SWATH WIDTH ACCURACY

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Introduction

Improving swath width accuracy improves weed control, crop yield, and safety and minimizes adverse environmental effects. Several studies involving sprayer application accuracy have been conducted in the past decade in North America. Because of these studies and the very popular article entitled "The Billion Dollar Blunder" (L. Reichenberger, Successful Farming, 1980), interest in improved application accuracy took off. The following conclusions were taken from three different studies on application accuracy in Nebraska in 1979 and 1986, and Manitoba in 1984.

1. A 1979 field survey to check both calibration and mixing accuracy was conducted in Nebraska and western Iowa (Rider & Dickey, University of Nebraska, 1982) of 152 private and commercial pesticide applicators. The survey showed that only one out of four pesticide applications were applied within 5 percent of the intended rate. The major source of application errors was incorrect calibration ranging from nearly 60 percent under application to more than 90 percent over application. Calibration errors were detected in 78 percent of the applications and tank mix errors were detected in 38 percent of the applications. Uniformity of application was also in error. The coefficient of variation among nozzles averaged 22 percent. Only 11 percent of the applicators had a coefficient of variation of 5 percent or less. "No significant relationship between application error and uniformity of application was measured. The most common method of calibration used was the Known Area method. No statistical differences between calibration methods and pesticide application errors were detected. However, the most successful calibration method, based on observed trends, was to adjust equipment following operator manual recommendations and to make appropriate field adjustments as necessary."
2. A 1986 field survey of 140 private and commercial pesticide applicators was conducted in central and eastern Nebraska (R. Grisso- University of Nebraska, 1987). "Only one out of three liquid pesticide applicators applied chemicals within ± 5 percent of their intended application rate. The major source of application errors was incorrect calibration (55 percent). Tank mix errors were detected in 19 percent of the applicators. These results indicated that applicators have reduced application errors from that of a similar survey conducted in 1979. The commercial applicators made approximately 50 percent fewer errors in applying chemicals than private applicators and of those sampled, they accounted for twice the land area chemically treated. Uniformity of nozzle discharge on a spray unit was not a major concern. Over 75 percent of the applicators had CW's less than 5 percent which is compared to only 11 percent 7 years earlier. This suggested that applicators were replacing nozzle tips more frequently and were not damaging tips during cleaning and installation procedures. Most often used nozzles tips were flat-fan and flooding nozzles. Ninety-four percent of the applicators used a calibration method and almost 20 percent used more than one method. Most applicators used the Known Area method of calibration. Those that used Monitors/Controllers had the fewest application errors of the calibration methods listed. Over 70 percent of the applicators calibrated only once a year and improvement in application accuracy could be shown by more frequent use of a calibration method."
3. A 1984 survey of 49 sprayers was conducted throughout Manitoba (B.W. English and O.H. Friesen- Manitoba Agriculture, 1985). The survey showed that three out of four applicators were within ± 10 percent of the desired application rate and all were within ± 20 percent. Nozzle discharge uniformity was within ± 5 for over 95 percent of the nozzles checked.

Similar results were obtained in a survey conducted by Alberta Agriculture in Alberta.

Objective

As shown in the studies, application accuracy has improved some in the states, but more so in the prairie provinces. So it seems farmers have been attending sprayer clinics, seminars and have been reading spraying articles and adopting these new spraying practices. That's encouraging. In addition, spraying equipment has improved tremendously in the past 15 years and that has improved spray accuracy. So this report on swath width accuracy will be a review for most of you. In addition, the report should encourage farmers to continue adopting new spraying practices and calibrations to improve spray uniformity across the swath width and application rate accuracy.

Also I'd like to point out some short cuts in calibrating modern sprayers. Most sprayer calibration publications are based on old sprayers with 1.25 cm wet booms, ball check valves and brass nozzles. Long and tedious calibration procedures are not necessary with today's sprayers. It seems that farmers and sprayer manufacturers have done their homework to improve swath width accuracy in the past 10 years.

Swath Width Accuracy

Swath width accuracy depends on the following:

1. application rate
2. spray pattern uniformity

Application Rate

Surveys show that most spraying errors are directly related to wrong chemical dosage and improper application rates. The three variables that affect application rate are:

1. nozzle delivery rate (size and pressure)
2. sprayer ground speed
3. nozzle spacing (for broadcast spraying - 50.8 cm)

To operate the sprayer properly, the effect of each variable must be known.

Nozzle Delivery Rate

Nozzle tip delivery rate varies with the size of the nozzle tip and the nozzle pressure as shown in FIGURE 1. In mathematical terminology, nozzle delivery rate varies in proportion to the square root of the pressure. The pressure must increase four times to double the delivery rate. Changing nozzle pressure should not be used to change application rate. Small pressure changes (less than 20%) should only be used to improve spray pattern uniformity, reduce drift, and compensate for worn nozzles.

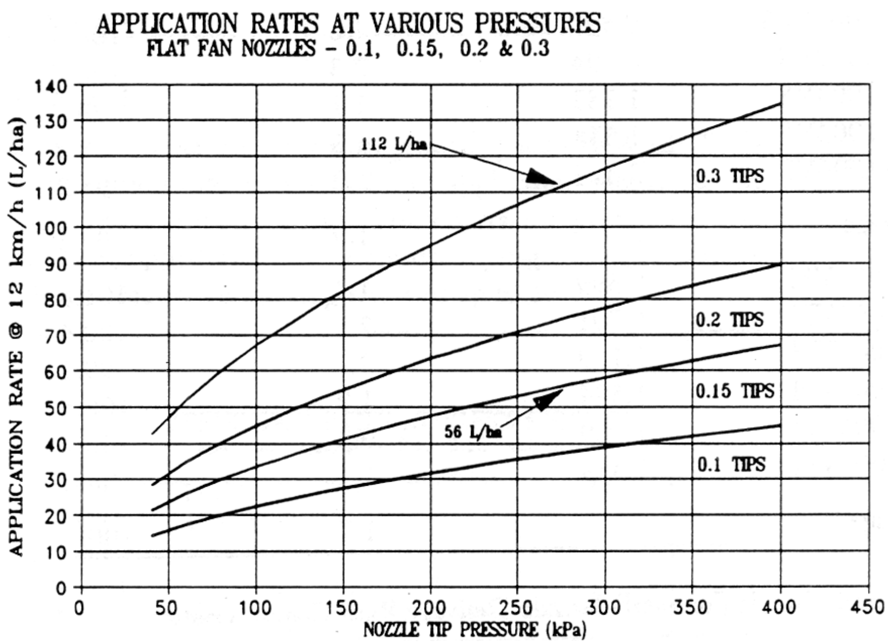

Figure 1. Application rate at various nozzle pressures and sizes at a ground speed of 12 km/h.

Nozzle delivery rates for each nozzle tip can be obtained from nozzle manufacturer catalogues or research institutes like AFMRC. In the past 7 years AFMRC's measured nozzle delivery rates have been within ± 3% of the nozzle manufacturers indicated rates (TABLES 1 and 2). In the late 1970's the difference was as high as ± 6%. The delivery rate variability coefficient among nozzles now is within 2%. A low coefficient of variation (CV) indicates similar delivery rates for all nozzles. A high CV (greater than 3%) indicates large variations among individual nozzle delivery rates with some nozzle delivery rates ± 5% from the average delivery. In the late 1970's the CV was as high as 5%. This shows that nozzle manufacturing techniques and quality control have improved over the years.

Table 1. Spraying Systems TeeJet Extended Nozzle Delivery Rate Characteristics

Nozzle Tip	Delivery @ 300 kPa (L/min)	Coeff. of Variation (CV)	Percent of Manufacturers Rated Output
XR8001VS	0.396	0.7	100.4
XR80015VS	0.593	2.9	100.6
XR8002VS	0.777	2.1	98.3
XR8003VS	1.175	1.1	99.3
XR8004VS	1.576	1.1	99.7
XR8006VS	2.326	1	98.3
Average		1.5	99.4
XR11001VS	0.389	2.4	98.6
XR110015VS	0.591	1.6	100.5
XR11002VS	0.794	2.3	100.7
XR11003VS	1.183	1.1	99.9
XR11004VS	1.558	1.6	98.8
XR11006VS	2.325	2.3	98.2
Average		1.9	99.5
XR8001VH	0.399	1.3	101.5
XR8002VH	0.791	2.8	100.4
XR8003VH	1.169	2	99.2
VR8004VH	1.584	1.9	100.5
VR8005VH	1.969	0.9	100.1
VR8006VH	2.319	1.2	98.6
Average		1.7	100.1

Table 2. Lurmark Plastic (kematal) Nozzle Delivery Rate Characteristics

Nozzle Tip	Delivery @ 300 kPa (L/min)	Coeff. of Variation (CV)	Percent of Manufacturers Rated Output
01-F80	0.395	0.9	98.9
015-F80	0.610	0.7	101.8
02-F80	0.786	2.4	98.4
03-F80	1.189	1.1	99.1
04-F80	1.632	0.8	101.6
06-F80	2.397	0.8	100
Average		1.1	100.0
0I-Fl10	0.406	2.7	101.9
015-F110	0.625	0.7	104.5
02-Fl10	0.813	3	101.8
03-F110	1.218	2.4	10
04-F110	1.605	0.8	100.5
06-F110	2.338	0.9	97.7
Average		1.8	101.3
SD015-F110	0.577	0.7	95.9
SD02-F110	0.765	1.2	95.8
SD03-F110	1.194	0.7	99.6
SD04-F110	1.940	0.6	121.9
Average		0.8	103.3

Ground Speed

Application rate varies inversely with ground speed (FIGURE 2). Doubling ground speed reduces application rate by one-half. For application rate to remain constant the sprayer ground speed must remain constant. Truck or tractor speedometers should not be used unless calibrated or equipped with a radar sensor. Slippage, changes in tire size and changes in soil can result in speedometer reading errors of up to 30%.

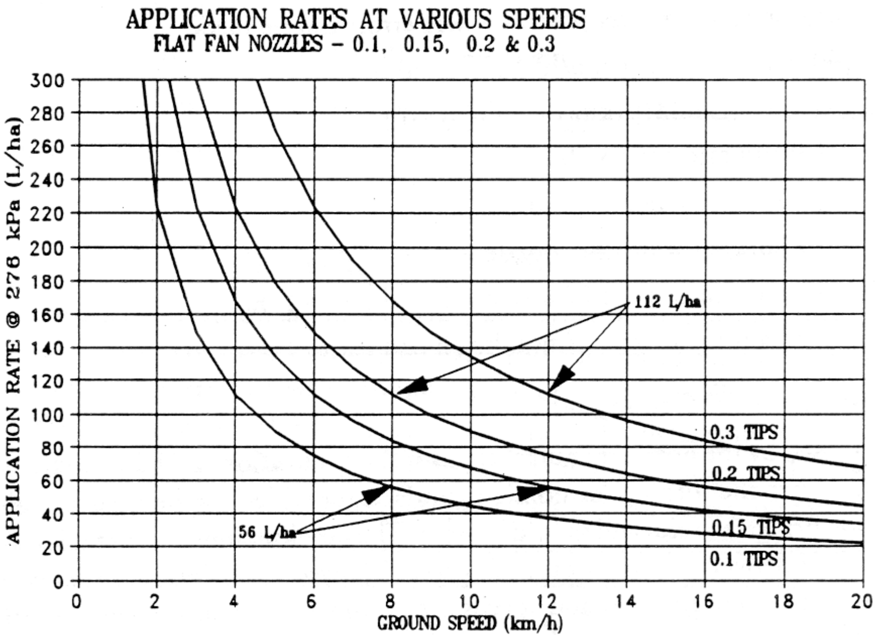

Figure 2. Application rates at various ground speeds at a nozzle pressure of 276 kPa using 0.1, 0.15, 0.2, and 0.3 nozzle tips.

Ground speeds should be measured at several gear and throttle settings (range of speeds) to eliminate the need to calibrate each time a new speed or application rate is desired. Ground speed can be measured by simply staking out a 150 m distance in the field to be sprayed or in a field with similar surface conditions. Operate the loaded sprayer at selected speed and measure the time it takes to travel the 150 m distance. Do this at least 2 times and average the times. The following formula will determine the ground speed for a 150 m track:

km/h = 9 / average time (min)

Sprayed Width

The width sprayed per nozzle affects the application rate. That is, doubling the effective sprayed width per nozzle decreases the application rate by one-half. Application rate calculations are easier when swath sprayed is in terms of sprayed width per nozzle instead of effective sprayer width. The width of the sprayer and the number of nozzles on the sprayer are not required to calculate application rate.

The sprayed width per nozzle varies depending on the spray application. For broadcast spraying where flat fan nozzles are more commonly used, the sprayed width is actually the nozzle spacing (20 in or 50.8 cm). For single nozzle banding or boomless spray applications the sprayed width is the band width. For multiple nozzle direct spray applications the sprayed width is the row spacing divided by the number of nozzles per row.

Application Rate Formula

The following formula takes each variable into account to determine application rate. The formula is shown twice to indicate application rate in L/ha and L/ac. AFMRC prefers using L/ha because its easier to calculate the chemical dosage per area or per tank when using the same units. Converting is an extra process where errors can be made.

L/ha = [60000 x (L/min)] ÷ (km/h) x SW (cm)
L/ac = [24300 x (L/min)] ÷ (km/h) x SW (cm)
L/min = delivery rate per nozzle
km/h = sprayer ground speed
SW = sprayed width per nozzle
60000 = constant to convert L/min, km/h and cm to L/ha
24300 = constant to convert L/min, km/h and cm to L/ac

Nozzle Manufacturers' Catalogues
The formula is used by the nozzle manufacturers for the application rate tables in their nozzle catalogues. So either the formula or nozzle manufacturer tables can be used to determine application rate. Both are useful and should be used. The nozzle manufacturer tables are based on nominal nozzle delivery rates and ground speeds. Therefore, the formula method should be used when nozzle delivery rate and speeds are calibrated or when nozzle pressures and speeds other than that given in the tables are desired.

Nozzle Identification
When neither the formula nor an application rate table is available, the application rate can easily be determined by the number indicated on each nozzle. All nozzles are identified by a number that also describes the nozzle type and size. TABLE 3 shows how some nozzle manufacturers identify their nozzle tips. From the nozzle number, the operator can identify the nozzle manufacturer, delivery rate, spray angle and whether the nozzle is a standard, extended or low-pressure flat fan tip. Note the delivery rate of the nom le is in U.S. gallons per minute at a nozzle pressure of 276 kPa (40 psi) for all flat fan nozzles except the low-pressure nozzle. The delivery rate for the low-pressure nozzle is in U.S. gallons per minute at a nozzle pressure of 103 kPa (15 psi). The following formulas should be used to convert U.S. gpm to L/min and to determine delivery rates at other nozzle pressures based on 276 and 103 kPa.

L/min = US gpm x 3.785
L/min = L/min @ 276 kPa x [0.06 x (kPa) ^ 0.5]
kPa = desired nozzle pressure

Table 3. Flat Fan Nozzle Identification

Spraying Systems	Delavan	Lurmark	Delivery (US gpm)	Angle	Type (flat fan)
8001	LF 1-80	0l-F80	0.1	80 deg.	standard
80015	LF1.5-80	015-F80	0.15	80 deg.	standard
8002	LF2,80	02-F80	0.2	80 deg.	standard
11001	LFI-110	01-F110	0.1	110 deg.	standard
110015	LF1.5-110	015-F110	0.15	110 deg.	standard
11002	LF2-110	02-F110	0.2	110 deg.	standard
XR8002	LFR2-80	n/a	0.2	80 deg.	extended range
XR11002	LFR2-110	n/a	0.2	110 deg.	extended range
8004LP	n/a	LP04-80	0.4*	80 deg.	low-pressure
11004LP	n/a	LP04-110	0.4*	110 deg.	low-pressure

**nozzle pressure at 15 psi*

Selecting Application Rate

Selecting an application rate usually depends on the type of spray application, field conditions, chemical and sprayer constraints. Most farmers have one set of nozzles and one sprayer. Therefore, application rate is limited to the nozzles on hand, usually 112 L/ha (45 L/ac). However, the first step in selecting application rate is to determine the type of spray application involved. That is, determine whether the spray application is herbicide, fungicide, insecticide, broadcast, band, post-emergent, pre-emergent, soil incorporated, chemfallow, contact, or systemic. Then choose the appropriate nozzle type. Nozzle type means flat fan, flooding, or cone tips. This information can be obtained from nozzle manufacturers catalogues or research papers from varies universities or research stations. Spraying Systems catalogue lists the type of application each type of nozzle is best suited for.

Having selected the nozzle type, select the desired application rate in L/ha as recommended by the pesticide label or as spraying conditions will allow. The application rate is the amount of water and chemical applied per area. For most chemicals used in the prairies, this rate is 112 L/ha. However, the trend is toward lower rates. With the nozzles, shrouds and multi-tip nozzle bodies available today, application rates can be changed easily several times during the day to continue spraying when adverse wind and field conditions develop.

Select an appropriate ground speed in km/h according to existing field conditions and workrate required. Most conventional sprayers today are equipped with suspension systems on the castor wheels that allow ground speeds up to 16 km/h even in adverse field conditions.

The formula should be used, not only to determine application rate, but also to determine delivery rate per nozzle or speed required for a specific application rate. New spraying trends towards increased ground speeds and lower water rates require calculating nozzle delivery rate. Re-arranging the formula is all that is required. For example, if field and sprayer conditions allow for faster ground speeds, say 12 km/h and the chemical company recommends that 112 L/ha be put on, then L/min per nozzle must be calculated. Select a nozzle tip that will deliver the rate calculated by the formula. To calculate liquid delivery per nozzle use:

L/min = [(L/ha) x (km/h) x SW] ÷ 60000

L/min = [(L/ac) x (km/h) x SW] ÷ 24300

Ground speed should be calculated if a specific nozzle tip, pressure and application rate are desired. In addition, calculating ground speed gives the operator an idea how fast the sprayer will be traveling at a desired application rate and nozzle size. This is the case when operators continue using the same nozzle for most of their spray applications. To calculate ground speed use:

km/h = [60000 x (L/min)] ÷ [(L/ha) x SW]

km/h = [24300 x (L/min)] ÷ [(L/ha) x SW]

The sprayed width per nozzle depends on the sprayer. Measure the distance between nozzles for broadcast spraying or calculate the spray width in banding or row crop spraying. For banding, the nozzle spacing is the band width and for row-crop spraying the nozzle spacing is the row spacing or band width divided by the number of nozzles per row or band.

Adjusting Application Rate

Application rate can be adjusted by changing the nozzle size, nozzle pressure or ground speed, as shown by the application rate formula. If a small change in application is required (less than 10%) the pressure can be adjusted to obtain the desired change. The resulting pressure must be within the recommended pressure range. That is above 250 kPa when using standard flat fan nozzles and above 150 kPa using extended range flat fan nozzles. This method should be used as little as possible since spray pattern and droplet characteristics change with changing pressure. A 20% change in pressure results in a 10% change in application rate.

If a 10 to 25% change in application rate is required, the ground speed should be adjusted. A change in ground speed produces an inverse, proportional change in application rate. However, avoid excessive speeds for boom stability and safety reasons. If the application rate has to be changed more than 25%, a different sized nozzle tip must be installed. This permits use of proper pressure, maintains spray pattern and helps control drift. This is usually the preferred way of changing application rate.

Calibration

With application rate selected and the correct nozzle tips installed, the next step is to calibrate the sprayer volume output. The most common method of calibration is collecting the output of each nozzle in a container for a specific time. If the output of any nozzle is not within 10% of the manufacturers rated output, then the nozzle should be replaced. In addition, ifa nozzle output varies more than ±5% of the average, then that nozzle should also be replaced. This saves time in the long run, since larger variations in nozzle outputs will be evident in the following calibration.

This calibration procedure requires that all nozzles on the sprayer be tested. As mentioned previously, sprayer calibration procedures are based on old spraying practices and sprayer accessories (TABLE 4). If your sprayer is equipped with some of the old accessories, then all the nozzles should be calibrated. In addition, AFMRC recommends tat the pressure be measured at several nozzle locations to determine line pressure losses. High nozzle delivery variability may not be the result of nozzle wear only, as line losses may be a factor.

Table 4. Sprayer Accessories that Affect Nozzle Output.

Old Accessories	Modern Accessories
1. ball check valves	diaphragm check valves
2. 12 and 19 mm wet booms	one-inch wet booms
3. 12 mm solenoid valves	31 mm solenoid valves
4. middle boom with 2 or 3 nozzles	no middle booms
5. brass nozzles	stainless steel, plastic

All sprayers tested by AFMRC in the past 7 years have been equipped with the modern accessories. Therefore, if your sprayer is equipped with the modern accessories, only a few nozzles need to be calibrated to determine nozzle wear. Measuring the delivery of every 5 nozzles on the boom is adequate. In addition, new nozzles just installed don't have to be calibrated. AFMRC nozzle delivery rate measurements in the past 10 years show nozzle variability has been very low and similar to manufacturer's rated output (TABLES 2 and 3). Nozzles found to be out more than 10% were usually of a different size. Color coded nozzles now eliminate this type of error. Line pressure losses are insignificant with diaphragm nozzle bodies, 32 mm soleniod valves and 25 mm diameter wet booms.

Most nozzle wear tests use artificial media to accelerate wear. This wear is difficult to relate in real time. AFMRC's non-accelerated tests show stainless steel nozzles wear was insignificant after 200 hours using spring water and a typical herbicide. A non-accelerated test (Reed and Ferrazza in 1984) using a suspension of 1.81 kg of Aatrex 80% atrazine WP in 57 L of water at 275 kPa pressure showed that a brass 8003 nozzle reached 15% wear in 30 hours. Stainless and hardened stainless steel nozzles reached 15% wear in 90 and 700 hours, respectively. Wear on a ceramic nozzle tip increased less than 4% after 1000 hours. The test also showed that smaller sized nozzles wear faster than larger sized nozzles.

Spray Pattern Uniformity

Variables that affect spray pattern uniformity across the swath width:

- nozzle height
- nozzle size
- nozzle fan angle
- nozzle type
- nozzle pressure
- nozzle material and manufacturer

Nozzle material and manufacturer affect swath width spray patterns, although not to the degree nozzle height, fan angle and pressure do. These three variables will be discussed during this presentation.

Variables that affect spray pattern uniformity along the swath:

- ground speed
- boom stability
- weather (wind, humidity, temp. etc.)

These will not be addressed in this report.

Coefficient of Variation (CV)

Spray pattern uniformity is reported in terms of coefficient of variation (CV). At AFMRC, spray pattern uniformity across the swath width is usually measured by spraying onto a spray table which has grooves about 16 mm wide and parallel to the direction the sprayer travels. Under that test condition, the CV is the standard deviation of application rates for successive 16 mm sections along the boom expressed as a per cent of the mean application rate. The lower the CV, the more uniform is the spray coverage. A CV below 10 percent indicates very uniform coverage across the width of the sprayer, while a CV above 15 percent indicates inadequate coverage. These numbers represent spray uniformity in laboratory conditions. In the field, CV's are 10 to 20 percent higher, depending on boom stability, ground spread and weather conditions.

Many published reports indicate that, with flat fan nozzles on conventional sprayers, a CV below 15% is acceptable. Although this is attainable in laboratory conditions, it is unlikely to occur under field conditions. This is tree, but 15% is an indication of the nozzles spray pattern characteristics. That is, if a set of nozzles produce a CV of 5% in the lab, in the field the chances are the CV will be higher. If a set of nozzles produce a CV of 25% in the lab, it is highly unlikely that the CV will improve in the field. As a matter of fact, CWs of 25% in the lab will tend to produce CV's of over 3 5% in the field. So stationary spray uniformity tests initially help to set up the sprayer with the proper nozzles at the proper pressure and height. There is no sense in going out to the field knowing that a set of nozzles at a specific height and pressure produces CV's above 15%. The spray uniformity will not improve in the field.

Figures 3 to 6 show typical spray patterns with CV's of 3, 5, 12 and 25 percent, respectively. At a CV of 5% and a mean application rate of 112 L/ha, the application rate across the swath width varies from 99 to 123 L/ha. Even at a low CV of 3% the application rate varies from 103 to 119 L/ha. At a CV of 12%, the application varies from 91 to 139 L/ha and at a CV of 25% the application rate varies from 68 to 158 L/ha. High spray concentrations occur below each nozzle tip with inadequate coverage between nozzle tips.

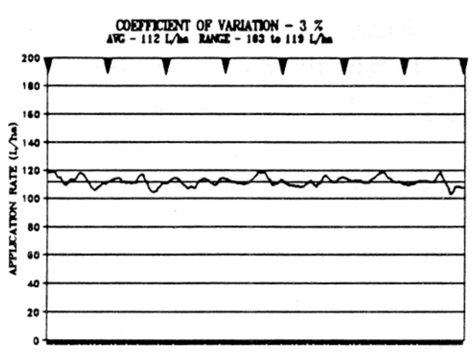

Figure 3

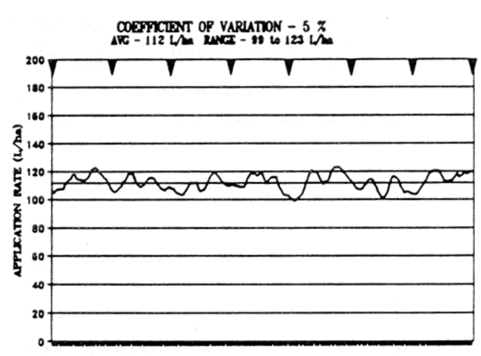

Figure 4

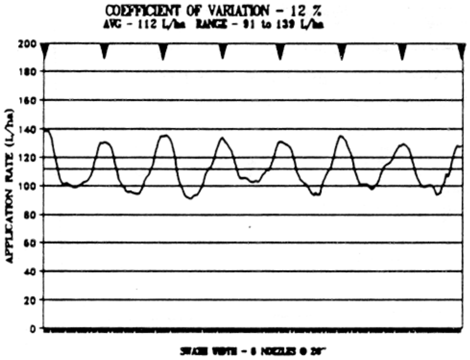

Figure 5

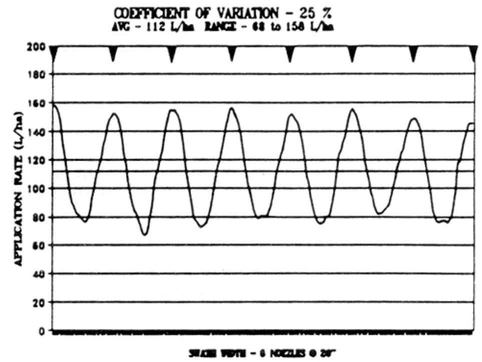

Figure 6

Figures 3 to 6. Typical examples of spray distribution patterns at various coefficient of variation percentages (CV).

Nozzle Size

Generally, larger sized nozzles produce more uniform spray swaths (lower CV's) than the smaller sized nozzles as shown in Figure 7. Spray pattern uniformity results at various nozzle pressures for Lurmark 80 degree flat fan nozzles are shown here as an example. Six different Lurmark nozzle sizes were tested on AFMRC's spray table that included 0.1,0.15, 0.2, 0.3, 0.4, and 0.6 tips. The CV at a 300 kPa nozzle pressure was 8 and 21 percent for the 0.6 and 0.1 tips, respectively. Because the CW's are normally above 15% for the low capacity nozzles, AFMRC and most other researchers do not recommend low water rates when using standard flat fan nozzles.

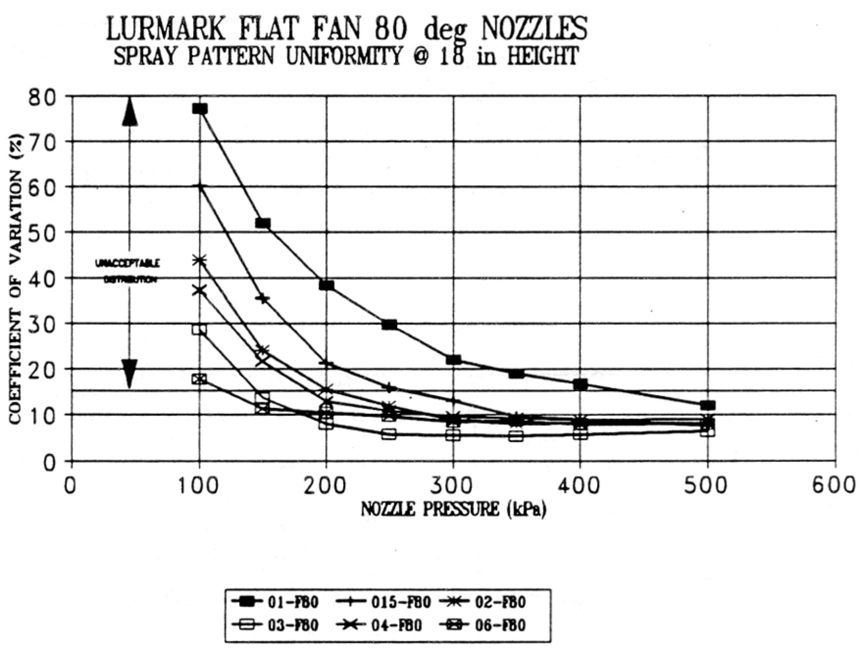

Figure 7. Spray pattern uniformity for Lurmark 80 degree flat fan (kematal) nozzle tips at a nozzle height of 457 mm.

Nozzle Pressure

Nozzle delivery and nozzle fan angle both increase as nozzle pressure increases. As a result spray patterns are generally more uniform at higher pressures even with the smaller sized nozzles. At low pressures the nozzle fan angle is much less than the rated 80 or 110 degrees, resulting in inadequate spray overlaps. Spray overlap is the amount of the spray pattern that gets coverage from the adjacent nozzle. As the pressure increases the fan angle fully develops to the rated nozzle spray angle. This is normally at 276 kPa with a standard flat fan nozzle. As shown in Figure 7, the CV for Lurmark 80 degree standard flat fan nozzles ranged from 18 to 77 percent at a nozzle pressure of 100 kPa. At 500 kPa the CV ranged from 8 to 12 percent. The results are similar for Lurmark 110 degree standard flat fan nozzles (Figure 8). Above the rated pressure of 276 kPa, the CWs are similar for the different sized nozzles, showing that the fan angle is fully developed to obtain uniform spray swaths. So why not operate nozzles at high pressures if the pattern is so much better? Simply to avoid an increase in spray drift. At high pressures, more droplets that are less than 125 microns in diameter are produced. Small droplets increase the potential for spray drift.

Note that the batch of 110 degree 0.15 standard flat fan nozzle tips did not produce acceptable spray patterns at any pressures. In Figure 7, 80 degree 0.1 tips produced unacceptable spray patterns at most nozzle pressures. This type of inconsistency is typical for low capacity nozzles and is why AFMRC continually tests batches of nozzles and why low application rates are not always recommended.

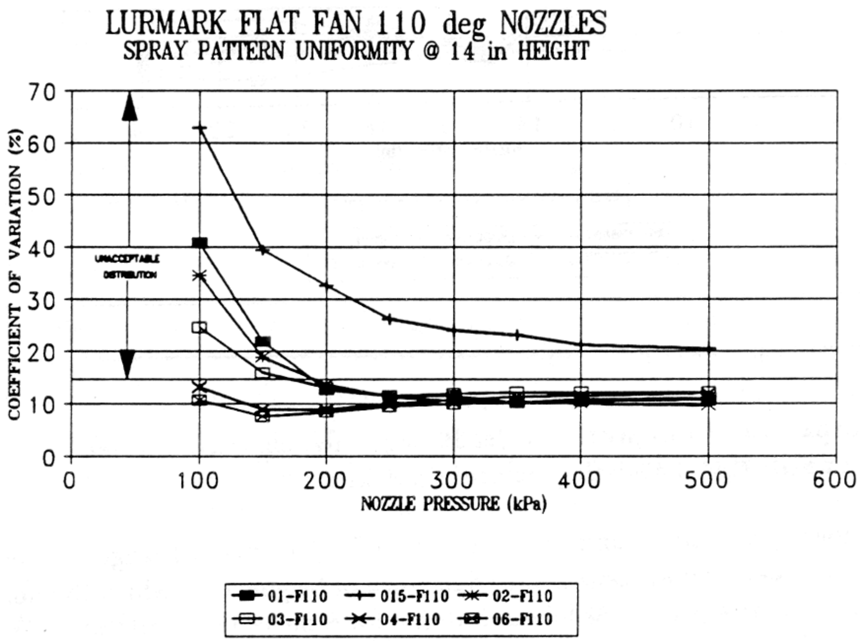

Figure 8. Spray pattern uniformity for Lurmark 110 degree flat fan nozzle tips at a nozzle height of 356 mm.

Nozzle Height

Nozzle height is the variable that affects spray pattern uniformity the most, especially when using standard 80 degree nozzle tips. Figure 9 shows spray pattern uniformity results of six different sizes of TeeJet extended range 80 degree nozzle tips over a range of heights. Most nozzles produced the best spray patterns at a nozzle height of 381 mm. Except for the 0.1 tips, spray pattern uniformity remained below 15% at all the nozzle heights above 381 mm. Below 381 mm, the spray pattern CV's increased significantly.

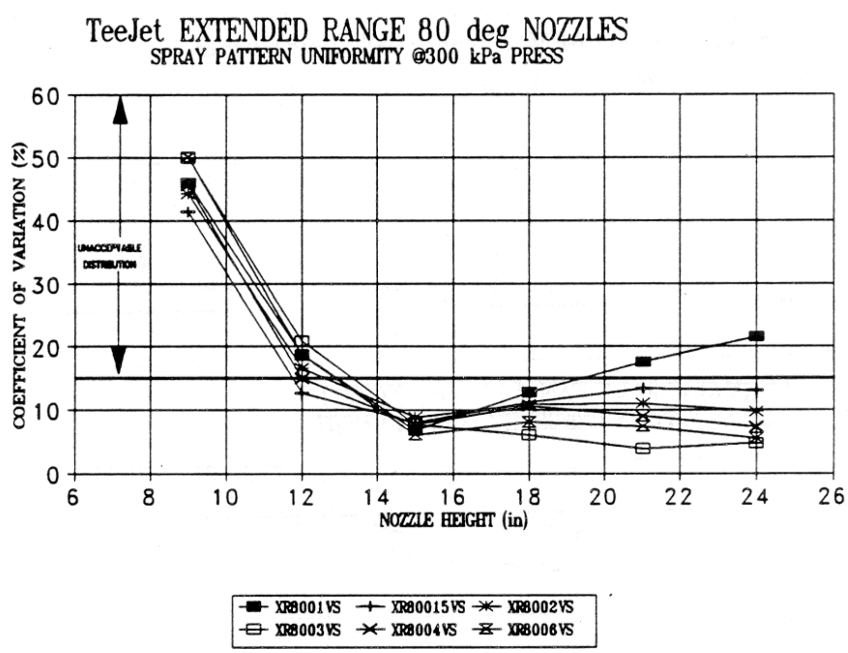

Figure 9. Spray pattern uniformity for TeeJet 80 degree flat fan (stainless steel) extended range nozzle tips at a nozzle pressure of 300 kPa.

Figure 10 shows spray pattern uniformity results for TeeJet extended range 110 degree nozzle tips. What is clearly noticeable is the wide range of heights over which the nozzles produced acceptable spray patters. As low as 230 mm for some of the nozzle sizes. This is typical for TeeJet flat fan 110 degree extended range nozzles.

When using the AFMRC spray pattern uniformity graphs shown in this report to set your sprayer nozzle height, choose the lowest nozzle height possible where the CV is still below 15%. The lower the nozzle height, the less potential there is for spray drift. For cantilever type boom sprayers like truck mount sprayers, allowances should be made for the amount the boom tips move downward during field operation. Therefore, the truck mount sprayer booms should be operated at heights about 150 mm above the lowest height shown on the spray uniformity graphs.

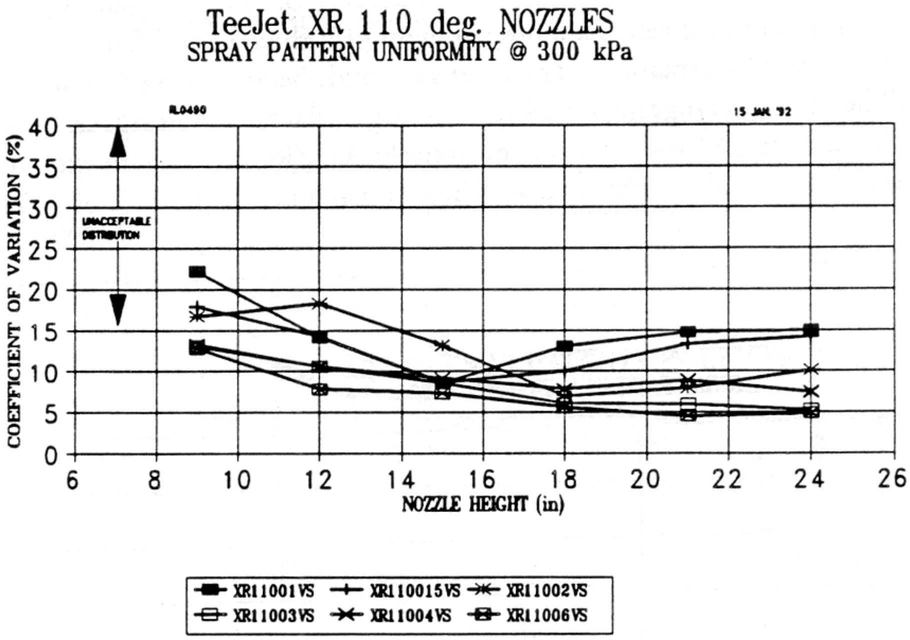

Figure 10. Spray pattern uniformity for TeeJet 110 degree fiat fan (stainless steel) extended range nozzle tips at a nozzle pressure of 300 kPa.

Nozzle Angle

Whether standard or extended, 110 degree flat fan nozzle tips produce acceptable spray patterns over a larger range of nozzle pressures (Figures 7 and 8) and heights (Figures 9 and 10) than the 80 degree nozzles. To ensure acceptable spray patterns, the standard 80 degree nozzle rips should not be operated below a nozzle pressure of 250 kPa (Figure 7) and below a nozzle height of 457 mm (Figure 11). The standard 110 degree nozzle tips can be operated at nozzle pressures as low as 200 kPa (Figure 8) and nozzle heights as low as 381 mm (Figure 11).

Whether to use 80 or 110 degree flat fan nozzles is a question asked by many farmers and researchers. The 110 degree nozzle tips produce smaller droplets, that are more susceptible to drift, than the 80 degree nozzle tips. However, some researchers are recommending smaller droplets for better weed control. To reduce spray drift, ocher researchers recommend using 80 degree nozzles. If 110 degree nozzles are operated at low pressures and heights as recommended by AFMRC, spray drift can be reduced.

Extended Range Nozzles (XR)

Generally, extended range flat fan nozzles produce acceptable spray patterns over a wider range of pressures and heights than do standard fiat fan nozzles. AFMRC highly recommends extended range nozzles on all broadcast type sprayers, especially on sprayers with automatic rate controllers and truck mount sprayers.

Figures 11 and 12 show the average CV's of the six sizes of nozzles tested over a range of heights and pressures, respectively. As shown in Figure 11, the standard flat fan 80 and 110 degree nozzles produced acceptable spray patterns at nozzle heights above 457 and 381 mm, respectively. The extended range flat fan 80 and 110 degree flat fan nozzle tips can be operated at nozzle heights as low as 381 and 305 mm, respectively. AFMRC has used the extended range nozzles successfully at nozzle heights as low as 229 mm at a nozzle pressure of 300 kPa.

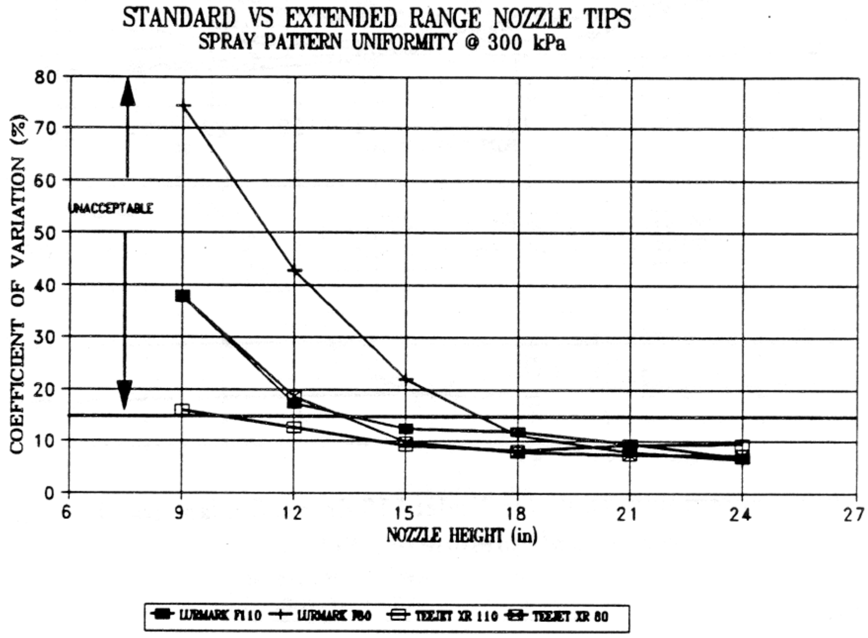

Figure 11. Spray pattern uniformity comparison between standard and extended range flat fan nozzle tips over a range of nozzle heights.

Figure 12 shows a comparison between the standard and extended range flat fan nozzle tips over a range of nozzle pressures. To obtain acceptable spray patterns, standard flat fan 80 and 110 degree nozzle tips should be operated above nozzle pressures of 250 and 200 kPa, respectively. The extended range 80 and 110 degree nozzles ran be operated at nozzle pressures as low as 200 and 100 k Pa, respectively. AFMRC has lowered the extended range nozzle pressures to as low as 150 kPa as wind speeds picked up during spraying.

Equipment That Improves Application Rate Accuracy

In the past 10 years radar speedometers, ground driven sprayers, extended range nozzles, electronic monitors and controllers all have improved application accuracy. However, it has been the radar speedometer and the extended range nozzle tips that have improved application rate accuracy the most. Radar speedometers coupled With electronic monitors are highly recommended for truck mount or towed sprayers. With extended range nozzles, automatic rate controllers can be used more effectively over a wide range of speeds, as long as the nozzle pressure doesn't fall below 100 kPa. In the past, standard flat fan nozzles limited the controllers effectiveness in operating over a wide speed range. Slowing tractor speed 1 km/h resulted in the pressure dropping below 200 kPa, where both spray pattern and droplet size were adversely affected.

All three components of a monitor system; regulator, speed, flow and pressure sensors have improved since AFMRC tested them in the early 1980's. The regulators are faster and can adjust the application rate within a couple of seconds of a speed change. The flow and pressure sensors are more accurate and durable.

One of the things AFMRC liked about the electronic monitoring and controlling systems was that it required the operator to calibrate tractor speed and nozzle output. This helped the operator understand basic spraying principles, thus increasing his spraying accuracy.

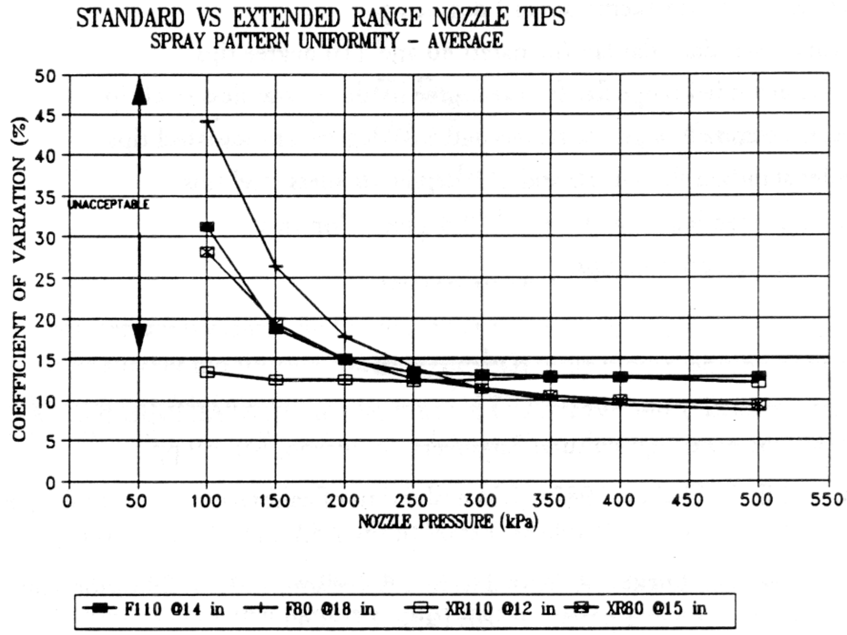

Figure 12. Spray pattern uniformity comparison between standard and extended range fiat fan nozzle tips over a range of nozzle pressures.

Note

An attempt was made in this report to show all the spray pattern uniformity results of the nozzles tested by AFMRC in the past two years. However, only a few nozzle sets were used for illustration. Complete spray pattern uniformity results can be obtained from AFMRC for the following nozzles:

1. Lurmark low-drift (kematal) 110 degree tips.
2. Lurmark standard flat fan (kematal) 80 and 110 degree tips.
3. TeeJet extended range flat fan 80 degree hardened stainless steel tips.
4. TeeJet extended range flat fan 80 and 110 degree stainless steel tips.
5. TeeJet standard flat fan 80 and 110 degree stainless steel tips.
6. Delavan extended range 80 and 110 degree nylon tips.
7. Albuz flat fan ceramic tips.

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