The Andhra Agric. J 66 (1): 195-199, 2019

Performance Evaluation of High Clearance Tractor Sprayer for Cotton Crop

D Ananda Babu, C Ramana, S Joseph Reddy, L Edukondalu and V Srinivasa Rao
College of Agricultural Engineering, Bapatla, A.P.

ABSTRACT

Agriculture is one of the major sectors in Indian economy. Cotton 'the white gold' is one of the most important commercial. It sustains the country's cotton textile industry, which is perhaps the largest segment of organized industries in the country. India ranks third in the world in production of cotton crop.The spraying and weeding units were constructed on the developed high clearance unit for cotton crop. Sprayingsystem was fabricated for applying chemicalat various stages of the crop, a spraying unit with liquid quantity of 300 litres' with developed and attached to the high clearance tractor. Three nozzles were used for spraying and mounted on the boom to cover three rows of the crop. The nozzle height can be adjusted based on the crop requirement.The field performance of developed high clearance sprayer indicated that the machine can cover an area of 1200 m^2 with 150 litres, the tank is refilled after spraying of the 0.24 ha area, the tank refilling time was 15 minutes and the boom sprayer field speed was varied from 2 to 4 km/h depending upon the field condition.

Key words: *High clearance tractor, sprayer, nozzles, cotton crop*

Agriculture is one of the major sectors in Indian economy.Cotton, popularly known as 'white gold'nearly 65 percent of the cotton crop is cultivated under rain fed conditions in the country.The world cotton acreage in 2013-14 has declined by around 5% i.e. 32.46 million hectares.As cotton crop grows, the plant height increases morethan plant width, making it almost impossible topenetrate the canopy at over shoulder height with manual spraying. At suchstages overhead spraying will not give proper spraydistribution (Mahal*et al*. 2007).Toimprove pest control applications, instrumentation isneeded to accurately and rapidly determine thedistribution of sprays across the swath for variousnozzle operation conditions (Pline*et al*. 2001).

The present study was conducted on cotton crop at various stages of spraying in field. Based on the crop the high clearance tractor sprayer were fabricated. The yield apart from the variety mainly depend on the crop management like chemical spraying: plant protection is very important in cotton crop and farmers spray very high concentrated pesticides for several times (6 to 8 times) with manual spraying. Since the chemicals are highly toxic and cause lot of operational discomfort sometimes detrimental Secondly intercultural operation.

MATERIAL AND METHODS

Presently the spraying is done by knapsack motorized sprayer by an agricultural work force. Since it has to be sprayed over and above the average shoulder height of a subject (operator), operator is completely exposed to the highly toxic spray chemical and causes healthy hazards, i.e. reducing the human exposure to the highly toxic chemical during plant protection process. More importantly to administer effective spraying for better controls of pest and disease complex the required dose (lethal dose) need to be sprayed over the plant and with required droplet size to achieve required spray volume on crop. Components of the spraying system i.e.,pump, controls, pressure and nozzles need to be designed meticulously.

Pump

The pump was designed to supply the 3 nozzles of 1.6 L min^{-1} discharge at high pressure. The HTP (Horizontal Triplex Pump) with free discharge capacity of 36 litres per minute was selected. The mounting and drive arrangement from PTO (Power Take Off) for pump was at the rear of the tractor. The pump was as shown in Fig. 1.

Controls

Manual control valves were employed to operate the nozzles, which were individually mounted perpendicular to the main boom pipe. A main control valve was installed in the beginning of delivery line hose to regulate the desired flow rate in the main boom pipe and the over flow line to direct the excess chemical back to tank.

Pressure

pressure is a parameter which influences the droplet size and volume of spray; hence the maintenance of designated pressure is very important in the chemical spraying system. To measure the accurate pressure,

glycerine filled pressure gauge was used. This pressure gauge was capable of measuring pressure up to 2800 KPa.

Nozzles

Different types of commercial hydraulic nozzles available for spraying were considered for detailed investigation of nozzle characteristics with specific emphasis on spray angle (patternator studies). The nozzle will be selected based on performance to suit the selected cotton crop.

Selection of spray nozzle

Four types of spray nozzles recommended for the cotton crop (Ramana 2004) were selected for the study. 1. Current nozzle, 2. Regulating nozzle, 3. Aspee, 4. Local Guntur nozzle

The nozzles were evaluated through a series of standard procedures to measure spray pattern, discharge and droplet size.

Measurement of discharge rate

The spraying was done continuously and pressure was regulated to desired level. Sufficient time was allowed to bring the nozzle to constant discharge during this period, the discharge was diverted to a measuring cylinder and discharge obtained was clocked for a given interval of time. These values were expressed in terms of discharge per minute. Each nozzle was tested at three pressures and test was replicated thrice. The values were noted.

Determination of droplet size

The droplet size was determined by measuring the diametre of circles formed by droplet deposition on a white paper, 0.75 per cent (w/w)methelene blue was used as the dye solution. All the measurements were made at 500 mm from the nozzle along axis of spray for each nozzle.

Measurement of spray pattern

The spray pattern was evaluated by using the patternator as shown in Fig 2. The patternator had an area of 2250 mm length and 1250 mm width with 20 channels of 7.5 + 2.5 mm (width. The nozzle to be tested was located so that the nozzle height was 700 mm from the patternator. The pressure was controlled and regulated from the tractor operating pumping unit through regulating valves. The nozzles were tested at operating pressure of 7 – 21 kPa and experiment was replicated three times.

Design of sprayer tank size

The rectangular hollow frame was fabricated for mounting the sprayer tank in to the frame. The length, width and height of the frame were 900, 600 and 600 mm respectively. The sprayer tank was designed to occupy solution 150 litres in one filling. The spray tank was as shown in Fig 3.

Field experiment on spread of spray fluid to leaves at different levels

The spray fluid deposited on various strata of leaf canopy was studied by collecting the leaves immediately after spraying (Fig 4.). The cotton leaves collected from top, middle and bottom level were extracted for insecticide residues as per the standard protocol by using Primary Secondary Amine (PSA). The extracted leaf sample solution was analyzed in Gas Chromatography with Flame Photometric Detector (GC-FPD) available at Pesticide Residue Testing Laboratory at regional agricultural research station, Tirupati.

RESULTS AND DISCUSSION

Spraying of the chemical at various stages of the crop, a spraying unit with liquid quantity of 300 litres' capacity was developed and attached to thehigh clearance tractor. Three nozzles were used and mounted on the boom to cover three rows of the crop. The height of nozzles from the ground can be adjusted based on the crop height.

Spraying unit evaluation

Tractor operated high clearance boom sprayer was designed based on the height of the cotton crop to cover the rows at a time. Functional requirement of developed tractor operated high clearance boom sprayer includes pressure calculation in nozzles, characteristics of nozzles; pressure vs discharge characteristics, droplet size distribution, spray pattern characteristics, drift characteristics.

Construction details of sprayer

A circular cylindrical tank of 300 litres capacity was made with corrosion resistant synthetic plastic material.A flexible PVC hose pipe whose diametre was 7 mm used to carry the fluid from circular cylindrical tank to reciprocating pump. A pressure gauge is attached to the pump to moisture fluid pressure during the working period. The developed sprayer was tested with three nozzles on a boom.

Evaluation of hydraulic nozzles

In designing spraying system for a particular crop, the very important feature is selecting a proper nozzle and its discharge. Depending upon the leaf, crop canopy and height from which spraying is administrated the characteristics of the nozzle requirement changes. Hence in the process of picking a best performer. From

Fig. 1. Horizontal triplex pump (HTP)

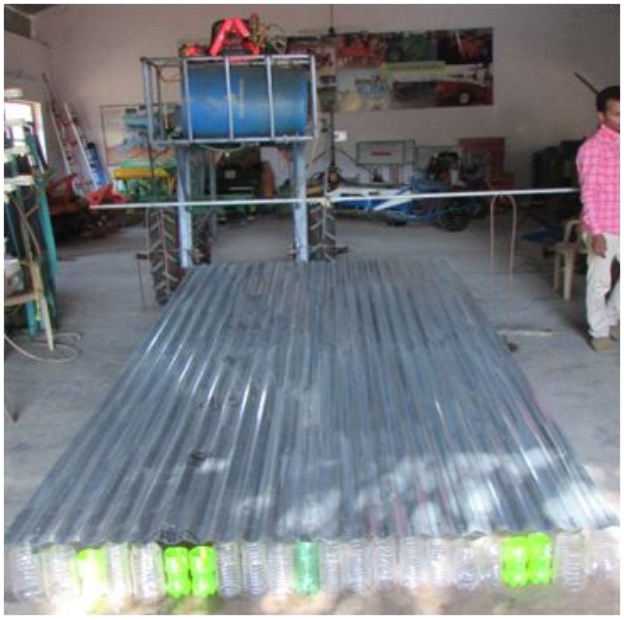

Fig. 2. Measurement of spray pattern

Fig. 3. Chemical tank holder fitted to the tractor

the table 2 specification of nozzles with moderately low discharge *i.e.* 0.6 to 0.7 L min^{-1} and at a pressure of 588 kPa were evaluated.

Effect of pressure on Discharge characteristics

It was observed that minimum resistance of flow was offered by current nozzle (fig 1a) at a pressure of 784 kPa with a discharge of 1.8 - 2.2 L min^{-1} compared with other three nozzles at 588 kPa and 980 kPa. Based on the investigation the operating pressure

Fig. 4. Arrangement of glossy papers on cotton crop

Fig. 5. Spraying on cotton crop using high clearance sprayer

was fixed at 784 KPa was obtained through regression equation is furnished in table 3. From fig (a), (b), (c) and (d) the pressure were increased in the pump, the resistance flow was increased in the nozzle outlet.

Swath width and area observed

The size of the droplet is the most important parameter that influences the penetration and carrying ability of sprayer. It also influences the efficiency of catch of sprays by plant surfaces and insects. Droplet sizes also affect the uniformity and completeness of coverage on plant surfaces and drift of the material from the treated area (Ramana.C, and Jesudas. D.M., 2009). By testing the solid cone nozzle, the swath width was observed in the field as well as laboratory. The width of covered nozzle was measured 140 cm by using the tape.

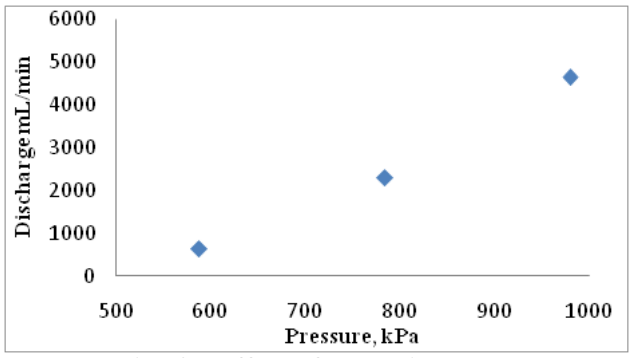

Fig. 6a. Effect of operating pressure on discharge for current nozzle

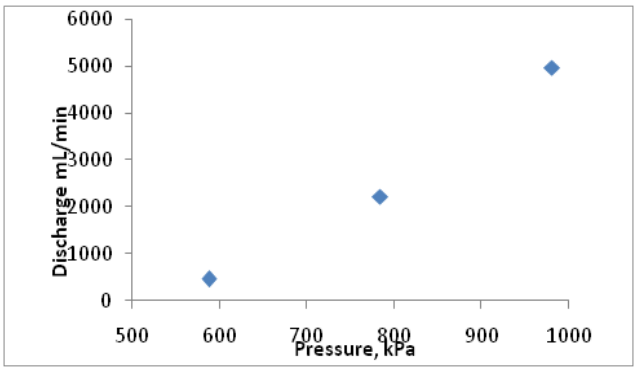

Fig. 6b. Effect of operating pressure on discharge for regulating nozzle

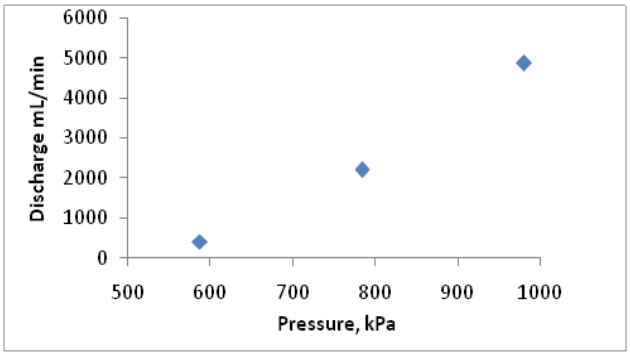

Fig. 6c. Effect of operating pressure on discharge forAspee nozzle

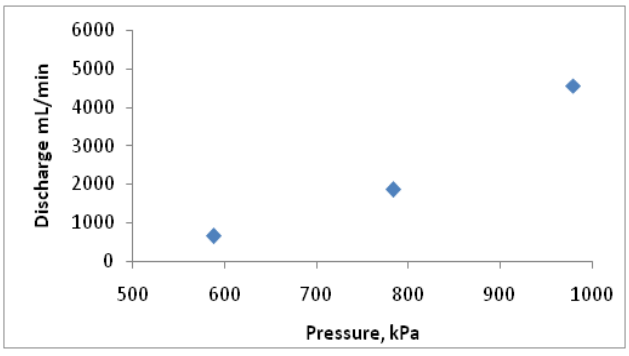

Fig. 6d. Effect of operating pressure on discharge for Local Guntur nozzle

Field experiment on spread of spray fluid to leaves at different levels

A field experiment conducted to study the spread of spray fluid to leaves at different levels in cotton by spraying one systemic insecticide (monocrotophos @ 1.6mL/Lwater) and one contact-stomach insecticide (chlorpyriphos @ 2.5mL/ L water) revealed that the spray fluid reached all the leaves at three different levels. There was variation in the level of pesticide deposited on leaves at three different levels. In chlorpyriphos the residue levels were high in top leaves (31.464 µg/g) followed by middle leaves (19.032 µg/g) and bottom leaves (17.043 µg/g). In case of monocrotophos, the residue levels were high in middle leaves (1.043µg/g) followed by top leaves (0.669µg/g) and bottom leaves (0.425µg/g). However the spray fluid deposited on top, middle and bottom leaves were not uniform. It might be due to progressive decrease in pressure of deposition of pesticide spray fluid from top to bottom leaves. The experiment was conducted based on the chemical solution was reaching or not at the bottom of cotton crop. Finally the solution was reached to the bottom of crop with low intensity. The pesticide residue levels were as shown in the Table 1.

Spray pattern characteristics

The nozzle spray distribution from the boom for four nozzles was studied by keeping them 600 mm apart and 700 mm above the patternator. The observed distribution was as shown in Fig 5. The spray deposition at 1300 mm nozzle height and 600 mm nozzle spacing for 784 KPa pressure was observed to be uniform on both sides of the patternator for the four nozzles of the spray boom.

The discharge rate of each nozzle in the boom for operating pressure of 588, 784 and 980 kPa were calculated, it was concluded that, discharge rate of each nozzle in the boom was directly proportional to the operating pressure and also it was found that the average discharge rate of 468.6 mL/min was recorded for 588 kPa followed by 1865.6 and 4629.6 mL/ min respectively for 784 and 980 kPa.

Testing of prototype high clearance sprayer

The performance of the developed high clearance sprayer was evaluated in the field during the period of rabiF season in 2015-16. The height of the boom and position of the nozzles were adjusted with cotton crop so that the crop was not damaged by the boom and also without interfering with spray swath and characteristics of droplets coverage over plants. The constant pressure was maintained by boom sprayer for entire operation of the crop. The field performance of developed high clearance sprayer indicated that the machine covered an area of 1200 m^2 with 150 litres,

the tank is refilled after spraying of the 0.24 ha area, the tank refilling time was 15 minutes and the boom sprayer field speed was varied from 2 to 4 km/h depending upon the field condition. The developed high clearance sprayer as shown in the fig 5.

CONCLUSION

The spraying unit were constructed and successfully tested in the field of cotton. Spraying of the chemical at various stages of the crop, a spraying unit with liquid quantity of 300 litres capacity was developed and attached to thehigh clearance tractor. Three nozzles were used and mounted on the boom to cover three rows of the crop. The height of nozzles from the ground can be adjusted based on the crop height.The height of the boom and position of the nozzles were adjusted with cotton crop so that the crop was not damaged by the boom and also without interfering with spray swath and characteristics of droplets coverage over plants. The field performance of developed high clearance sprayer was 0.24 ha/h, the field speed was varied from 2 to 4 km/h depending upon the field condition.

LITERATURE CITED

Karale D S, Kankal U S, Khambalkar V P and Gajakos A V 2014 Performance and evaluation of self propelled boom sprayer. *International journal of agricultural engineering*. 7(1): 137-141.

Mahal J S, Garg I K, Sharma V K and Dixit A K 2007 Development of high clearance power sprayer for cotton. *Journal of agricultural engineering*. 44(3): 92-96.

Mathew V J, Das D K, Dash S K and Pradhan S C 1992 Development and testing of a power tiller-operated boom sprayer. *Agricultural mechanization inAsia, Africa, andLatin America.* 23(4): 25-27.

Padmanathan P K and Kathrivel K 2007 Performance evaluation of power tiller operated rear mounted boom sprayer for cotton crop. *Research journal of agriculture and biological science*. 3(4): 224-227.

Pline W A, Price A J, Wilcut J W, Edmisten K L and Randy Wells 2001 Absorption and translocation of glyphosate in glyphosate-resistant cotton asinfluenced by application method and growth stage. *Weed science,* 49:460-467.

Ramana C andJesudas D M 2009 Parasol sprayer for efficient chemical application in dwarf and semi dwarf mango orchards. Agricultural mechanization inAsia, Africa, and Latin America. 40(3): 9-14.

Received on 04.01.2017 and Revised on 15.10.2018