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Performance Evaluation of Power Tiller Operated Rear Mounted Boom Sprayer for Cotton Crop

P.K. Padmanathan and K. Kathirvel

Department of Farm Machinery, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Abstract: Crop yield is reduced by mainly due to attack of pests, diseases and weeds. Chemical control is the popular method adopted for controlling most insects, weeds and diseases. The chemicals are spraying due of the most effective and efficient techniques for applying small volume of spray liquid to protect crops. A power tiller operated rear mounted boom sprayer was developed for spraying cotton and other crops planted in rows and to produce uniform spray pattern using minimum amount of spray materials. Test was carried out on the developed sprayer both in laboratory and in the field. The spray boom has sixteen hollow cone nozzles, placed 40 cm apart. It has a swath width of 3.2 m for a forward speed of 2 km/h. The effective field capacity of the sprayer was 0.72 ha/h. The performance of the power tiller operated boom sprayer was satisfactory at a pressure of 3 kg / cm^2 and can be adopted by the farmers for spraying cotton crop and other row crops. The entire boom assembly fixed at the rear of the power tiller, behind of the operator seat. Even in adverse wind conditions, by the time the power tiller would have moved through considerable distance, the chemical would be deposited on the canopy, there by reducing the effect of chemical inhalation by the operator almost to nil. To facilitate for the convenience of the operator the design of the entire controls were provided near the operator seat so that very efficient spraying can be achieved without affecting the health of the operator. Providing additional clamp and pipes keeping in view the safety of the operator controlled the boom, chemical spraying did not affected the operator.

Key wards: *Boom sprayer, swath width, hollow cone nozzle, field efficiency*

INTRODUCTION

Crop yield is reduced mainly due to attack of pests, diseases and weeds. Chemicals control is the popular method adopted for controlling most insects, weeds and diseases. They are applied in varying amounts, depending upon the type and concentration of active ingradients. India are mainly operated knapsack sprayers, power operated pneumatic sprayer-cum-duster and tractor mounted sprayer. In Tamil Nadu 74% of the farmers are under small and marginal categories and they farms only 38% of the cultivable land. Due to small and scattered farms the farmers mainly depend upon draft animals inspite of their high maintenance cost. The initial investment of tractor is very high which is beyond the reach of a common farmer. Hence, power tillers were introduced in the state of Tamil Nadu. In order to power tillers more versatile, a power tiller-operated rear mounted boom sprayer was designed and developed for effective spraying operational in cotton crop planted in rows.

MATERIALS AND METHODS

Description of Machine: Power tiller rear mounted boom sprayer consisted of a pesticide tank, spray pump, spray boom, tank support wheel with tread adjustments. The chemical tank is an integral reinforced fiberglass tank of 100 lit. capacity were fixed. The tanks were fixed on the power tiller hitch frame extended suitably. Two channel section were welded together to form a square hallow box shaped and made another square shaped hallow shaped box and joint together at inverted 'T' shaped and fixed to the power tiller hitch bracket with swivel arrangement. This facilities the bracket to move in both the vertical and horizontal plane. Four-angle iron size 500 x 25 x 6 mm were bent and bolted to the main frame so that it secured the tank without any slippage. The integral reinforced fiberglass tank was interconnected using 40mm PVC pipes and attached to the inlet of the spray pump. A hole of 110 mm diameter was drilled on the pesticide tanks and fixed with PVC male threaded adapter and capped for easy filling of pesticide. Horizontal double piston pump was attached the power tiller operated a high volume sprayer with hollow cone nozzle having field application rate of 400-500 lit.ha^{-1}. For design purpose the maximum application rate was taken as 600 lit. ha^{-1}. The pump was fitted on a right frame made of angle iron of size 25 x 25 x 6 mm above the power tiller. Power to the pump was taken from the power tiller clutch pulley through V belt transmission. A 40mm diameter flexible hose was

Corresponding Author: P.K. Padmanathan, Department of Farm Machinery, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India
Email: pathuphd@gmail.com

Table 1: Specification of the Power tiller operated Boom sprayer

Power source	12 HP Power tiller
Type of pump	Centrifugal pump
Swath width of boom	6.4 m
Boom discharge	4.13 lit. min^{-1}@ 3 kg/ cm^2
No of nozzles	16
Type of nozzle	Hollow cone
Nozzle spacing	450 mm (adjustable)
Tank capacity	100 lit

used as suction to transmit the spray liquid from the tank to the pump. On the discharge side the hose was provided as a by-pass with a control valve to drain off the excess pesticide back to the tank. A pressure gauge of 0-10 kg cm^{-2} was mounted after the by-pass to monitor the pressure in the nozzle. The boom length was chosen as on either side of the power tiller. Each section of the boom was fitted with 8 nozzles. Pesticide was supplied to each boom separately to reduce the hydraulic losses. The nozzles were mounted on a flexible hose of 6mm internal diameter and were clamped to a rigid pipe of 13mm diameter. The spacing between nozzles on the boom can be adjusted by means of adjusting the clamps.

To mount the boom in rear side of their power tiller, the chassis was extended of power tiller. The boom was attached on either side of the power tiller at the bottom of the vertical frame using a mast. The height of the boom can be varied from 400 – 900mm at 100mm intervals with the help of the holes provided on the vertical frame. The boom was tied using stay chain to the vertical frame to keep them in position while spraying. Provision was also made to fold the spray boom while in transport. The spraying system requires stability for better maneuverability in the field. Adding 100 lit capacity pesticide tank, the centre of gravity of the power tiller may shift from the centre top the rear of the power tiller. Hence to have the centre of gravity in the middle of the power tiller support wheel should be provided at the rear of the power tiller directly under the pesticide tank. If a single wheel is provided, it has to ride in a position midway between the power tiller wheels. If the row crop spacing is <300 mm or >450 mm, a single support wheel has to necessarily run over and trample a row. Therefore double pneumatic support wheels with provision of tread adjustments were provided to increase or decrease the tread width in alignment with that of power tiller wheels. The tread width of support wheels could be adjusted from 550-850mm like that of power tiller wheels with the help of the telescopic arrangement. A telescopic arrangement to increase or decrease the horizontal width was provided by inserting two square sections of size 270 x 50 x 50 mm made of angle iron of size 50 x 50 x 6 mm on each side. The adjustment could be made at an interval of 25mm. At the end of the horizontal frame, two pneumatic support wheels of size 3.5 x 8, 4 ply were fixed on both sides. The support wheels were attached to the telescopic sections through flange plates of size 175 x 100 x 6 mm. The flange facilitated fixing the wheel mounting in such a way that the wheels could be oriented outwards or inwards with respect to the support frame. The specification of the machine is given in Table 1.

RESULTS AND DISCUSSIONS

Experiments were conducted in laboratory condition for varying pressure of 2, 3 and 4 kg/cm^2 on the power tiller operated rear mounted boom sprayer provided with hollow cone nozzle Fig.1 shows the relationship between pressure and nozzle discharge. The relationship between pressure and discharge follows.

$Y = 62.5 X + 237$
Y = discharge in mm/min
Where
X = pressure in kg/cm^2

Table 2. Illustrates the relationship between pressure and cone angle, where cone angle is the angle subtended at the orifice by the edge of the spray pattern. This angle is formed due to tangential axial velocity component of the fluid coming out of the nozzle. Cone angle increases with an increase in pressure.

The nozzle spray distribution from the boom for two nozzles was studied by keeping them 450 mm apart and 500 mm above the patternator. The observed distribution is shown in Fig. 2. The spray deposition at 500 mm nozzle height and 450 mm nozzle spacing for 3 kg/cm^2 pressure was observed to be uniform on both sides of the patternator for the two nozzles of the spray boom.

The discharge rate of each nozzle in the boom for operating pressure of 2, 3 and 4 kg/cm^2 were observed and tabulated in Table 3. It was concluded that, discharge rate of each nozzle in the boom was directly proportional to the operating pressure. Average discharge rate of 468.75 mm min^{-1} was recorded for 2 kg/cm^2 followed by

Table 2: Relationship between pressure and cone angle of hollow cone nozzle

Pressure (kg/cm^2)	Width of spray (mm)	Spray Cone angle
2	530	55°.51'
3	560	58°.30'
4	640	65°.14'

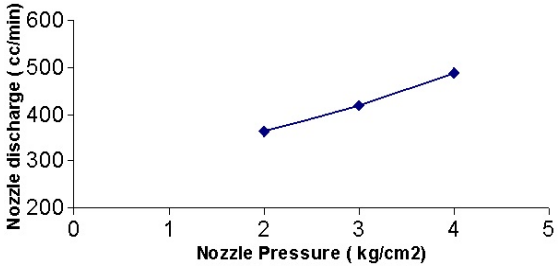

Fig. 1: Relationship between the Nozzle pressure and Nozzle discharge of hollow cone nozzle

Table 3: Discharge rate of the spray boom

Nozzle pressure	Nozzle discharge rate, mm. min^{-1}								Total discharge	Average
Kg/cm^2	1	2	3	4	5	6	7	8	l. min	dischargemm.min^{-1}
2	0.462	0.457	0.459	0.471	0.470	0.480	0.479	0.472	3.75	468.75
3	0.522	0.518	0.522	0.521	0.525	0.512	0.506	0.502	4.128	516
4	0.642	0.647	0.651	0.658	0.642	0.640	0.641	0.642	5.163	645.37

Table 4: Droplet size analysis for nozzle at different pressure

Pressure (kg/cm^2)	VMD (mM)	VMD (mM)	UC = VMD/NMD
2	265	120	2.2
3	248	113	2.2
4	232	93	2.5

Table 5: Comparison of power tiller operated boom sprayer with power operated knapsack sprayer

Item	Field capacity ha /h	Time required h/ ha	Cost of operation Rs. /h	Cost of operation Rs./ ha
Power tiller operated boom sprayer	0.72	1.55	76.45	88.25
Power operated knapsack sprayer	0.42	2.95	36.50	71.70

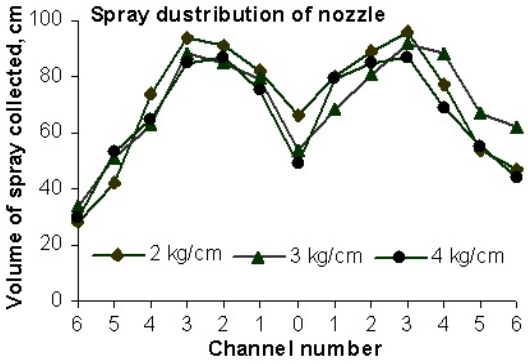

Fig. 2: Spray distribution of two nozzles

Fig. 3: Operational View in Power Tiller Operated Rear Mounted Boom Sprayer in Cotton Crop

516 and 645.37 mm. min^{-1} respectively for 3 and 4 kg/cm^2 operating pressure. The total discharge rate of the boom was observed as 3.75 lit min^{-1}, 4.128 lit. min^{-1} and 5.163 lit. min^{-1} for operating pressure of 2, 3 and 4 kg/cm^2 respectively. From the Table 3, it was concluded that the discharge rate increased as the operating pressure was increased.

The droplet size of the selected nozzle studied of various pressure and volume mean diameter (VMD), number mean diameter (NMD) and uniformity coefficient (UC) were calculated and shown in Table 4. Increasing the pressure attains a decrease in particle size (VMD) and uniformity coefficient at 2 kg/cm^2 and 3 kg/cm^2 were better than that of 4 kg/cm^2.

Field tests (Fig.3) were conducted to compare of the power tiller operated rear mounted boom sprayer with a power operated knapsack sprayer.

From the above Table 5. there was not much variation in the cost of operation between boom and power knapsack sprayer. In using the power tiller operated rear mounted boom sprayer, there was a saving of 51 percent time over power knapsack sprayer.

Conclusion: The effective field capacity of the sprayer was 0.72 ha/h for a power tiller speed of 2 km/h. The performance of the power tiller operated boom sprayer was satisfactory as a pressure of 3 kg/cm^2 and can be adopted by the farmers for spraying row crops as it saves the cost and time of operation per ha by 51per cent power operated knapsack sprayer.

During the filed operation it was noticed that the spray chemicals affected the operator who was sitting on the seat behind the power tiller. The problem was aggressive which increased the health hazards of the operator. Even though the operator was wearing the mask, it did not filter the chemicals completely, subsequently damaging his health conditions. To nullify the negative effects it was decided to shift the entire boom assembly to the rear of the power tiller, behind of the operator seat. Even in adverse wind conditions, by the time the power tiller would have moved through considerable distance, the chemical would be deposited on the canopy, there by reducing the effect of chemical inhalation by the operator almost to nil. To facilitate for the convenience of the operator the design of the entire controls were provided near the operator seat so that very efficient spraying can be achieved without affecting the health of the operator. Providing additional clamp and pipes keeping in view the safety

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