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Laboratory Performance Evaluation of Tractor Mounted Boom Sprayer on Brinjal Crop

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Abstract

Brinjal is one of the most popular and principal vegetable crops grown in India. The most common method of applying pesticides to the field crops in the more developed and relatively wealthy agricultural regions of the world is with hydraulic boom sprayers. The working principal of the tractor mounted boom sprayer is to move the spray liquid to the individual nozzle along the boom. Due to inefficient spraying machine lot of pesticide was loss. The proposed sprayer was therefore tested using the pressure gauge and droplet analyzer in the laboratory for brinjal crop. The developed control valve assembly of boom sprayer was tested in a laboratory in terms variables *viz*., of droplet size, droplet density, uniformity coefficient, nozzle pressure and nozzle discharge for four level of operating pressure (278, 413, 551 and 689 kPa) and number of active openings of on-off valves (all valves open, one valve closed, two valves closed, three valves closed and four valves closed). The deposition of droplet was taken at top, middle and bottom position of plant and on upper and lower leaf surface. The nozzle pressure increases from 501.13 to 1093 kPa while closing the on-off valves of boom sprayer at 689 kPa operating pressure. The nozzle discharge increases from 0.88 to 1.35 l min^{-1} while closing the on-off valves of boom sprayer at 689 kPa operating pressure.

Key words : Boom sprayer, Nozzle discharge rate, Nozzle pressure and Brinjal.

Brinjal is one of the most commonly grown vegetable crop of India. West Bengal, Orissa, Adhar Pradesh, Gujarat, Bihar, Madhya Pradesh, Maharashtra, Chattisgarh, Karnataka and Haryana are major brinjal growing states. It is an important cash crop for more than 1.4 million small, marginal and resource-poor farmers. In India, brinjal is cultivated in 7.30 lakh hectares with a productivity of about 17.5 MT ha^{-1} (Anonymous, 2018). India is second second largest producer of brinjal with a share of 23.3 per cent (Anonymous, 2018). The world's population is continuously increasing, especially in most of the developing countries. To satisfy the demand, food crop yields need to be increased. Continuous growing of world population and an increased pressure on the available land to produce more crop, demands for more intensive agriculture. The challenge for

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Indian agriculture is to achieve the higher productivity in a sustainable manner which despite constraints on availability of land, irrigation and labour. To achieve all these, farmers need to be empowered with new farming technologies like irrigation systems, high yielding seeds, advanced crop protection technologies etc.

Plant protection strategies have significant role in the overall crop production programmes for sustainable agriculture and keeping aim to minimizing crop losses due to ravages of insect pests, diseases, weeds, nematodes, rodents, etc. Total field losses in India due to insects, diseases and weeds were ranged from 10 to 30 per cent (Anonymous, 2016).

Adopting the crop protection technology which includes application of pesticides, herbicides, insecticides, fungicides etc. which helps to control the weeds, harmful insects and numerous plant diseases those effects the crop yield. Thus, it becomes imperative for Indian producers to increase crop yields and efficiency of food production processes, as the use of pesticides improves crop yields. Crop protection technologies also have impact on the cost of food due to increase in input cost. Without crop protection chemicals, food production may decline and many cereals, fruits and vegetables would be in short supply and prices of these commodities may rise. Chemical method for control of insects and pest play a major role in rapid advancement of agriculture. The per hectare consumption of pesticides in India is amongst the lowest in the world and currently stands at 0.6 kg ha^{-1} against 5-7 kg ha^{-1} in UK and 13 kg ha^{-1} in China (Anonymous, 2016). In order to increase yield and ensure food security for its enormous population, use of agro-chemicals in India need to be increased.

Boom sprayers are hydraulic equipment used for pesticide application in field row crops. Uniform distribution and deposition of chemical from top to bottom of plant canopy and on the undersides of leaves is of utmost importance for effective pest control. Wastage of pesticides and poor pest control give rise to loss of yield in field crops.

Materials and Materials

The proposed study was conducted with the technical assistance of ASPEE, Agricultural research and development foundation, Mumbai. A 12 meter tractor mounted boom sprayer was selected for study and tested in the laboratory (Table 1). The power for the operation of the boom sprayer was supplied by the power take-off (PTO) shaft of the tractor. For spray deposition on brinjal crop independent variables were operating pressure 278, 413, 551 and 689 kPa (Gholap *et al.*, 2012), respectively, while the number of active openings of on-off valves were all valves open, one valve closed, two valves closed, three valves closed and four valves closed. The experiment was replicated three times under laboratory condition on brinjal crop.

Measurement of droplet depositions : The laboratory experiment was conducted to study the effect of different experimental variables on spray deposition at different

Table 1. Specifications of the boom sprayer

Technical descriptions	Boom sprayer
Tank capacity	400 lit
Working pressure (system pressure)	278 - 689 Kpa
Maximum pressure	2758 Kpa
PTO rpm	540
Pump	HTP
Pump discharge	36 l/min
Gross weight of sprayer	270 kg
Size of sprayer (L × W × H)	1364x1000x1212mm
Application Rate	580 lit/ha
Type and number of nozzles used	Hollow cone, 25

position on the plant (Fig. 1). For determination of droplets size of each sprayer, a blue coloured dye was mixed with water and the impression of droplets was taken on glossy paper (Jassowal and Singh 2016). Three glossy papers were stapled on each position to observe the deposition of the droplets. After making all adjustments, set-up of the equipment was run for 30 minutes before actually starting the experiment. In order to achieve uniform exposure of crop to the spraying the set up was started 3m before the canopy and was collected on the sample cards of glossy paper, sample cards of size 62 mm x 44 mm were used to collect the sample. Royal blue indigo dye was mixed with water to prepare a coloured spray solution. The coloured spray was allowed to fall onto the sample glossy photographic paper.

Fig. 1. Brinjal plant with glossy paper

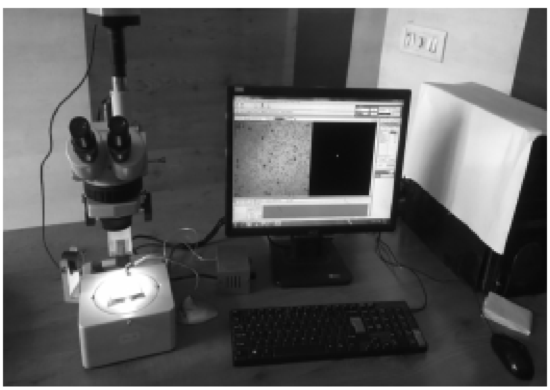


Fig. 2. Electronic imaging instrument for analysis of droplet deposition

After the experiment, the sample 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. 'Image pro plus' most powerful electronic imaging program was used was an analyzer for analysis of glossy paper (Fig. 2). The advanced image processing features of the program are provided through the Microsoft Windows, consisted of microscope connected to computer software through Graphical interface card, which enable us directly visualize the image on computer screen. Then these images were processed in a computer which directly gave droplet size and droplet density

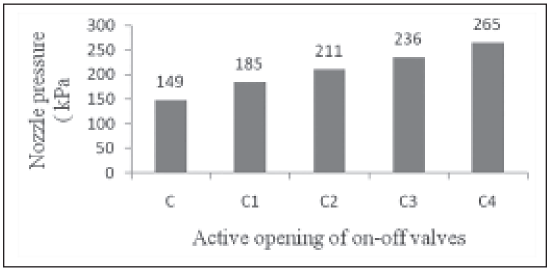
Data Analysis : The data obtained in different experiment was stored in M.S. Excel for analysis. The image- pro program was used to calculate the VMD and Mean diameter of the droplet spectrum collected on the sample card at a specific location. The data were analyzed on computer using factorial CRD statistical software packages. It was found that data for VMD, NMD, DD and UC was significant at 1% level.

Results and Discussion

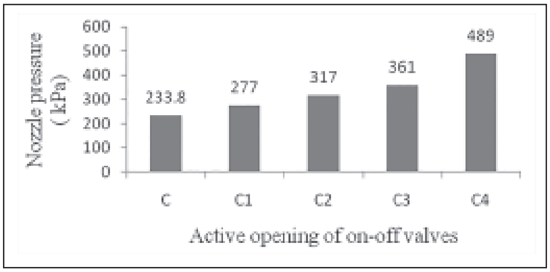
The different tests were conducted in the laboratory to evaluate the performance evaluation of the existing ASPEE boom sprayer. The results of the existing boom sprayer are discussed in the following subsequent sections.

1) Discharge and pressure measurements of nozzles

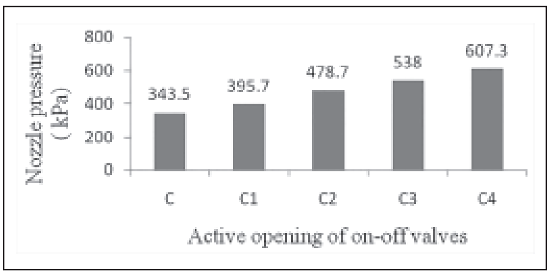
Effect of operating pressure and number of active openings of on-off valves on nozzle pressure : The mean values of nozzle pressure are plotted in Fig. 3. The nozzle pressure increases with closing the on-off valves and it also increases with increasing operating pressure.



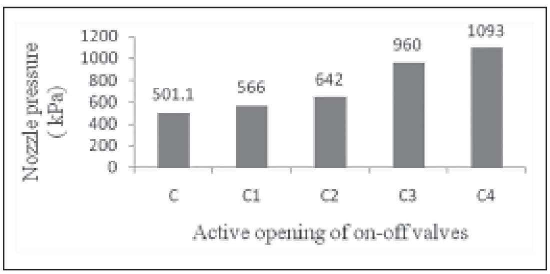
(a) Operating pressure 278 kPa



(b) Operating pressure 413 kPa



(c) Operating pressure 551 kPa

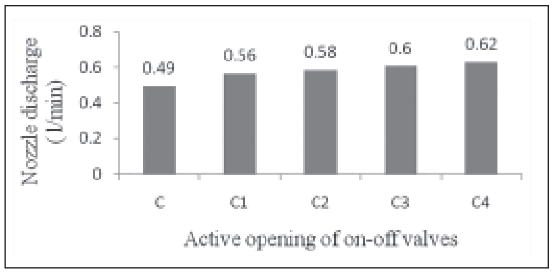


(d) Operating pressure 689 kPa

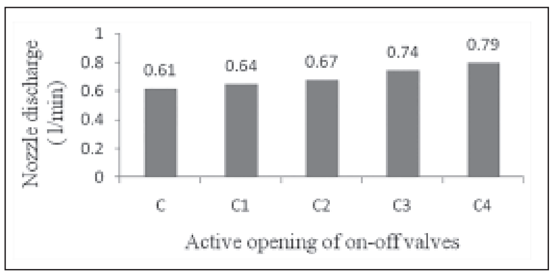
Fig. 3. Effect of operating pressure and number of active opening on nozzle pressure (C- All valves open, C1- One valve closed, C2- Two valves closed, C3- Three valves closed and C4- Four valves closed)

The maximum nozzle pressure of 1093 kPa was observed with 689 kPa operating pressure and four valves close condition whereas minimum nozzle pressure of 149 kPa was observed with 278 kPa operating pressure and open all on-off valve condition.

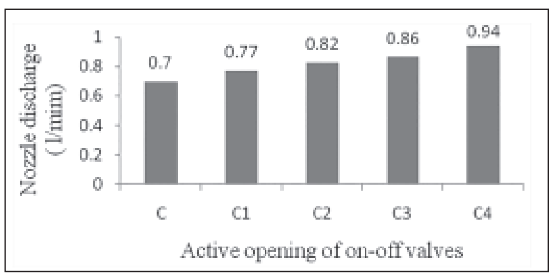
Effect of operating pressure and number of active openings of on-off valves on nozzle discharge : The maximum nozzle discharge of 1.35 l min^{-1} was observed with 689 kPa operating pressure and four valves close condition whereas minimum nozzle discharge of 0.49 l min^{-1} was observed with 278 kPa operating pressure and open all valve condition. The mean values of nozzle discharge are plotted in Fig. 4. The nozzle discharge incre-



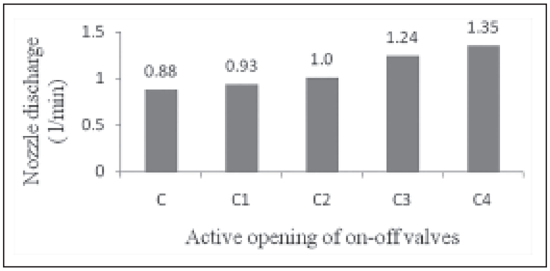
(a) Operating pressure 278 kPa



(b) Operating pressure 413 kPa



(c) Operating pressure 551 kPa



(d) Operating pressure 689 kPa

Fig. 4. Effect of operating pressure and number of active opening on nozzle discharge (C-All valves open, C1- One valve closed, C2- Two valves closed, C3-Three valves closed and C4- four valves closed)

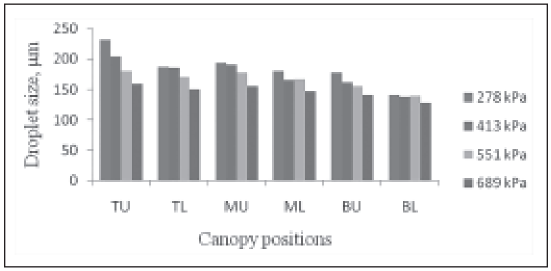


Fig. 5. Effect of operating pressure on droplet size

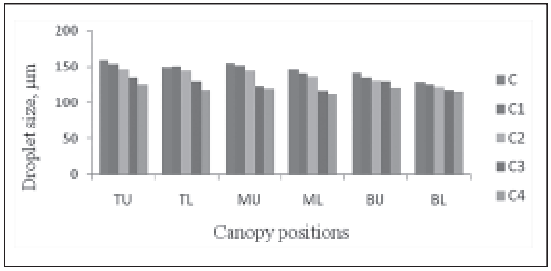


Fig. 6. Effect of active openings on droplet size at 689 kPa operating pressure

ases with closing the on-off valves and it also increases with increasing operating pressure.

2) Effect of operating pressure and number of active opening on droplet size (VMD), droplet density (DD) and uniformity co-efficient

The sprayer was tested at four operating pressure (278, 413, 551 and 689 kPa) and five level of active opening of on-off valves (all valves open, one valve closed, two valves closed, three valves closed and four valves closed) for brinjal crop. The results on droplet size, droplet density, uniformity coefficient and spray deposition for different levels of independent variables are discussed through section.

Effect on droplet size (VMD) : The observed droplet size obtained for effect of operating pressure and effect of number of active openings are plotted in Fig. 5 and 6, respectively. Maximum droplet size of 231 µm was observed on upper leaf surface at top plant position with combination of operating pressure of 278 kPa and open all on-off valve condition whereas minimum droplet size of 115 µm was observed at bottom plant position and on lower leaf surface with combination of operating pressure of 689 kPa and four valves shut-off condition. At all selected plant positions, droplet size decreased with increase in operating pressure and also decreasing trend was found while closing the on-off valves. Higher values of droplet size were observed on upper leaf surface as compared to lower leaf surface and droplet size values observed at top plant position were marginally higher than the values observed at other plant positions.

Effect on droplet density (DD) : The observed droplet density obtained for effect of operating pressure and effect of number of active openings are plotted in Fig. 7 and 8, respectively. The maximum droplet density of 32 nos cm^{-2} was observed at top plant position and on upper leaf surface with combination of operating pressure of 689 kPa and closing four valves condition and minimum droplet density of 16 nos cm^{-2} was observed at bottom plant position and on lower leaf surface with combination of operating pressure of 278 kPa

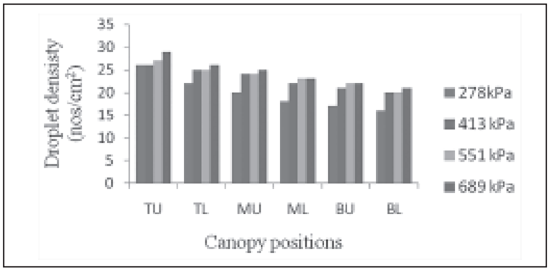


Fig. 7. Effect of operating pressure on droplet density

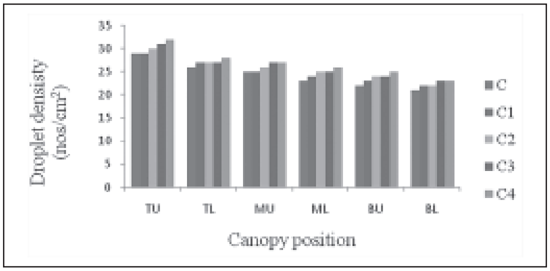


Fig. 8. Effect of active openings on droplet density at 689 kPa operating pressure

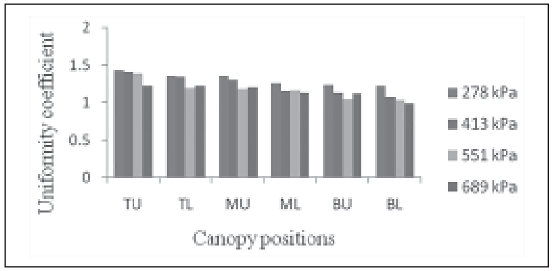


Fig. 9. Effect of operating pressure on uniformity coefficient

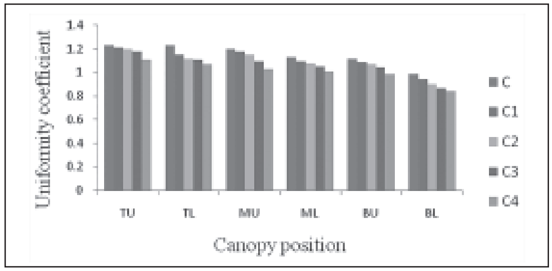


Fig. 10. Effect of active openings on uniformity coefficient at 689 kPa operating pressure

and open all valves condition. Droplet density increased with increase in operating pressure from 278 to 689 kPa whereas number of active opening of on-off valves had significant effect on droplet density at all selected plant positions. Higher droplet density was observed at top plant position on upper leaf surface as compared to other plant positions.

Effect on uniformity coefficient (UC) : The observed droplet size obtained for effect of operating pressure and effect of number of active openings are plotted in Fig. 9 and 10, respectively. The maximum uniformity coefficient of 1.43 was observed at top plant position and on upper leaf surface with combination of operating pressure of 689 kPa and open all valves condition and minimum uniformity coefficient of 0.84 was observed at bottom plant position and on lower leaf surface with combination of operating pressure of 278 kPa and closing four valves condition. Uniformity coefficient decreases with increase in operating pressure from 278 to 689 kPa whereas number of active opening of on-off valves had significant effect on uniformity coefficient at all selected plant positions. Higher uniformity coefficient was observed at top plant position on upper leaf surface as compared to other plant positions.

Conclusions

The average nozzle pressure of boom sprayer was increased from 501.13 to 1093 kPa, respectively when numbers of on-off valves were closed. Because of this discharge of nozzle was increased. On the basis of performance evaluation of boom sprayer, found one problem in this sprayer. The pressure of the nozzle was increased while closing number of opening of valves. Because of this more spray was applied on the crop. Other factors like uniformity coefficient, droplet density and droplet size also affect by this pressure. Hence there is need to modify controlled valve assembly of the available boom sprayer.