RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 8 | Issue 1 | April, 2015 | 85–91

e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/8.1/85-91**

Comparative performance of tractor operated boom type field sprayers on cotton crop

BABASAHEB GHOLAP AND OMKAR SINGH KUSHWAH

Received : 06.02.2015; **Revised :** 01.03.2015; **Accepted :** 12.03.2015

See end of the Paper for authors' affiliation

Correspondence to :

BABASAHEB GHOLAP
Agricultural Energy and Power Division, Central Institute of Agricultural Engineering, BHOPAL (M.P.) INDIA

ABSTRACT : Boom sprayers are the hydraulic equipment in which sprayers move the liquid to the individual nozzles along the boom and generally used for application of pesticides on field crops such as cotton, soybean etc. Two 12 meter tractor operated boom type field sprayers of the ASPEE make one of the existing design and other of new design (developed) having similar specifications were selected for the study. The necessary set up was built up in the laboratory and said sprayers were evaluated for their performance for the parameters such as liquid distribution, flow rate of the pump, pressure and discharge of nozzles and droplet deposition on the leaves of cotton plant. Comparative performance showed that the liquid distribution under the developed boom sprayer improved, the mean discharge and pressure of developed boom sprayer increased by 49 per cent and 184.4 per cent, respectively. The discharge and pressure of the developed boom sprayer was nearly uniform in all nozzles, droplet size (VMD), droplet density (DD) and uniformity co-efficient (UC) for the existing sprayer ranged from 130.9 to 206.39 µm, 11 to 27 drops/cm^2 and 1.18 to 1.31, whereas for developed sprayer it was ranged from 155.44 to 181.55 µm, 17 to 29 drops/cm^2 and 0.99 to 1.23, respectively.

KEY WORDS : Boom sprayer, Cotton crop, Droplet deposition, Comparative performance

HOW TO CITE THIS PAPER : Gholap, Babasaheb and Kushwah, Omkar Singh (2015). Comparative performance of tractor operated boom type field sprayers on cotton crop. *Internat. J. Agric. Engg.*, **8**(1) : 85-91.

Boom sprayers are the hydraulic equipment in which sprayers move the liquid to the individual nozzles along the boom and generally used for application of pesticides on field crops such as cotton, soybean etc. The most common method of applying pesticides to the field crops in more developed and relatively wealthy agricultural regions of the world is with hydraulic boom sprayers. Two 12 meter tractor operated boom type field sprayers of the ASPEE make one of the existing design and other of new design (developed) having similar specifications were selected for the study. The necessary set up was built up in the laboratory and said sprayers were evaluated for their performance for the parameters such as liquid distribution, flow rate of the pump, pressure and discharge of nozzles and droplet deposition on the leaves of cotton plant. Further results of both the sprayers for the above parameters were compared. The developed sprayer showed better performance than existing one.

METHODOLOGY

The technical specifications of the selected sprayers for the study are given in Table A. The experimental set up and methodology for study is described are as follows:

Experimental set-up :

Different set ups were used in the laboratory for evaluating the performance of the hydraulic boom

Table A : Technical specification of the sprayers

Descriptions	Hydraulic boom sprayer
Tank capacity	400 l
Working pressure	689.5 kPa
Maximum pressure	2758 kPa
PTO rpm	540
Minimum hp required	35
Gross weight of sprayer	270 kg
Size of sprayer (L × W × H)	1364 × 1000 × 1212 mm
Application rate	580 l/ha
Type and number of nozzles used	Hollow cone, 25

sprayers. These were to measure liquid distribution under the spray boom, flow rate of pump, pressure and discharge of each individual nozzle, calibration of pressure gauge and droplet deposition. For measurement of parameters equipments such as spray scanner, pump tester, pressure gauge manufactured by AAMS (Advanced Agricultural Machinery System, Belgium), manometer tester, graduated cylinder, stop watch and droplet size analyzer were used.

Methodology :

Different measurements were done on the set ups prepared to evaluate and compare the performance of the selected sprayers. These are discussed as follows:

Liquid distribution :

Spray scanner was used to measure the liquid distribution from the spray booms. It was measured for 0.9 l/min discharge and pressure of 689.5 kPa (Anonymous, 2009). Spray scanner was placed on the reel. It automatically moves and measures liquid distribution under spray boom. The distribution was measured with a high precision and was independent of the operator. It was provided with 12 V rechargeable batteries. The data were stored in memory box of the spray scanner. AAMS software, already installed in computer, was used for the detailed analysis. The setup is shown with existing sprayer in Fig. A(a) and with developed sprayer in Fig. A(b).

Flow rate of pump :

The pump tester is an instrument to determine the flow rate of the pump on agricultural sprayers. The HTP pumps of the both sprayers were dismounted from the sprayers and coupled with 5 hp motor with the help of two V belts. The suction and delivery hoses of pump tester were connected to suction and delivery of pump. The tanks were filled with water and suction and delivery

(a) Existing sprayer (b) Developed sprayer

Fig. A : View of sprayers with the spray scanner

hoses were connected to the tank, so that water sucked from suction pipe will be received back in tank through delivery hose.

Pressure and discharge of nozzles :

The pressure and discharge of each individual nozzles of the both the sprayers were measured from left to right of the booms. The pressure was measured with manometer tester. The discharge was measured with the help of graduated cylinder and a stop watch for one minute.

Pressure of the pressure gauge :

Pressure gauge tester was used to check the pressure gauge of the sprayer. Pressure gauges of the both sprayers were calibrated with AAMS master pressure gauge tester for known pressures ranging from 100-600 kPa.

Droplet deposition :

To facilitate the evaluation of spray deposition on the artificial canopy of the cotton plant, the plant was divided into six different positions *viz.*, top upper and lower, middle upper and lower and bottom upper and lower. Six glossy papers were stapled on each position to observe the deposition of the droplets. After the experiment, the glossy paper cards were carefully removed and then taken for further analysis in the laboratory. Digital image analyzer was used to determine stain diameter and droplet size which analyze these samples after 24 hours of application to ensure that droplets had stopped spreading.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Comparative performance of the sprayers :

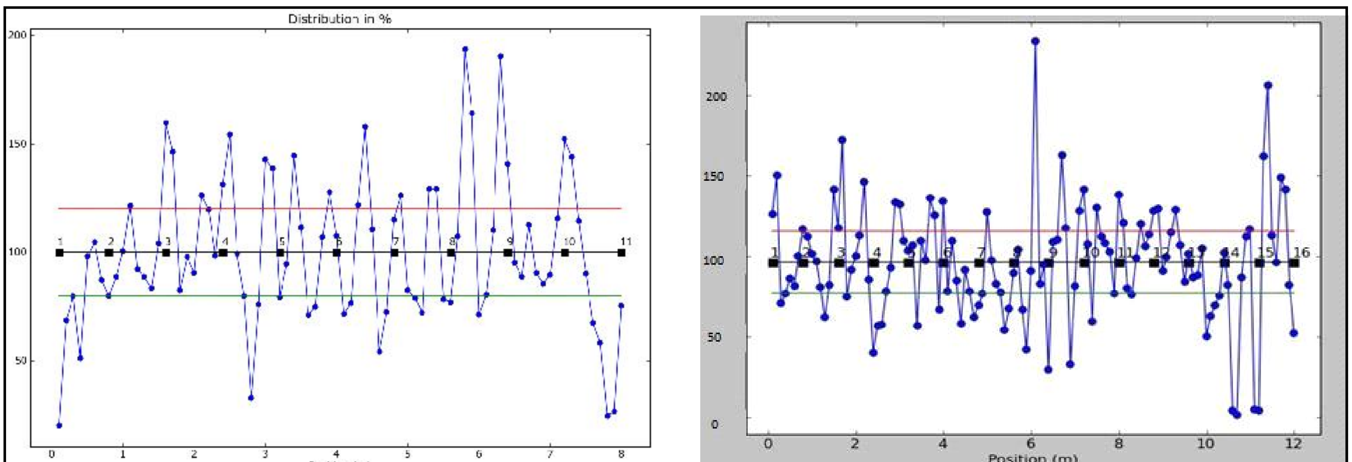
The performance of the sprayers were evaluated independently for the same parameters and compared with each other. These are described in subsequent paragraphs as follows.

Liquid distribution under the spray booms :

Measurement of liquid distribution under spray boom was measured for nozzle discharge of 0.90 l/min and operating pressure of 689.5 kPa in the laboratory for both the sprayers. From the Fig. 1a wide scattering of liquid distribution was observed and liquid distribution deviated more than ± 20 per cent of total mean value. Also the spray scanner operated up to boom length of 8 m. It can be observed from Fig. 1b that liquid distribution was close to the total mean value and more liquid distribution was observed within ± 20 of total mean value. Also the spray scanner was operated up to boom length of 12 m. This shows more uniform distribution in the developed sprayer and more distribution was within the ± 20 per cent of total mean value.

Flow rate of the pumps :

The pump speeds selected were 800, 850, 900 and



a. Existing sprayer

b. Developed sprayer

Fig. 1 : Liquid distribution under the spray booms for the sprayers

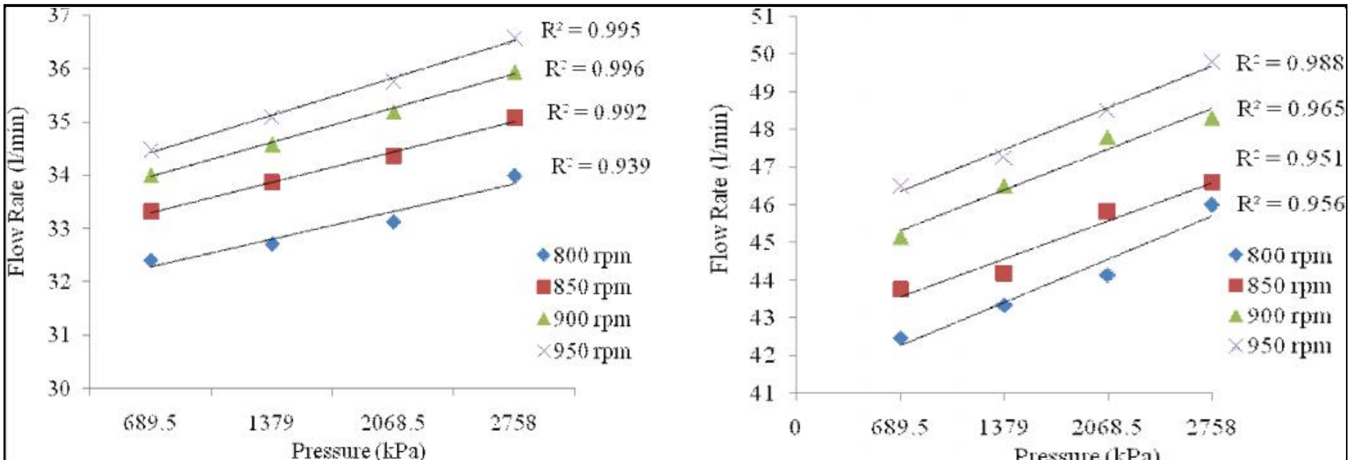
950 rpm for the pump pressures of 689.5, 1379, 2068.5 and 2758 kPa for both the sprayers. At all selected speeds of pumps with increase in pressures, flow rate were increased (Hoffman, 2004). The minimum and maximum flow rates for both the sprayers were found to be 32.40, 35.94 (Fig. 2a) and 42.45, 49.80 l/min (Fig. 2b) for 800 and 950 pump rpm, respectively.

Testing of pressure gauge :

The pressure gauges of the sprayers were calibrated with the AAMS master pressure gauge. The maximum and minimum commercial pressure gauge reading were observed as 520.6 and 80.5 kPa (Fig. 3a) and 570.6 and 96.3 kPa (Fig. 3b) for 600 and 100 kPa for pressure of AAMS master gauge, respectively for both the sprayers. This shows that pressure gauge of the developed sprayer was more accurate than the existing one.

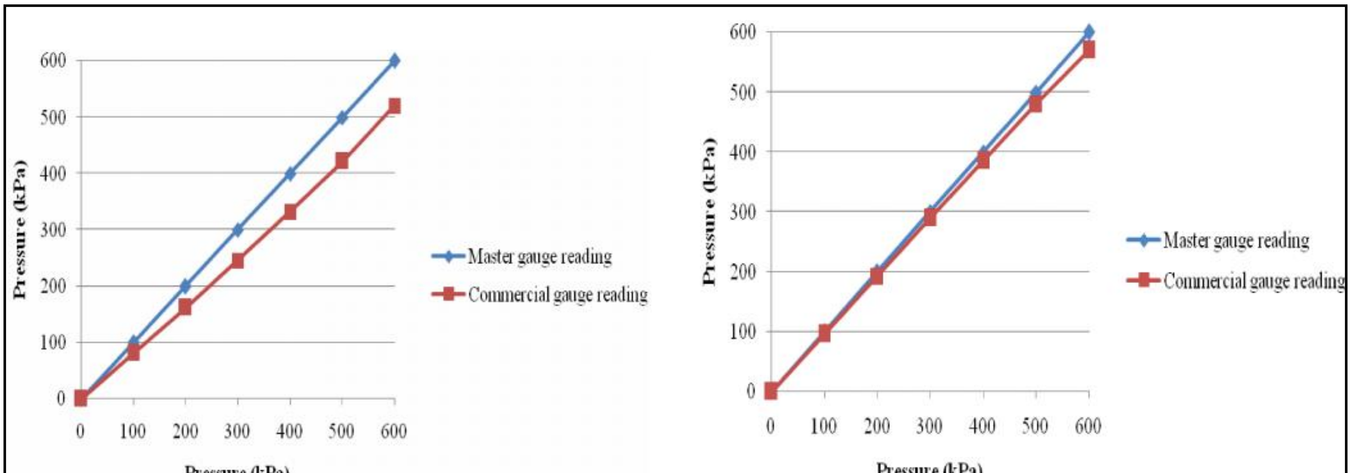
Discharge and pressure measurement of nozzles :

The nozzle discharge varied from 0.53 to 0.77 l/min and 0.87 to 0.90 l/min for both the sprayers when measured from left to right of boom. The nozzle pressure varied from 241.32 to 248.22 kPa and 510 to 530 kPa for both the sprayers. The mean discharge and pressure of developed boom sprayer increased by 49 per cent



a. Existing sprayer   b. Developed sprayer

Fig. 2 : Flow rate vs. pressure at different pump speeds for the sprayers



a. Existing sprayer   b. Developed sprayer

Fig. 3 : Calibration of pressure gauges of the sprayers with AAMS master gauge

(Fig. 4a) and 184.4 per cent (Fig. 4b) compared to the existing boom sprayer, respectively. The discharge and pressure of the developed boom sprayer was nearly uniform in all nozzles (Zhang *et al.*, 1994).

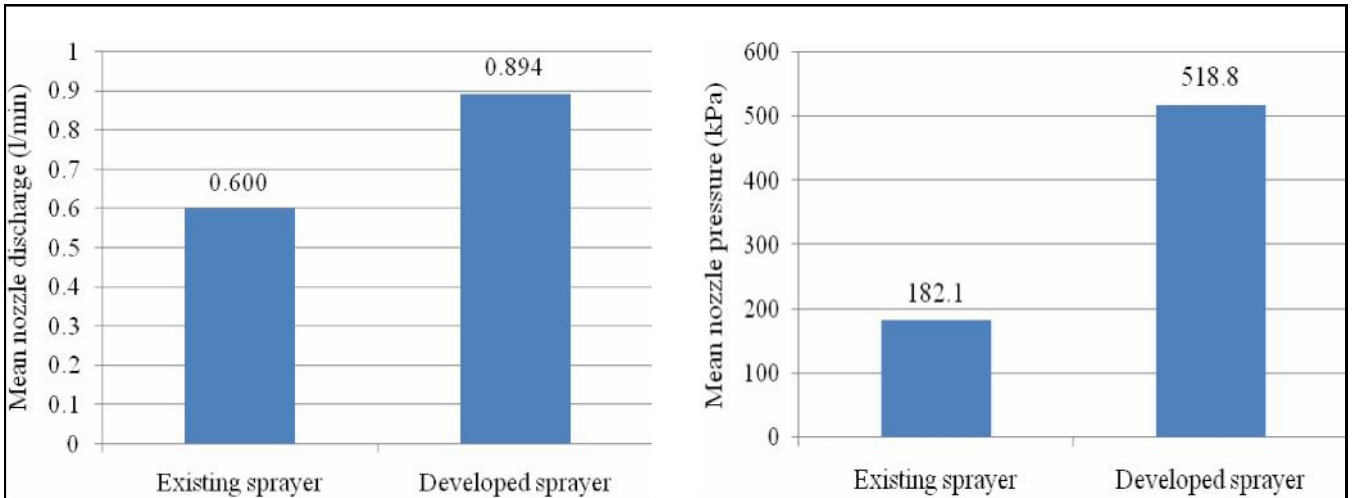
Droplet deposition :

The statistical analysis of data was carried out to determine the significance of dependent variables on independent variables using CRD ANOVA. It was found that the data were significant at 1 per cent level of significance for three replications of droplet size (VMD), droplet density (DD) and uniformity coefficient (UC).

Effect on droplet size (VMD) :

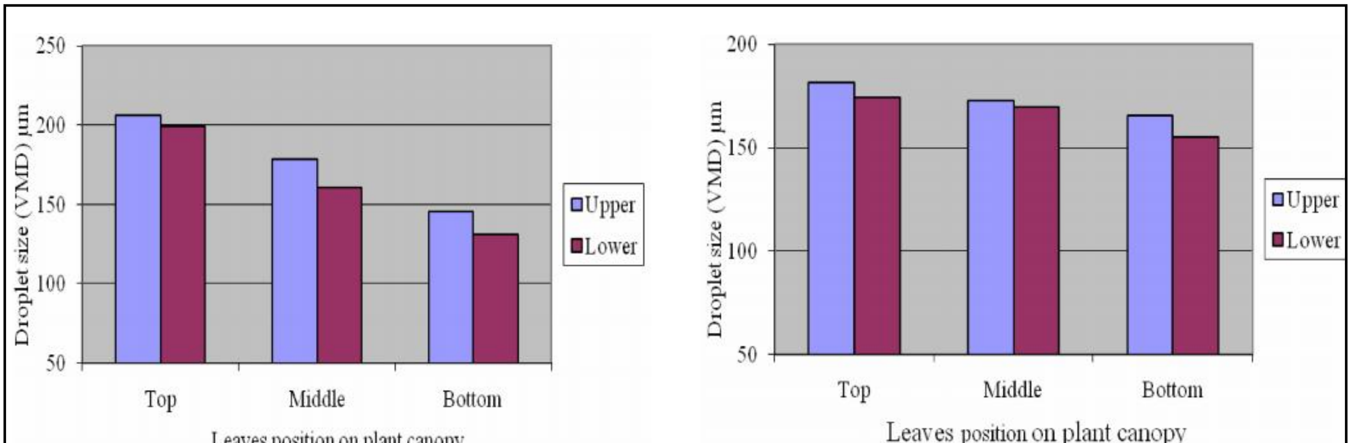
The VMD of both the boom sprayers varied from 130.9 µm to 294.41 µm and 122.53 µm to 284.80 µm at nozzle discharge rate of 0.45, 0.70, 0.90 and 1.35 l/min and nozzle pressure of 275.8, 413.7, 551.6 and 689.5 kPa. The droplet size for top upper and top lower plant position were found 206.36 µm and 199.5 µm, middle upper and middle lower were found as 178.67 µm and 160.5 µm, whereas for bottom upper and lower it were 145.3 µm and 130.9 µm for existing sprayer (Fig. 5a).

The droplet sizes (VMD) for developed sprayer were very close to the effective range of 150 µm to 250



a. Nozzle discharge b. Nozzle pressure

Fig. 4 : Comparative performance of nozzle discharge and nozzle pressure for the sprayers



a. Existing sprayer b. Developed sprayer

Fig. 5 : Droplet size at different position of the plant for nozzle discharge rate of 0.90 l/min and pressure 689.5 kPa for developed boom sprayer

µm (Mathews, 1979). The droplet size for top upper and top lower plant position were found as 181.55 µm and 174.47 µm, bottom upper and bottom lower were found as 172.80 and 169.71, whereas for bottom upper and bottom lower it were 165.68 µm and 155.44 µm (Fig. 5b).

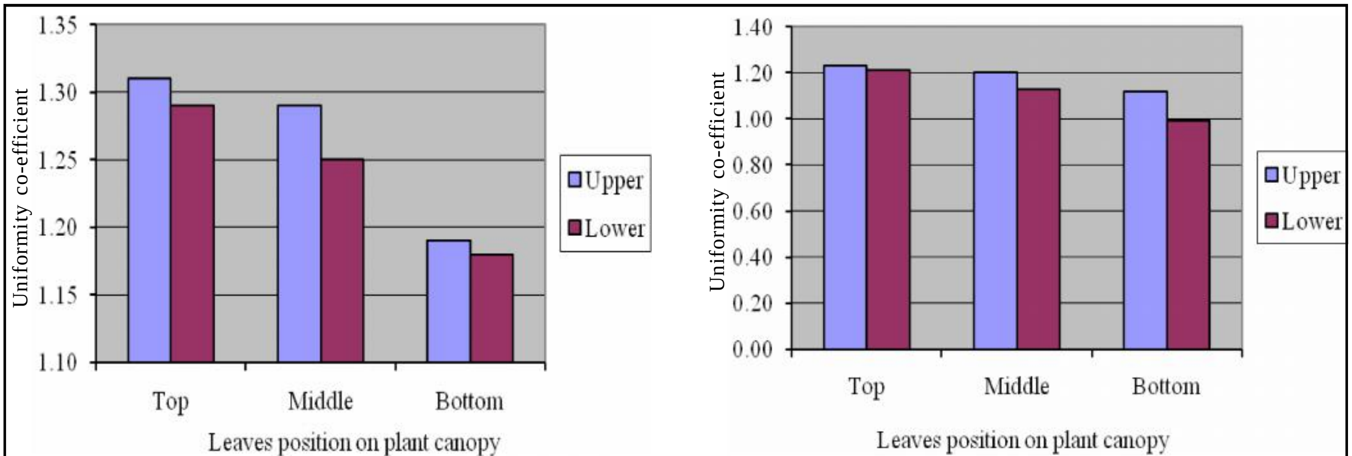
Effect on uniformity co-efficient (UC) :

The uniformity co-efficient of sprayer was found in the range 0.70 to 2.21 and 0.73 to 2.10 for both the sprayers. The uniformity co-efficient for top upper and top lower plant position were 1.31 and 1.29, middle upper and middle lower were 1.25 and 1.23, whereas for bottom upper and lower plant position it were 1.19 and 1.18 at nozzle discharge of 0.9 l/min pressure 689.5 kPa for the existing sprayer (Fig. 6a).

The uniformity co-efficient for top upper and top lower plant position were 1.23 and 1.23, middle upper and middle lower were 1.20 and 1.13, whereas, for bottom upper and bottom lower plant position it were 1.12 and 0.99 for developed sprayer (Fig. 6b).

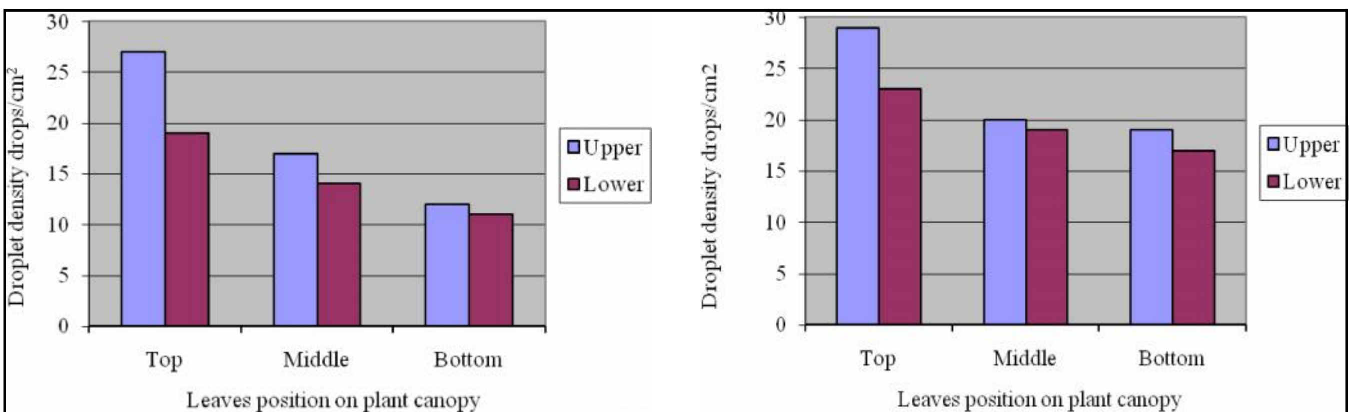
Effect on droplet density (DD) :

The droplet density of boom sprayers varied from 11-32 drops/cm^2 13-29 drops/cm^2 for both the sprayers. The droplet densities for top upper and top lower position



a. Existing sprayer **b. Developedprayer**

Fig. 6 : Uniformity co-efficient at different position of the plant for nozzle discharge rate of 0.90 l/min and pressure 689.5 kPa for developed boom sprayer



a. Existing sprayer **b. Developed sprayer**

Fig. 7 : Droplet size at different position of the plant for nozzle discharge rate of 0.90 l/min and pressure 689.5 kPa for developed boom sprayer

were 27 and 19 drops/cm^2, middle upper and middle lower position were 17 and 14 drops/cm^2, whereas for bottom upper and bottom lower plant position it were 12 and 11 drops/cm^2 for existing sprayer (Fig. 7a).

The droplet densities for top upper and top lower position were 29 and 23 drops/cm^2, middle upper and middle lower position were 20 and 19 drops/cm^2, whereas for bottom upper and bottom lower plant position it were 19 and 17 drops/cm^2 for developed sprayer (Fig. 7b). Gholap and Mathur (2013) and Karale *et al.* (2014) worked on the tractor operated boom sprayer and tractor operated slasher, respectively.

Conclusion :

On the basis of the results obtained from the laboratory performance the following conclusions were drawn :

– The liquid distribution under the developed boom sprayer improved and more distribution was within the ± 20 per cent of total mean value.

– The mean discharge and pressure of developed boom sprayer increased by 49 per cent and 184.4 per cent compared to the existing boom sprayer, respectively.

– The discharge and pressure of the developed boom sprayer was nearly uniform in all nozzles.

– Droplet size (VMD), droplet density (DD) and uniformity co-efficient (UC) ranged from 130.9 to 206.39 µm, 11 to 27 drops/cm^2 and 1.18 to 1.31, respectively for the six plant position in existing boom sprayer.

– Droplet size (VMD), droplet density (DD) and uniformity co-efficient (UC) ranged from 155.44 to 181.55 µm, 17 to 29 drops/cm^2 and 0.99 to 1.23, respectively for the three plant position in the developed boom sprayer for effective pest control on cotton crop.

Authors' affiliations:

OMKAR SINGH KUSHWAH, Agricultural Energy and Power Division, Central Institute of Agricultural Engineering, BHOPAL (M.P.) INDIA

REFERENCES

Anonymous (2002). Pesticide information. *Tech. Bull.*,**42** (1).

Anonymous (2009). American Society of Agricultural and Biological Engineers, St. Joseph, MI; (accessed: January 12, 2009).

Gholap, Babasaheb and Mathur, Ravi (2013). Field evaluation of tractor operated boom sprayer of cotton crop. *Internat. J. Agric. Engg.*, **6**(2) : 372-374.

Hoffman (2004). Pump characteristics. *J. Vaccum Sci. & Technol.*, **22**: 108-111.

Karale, D.S., Khambalkar, V.P. and Kankal, U.S. (2014). Development and testing of tractor operated slasher. *Internat. J. Agric. Engg.*, **7**(1) : 160-164.

Matthews, G.A. (1979). *Pesticide application methods*, ELBS/ Longman, England.

Matthews, G.A. and Thronhill, E.W. (1994). Pesticide application methods. Pecticide application equipments for use in agriculture. FAO Agricultural Services Bulletin 112/1 and 112/2.

Thakare, S.K. (2004). Design development and performance evaluation of air assisted sleeve boom for tractor mounted sprayer. Ph.D. Thesis, ME (Ag. Engg.), CTAE, Maharana Pratap University of Agriculture and Technology, Udaipur, RAJASTHAN (INDIA).

Zhang, N., Wang, L. and Thierstein, G.E. (1994). Measuring nozzle spray uniformity using image analysis. *Trans. ASAE*, **37** (2) : 381-387.

WEBLOGRAPHY

Nalavade, P.P., Salokhe, V.M., Jayasuriya, H.P.W. and Hiroshi, N. (2008). Development of a tractor mounted wide spray boom for increased efficiency. *J. Food, Agric. & Environ.*, **6** (2): 164-169. *www.world-food.net*