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AN INVESTIGATION OF AIR SEEDER COMPONENT CHARACTERISTICS

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SUMMARY: Air seeder component characteristics, based on the evaluation of nine machines, are discussed. Most air seeder metering systems were affected by changes in ground speed and field slope. Distribution system uniformity was affected by field slope, blocked header outlets, corrugated inlet tubes, deflectors in inlet tubes and header impact plates.

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INTRODUCTION

There are numerous types and sizes of air seeders available in western Canada at present. Some of the designs and concepts used for air seeders originated in Germany while many have been further developed in Australia, the United States and Canada. Since 1980, the Prairie Agricultural Machinery Institute has evaluated nine different air seeders. Based on these evaluations, this paper discusses some performance characteristics of common components used on air seeders. The effect of variables, including operating on a slope, ground speed, vibration and level of material in the tanks are also discussed.

AIR SEEDER COMPONENTS

All air seeders evaluated used a centrifugal fan, which conveyed metered material through a distribution system. A number of different configurations of these components were encountered for use on cultivators of various working widths.

Different sizes of centrifugal fans were used for delivery of high velocity, low pressure air. The fans were driven by either the tractor power take-off, a hydraulic motor or an air cooled engine.

Metering systems varied widely in design and included fluted feed rolls, double rollers, conveyor belts, pegged rollers and augers. Three different methods were used for delivering metered material into the distribution air stream. These included the use of an air lock, a pressurized tank or a venturi.

The distribution systems used could be classified into three main types according to how the material being conveyed was divided. Type A used both primary and secondary headers for material division and distribution (FIGURE 1). With Type B, primary division occurred at the meters while headers were used for secondary division (FIGURE 2). Type C divided all the material right at the meter and there was no need for secondary division (FIGURE 3).

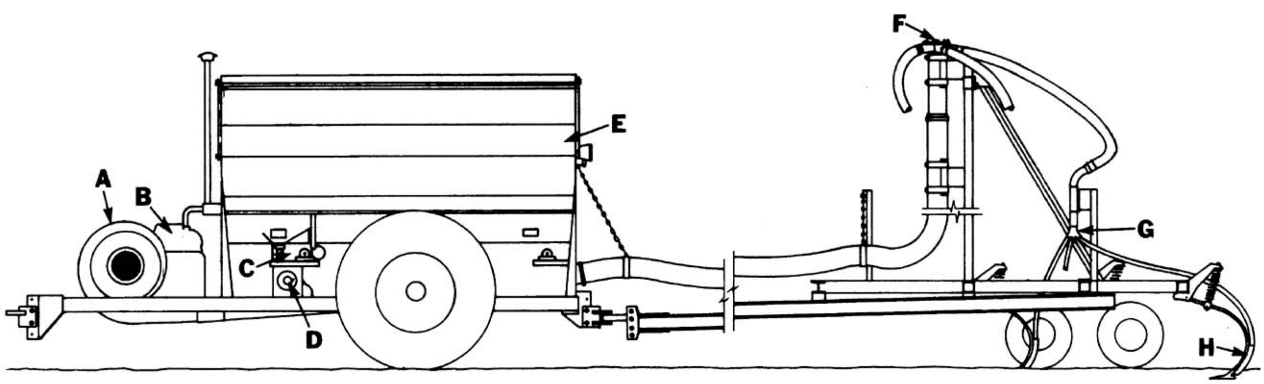

FIGURE 1. Air Seeder with Type A Distribution System: (A) Fan, (B) Fan Engine, (C) Metering System, (D) Air lock, (E) Tank, (F) Primary Header, (G) Secondary Header, (H) Seed Boot.

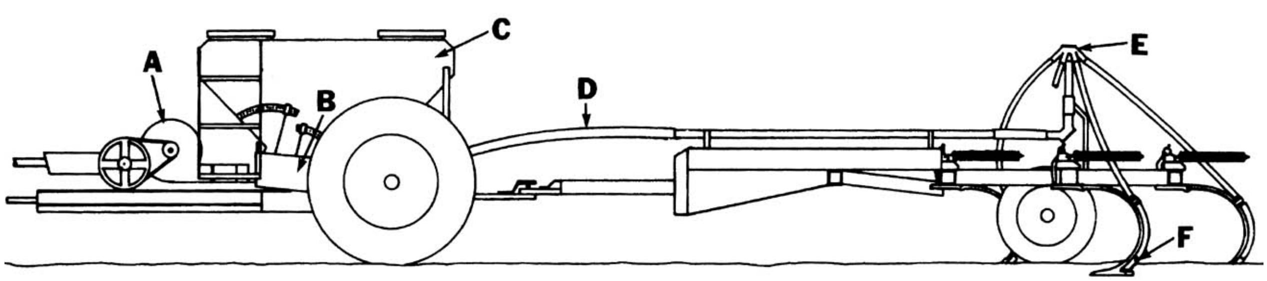

FIGURE 2. Air Seeder with Type B Distribution System: (A) Fan, (B) Metering System, (C) Tank, (D) Primary Tube, (E) Secondary Header, (F) Seed Boot.

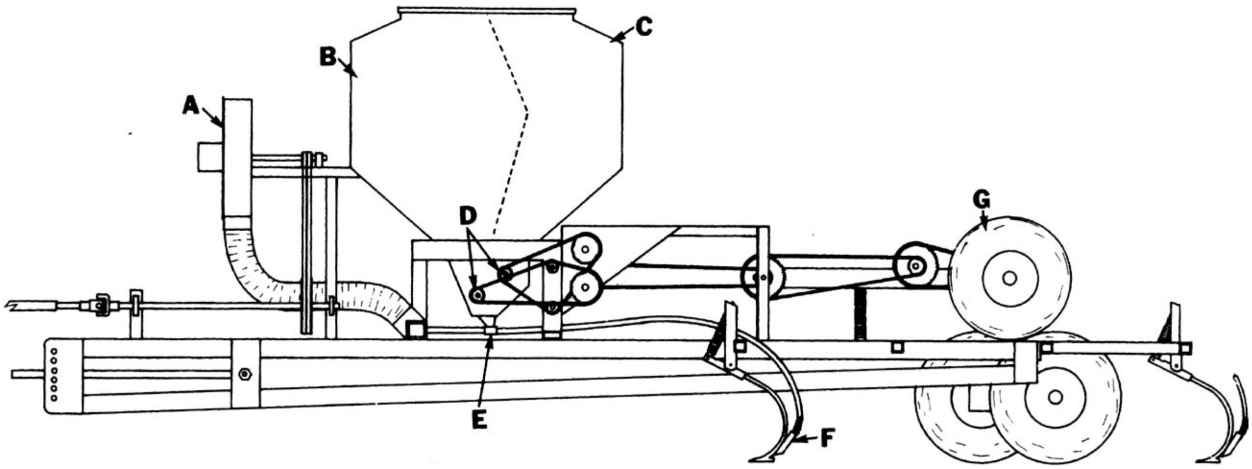

FIGURE 3. Air Seeder with Type C Distribution System: (A) Fan, (B) Front Tank, (C) Rear Tank, (D) Metering System, (E) Divider Cups, (F) Seed Boot, (G) Meter Drive Wheel.

<u>THEORY OF OPERATION AND LITERATURE REVIEW</u>

Metering accuracy and distribution uniformity are the two main concerns for application of seed and fertilizer with air seeders.

Some of the variables affecting metering accuracy are:

1. The type of material metered. Density, texture and size of material affect the metering rate in various ways.
2. The size of increments between meter rate settings. For example, variable speed gear boxes generally provide better resolution than changing sprocket combinations to change metering rates.
3. Ground speed and slopes such as would be encountered when working in hilly terrain.
4. The air pressure differential between the grain and fertilizer tanks and the distribution system.
5. The relationship between ground speed and meter drive speed. Meter drive wheel slippage is common to some ground driven meters.
6. The method used for introducing the metered material into the distribution system air stream.

Some of the variables which affect distribution uniformity include:

1. Devices to induce air turbulence in the primary and secondary headers. These include inlet tubes that are corrugated or contain indentations to cause air turbulence.
2. Deflectors in the primary and secondary header inlet tubes. These deflectors are used for maintaining material in suspension while turning corners and for directing material flow to all header ports evenly.
3. Impact plates in the primary and secondary headers. These plates direct material flow as it reverses direction upon entry to the headers and distribute material to individual header outlets (1).
4. The length of straight inlet pipe preceding the secondary headers. Recommendations have been made on lengths of secondary header inlet pipe by McKay (1).
5. The mass flow rate of material through the distribution system. Changes in distribution uniformity with changes in mass flow rate have been reported on by Allam and Wiens (2, 3).
6. The total pressure within the distribution system.
7. The mechanical division of material by the metering systems on machines with B and C type distribution systems.
8. The blocking of header outlets on primary and secondary headers to suit various implement sizes.

Only some of the above variables affecting distribution uniformity and metering accuracy are discussed in this paper.

RESULTS AND DISCUSSION

METERING SYSTEMS

A number of laboratory tests were performed on the air seeder metering systems. These tests included the effect on metering rates in wheat and 11-51-00 fertilizer, when ground speed, slope and level of material in the tanks were varied. The effect of field vibrations on metering rate was also determined when metering fertilizer and canola.

***Fluted Feed Roll System*:** Three of the machines tested used fluted feed roll systems which controlled the metering rate by varying the area of fluted roll exposed to the material as the feed rolls rotated. A central ground driven metering system situated below the tank, metered material into the air stream. With these meters, an increase in ground speed from 5 to 12 km/h resulted in a decrease in the metering rate up to 5%. A 5% change in metering rate was also common on a 10 degree side slope or hill. A decrease in rate occurred when the unloading side of the meters was on the high side while an increase occurred when the unloading side was on the low side.

A fourth machine used a shallower fluted feed roll with a sliding gate placed above the meter for rate adjustment. Increasing the ground speed from 5 to 12 km/h with this system, resulted in a decrease in metering rate up to 11%. This decrease in metering rate was attributed to poorer loading characteristics of the flutes at higher meter speeds. A change in metering rate up to 8% occurred when the machine was operated on a 10 degree side-slope. A decrease in metering rate, due to the rate adjustment gate effectively covering a larger portion of the metering flutes, occurred when the machine was tilted in one direction. Reversing the slope, caused the metering rate to increase, due to the adjustment gate effectively covering a reduced portion of the metering flutes. The rate adjustment gate was not very effective in controlling the metering rate of small seeds such as canola. At very low meter settings, metering resolution was good. However, as the gate was opened, the increments between rate settings became very large due to material pouring past the gate and into the metering flutes.

Field vibrations and level of material in the tanks had no significant effect on either of the fluted feed roll metering systems discussed above.

Smooth Double Roller System: One of the machines evaluated used two rubber rollers, located at the bottom of each of two tanks, which metered material into collection cups. These ground driven rollers rotated in opposite directions and pulled the material through by friction. Metering rate was controlled by changing roller speed. The metering rollers on the front tanks were covered with a very soft rubber for metering grain while the rollers on the rear tank were covered with a firmer rubber for metering fertilizer. Field vibration, slope and level of material in the tank all had little effect on the metering rates. A decrease in the rear metering rate of about 6% occurred with fertilizer when ground speed was increased from 5 to 12 km/h. No significant change in the metering rate of the front tank occurred when ground speed was changed.

***Pegged Roller System*:** Two of the machines evaluated used sets of ground driven pegged rollers which rotated inside cup shaped outlets and pulled material out of the tanks and into the air stream. Metering rate was controlled by changing roller speed. Ground speed, vibration and level of material in the tanks all had little effect on the metering rate. When the unloading side of the meter was raised to simulate a i0 degree side slope, the metering rate decreased up to 17%. When the unloading side of the meter was lowered to simulate a 10 degree sides lope, the metering rate increased up to 12%. Field vibration and level of material in the tanks had no significant effect on the metering rate.

***Gate Over Conveyor System*:** Two of the machines evaluated used a ground driven conveyor belt which carried material into the air stream. The metering rate was controlled by changing the area of the opening above the conveyor with a sliding gate. A decrease in metering rate up to 8% was measured when ground speed was increased from 5 to 12 km/h. The metering rate decreased up to 9% when the unloading end of the conveyor was raised to simulate a 10 degree slope. The metering rate increased up to 11% when the unloading end of the conveyor was lowered to simulate a 10 degree slope. Field vibration and level of material in the tank had no significant effect on the metering rate. Metering of small grains such as canola, required the use of an adapter to effectively reduce the open area above the conveyor.

Auger System*:* One machine evaluated used a ground driven screw conveyor which carried material from the tanks into the air stream. The metering rate was controlled by changing auger speed. Increasing the ground speed from 5 to 12 km/h resulted in an increase in the metering rate up to 6%. A decrease in metering rate up to 14% resulted when the unloading end of the auger was raised to simulate a 10 degree slope. The metering rate increased up to 13% when the unloading end of the auger was lowered to simulate a 10 degree slope. Field vibration and level of material in the tank had no significant effect on metering rate.

For metering canola, slight surging of the material through the distribution system was evident. This occurred only for an auger speed less than 12 rpm, which corresponded to a metering rate of less than 4 kg/ha. Surging was attributed to the unloading characteristics of the auger as the flighting unloaded into the air stream at low speed.

AIR STREAM LOADING

For positive loading of metered material into the air stream, the pressure difference between the air stream and the storage tanks must be considered. The three different systems used to introduce material into the air stream were a venturi system, a pressurized tank and an air lock.

Venturi: A venturi, placed at the location of material entry into the air stream, was used to create a pressure drop which allowed air stream loading.

For two of the machines evaluated, the maximum application rate for fertilizer was limited by the capacity of the venturi. At maximum fan speed, fertilizer rates in excess of 35 kg/min for one machine and 48 kg/min for another, were not possible without material being blown out from around the area of the venturi. Maximum fertilizer application rate for another venturi loading system was limited by distribution hose plugging.

Pressurized Tanks: The use of pressurized tanks effectively allowed for positive air stream loading. The use of pressurized tanks required airtight seals at all tank openings. Air stream loading did not limit the maximum application rate for any of the machines using pressurized tanks.

One machine evaluated had a tank pressure adjustment valve. Tank pressure adjustments were required when changing application rates and when changing materials. Metering rate increased with an increase in tank pressure.

Air Lock: Another common device used to introduce material into the air stream was an air lock. A rotating sealed gate trapped material as it fell from the meter and carried it into the air stream. The seal between the air stream and the tanks, prevented pressure loss. Air lock capacity was determined by air lock speed.

Two of the machines evaluated used an air lock for air stream loading. One of the machines used an air lock speed ranging from 28 to 68 rpm for ground speeds ranging from 5 to 12 km/h. This range of air lock speeds did not limit application rate. The other machine had a smaller air lock with both a high and low range. In low range, the maximum application rate was 425 kg/ha at 9 km/h with an air lock speed of 24 rpm. In high range the air lock speed increased to 32 rpm at 9 km/h. This increase in air lock speed resulted in a reduction in maximum application rate from 425 kg/ha to 280 kg/ha. Rates in excess of 280 kg/ha in high range resulted in fertilizer building up in the air lock which eventually overflowed onto the ground. The decrease in capacity with increased air lock speed was attributed to poor unloading characteristics of the air lock at higher speeds. An optimum air lock speed had to be determined to prevent plugging of the air lock at high application rates.

DISTRIBUTION SYSTEMS

The air seeder distribution systems were subjected to a number of laboratory tests. These tests included determination of distribution uniformity for wheat, barley, oats, canola and 11-51-00 fertilizer. Machine slope, application rate and air velocity were varied to determine their effect on uniformity. A limited number of tests to determine the effect of rotating secondary headers, changing secondary outlet hose length and blocking outlets were also performed.

Distribution systems used on the machines evaluated could be categorized into one of three general distribution types. These three basic types, as discussed previously, are based on the differences in where and how material is divided.

Type A: Six of the air seeders evaluated used Type A distribution systems. Type A distribution systems utilized one metering device for each grain tank and pneumatic material division at primary and secondary header locations (FIGURE 1). After material left the metering system, it was initially divided by the primary header. Divided material from each primary header outlet was then divided further at one of a number of secondary headers. Divided material from the secondary header outlets was then routed to each opener. The variation among amounts of material delivered to each opener (distribution uniformity) depended on the accuracy of both the primary and secondary header pneumatic division. Distribution uniformity of seeding implements is commonly measured using the coefficient of variation (CV)*. The Machinery Institute considers a distribution pattern with an overall CV less than 15% as acceptably uniform. Distribution patterns with CV's greater than 15% indicate excessive variation and are considered unacceptable.

Distribution uniformity results for a Type A distribution system on machine 1A are presented in FIGURE 4. This distribution system used a corrugated tube (FIGURE 5) preceding the primary header and preceding each of the secondary headers. A deflector (FIGURE 6) was located in the 90 degree bends preceding each secondary header. The purpose of the deflector, located along the centre axis of the tube, was to keep the material flowing uniformly throughout the entire tube diameter and prevent it from being forced to the outer extremity of the 90 degree bend. Deflectors are not commonly used when a long length of straight inlet tube precedes a header. Curved (convex) impact plates were located in both the primary and secondary headers. The purpose of the impact plates was to change material flow direction and distribute it to individual header outlets.

The dotted lines in FIGURE 4 represent the total output for each primary header outlet. Primary header distribution uniformity in this example was very good, as noted by the relatively small variation among the primary header outputs, with a CV of only 2%. The solid bars in FIGURE 4 represent the output from each secondary header outlet. The CV's for each of the secondary headers varied from 5 to 10%. The overall variation for the data presented in FIGURE 4 is obtained by determining the CV for all outlets across the width of the machine. A CV of 10%, representing an acceptable distribution uniformity, was obtained in this case. Comparing the primary, secondary and overall variations indicated that secondary header variation was the major contributing factor to the overall variation in this example.

- The coefficient of variation (CV) is the standard deviation of outputs expressed as a per cent of the average output rate.

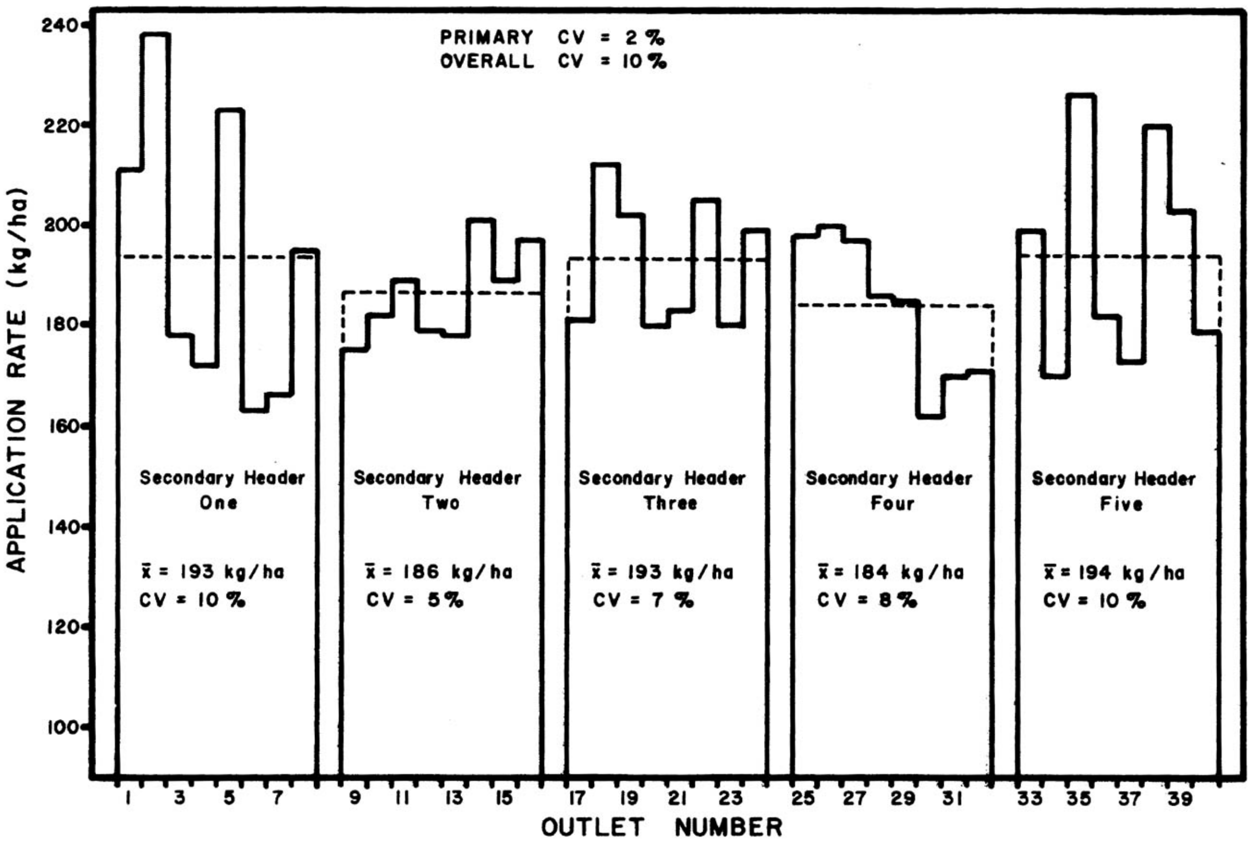

FIGURE 4. Distribution Uniformity in Fertilizer at 190 kg/ha for a Type A Distribution System.

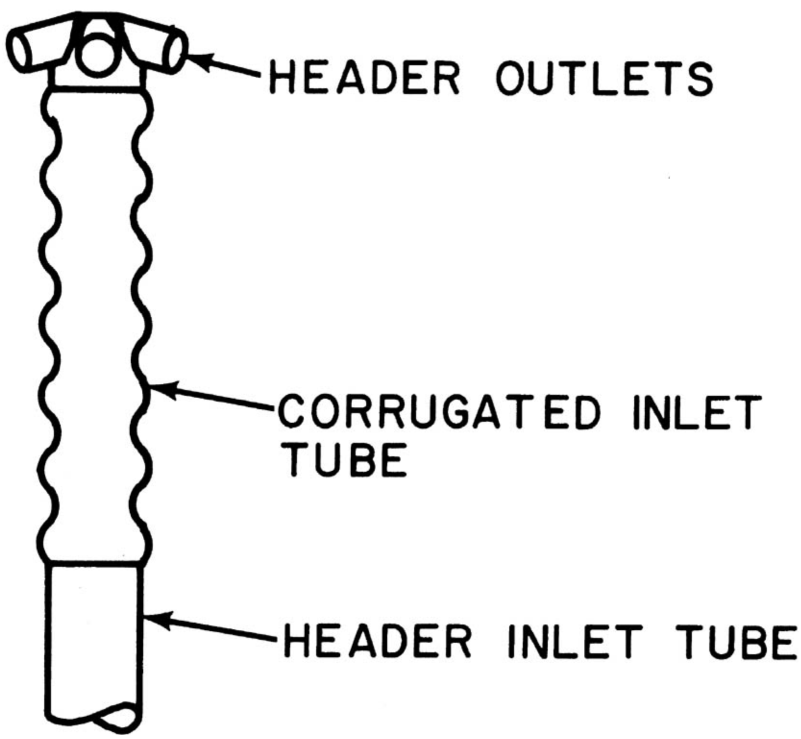

FIGURE 5. Corrugated Inlet Tube.

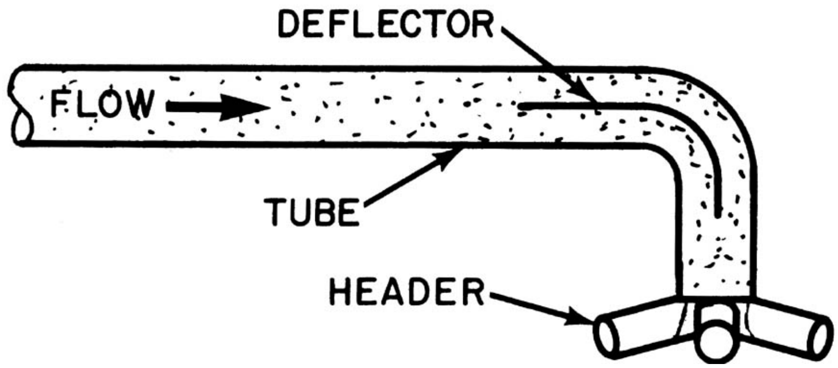

FIGURE 6. Deflector in Bend of Tube.

TABLE 1 presents a summary of data obtained during evaluation of four Type A distribution systems with 11-51-00 fertilizer and canola. Data given was based on results obtained in fertilizer and canola because distribution uniformity problems were most serious when applying these materials. The coefficients of variation for primary, secondary and overall distribution are given to show what areas have the greatest effect on overall distribution uniformity for each machine. Results for two other machines with Type A distribution systems are not included due to the use of blocked header outlets on these machines. The effect of blocking header outlets is discussed later in the paper.

TABLE 1. Distribution Uniformity with Type A Distribution Systems.

Machine	Material	Application Rate (kg/ha)	Deflector Location	Impact Plate Shape And Location	Corrugated Tube Location	Primary CV (%)	Range of Secondary CV's (%)	Overall CV (%)
1A	Fertilizer Canola	190 10	Secondary Inlet	Convex-Primary & Secondary	Primary & Secondary Inlet	2 1	5-10 12-14	10 12
2A	Fertilizer Canola	225 10	Primary Inlet & Meter Inlet	Concave-Secondary	None	5 7	5-17 7-36	12 23
3A	Fertilizer Canola	200 9	None	Flat-Primary Convex-Secondary	Primary & Secondary Inlet	5 10	3-12 5-11	8 13
4A	Fertilizer Canola	200 12	None	Flat-Primary Concave-Secondary	None	6 29	10-27 6-14	20 29

The four machines compared in TABLE 1 had two distinctly different primary header designs (FIGURE 7). Machines 1A, 3A and 4A used circular primary inlet tubes, running vertically up to the primary header. Machine 2A had a primary inlet tube and primary header which was horizontal and nearly rectangular in shape. Distribution uniformity could be altered by adjusting the deflectors (FIGURE 8) in the header. Results given are based on the manufacturer's primary deflector adjustments.

The acceptable distribution uniformity demonstrated by machine 1A in both fertilizer (overall CV = 10%) and canola (overall CV = 12%) was largely attributed to the use of corrugated inlet tubes and deflectors in the 90 degree bends preceding each secondary header.

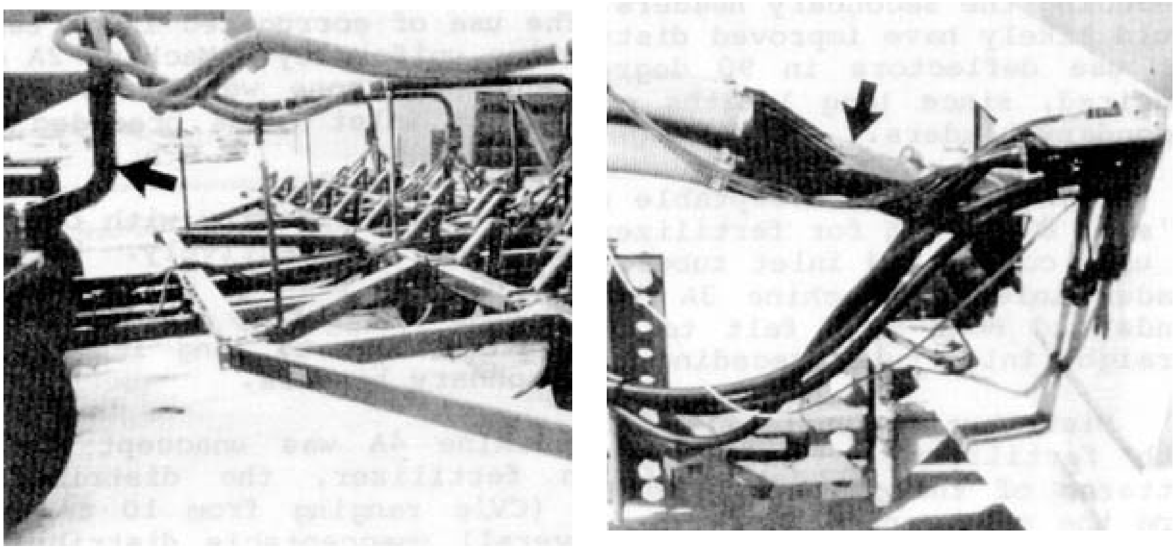

FIGURE 7. Primary Headers (Left: Circular Vertical Tube, Right: Rectangular Horizontal Duct).

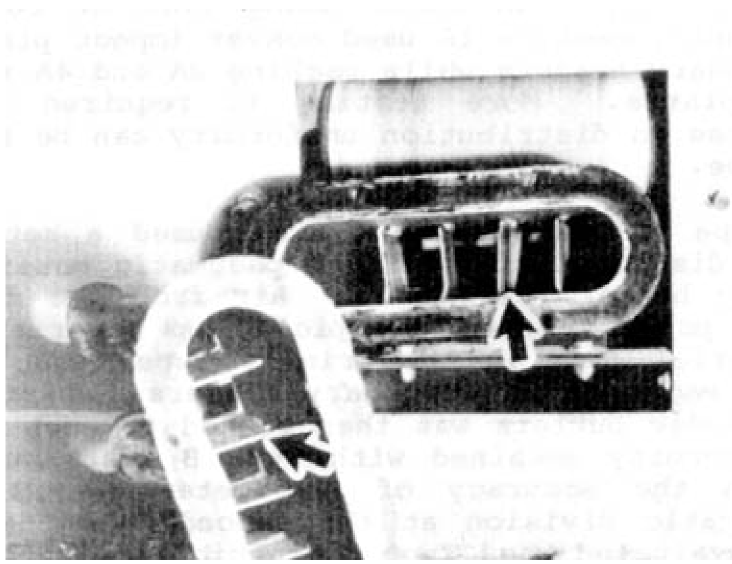

FIGURE 8. Adjustable Deflectors in Horizontal Primary Header.

Machine 2A demonstrated acceptable overall distribution uniformity in fertilizer (CV = 12%) and unacceptable overall distribution uniformity in canola (CV = 23%). The high CV's, ranging from 7 to 36%, encountered in the distribution patterns of the secondary headers, were the main reason for non-uniform distribution in canola. Corrugated inlet tubes were not used preceding the secondary headers. The use of corrugated inlet tubes would likely have improved distribution uniformity. Machine 2A did not use deflectors in 90 degree bends and none were felt to be required, since long lengths of straight inlet tubes preceded the secondary headers.

Machine 3A had acceptable distribution uniformity with overall CV's of 8 and 13% for fertilizer and canola, respectively. Machine 3A used corrugated inlet tubes preceding both primary and secondary header inlets. Machine 3A did not use deflectors in 90 degree bends and none were felt to be required, due to long lengths of straight inlet tube preceding the secondary headers.

Distribution uniformity for machine 4A was unacceptable in both fertilizer and canola. In fertilizer, the distribution patterns of the secondary headers (CV's ranging from 10 to 27%) were the main contributors to an overall unacceptable distribution pattern. In canola, a CV of 29% for the outputs from the primary header outlets, contributed to an unacceptable overall distribution uniformity. A 45 degree bend immediately preceding the secondary headers did not contain a deflector and corrugated inlet tubes were not used preceding either the primary or secondary headers. Use of these devices would likely have resulted in improved distribution uniformity.

Machines with headers using convex impact plates had better distribution uniformity than those using flat or concave impact plates. For example, machine 1A used convex impact plates for both primary and secondary headers while machine 2A and 4A used flat and concave impact plates. More testing is required to determine whether differences in distribution uniformity can be attributed to impact plate shape.

Type B: Type B distribution systems used a metering device for each primary distribution tube with pneumatic material division at each secondary header (FIGURE 2). Air from the fan travelled through separate primary tubes and picked up material below each meter. The material flow in the primary tubes was then divided pneumatically at each of the secondary headers. Divided material from secondary header outlets was then routed to each opener. The distribution uniformity obtained with Type B distribution systems depended on both the accuracy of the metering system and the accuracy of pneumatic division at the secondary headers. Two of the air seeders evaluated used Type B distribution systems.

Distribution uniformity results for two Type B distribution systems are presented in TABLE 2 for 11-51-00 fertilizer and canola.

TABLE 2. Distribution Uniformity with Type B Distribution Systems.

Machine	Material	Application Rate (kg/ha)	Primary CV (%)	Range of Secondary CV's (%)	Overall CV (%)
1B	Fertilizer	295	6	13-27	21
1B	Canola	9	5	9-14	13
2B	Fertilizer	220	4	5-15	9
2B	Canola	10	10	14-26	20

The primary mechanical division of material for both machines 1B and 2B was fairly accurate. Pneumatic division of material at the secondary headers, however, affected overall distribution uniformity to a much greater degree. For example, mechanical division of material at the meter for machine 1B resulted in a CV of only 6% while the CV's for secondary header distribution uniformity ranged from 13 to 27% in fertilizer. Similarly, machine 2B had high CV's for secondary header distribution uniformity ranging from 14 to 26% in canola. Neither machine 1B or 2B used corrugations in the secondary inlet tubes. Both machines had long lengths of straight tubing before secondary header inlets and both used flat impact plates.

Analysis of TABLES 1 and 2 shows that an acceptable distribution uniformity could be obtained for a limited number of materials and application rates without the use of such devices as deflectors and corrugations in the delivery tubes. For example, distribution uniformity was acceptable with machine IB in canola and with machine 2B in fertilizer while the distribution uniformity was unacceptable with machine IB in fertilizer and with machine 2B in canola. However, machines which produced acceptable distribution uniformity over a wide range of materials and application rates, used corrugations in header inlet tubes and deflectors in sharp tube bends just prior to header inlets. More testing is required to determine detailed effects of corrugations and deflectors.

Type C: Type C distribution systems used individual tubes running from the metering system to each opener (FIGURE 3). Division occurred at the double roller metering system as material fell into seed cups attached to each distribution tube. Distribution uniformity obtained with Type C systems depended only on division of material at the seed cups. No pneumatic division occurred with this type of distribution system. One of the air seeders evaluated used a Type C distribution system.

Distribution uniformity was good with a CV of less than 10% for all material used. A slight increase in CV was evident at increased metering rates in both grain and fertilizer.

BLOCKING HEADER OUTLETS

To accommodate the use of air seeders with all widths of cultivators, it was often necessary to block some header outlets to match the number of openers on the cultivator. Blocking of header outlets had a significant effect on distribution uniformity with both Type A and B distribution systems.

FIGURE 9 shows the distribution uniformity obtained with a Type A distribution system when using all outlets on a machine equipped with four, 10-outlet secondary headers. FIGURE 10 shows the distribution uniformity with the same distribution system, with one secondary header outlet blocked on each of three, 10-outlet secondary headers and two blocked outlets on the fourth header. A significant decrease in distribution uniformity, with an increase in the overall CV from 13 to 21%, occurred when secondary outlets were blocked in this non-symmetrical fashion.

Blocking of primary and secondary header outlets in a symmetrical pattern did not seriously affect uniformity of distribution. For example, one machine with a Type B distribution system used one, 8-outlet header with four outlets blocked in a symmetrical fashion. Distribution uniformity for this header was similar to the three other headers on the machine which had no outlets blocked.

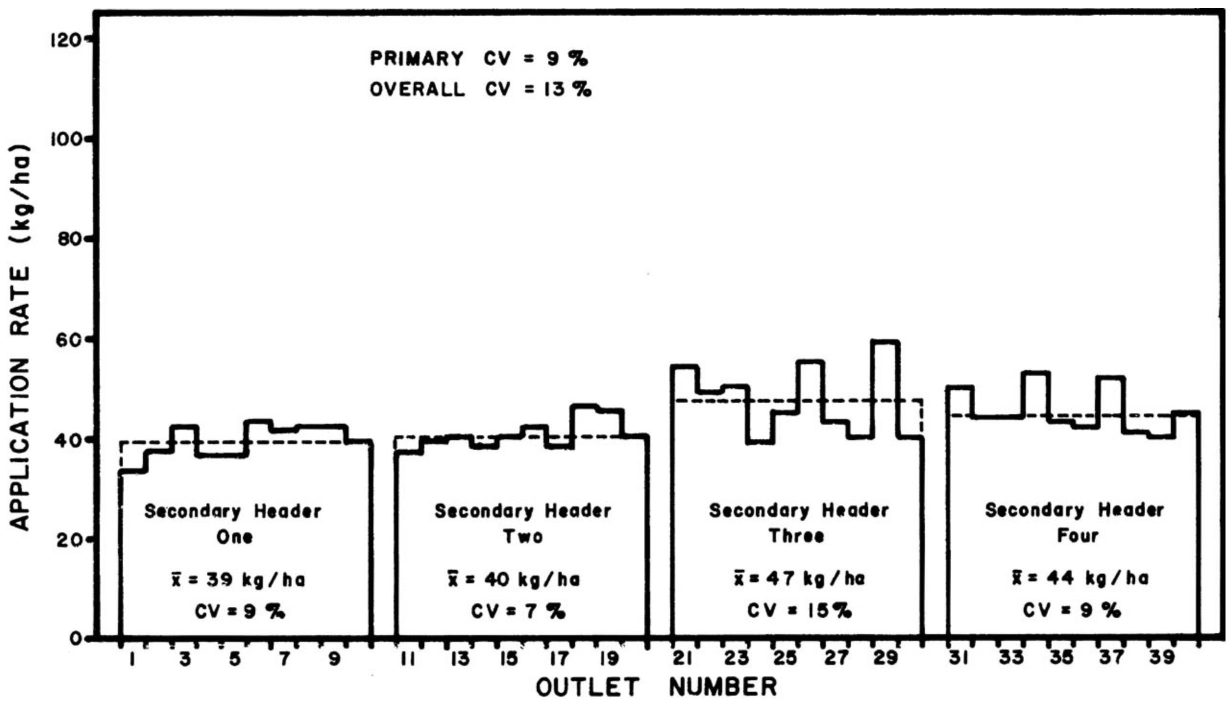

FIGURE 9. Distribution Uniformity in Fertilizer at 45 kg/ha Using All Header Outlets.

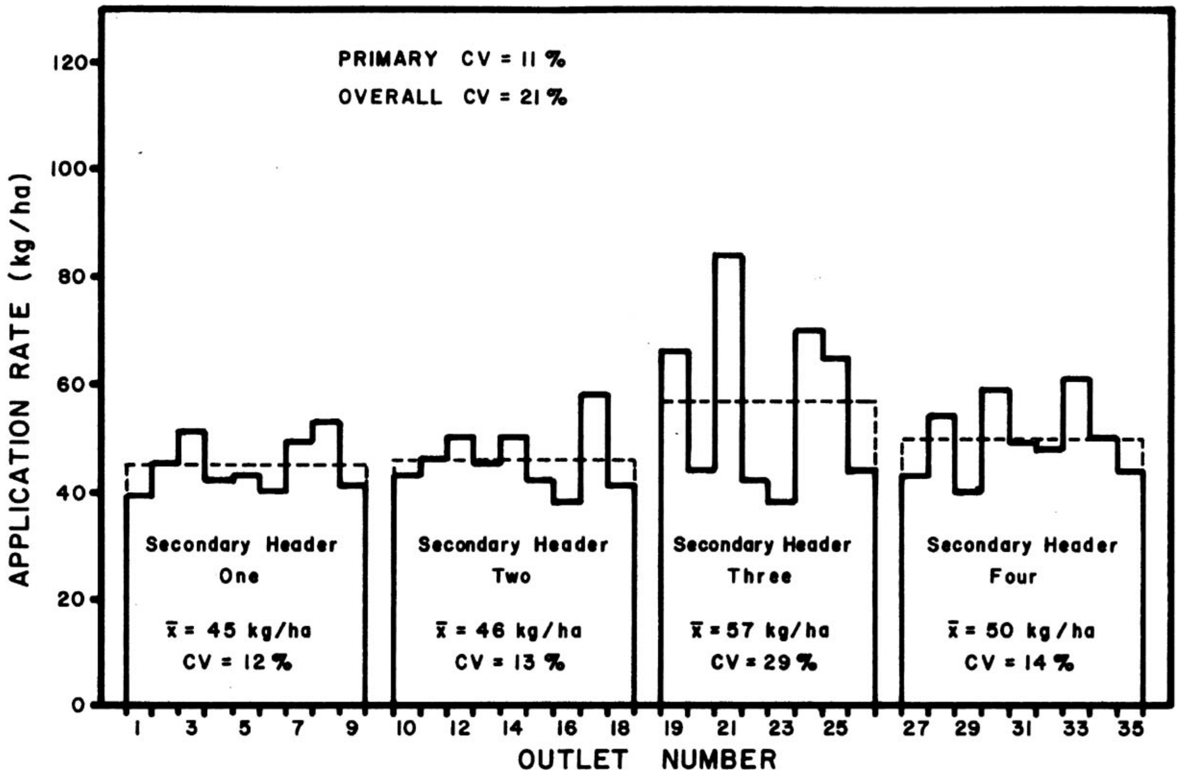

FIGURE 10. Distribution Uniformity in Fertilizer at 50 kg/ha with Blocked Outlets.

EFFECT OF SLOPE ON HEADER PERFORMANCE

Distribution uniformity of circular, vertical primary and secondary headers (FIGURE 7) was affected only slightly by machine slope. For example, a typical change in CV of secondary header distribution uniformity, when the header was inclined at 10 degrees, was 3%. The CV for the primary header distribution uniformity changed by about 2% when placed at a 10 degree angle. This resulted in an overall change in CV of about 2%. Results showed that outlets on the low side showed a slight increase in material rate while outlets on the higher side showed a slight decrease in rate.

Distribution uniformity with the horizontal rectangular primary header (FIGURE 7) was more severely affected by sides slope. FIGURE ii shows the distribution uniformity in wheat with the machine level, while FIGURE 12 shows the distribution uniformity with the machine tilted to simulate a 10 degree sides lope. The CV of the primary header distribution increased from 5 to 26% while the distribution uniformity of the secondary headers changed only slightly. The large change in CV of the primary header distribution caused the overall CV to increase from 7 to 25%. Comparing the average application rates of individual secondary headers in FIGURES 11 and 12 indicates that raising the left side of the machine, as is the case in FIGURE 12, resulted in a significant gravitational effect on flow characteristics. For example, the average application rate for secondary header number 1 changed from 86 to 65 kg/ha when tilted and header number 6 changed from 95 to 124 kg/ha when tilted. Increasing air velocity through the primary header, by increasing the fan speed to maximum, reduced this gravitational effect only slightly.

The deflectors on the horizontal duct work (FIGURE 8) could be adjusted to obtain a uniform distribution at the primary header with the machine level. However, due to the gravitational effect on flow pattern, deflector adjustment to suit the various side-slopes encountered in normal field conditions would be difficult to obtain.

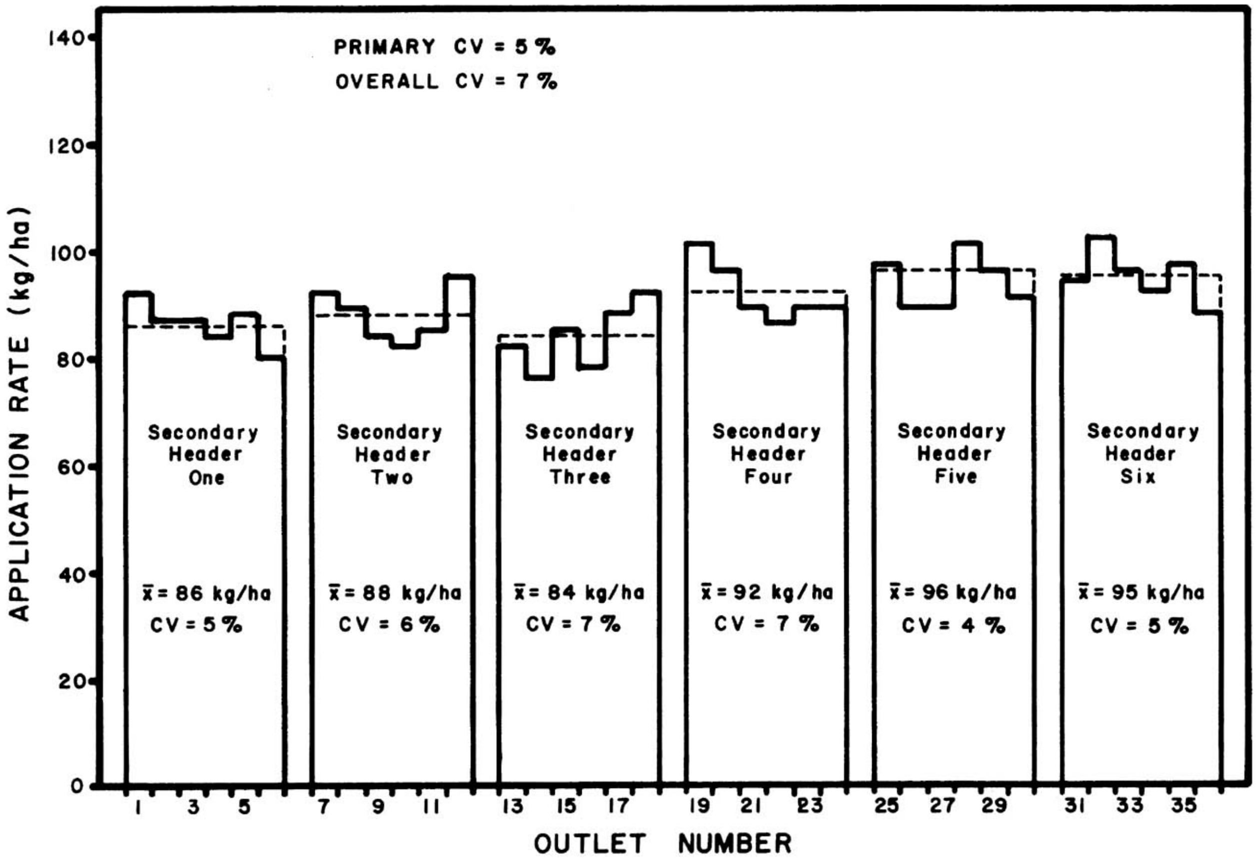

FIGURE 11. Distribution Uniformity in Wheat at 90 kg/ha with Machine Level.

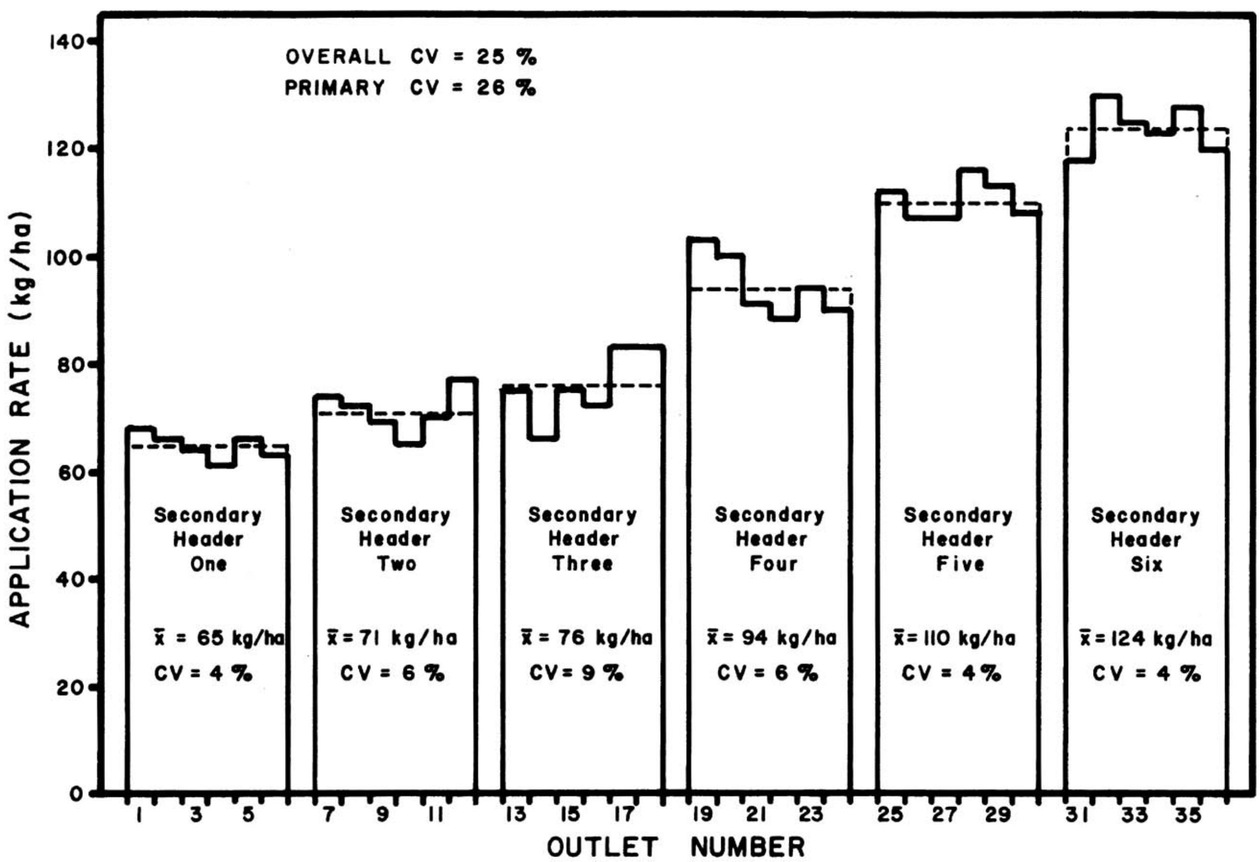

FIGURE 12. Distribution Uniformity in Wheat at 90 kg/ha on a 10 Degree Side slope.

EFFECT OF OTHER VARIABLES

Rotating Secondary Headers: Tests were conducted on one machine to determine what effect rotating the secondary headers with respect to the header inlet direction would have on distribution uniformity. For example, the right hand side of one header had an application rate 15% higher than the average. Rotating the header 180 degrees, still resulted in an application rate 13% higher than average on the right hand side of the same header. This indicated that the flow pattern for each header tended to remain similar with respect to the inlet direction and did not depend on characteristics of individual outlets.

Secondary Outlet Hose Length: Doubling the hose length on one outlet for one secondary header decreased flow rate for that outlet by only 3%. This was considered to be a relatively small change in output for an extreme hose length change. The small decrease in flow rate indicated that the flow pattern in the header was dependent on the path of the material as it entered the header but was not affected by differences in outlet hose lengths.

Air Velocity: Air velocity measurements indicated that secondary outlets with lower air velocity did not necessarily have lower application rates.

Tests were conducted to determine the effect on distribution uniformity due to changing air velocity. Air velocity was altered by changing fan speed. Overall distribution uniformity changed by less than 4% on most of the machines evaluated. On one Type A distribution system, the overall distribution uniformity changed from a CV of 23% to a CV of 30% when fan speed was increased from 1500 to 2500 rpm. Fan speeds higher than 2500 rpm resulted in excess grain crackage. This relatively large change in distribution uniformity resulted predominantly from a change in the CV of the primary header distribution from 23% at 1500 rpm to 29% at 2500 rpm. This vertical primary header was not equipped with a corrugated inlet tube, which indicated that changes in air velocity had a greater effect on headers not equipped with turbulence inducing devices.

CONCLUSIONS

The Prairie Agricultural Machinery Institute has to date evaluated nine air seeders. Air seeder evaluations have resulted in the following findings.

1. Field slope had an effect on all the metering systems evaluated with the exception of the smooth double roller metering system. When the unloading side or end of the meters was raised, the rate generally decreased and when the unloading side or end was lowered, the rate generally increased.
2. Air stream loading by use of a venturi limited air seeder maximum fertilizer application rate on some machines. The maximum application rate could also be limited by use of an air lock for air stream loading if the optimum air lock speed was not used. No differences in overall distribution uniformity were attributed to method of introducing material into the air stream.
3. Although air seeders on the market have been improved over the past few years, there are some machines marketed which produce unacceptable distribution uniformity patterns. Most distribution uniformity pattern problems occur when applying fertilizer at high rates or when applying light seeds such as canola at very low rates.
4. Deflectors, located along the centre axis of distribution tubes where they made sharp bends, significantly improved distribution header uniformity. The deflectors kept material flowing uniformly throughout the entire tube diameter and prevented it from being forced to the outer extremity of the tube bend.
5. Corrugated header inlet tubes, to create turbulence in the air stream, are used on some air seeders. Machines evaluated with corrugated header inlet tubes, tended to have better distribution uniformity characteristics, with various materials, over a wider range of application rates than those without. More testing is required to determine their specific effectiveness.
6. The practice of blocking header outlets to size air seeder distribution systems to various widths of cultivators had a significant effect on distribution uniformity. Blocking outlets in a non-symmetrical

fashion resulted in reduced distribution uniformity while blocking outlets in a symmetrical fashion did not seriously affect uniformity.

7. Headers on Type A distribution systems using convex impact plates tended to have better distribution uniformity than those using flat or concave impact plates. More testing is required to determine the effects of various impact plates on different header designs.
8. Gravitational forces affected air seeder distribution characteristics on all machines tested. Material flow tended to shift to the downhill side when the machines were operated on a 10 degree slope. This trend was reduced only slightly at higher air velocities. For machines using vertical headers, distribution uniformity was affected by about 2%. For one machine with a horizontally orientated rectangular primary header, uniformity became unacceptable when the machine was operated on a 10 degree side slope.
9. Air velocity changes within the range between distribution tube plugging at low velocity and grain damage at high velocity, had a small effect on distribution uniformity for most of the air seeders. Air velocity had a greater effect on distribution uniformity for one machine with a vertical primary header without a corrugated inlet tube, than for those with corrugated inlet tubes.
10. Variables such as small changes in secondary header outlet tube length and rotating secondary headers with respect to the secondary inlet direction had only a small effect on uniformity. This indicated that the flow pattern for each header tended to remain similar with respect to the inlet direction and did not depend on characteristics of individual outlets or individual hose lengths.

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