. Holding and adjusting the accelerator and watching the speedometer and path of travel for long periods of time was difficult and resulted in varying application rates.

Controls: The Summers sprayer was equipped with a Raven remote control system (FIGURE 9) to operate sprayer controls from the truck seat. Ease of controlling flow to the booms and nozzle pressure was good. The remote control system included a pressure gauge to monitor nozzle pressure, boom solenoid valve switches to control flow to the booms and a pressure regulating switch to control nozzle pressure. The desired nozzle pressure was difficult to adjust at first. Depending on the butterfly valve position, small adjustments of the pressure switch resulted in small or large pressure changes. With experience, nozzle pressure became easier to adjust. The pressure switch was a large toggle switch which was easy to use in rough fields.

The agitator control valve could not be operated from the truck seat. The valve was normally fully open during spraying and only had to be opened once.

The tank level indicator gave only a rough indication of liquid level. The tank liquid level indicator was only reliable when the sprayer was stopped on level ground.

FIGURE 9. Raven Remote Control Console.

Maneuverability: Maneuverability was very good both in transport and field position. Cornering, backing and transporting with a truck was easy. Turning radius was dependent on the truck the Summers sprayer was mounted on. Turning quickly in field position was easy because the boom swing assembly prevented the boom ends from striking the ground.

Boom Positioning: Boom positioning was rated as good. The Summers sprayer booms could be folded into transport (FIGURE 10) or placed into field position in less than two minutes, allowing getting in and out of fields quickly. Care had to be exercised handling the outer end booms. The end booms were heavy, awkward to handle and therefore, to avoid injury, the booms were dropped into position.

During spraying the transport pin had to be removed for the boom swing assembly to function properly. The booms had a breakaway assembly that conveniently returned to the normal spraying position after striking the ground or object. Greasing the boom pivot joint had to be done daily for the breakaway assembly to operate smoothly and to make folding easier.

Transporting: Transporting the Summers sprayer was very good in that the sprayer was compact (FIGURE 10) in transport position, making it easy to transport on roadways. Visibility to the rear was good.

FIGURE 10. Sprayer in Transport Position.

Nozzle Adjustment: Nozzle adjustment was rated as fair. Nozzle angle could not be adjusted forward and therefore the spray tended to deflect back at the high forward speeds.

The vari-clamp quick nozzle assembly allowed for adjusting nozzle spacing. The need to adjust nozzle spacing was limited and required installation of new boom spray hoses to accommodate the new nozzle spacing.

Nozzle height could be adjusted about 12.5 in (318 mm) from the lowest height adjustment increment. The nozzle height range varied depending on the truck used, amount of fluid in the spray tank and field conditions. With the sprayer mounted on a 3/4 ton truck, the minimum nozzle height varied from about 21 in (533 mm) in soft field conditions with the spray tank full to 26 in (660 mm) in firm field conditions with the spray tank nearly empty. Nozzle height was difficult to adjust and usually required two people. The entire boom had to be held and positioned at the next height adjustment. The sprayer dismount jack could be used, but the jack's range was limited. Blocks of wood were used to extend the jack's range. In addition, the jack caused the boom height adjustment sliding assembly to bind, increasing the difficulty of adjusting nozzle height.

The quick-disconnect and self-aligning nozzle caps made nozzle changing easy.

Tank Filling: Ease of filling the tank was good. The 305 gal (1386 L) spray tank could only be filled utilizing the filler opening. The spray tank was easier to fill by nurse trucks equipped with an auxiliary pump, even though the spray tank filler opening was low enough to be filled by gravity from large nurse trucks. The filler opening was located at the center of the spray tank and was not easily accessible. Taller operators had to stretch and shorter operators had to climb into the truck box to open the filler opening lid. It is recommended the manufacturer modify the filler opening to make it easily accessible.

Chemical Inducting: Chemical could only be inducted through the filler opening. This was inconvenient and reduced the rating to fair. The filler opening was not easily accessible, making adding chemical difficult and unsafe. Stronger and taller operators could pour chemical from the smaller containers by stretching from the side of the truck. However, majority of operators had to climb onto the truck box or spray tank while lifting and holding the chemical container. Accessing the truck box was difficult because there was no convenient place to step or place the chemical container.

The filler opening was small and chemical usually spilled around the filler opening, especially when using the 4.4 gal (20 L) containers. Rinsing chemical containers was also inconvenient because there was very little room between the spray tank and booms to work. Operators jumped off the truck, rinsed the chemical containers and climbed back on the truck. It is recommended the manufacturer consider modifying the method of inducting chemical into the spray tank to make it easier and safer to use.

Installation: Ease of installing the Summers sprayer on a truck was very good. The Summers sprayer was light and easily installed. Care had to be exercised driving the truck under the sprayer because there was very little room between the sprayer and sides of the truck box. The front of the sprayer was light and could easily be lifted by one man to adjust the front jack legs. The rear of the sprayer was heavy and had to be lifted by the dismount jack provided, to adjust the rear jack legs. The dismount jack's height range was limited and blocks of wood were used to increase the range. The operator had to climb on the back of the truck box to operate the jack, which was inconvenient. The lateral and end stop brackets were easy to adjust to secure the sprayer in the truck box. It took one man about ten minutes to load or unload the Summers sprayer.

Cleaning: Ease of cleaning was fair. Removing nozzle caps from the quick nozzle assemblies for cleaning was quick and convenient. Removing the strainers from the nozzle body assemblies was difficult at times. The top of the nozzle body assembly had to be tapped or the strainer pried with a screwdriver, causing chemical solution to splatter on the operator. Flushing the sprayer's plumbing system with clean water is recommended before cleaning the strainers.

The pump outlet hose strainer was accessible and easily removed for cleaning. The strainer was positioned above the spray tank and hoses, reducing chemical contact during bowl removal.

The spray tank was easily flushed by refilling the tank with clean water. The small filler opening inhibited spray tank cleaning with high pressure washers.

Draining: Ease of draining was poor. Draining the Summers spray tank was inconvenient and time consuming. The fluid drained slowly on the rear of the truck box, and did not completely drain the spray tank. To prevent exposure to the draining fluid, the operator had to quickly move away from the truck after removing the drainage plug. It is recommended the manufacturer consider improving spray tank draining.

Servicing: Ease of servicing was good. Checking the pump motor oil level was inconvenient, requiring the sprayer booms to be placed in field position for easier access to the dip stick. Draining the motor oil was messy because an oil pan could not be placed between the oil drain plug and the truck floor to collect the oil.

The gasoline tank filler opening was not easily accessible by a jerry can funnel due to interference caused by the truck box and sprayer booms. A flexible funnel had to be used to add gasoline to the motor gas tank.

The Summers sprayer had four grease fittings and two breakaway castings that required daily greasing. The four grease fittings were easy to grease. The grease was manually placed between the breakaway castings.

PUMP PERFORMANCE

Output: The pump capacity was good. The Scot Model 1451 centrifugal pump operated at about 4000 rpm directly from the Briggs and Stratton gasoline motor. In the Summers plumbing system the maximum pump delivery to the booms was about 15 gpm (1.13 L/s) at a 40 psi (276 kPa) nozzle pressure. This was adequate to apply 15 gal/ac (169 L/ha) at 10 mph (16.1 km/h).

Agitation: Normally recommended agitation rates for emulsifiable concentrates such as 2,4-D are 1.5 gpm per 100 gal of tank capacity (0.025 L/s per 100 L of tank capacity). For wettable powders such as Atrazine, recommended agitation rates are 3.0 gpm per 100 gal of tank capacity (0.05 L/s per 100 L of tank capacity).

The Summers sprayer was equipped with one jet agitator. At maximum motor speed and with the agitation valve wide open, the agitator output was about 10 gpm (0.75 L/s) during reloading and about 8.5 gpm (0.64 L/s) during spraying with the agitation valve wide open. The Summers agitator output met recommended agitation rates for emulsifiable concentrates and wettable powders. At high agitation rates, foaming may occur with some chemicals. However, the agitation rate could easily be reduced by partially closing the agitator valve.

ENGINE AND FUEL CONSUMPTION

The Briggs and Stratton I/C gasoline motor performance was very good. The motor started easily and had ample power to run the centrifugal pump.

Average fuel consumption was about 0.35 gal/h (1.6 L/h). The operator could spray for about 1.5 hours or 87 ac (35 ha) at 10 mph (16 km/h). Oil consumption was insignificant.

OPERATOR SAFETY

The operator's manual emphasized operator safety. A warning decal on the spray tank cautioned operators to wear rubber gloves. The sprayer was equipped with a slow moving vehicle sign.

Care had to be exercised when adding chemical to the spray tank, adjusting nozzle height and handling the outer end boom sections, as previously mentioned in the report.

Caution: Operators are cautioned to wear suitable eye protection, respirators and clothing to minimize operator contact with chemicals. Although many commonly used agricultural chemicals appear to be relatively harmless to humans, they may be deadly. In addition, little is known about the long term effects of human exposure to many commonly used chemicals. In some cases, the effects may be cumulative, causing harm after continued exposure over a number of years.

OPERATOR'S MANUAL

The operator's manual was very good and contained useful information. It was clearly written and well illustrated. It provided useful information on sprayer operation, maintenance, adjustments, trouble shooting, optional equipment and parts.

MECHANCIAL PROBLEMS

TABLE 3 outlines the mechanical history of the Summers skid mount sprayer during 78 hours of operation while spraying about 1765 ac (715 ha). The intent of the test was evaluation of functional performance. An extended durability evaluation was not conducted.

TABLE 3. Mechanical History

Item	Operating Hours	Equivalent Field Area ac	(ha)
- Carburator needle valve loosened and was adjusted at	9, 14, 24	211, 292, 611	85, 118, 247
- Engine base frame bolts loosened and were tightened at	24	611	247
- Motor operated rough and carburator was adjusted at	24	611	247
- Motor was powerless and the carburator was taken apart and cleaned at	40	1135	460
- Motor backfired frequently and was replaced at	52	1135	460
- Start rope on new motor did not recoil and was repaired at	60	1366	553

DISCUSSION OF MECHANICAL PROBLEMS

Motor: In dusty field conditions encountered the motor operated rough and with very little power after 24 hours of field operation. In the shop the motor operated fine, making it difficult to find the problem. The carburator was taken apart and cleaned. The motor was more powerful, but backfired frequently and was replaced by the manufacturer. The replacement motor operated very well in the dusty conditions, but the air cleaner had to be cleaned daily.

The spring on the carburator needle valve did not provide enough resistance to maintain the needle valve screw setting. During field operation the needle valve loosened frequently and replacing the spring with a longer spring corrected the problem.

APPENDIX I
SPECIFICATIONS

MAKE:	Summers Skid Mounted Agri-Sprayer
MODEL:	9FS3421
SERIAL NUMBER:	86159
MANUFACTURER:	Summers Manufacturing Co. Inc. Decals Lake, ND 58348
OVERALL DIMENSIONS:	
-transport height	10.9 ft (3.33 m)
-transport length	10.3 ft (3.14 m)
-transport width	8.9 ft (2.70 m)
-field height	5.9 ft (1.81 m)
-field length	9.6 ft (2.93m)
-field width	47.3 ft (14.43 m)
WEIGHT:	
-empty	745 lb (338 kg)
-loaded	3790 lb (1706 kg)
SPRAY TANK:	
-material	plastic
-capacity	305 gal (1387 L)
-agitation	hydraulic, 1 jet action
FILLER OPENING:	
-shape	round
-size	10 in (254 mm) ID
-location	top outer
STRAINERS:	
-pump outlet hose	50 mesh
-nozzle assembly	50 mesh
PUMP:	
-make	Scot
-model	1451
-type	centrifugal
-operating speed	4000 rpm
-type of drive	direct from motor
MOTOR:	
-make	Briggs and Stratton
-model	132232 Industrial
-hp	5
-gasoline capacity	0.55 gal (2.5 L)
CONTROL MONITOR:	
-make	Raven Industries Inc
-model	SCS200
-pressure gauge	dial, 0-100 psi (0-689 kPa)
SOLENOID VALVES:	
-make	Spraying Systems Co.
-model	8547
-size	three, 0.75 in (19 mm) NPT, 12 VDC, 35 watt
SPRAY BOOM:	
-material	plastic hoses
-size	0.75 in (19 mm)
-height adjustment	
-type	manual, sliding tubes
-range	12.5 in (318 mm)
-angle adjustment	none
-nozzle assembly	
-make	Spraying Systems Co.
-type	vari-spacing diaphragm check valve
-number	29
-spacing	20 in (508 mm)
-cap	quick disconnect and self aligning
-effective spraying width	48.3 ft (14.7 m)

APPENDIX II
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

-Excellent	-Very Good
-Good	-Fair
-Poor	-Unsatisfactory

SUMMARY CHART

SUMMER MODEL 9FS3421 FIELD SPRAYER

RETAIL PRICE:	$5,400.00 July 1988, f.o.b. Lethbridge
RATE OF WORK:	58 ac/hr (23 ha/hr) @ 10 mph 16.1 km/h)
QUALITY OF WORK:	
Application Rate	- application rate varied depending on forward speed
Nozzle Calibration	
- delivery	**- very good;** same as manufacturer’s
- wear	**- very good;** about 2% after 67 hours
- coefficient of variation	**- very good;** about 1%
Spray Distribution	**- very good;** acceptable above 19 psi (131 kPa) and very uniform above 21 psi (145 kPa)
Spray Drift	**- good;** coarse spray droplets reduced drift
Pressure	
- loss	**- fair;** resulted in varying application rates across the boom width
- gauge	**- very good;** reliable
Straining	**- very good;** 50 mesh with large size nozzles was effective
Boom Stability	**- good;** boom swing assembly and truck suspension reduced boom bounce
EASE OF OPERATION AND ADJUSTMENT:	
Application Rate	**- good;** difficult to keep forward speed constant
Controls	**- good;** pressure regulating valve was difficult to control at first
Maneuverability	**- very good;** easy with truck
Boom Positioning	**- good;** about two minutes, but difficult to fold or unfold outer end booms
Transporting	**- very good;** sprayer was compact
Nozzle Adjustments	**- fair;** nozzle height adjustment assembly binded
Tank Filling	**- good;** with nurse truck with auxiliary pump
Chemical Inducting	**- fair;** care had to be exercised
Installation	**- very good;** light
Cleaning	**- fair;** nozzle strainers difficult to remove
Draining	**- poor;** slow and messy
Servicing	**- good;** motor oil inconvenient to check and change
PUMP PERFORMANCE:	**- good;** adequate capacity for nozzles and agitation
ENGINE AND FUEL CONSUMPTION:	
Engine	**- very good;** ample power
Fuel Consumption	- 0.35 gal/h (1.6 L/h)
OPERATOR SAFETY:	- care had to exercised when adjusting nozzle height, adding chemical and folding outer boom sections
OPERATOR’S MANUAL:	**- very good;** informative
MECHANICAL HISTORY:	- replaced motor

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