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DROP SPECTRUM COMPARISON OF FIVE AERIAL APPLICATION NOZZLE ASSEMBLIES

INTRODUCTION

In Nova Scotia, Vision® (active ingredient: glyphosate 356 grams/litre) is the most common aerially-applied forestry herbicide. These applications are made with helicopter mounted spray systems utilizing various nozzle components and configurations. Although the nozzles are similar in size and output, they produce a noticeably different distribution of drop sizes (drop spectrum). The droplets generated commonly range in diameter from 10 to 2000 micrometres (µm) (Bode et al, 1981). Droplets less than 100 µm are undesirable due to their ability to drift off-target while droplets greater than 1000 µm result in reduced coverage and effectiveness (Akesson, 1987). The manufacturer of Vision® (Monsanto) recommends a droplet size range of 250 to 500 µm for effective vegetation control with their product. This range reflects a compromise between good drift control and adequate coverage (Monsanto, 1990).

The purpose of this report is to determine the drop size distribution of five nozzle assemblies commonly used in forestry: the D6 JET, D8 JET, D8-45, D8-46 and 8010 LP.

METHODS

Field Work

On an abandoned airstrip in Stanley, Hants County, a flight line was established approximately 75 metres (m) from the surrounding forest cover. A 57 m long data-collection line was laid out perpendicular to, and centered on the flight line. Kromekote cards measuring 10 x 10 centimetres were sequentially numbered from 1 to 20 and affixed to the data-collection line at 3 m intervals (Figure 1). These cards

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were used to record the droplets emitted during the trial.

A 0.2% solution of Bulls Eye® marker dye in water was pumped into a Jet Ranger 206 B helicopter equipped with a Simplex® model 4900 spray system. Boom width was 8.3 m with 51 active nozzles, twenty-two on each side plus seven nozzles between the skids. Boom nozzles were spaced evenly at approximately 15 cm and were angled in-flight at 135° (45° back). Passes over the cards were made at approximately 105 kilometers per hour at a release height of about 10 m. The center point of the flight line was clearly marked such that the pilot was able to center the pass accurately. Two passes were conducted for each nozzle type.

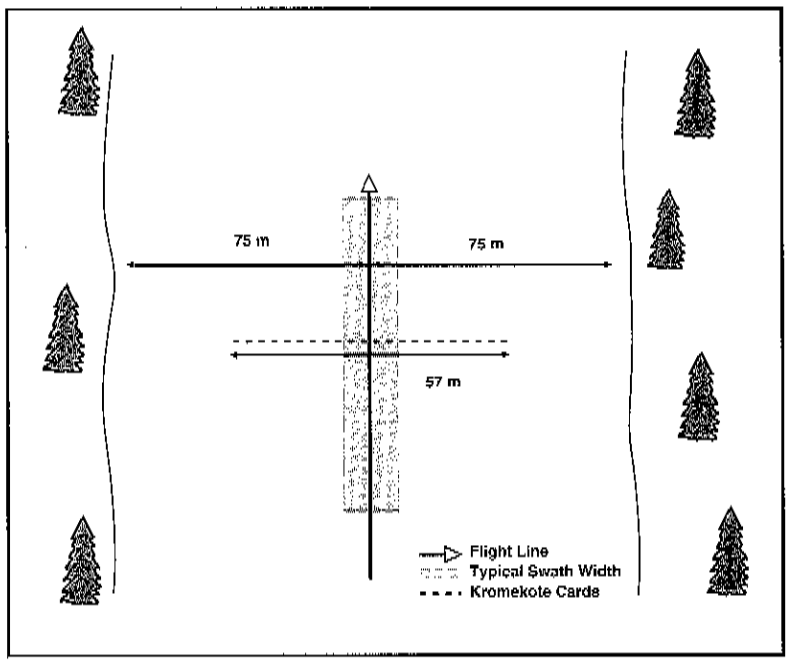

Figure 1. Schematic of data collection layout.

After each pass, the kromekote cards were collected and then replaced with fresh cards.

Through the use of a Crop Hawk® flow rate monitor, the pilot adjusted the pressure in flight, to maintain a total solution output of between 35 and 50 litres per hectare. This was necessary due to the difference in the orifice size of the different nozzle types. Appendix I shows the flow rate, application rate, boom, pressure and weather data for each pass.

Laboratory and Data Analyses

The following drop size determination was completed by Warnica (1990). Cells on the kromekote cards were sampled based on double digit random numbers generated from Mendenhall (1987). Sampling intensity ranged from 3 to 10% of each card to keep the total number of droplets sampled for each nozzle approximately equal. The diameter of each droplet within each sample cell was measured using a 12 power microscope with a graduated eye piece. When oval drops were encountered, they were measured across their length and width with the average being recorded as the diameter. Drops on sample cell boundaries were measured only if one half their area was within the designated cell. Droplets were measured in units, as defined by the graduated eyepiece, with each unit equalling 83 μm in size. On impact with the kromekote card, a droplet forms a stain larger in diameter than the original drop. The relationship between the droplet and the stain is known as the spread factor and must be determined for each sample surface and

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® **Simplex Inc.**
® **Crop Hawk - Onboard Systems**

liquid. Barry et al. (1978) found that the spread factors for a .1% and .5% dye solution in water on kromekote cards were 1.7 and 2.0 respectively. For the purpose of this report, a spread factor of 1.8 was used, meaning, the recorded stain is actually 1.8 times larger than the original droplet. This reduced the value of each graduated unit to 46 µm in size prior to impacting on the kromekote card. Therefore, all droplets less than or equal to 46 µm fell into the 46 µm class; all droplets greater than 46 and less than or equal to 92 µm fell into the 92 µm class, etc. (Appendix II). Classes were then grouped to provide four ranges of drop sizes. The drift prone range was defined as 0 to ≤231 µm. The manufacturer's recommended range (Monsanto) was defined as >231 to ≤461 µm[1]. Recognizing the potential for good efficacy of slightly larger drops, an acceptable range of >231 to ≤1153 µm was also defined. All drops larger than 1153 µm were grouped in the over size range due to the efficacy reduction and poor leaf area coverage associated with these drop sizes (Table 1).

Once actual drop sizes were calculated, volumes were determined using the volume equation for a sphere. Drops were then categorized in the aforementioned diameter ranges and volumes and percent of total volumes were calculated.

Table 1. Droplet diameter range classification

Range Name	Lower Diameter Limit (>µm)	Upper Diameter Limit (≤µm)
Drift Prone	–	231
Manufacturers Recommended	231	461
Acceptable	231	1153
Over Size	1153	–

RESULTS AND DISCUSSION

D6-JET

The D6-JET (disc type, 6/64" orifice) nozzle lacks a swirl plate which results in the production of a solid stream of liquid during operation. Formation of the droplets is dependent almost entirely on wind shear created by the forward motion of the helicopter (Matthews, 1984). This produces a broad spectrum of droplet sizes (Figure 2). The D6-JET produced drops between the 92 and 4150 µm classes inclusive (Appendix II). Only 18% of the total volume was in the acceptable range and only 4% in the range recommended by the manufacturer of the herbicide (Table 2). Although less than 1% of the volume was in the less than 231 µm category (defined as the drift prone range), 82% was in the larger than recommended category. The droplets produced in this larger category are less

1. **Monsanto recommends a range of 250-500 µm. Since the class limits did not correspond, the manufacturer's range was adjusted to >231 - ≤461 µm.**

Table 2. Percent of droplet volume for each nozzle by diameter class.

Droplet Size Range Classification	Midpoint of Diameter Class	Nozzle Type				
		D6-JET	D8-JET	D8-45	D8-46	8010
Drift Prone (≤231 µm)	115	0.4	0.3	4.2	1.2	3.0
Acceptable (>231 to ≤1153 µm)						
Manufacturers Recommended (>231 to ≤461 µm)	345	3.6	2.6	22.2	8.0	19.8
	576	4.9	4.0	35.2	12.2	20.6
	806	3.1	6.6	16.7	13.7	9.8
	1037	6.3	7.1	10.7	14.5	17.3
Total		**17.9**	**20.3**	**84.8**	**48.4**	**67.5**
Over Size (>1153 µm)	1268	6.2	8.2	4.3	7.7	13.7
	1498	5.6	10.4	6.7	10.9	15.9
	1729	7.0	7.5	0	12.9	0
	1959	6.0	12.9	0	7.3	0
	2190	7.3	11.9	0	6.7	0
	2420	1.6	12.0	0	4.9	0
	2651	5.3	4.9	0	0	0
	2882	2.6	6.5	0	0	0
	3112	3.3	0	0	0	0
	3343	11.6	5.1	0	0	0
	3573	4.9	0	0	0	0
	3804	0	0	0	0	0
	4034	20.2	0	0	0	0
Total		**81.6**	**79.4**	**11.0**	**50.4**	**29.6**

Monsanto® recommends a range of 250 - 500 µm. Since the class limits did not correspond, the manufacturers range was adjusted to >231 - ≤461 µm.

efficacious due to the reduction in coverage on target vegetation. Twenty percent of the total volume produced by the D6-JET was contained in the 4034 µm class. This volume was accounted for by only three droplets. The volume contained in one 4000 µm droplet is equivalent to over 1200 droplets, 375 µm in size.

D8-JET

The D8-JET (disc type 8/64" orifice) as in the D6-JET, has no swirl plate but has an orifice of a slightly larger size. The difference in the orifice size produces a similar solid stream at a lower pressure, therefore results were found to resemble those for the D6-JET. The droplet spectrum included drops from the 92 µm class to the 3320 µm class (Appendix II). The drift prone range of droplets accounted for less than 1% of the total volume, while 79% of the volume was in the larger than recommended category (Figure 3). This leaves only 20% of the total volume in the recommended size class range, with 3% of the volume in the category recommended by the herbicide manufacturer