EVALUATION OF SPRAY UNIFORMITY DISTRIBUTION BY ENVIRONMENT FRIENDLY UNIVERSITY BOOM SPRAYER TEST BENCH

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This paper describes the effects of three levels of spraying fluid pressure, three levels of sprayer velocities, and three levels of vertical heights, on spray uniformity distribution on the undersurfaces of water sensitive papers. The University Boom Sprayer Test Bench designed in the Department of Farm Machinery & Power, University of Agriculture, Faisalabad, had been employed for the investigations of spray uniformity distribution. The recommended hollow cone nozzles for controlling cotton insect/pest were used. Average uniformity of coverage found was 90.8%, 73.7% and 32.6% at 30 cm, 50 cm, and 70 cm heights respectively. The increase in height from 30 to 50cm and 50 to 70cm decreased uniformity of coverage 18.8% and 56% respectively, indicating strong effect of water sensitive paper height on uniformity of coverage from nozzle. The pressure did not affect uniformity of coverage significantly. However, the increase in pressure from 300 to 400 kPa and 400 to 500 kPa increased uniformity of coverage 1.05 and 1.04 times respectively. The average spray uniformity of coverage values at 2.5 Km/hr, 4.0 Km/hr, and 5.5 Km/hr were 75.7%, 66.7% and 54.7% respectively.
Key words: Uniformity of coverage; nozzle; pressure; velocity; water sensitive paper (WSP)

INTRODUCTION

Chemical pesticides have played and will continue to play a major role in the rapid advancement of agricultural production. Farmers are now realizing the use of pesticides. Despite the competition of weed, pathogen, insects and pests, the farmers are continuously applying pesticides to achieve maximum production. It has now become essential to spray the growing crops economically and profitably. Crop losses remain severe in many areas of the world particularly in the developing countries, where irrigation allows pest to survive throughout the year (Mathew, 1992). Insect pest continues to cause losses of yield and quality either directly by feeding, or indirectly as a vector of disease. These losses can be extremely serious and may result in total loss of a crop in some fields.

The quantity of pesticide applied depends on a number of factors including amount of material sprayed, physiochemical properties of pesticides and dispersion vehicle, particle size distribution, height at which material is released, wind speed and atmospheric conditions (Robert, 1976). Usually the amount of liquid sprayed is metered at the nozzle. The nozzle is, therefore, one of the most important parts of a sprayer, yet it is often neglected and seldom checked to ensure that expensive chemicals are being applied at correct rate (Matthew, 1992). A variety of nozzle types is used to distribute chemicals. However, hollow cone nozzles have been recommended for insect/pest control on cotton crop. The spray uniformity distribution is affected by the nozzle aperture diameter, fluid pressure, cone angle, and distance from the target.

Kepner *et al.* (1978) reported that uniformity of spray distribution could be determined in the laboratory or in the field by means of sensitized paper or by spraying colored liquid on to plain paper. Uniformity of coverage on plant surfaces can be checked by adding fluorescent dyes to the spray and then viewing the surfaces with a fluorescent light after dark. Holownicki *et al.* (2002) reported that most common artificial targets for spray coverage evaluation are water sensitive papers (WSP). They are widely used for visual assessment of spray distribution as well as for image analyses in spray application experiments. The WSP turns blue at relative humidity above 80 %, and, therefore, it can not be used under very humid conditions.

Most of the sucking insects have their kitchen houses on the lower side of leaves of the upper half portion of the cotton plant which not only get protection from sprays but also enjoy the shadow of leaves as umbrella coverage. Therefore, the spray chemicals by conventional sprayers do not hit the actual target and cause wastage of the spray material to the ground and air. A university boom sprayer has been designed which has the ability to spray the crop on both over and under the leaves surfaces (Mahmood, 2004). No effort has yet been made to find the uniformity distribution on the lower surfaces of crop leaves. Therefore, the objective of this research project was to evaluate the spray uniformity distribution of hollow cone nozzles while spraying at an angle on the undersurface of cotton leaves against gravity.

MATERIALS AND METHODS

A University Boom Sprayer Test Bench designed by the Department of Farm Machinery & Power, University of Agriculture, Faisalabad, had been employed for spray uniformity of coverage evaluation (Mahmood, 2003). A 3x3 factorial design was used to determine the effects of three spraying fluid pressures (300, 400 and 500 kPa) at three levels of belt speeds (2.4, 4.0 and 5 Km/hr) on uniformity of coverage measured on the underside of water sensitive papers (WSP). The WSP were held by rubber holders mounted on the vertically moving canvas belt. The rubber holders for WSP were mounted on belt at every 10 cm distance in vertical direction. In this experiment the WSP were inserted in rubber holders, at 30 cm, 50 cm and 70 cm height from the corrugated sheet. The desired fluid pressures were obtained with the help of regulator valve installed in the main pipe line coming from the rotary pump. The belts speeds were obtained with the help of variable speed 2.24 kW (3 hp) motor. Each of the 9 treatments was replicated three times. The boom pipe was rotated to direct the nozzle spray discharge at 45^{θ} with horizontal towards the moving belt plateform. Moreover whole of the nozzle assembly was brought to lowest possible vertical position above the corrugated sheet and 19.05 cm (average value) horizontally away from the moving belt plateform. For each treatment of pressure and speed, as the required fluid pressure was obtained by switching on the pump and uniform speed of belt was achieved, the nozzle restriction mechanism was pulled to direct the nozzle discharge towards the belt to spray on the under surface of water sensitive papers. After the WSP once sprayed, spraying system and moving belt were stopped and WSP were taken out from holders for analysis in the computer lab. Same procedure was replicated for all the combinations of pressure and speed. Hp-Scanner was used to take images of WSP, then transferred to Pentium 4 computer, for measuring percent spray uniformity by using adobe photo shop software (Version 7). Treatments have been explained in Table 1.

Table 1. Treatment table for measuring spray uniformity

Item	Level	Values
Belt velocity (V), Km / hr	3	(2.5 4 5.5)
Fluid pressure (P), Kpa	3	(300 400 500)
Nozzle angle of spray (θ), degree	1	(45•)
Horizontal distance (D), mm	1	(190.5)
W.S.P. height, cm (block)	3	(30 50 70)

RESULTS AND DISCUSSION

Data collected from the experiment were statistically analyzed. The analysis of variance was carried out using PROC GLM (General Linear Model) procedures of the SAS Institute (1998). The effects of mean belt velocity, water sensitive paper height from the test bench corrugated sheet, and fluid pressures on uniformity of coverage were studied. The analyzed results were discussed as following.

Effect of Water Sensitive Paper (WSP) Height on Uniformity of Coverage

Height of water sensitive paper (WSP) from corrugated sheet had highly significant effect (α=0.05) on uniformity of coverage Table 2. Average uniformity of coverage was 90.8%, 73.7% and 32.6% at 30 cm, 50 cm, and 70 cm heights respectively. It is clear from Table 2 that percentage of uniformity of coverage decreased significantly with the increase in vertical height of the water sensitive paper from the spraying nozzle and vice versa. The increase in height from 30 to 50cm and 50 to 70cm decreased uniformity of coverage 18.8% and 56% respectively, indicating strong effect of water sensitive paper height on uniformity of coverage from nozzle. The reason could be that the increased gravitational effect on droplets reduced spray deposition at greater height. Moreover the increasing swath width decreased number of drops to be hitting the target at far distance.

Table 2. Average effect of Water Sensitive Paper (WSP) height from the corrugated sheet on uniformity of coverage

Height (cm)	Mean Uniformity of Coverage (% age)
30	90.8 [a]
50	73.7 [b]
70	32.6 [c]
Mean	65.7
LSD	7.9

Effect of fluid Pressure on Uniformity of Coverage

Statistically analyzed results for effect of nozzle pressure on uniformity of coverage are presented in Table 3. The pressure did not affect uniformity of

Table 3. Average effect of pressure on uniformity of coverage

Pressure (kPa)	Mean uniformity of coverage (% age)
300	62.8 [a]
400	65.7 [a]
500	68.5 [a]
Mean	65.7
LSD	8.3

[abc] Means followed by the same letter are not significant at 5 % probability level.

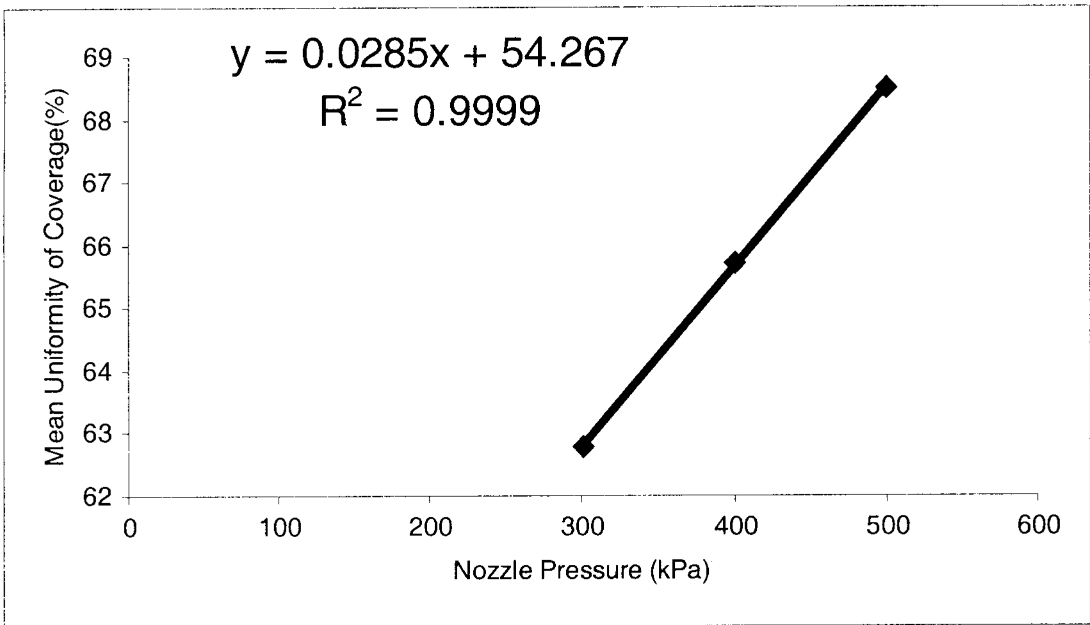

Figure 1. Effect of nozzle fluid pressure on uniformity of coverage

coverage significantly. However, the increase in pressure from 300 to 400 kPa and 400 to 500 kPa increased uniformity of coverage 1.05 and 1.04 times respectively. Regression analysis indicated that the linear model was the best to predict the uniformity of coverage at different pressure values. Therefore, it could be safely concluded that the increase in pressure increases the uniformity of coverage linearly while keeping the other parameters constant (Figure 1).

Effect of Belt Velocity on Uniformity of Coverage

Statistically analyzed results are presented in Table 4. It was found that the belt velocity significantly affected (α=0.05) the uniformity of coverage. The average uniformity of coverage value was significantly greater (75.7%) at 2.5 Km/hr velocity than those both at 4.0 Km/hr velocity (66.7%) and 5.5 Km/hr velocity (54.7%). Moreover, average uniformity of coverage value at 4.0 Km/hr velocity (66.7%) was also significantly greater than that at 5.5 Km/hr velocity (54.7%). A very careful analysis indicated that the increase in velocity from 2.5 to 4.0 Km/hr and 4.0 to 5.5 Km/hr decreased the uniformity of coverage 11.8% and 18% respectively (Figure 2). Therefore, it can be safely concluded that the increase in velocity decreases the uniformity of coverage at faster rate.

Table 4. Average effect of belt velocity on uniformity of coverage

Velocity (km/h)	Mean Uniformity of Coverage (% age)
2.5	75.7 [a]
4.0	66.7 [b]
5.5	54.7 [c]
Mean	65.7
LSD	8.3

[abc] Means followed by the same letter are not significant at 5 % probability level.

Combined Effect of Nozzle Pressure and Belt Velocity on Uniformity of Coverage

The statistically analyzed results for the combined effect of nozzle pressure and belt velocity have been recorded in Table 5. Interaction p x v had been found insignificant (α=0.05) indicating that p and v acted independently. However, it could be depicted from the Table 5 that keeping pressure constant, the increase in velocity decreased the percentage of uniformity of spray coverage and vice versa. Same trend was observed at 300 kPa, 400 kPa, and 500 kPa fluid pressures. Figure 2 shows that the increase in velocity decreased uniformity of coverage at all levels of pressure studied in this investigation. Moreover, increase in pressure at all levels of velocity increased uniformity of coverage.

Table 5. Combined effect of nozzle pressure and belt velocity on uniformity of coverage

	V1	V2	V3	Mean
P1	72.9	65.4	50.3	62.8
P2	75.6	65.5	55.9	65.7
P3	78.5	6.3	57.6	68.5
Mean	75.7	66.7	54.4	

Where, P1, P2, & P3 =Pressure levels 300 kPa, 400 kPa, & 500 kPa respectively
V1, V2, & V3 = Velocity levels 2.5 km/hr, 4.0 km/hr, & 5.5 km/hr respectively

Mahmood, R.K. 2003. Development of a test bench for performance evaluation of locally developed nozzles for a sprayer. M.Sc. (Hons) Thesis of Agricultural Engineering, Department of Farm Machinery & Power, Faculty of Agricultural Engineering & Technology, University of Agriculture, Faisalabad, Pakistan.

Mahmood, H.S. 2004. Development of a drop-pipe tractor mounted boom sprayer for cotton crop. Unpublished M.Sc. (Hons.) Thesis. Faculty of Agricultural Engineering & Technology, University of Agriculture, Faisalabad.

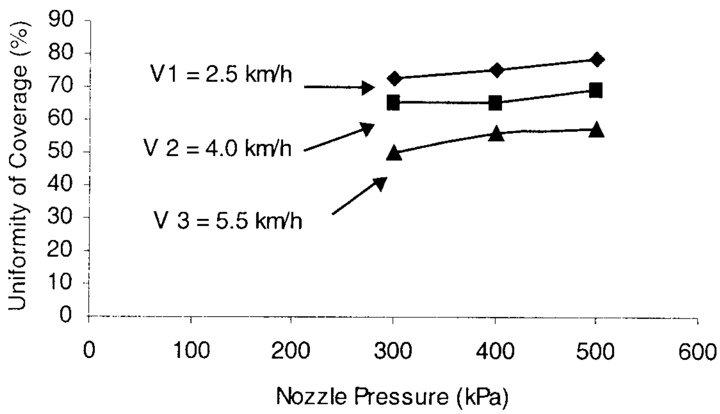

Figure 2. Combined effect of nozzle pressure and belt velocity on uniformity of coverage.

REFERENCES

Holownicki, R., G. Doruchowski, W. Swiechowski, and P. Jaeken. 2002. Methods of evaluation of spray deposit and coverage on artificial targets. Research Institute of Pomology and Floriculture, Skierniewice, Poland. In Electronic Journal of Polish Agricultural Universities. 5(1).

Kepner, R.A., B. Roy and Barger E.L. 1978. Principles of farm machinery. 3rd edition. CBS Publishers & distributors. 485, Jain Bhawan Nath Nagar. Shahdara, Delhi-110 032 (India).

Matthews, G.A. 1992. Pesticide application methods (2nd edition). 104. John Wiley and Sons, inc. 605, Third Avenue, New York, NY 10158.

Robert, E.L., Jr. 1976. Air pollution from pesticide and agricultural processes. CRC press, inc. 18901 Cranewood Parkway, Cleveland, Ohio 44128.

SAS Institute. 1998. SAS/STAT users Guide: Revised Version 6.12. SAS Institute Inc. Carry. N.C.