SOME FURTHER CHARACTERISTICS OF LOW VOLUME NOZZLES

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IN the following studies all tests were run at a pressure of 30 p.s.i. unless otherwise stated. The height of the nozzle is the distance H measured in inches from the tip orifice to the top of a lead fence on the spray distribution machine. The distance between two nozzles D is the distance measured in inches between the centre lines of two nozzles.

EFFECT OF PRESSURE ON HEAVY BANDS

After the suggestion of a member of the audience at the 5th National Weeds Conference a study was made of the effect of pressure on the heavy bands known to exist on the outer edges of the fan of spray particles from a typical fan nozzle. A Monarch 32 nozzle known to carry two heavy bands on its outer edges was mounted on the spray distribution machine (built to the recommendations of Shanks¹). With the use of a special black spray solution described previously,² successive spray patterns were taken at 5lb. intervals upwards from 15 p.s.i. The angle of the fan increased markedly between 15 and 30 p.s.i. and thence at a lower but sustained rate until 95 p.s.i. at which stage the test was discontinued.

One of the heavy bands disappeared at 70 p.s.i. and the other at 85 p.s.i. It is known that the intensity of the heavy bands varies in different fan nozzles and it is concluded that pressure will dissipate the bands, the actual pressure necessary depending on the intensity of the band.

THE RILEY SPRAYOGRAPH

The Riley Sprayograph is another machine designed to further the visual study of the characteristics of low volume nozzles. It has been described by Shanks and Paterson³ and consists essentially of a nozzle mounted over a wide belt, moving at 200ft. per minute. A 3in. slit in the belt allows the spray particles to pass through it on to a paper mounted on a slide below the belt.

A modified version of this machine was constructed. It consisted essentially of a wooden sledge on which 2ft. wide tin trays were mounted with a 3in. gap between them. A paper was placed on the floor under a suitably mounted nozzle and the sledge drawn forward so that the first tray covered the paper. When the nozzle was spraying the black spray solution the sledge was caused to move forward at 200ft. per minute so that a typical pattern was obtained on the paper as the 3in. gap moved forward over it. A suitable stop was arranged so that the sledge was halted when the second tray covered the paper.

With this machine studies were made of fan, hollow cone, and solid cone nozzles.

INTERACTION OF LOW VOLUME NOZZLES

Until now only single nozzles had been dealt with and it was felt that a study of their interaction would be informative.

A line of 12 Monarch 32 nozzle tips which had been manufactured in New Zealand was run at 30 p.s.i. for $\frac{1}{2}$ hour to wear them in, and then tested for delivery.

The times taken to deliver 1 Imperial gallon at 30 p.s.i. ranged from 9 min. 46 sec. to 10 min. 43 sec., the batch mean averaging out at 10 min. 22.5 sec. which time is 3.6 per cent. higher than their rated output (10 min.), that is, their delivery rate in G.P.H. was lower than the rated value. It has previously been established² that it was reasonable to discard all nozzles whose delivery rates exceeded plus or minus 5 per cent. of the batch mean. When these limits were applied to the 12 tips under study only one failed to meet the requirements—a discard rate that compares favourably with overseas manufactured tips which have been tested on earlier occasions.

Spray patterns were obtained for the 12 tips and the distribution graphs obtained on the spray distribution machine. As a result two tips approaching the ideal were selected for the following test.

INTERACTION OF TWO FAN TIPS

The two tips 32/4 and 32/12 were mounted on the spray distribution machine at $H = 28$. The distribution was measured at $D = 12$ and then successively at $D = 14, 18, 22, 26, 30$, and 34 at which stage interaction ceased and the two nozzles emerged as separate entities. Two further tests at $D = 32$ and 33 indicated that the most even spraying occurred when $D = 32$, that is, when the boom was a little lower than the distance between the two nozzles. The test indicated that the most even spraying occurred when the fans overlapped 2 in.

THE GEOMETRY OF NOZZLE INTERACTION

When a boom was drawn on paper with nozzles at $D = 14$, and lines drawn to show the path of the spray particles, assuming a 70 degree fan from each nozzle, the interaction of the fans could be studied. An overlap of 2 in. occurred when $H = 11\frac{1}{2}$, while further overlaps of 4 and 6 in. occurred when $H = 23$ and $34\frac{1}{2}$ at the levels of double and triple lapping of the fans. It was realised that these optimum heights would rarely occur in practice, but would serve as a guide when setting up a boom. The actual heights for optimum spraying at single, double, and triple laps were investigated in the next test.

INDEX NUMBERS

At this stage it became difficult to determine which distribution curve gave the most even spray distribution.

Accordingly a numerical factor was developed, known as the index number. The index number is a measure of the variation from the mean of any one distribution curve and is obtained by adding the sum of all the readings above the mean to the sum of all the readings below the mean.

INTERACTION OF FOUR FAN TIPS

The above two tips were mounted on a boom with 14in. nozzle centres owned by the Department of Agriculture and supplemented with two others from another batch C.32/3 and C.32/1. So with $D = 14$, and $P = 30$, graphs were obtained for the interaction of 4 tips at $H = 12, 13, 14, 15, 17$, and 19 . Index numbers readily indicated that optimum spraying occurred at $H = 13$.

Tests at $H = 21, 22, 23$, and 24 indicated that optimum spraying for the double lap occurred at $H = 24$; while tests at $H = 33\frac{1}{2}, 34\frac{1}{2}$, and $35\frac{1}{2}$ indicated that the optimum triple lap occurred at $H = 35\frac{1}{2}$. No decision was reached as to whether double or triple laps offered more even spraying than the optimum single lap. At this stage it was realised that one of the sockets had been welded on to the boom in such a way that the nozzle was not perpendicular (as the other 3 were) and accordingly the nozzle interaction would be affected.

But examination of a commercial boom with 14in. nozzle spacings as manufactured by a large firm retailing units throughout New Zealand showed that all the sockets on the boom were off square to a greater or larger extent—apparently the effect of electric welding in their construction. This opinion is based on the examination of one boom selected at random and is not the result of a survey of a number of booms made by various manufacturers.

Accordingly, the above results are felt to be not greatly different from those that would pertain in the field.

INTERACTION OF 12 FANS ON A COMMERCIAL 14in. BOOM

In view of the above examination of a commercial boom it was felt that it would be interesting to investigate the spray pattern from a random set of nozzles on a commercial boom. Accordingly, the batch of Monarch 32 tips was mounted in 3 random groups of 4 on the above boom at a height recommended by the above firm throughout New Zealand for field spraying (16in.). So at $H = 16, D = 14$, and $P = 30$ the tests were carried out. A new factor had to be developed to differentiate the performance of this boom at $H = 16$ with the same and other booms at different heights.

PERCENTAGE WASTAGE

The factor chosen was "percentage wastage" and was obtained by adding together all the readings above the mean and expressing them as a percentage of the total readings under the mean.

When any one distribution curve on which the mean has been lined in is considered, the mean represents the calculated rate at which an area is to be sprayed and presumably contains sufficient weedicide to give 100 per cent. control of the weeds on the area. Readings above the mean represent additional spray applied to the area under those points—additional spray that cannot improve 100 per cent. control and thus must

be regarded as spray wasted. Thus percentage wastage is in fact real waste of spray material and the factor assumes importance when it is realised that a reliable estimate shows that £260,000 worth of hormone was applied with boom sprays in New Zealand in 1953.

In the above test of 12 tips on a commercial boom at $H = 16$ and $D = 14$, the wastage was 11.6 per cent.

When the same nozzles were tested on the same boom at $H = 11\frac{1}{2}$ the wastage was reduced to 6.1 per cent. However, from a practical point of view, it is impossible to operate in the field with a 12, 14, or 16ft. boom at a height of only $11\frac{1}{2}$ in. But the same degree of interaction between the fans of the nozzles can be obtained with a higher boom if the nozzles are placed further apart on the boom.

INTERACTION OF THREE FANS ON AN 18in. BOOM

Three tips from one of the above groups of 4 tips were mounted on a boom with 18in. nozzle centres. Tests were made to determine the optimum height and at $D = 18$ and $H = 18$ the wastage was only 4.4 per cent. It is interesting to note that at the double lap, that is, $H = 36$, wastage was further reduced to 4.2 per cent.

It is thus possible to operate a boom in the field at a workable height and yet markedly reduce the wastage that must be occurring from those machines operated at the firm's recommendations.

INTERACTION OF SIX RANDOM HOLLOW CONE NOZZLES

Because individual hollow cone nozzles were markedly superior to fan nozzles when their distribution graphs were compared previously,² a batch of 6 Monarch 18.0 tips were "worn in" and tested in 2 random batches of 3 on an 18in. boom. At $H = 11\frac{1}{2}$ the most even spraying was obtained and waste was 6.0 per cent.

INTERACTION OF TWO SOLID CONE NOZZLES

Two solid cone nozzles 30/2 and 30/3 were tested individually and their readings compounded at $D = 18$ to give a calculated graph of their interaction. This resulted in an index number of 143. When the two tips were tested simultaneously at $D = 18$ the actual readings had an index number of 134, that is, better and flatter than the calculated graph. Further tests at the same height, but $D = 22, 24$, and 26 , resulted in poorer distribution as the cones moved apart and finally emerged as separate entities. The index numbers rose to 263 at $H = 26$.

It was concluded that the best spraying with solid cone tips occurred at or about the double overlap.

INTERACTION OF SIX RANDOM SOLID CONE NOZZLES

A batch of 6 Monarch 30.0 solid cone tips were worn in and tested in 2 random batches of 3 on a 14in. boom. It was established that the most even spraying occurred at $H = 19$ at which height the waste was only 2.4 per cent. This indicated that there was considerable future in using solid cone nozzles for boom work and supports the North Island practice of using them in some districts for ragwort control.

CONCLUSIONS

While the study of the interaction of fan, hollow cone, and solid cone tips has been a time consuming investigation and the numbers of tips tested have not been great, in view of the results obtained it is concluded that:—

1. There is room for considerable improvement in the heights at which booms are operated in the field in New Zealand.
2. That there is an annual wastage of up to £26,000 worth of hormone in New Zealand.
3. That this wastage can be considerably reduced if (i) present 14in. booms carrying fan tips are operated at a lower height (11½in.) or (more practicably) at the double overlap level (24in.), or (ii) we revert to the 18in. boom carrying fan tips as used some years ago and operate at the single overlap level of approximately 18in. high.
4. That there is a future in changing from fan to solid cone tips for boom work.
5. That if these changes are made, the same weed control can be achieved with applications of weedicides at rates of up to 10 per cent. lower than those recommended at present. This could result in an annual saving for the spraying industry of up to £20,000.

In that the above investigations were made with tips that were newly worn in and it is known (2) that with further use the distribution graphs of fan tips flatten out as they become worn, the position in the field may not be as bad as that pictured above. However, in that it is known² that after use on 1000 acres one batch of fan tips increased in output by 25 per cent. above their rated capacities, the annual wastage may in fact be worse, unless operators recognise this last fact and periodically check the tips for output and recalibrate their machines.

References

1. Shanks, G. L. Agric. Eng. p. 539. Dec. 1948.
2. Crosbie, C. J. Proceedings of the 5th Conference, N.Z. Weed Control Conference (Inc.). 1952. p. 69.
3. Shanks, G. L., and Paterson, J. J. Agric. Eng. p. 428. July. 1952.

DISCUSSION

Q.—Were spreaders incorporated in the nozzles tested?

A.—Yes, at standard adjustment.

Q.—I consider that double overlap at 14in. centres is not warranted in view of practical experience.

A.—A single overlap may not be sufficient on uneven ground.

Q.—Is it not important to have the spray boom as low as possible?

A.—Theoretically, a boom with nozzles at 18in. centres and 23in. above the crop should be better.

Q.—Would the angling of the boom affect the efficiency of the spray cover?

A.—That point had not been considered in this work.

Q.—Was this work done inside a shed under optimum conditions?

A.—Yes, this ensured that temperature was the only variable.

Comment: Angling the boom would probably give better penetration.