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Original Research Article

Performance Evaluation of Power Tiller Operated Tall Tree Sprayer

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A B S T R A C T

Sprayers are used to spray pesticides to control pest and disease. Sprayer must break liquid into droplet of effective size, also distribute them uniformly over the plants and regulate the amount of liquid to avoid excessive chemical application. In view of these problems performance evaluation of power tiller operated tall tree sprayer were carried out in litchi orchards. It was found that included angle of the nozzle and its cross-section area of spray increased with increase in pressure and became constant at pressure of 3.5 kg/cm^2 (34.34 x 10 Pa). The included angle of nozzle was 92.66° and cross-section of spray was 3421.20 cm at this pressure. Discharge rate of the nozzle increased with increase in pressure. It was 706 ml/min per nozzle at 3 kg/cm^2 (29.43 x 10 Pa) pressure. The working capacity was 80 and 6 trees/h for Tall Tree and Gator Sprayer respectively. The maximum height of reach was 7.2 m and 6 m for tall tree and Gator sprayer respectively. The cost of operation was Rs 3.0 and Rs 13.4 per tree for Tall Tree and Gator Sprayer respectively. The results of laboratory and field testing of tall tree sprayer showed uniform and efficient coverage throughout the tree.

Keywords

Litchi orchard, Boom sprayer, Gator sprayer, Hollow cone nozzle

Introduction

Crop yield is reduced by mainly due to attack of pests and diseases. Chemical control is the popular method adopted for controlling most insects, pests and diseases. Over 99 percent of the applied chemical moves into the eco-system to contaminate the land, water and air (Pimental and levitan, 1986). The chemicals are applied either by spraying or dusting. Spraying is one of the most effective and efficient techniques for applying small volume spray liquid to protect crops. In conventional method, manually operated low and high volume hydraulic sprayer and power operated hydraulic sprayer with long boom, long lances or spray gun are used to carry fluid at different target. In this method the time and labour requirement is more. It is difficult to spray the pesticide uniformly and effectively throughout the tree by conventional method of spraying. Though this method gives good pest control but consumes large volume of liquid per plant, also great amount of time and labour is required.

Spraying by power tiller operated tall tree sprayer has become the accepted method of pesticide application among fruit growers in developed countries. In spite of its high initial cost, power tiller operated tall tree sprayer has certain advantages of high efficiency, economical and time saving.

There is an urgent need of the suitable spraying system for orchard crops with which uniform and efficient spraying can be achieved. However, various types of sprayers have been tested in different parts of India (Bisen and Srivatava, 1985; Manian *et al.,* 2003. Shridhar *et al.,* 2007) on various crops but very few small sprayers are being practiced in Bihar and Jharkhand state. Considering the above factor, the performance of power tiller operated tall tree sprayer has been presented in the paper.

Mathew *et al.,* (1992) studied test of power tiller operated boom sprayer and found that at higher pressure of 3kg/ cm^2, shows more even distribution than that of 2kg/cm^2 pressure and cost of operating the boom sprayer reduced 29% as compare to the hand compression Knapsack sprayer. Padmanathan and Kathirvel (2007) evaluated the power tiller operated rear mounted boom sprayer for cotton crop and found satisfactory at a pressure of 3kg/cm^2 and it saves the cost and time of operation per ha by 51% as compared to power operated Knapsack sprayer.

Materials and Methods

Power tiller operated tall tree sprayer consists of the frame, pump, power transmission unit, booms and tank. The details specifications of Power tiller operated tall tree sprayer are given in Table 1. All assembly of the sprayer was mounted on the frame which was made of flat iron plate and angle iron and fixed in front of the power tiller. Pump assembly was on the base plate and bolted with nut and bolt. Pulley of the pump of diameter 30 cm was connected to the pulley of the engine of diameter 10 cm with belt of size B 48. A suction pipe of length 360 cm was connected from the suction chamber of the pump to the tank which was placed on the trolley. The by-pass hose of the pump was connected to the tank with pipe. Pipes of all the three booms were connected to the delivery hose of the pump.

Pump assembly attached to the power tiller was taken in the laboratory to test the discharge of the nozzle, included angle of the nozzles and distribution pattern of the spray of the nozzle. For performance testing of nozzle in the laboratory, pressure measuring instrument, patternator, measuring cylinder, stand, drawing board were used.

Field trials

The performance testing of power tiller operated tall tree sprayer was done in lichi orchards of Rajendra Agricultural University, Pusa. Performance parameters like, working capacity of sprayer, application rate of chemical, fuel consumption, maximum height of reach, average chemical required, average time required per tree etc were recorded. A plot of one hectare having 68 plants was selected for experiment. Five men were required to conduct the spraying operation through power tiller operated tall tree sprayer. One to drive the power tiller, three for holding three different booms and other one for holding the delivery pipe. Before actual experiment, different parts of sprayer and power tiller were tested. Three booms holding by three different man were set in such a way to cover two rows in single pass. Spraying was done in four sets having 11, 16, 12 and 29 plants.

Each set of plants was sprayed with three replications. Fuel consumed and time taken during each replication was recorded. The performance testing of power tiller operated tall tree sprayer in lichi garden was shown in Figure 1. The nozzle when screwed to the

inner end position sprayed in the form of hollow cone, and in the form of straight jet when at the outer end position. While spraying the bottom part, the nozzle was adjusted to inner end position and for top part, it was adjusted to the outer end position. The tree was first sprayed from the periphery and then from the trunk. Bottom part of the tree was sprayed well on outer as well as inner side of the tree and upper as well as lower side of the leaves. Middle position of the tree was also sprayed satisfactorily except the back side of the leaves on periphery, but the front as well as back side of leaves in inner portion received the spray droplets at mid height. This is due to the fact the tree was sprayed from periphery to trunk. It covered front side of leaves while spraying from periphery, front and back side of leaves in inner portion while spraying from trunk.

A Gator sprayer with one spraying gun was used for spraying the lichi tree by conventional method. Gator had a reciprocating pump and air chamber for providing constant nozzle pressure. Pressure was developed by pushing the paddle of the sprayer. But the spray could not penetrate to cover back side of leaves at the periphery. Three men were required to conduct the spraying operation. One for operating the reciprocating pump and other two for spraying on the tree. For experiment five plants were selected and spraying was done. Three replications were done for time required and quantity of chemical solution consumed and by doing average time and chemical solution consumed was calculated. Time and quantity of solution consumed per tree were calculated by dividing that amount by number of trees.

Results and Discussion

All nozzles of the sprayer were tested separately at different pressures and that tested parameters were included angle of nozzle, discharge of nozzle and spray pattern.

Included angle of nozzle

Included angle of nozzle at different pressures was shown in Figure 2. The included angle of nozzle was determined when it was fixed at a distance of 31.5 cm from the object. The cross-sectional area of spray was 1520.53 cm^2 at pressure of 1 kg/cm^2. It increased with increase in pressure and became constant 3421.20 cm^2 at pressure of 3.5 kg/cm^2.

It was observed that included angle of nozzle increased from 69.86° to 92.66° with increase in pressure from 1 kg/cm^2 to 3.5 kg/cm^2 and became constant at pressure 3.5 kg/cm^2 and this maximum value of included angle of nozzle was 92.66°.

Discharge of nozzle

Discharge at various pressures and at various distances from the centre of nozzle was shown in Figure 3. Total discharge of single nozzle in one minute at different pressures of 1 kg/cm^2, 3 kg/cm^2 and 5 kg/cm^2 was 370.9 ml, 706.2 ml and 911.2 ml respectively.

Relationship between height of nozzle and degree of overlap was shown in Figure 4. The table as well as figure shows that discharge of the nozzle was less at the centre and it increases in both sides from the centre and then decreased with increase in distance. The low discharge at the centre of the nozzle was found due to hollow cone shape of nozzle. The pattern was same at all pressure. The cross-section of spray was circular in shape. The spray particles were distributed on the outer side and practically no droplets existed in the central portion of spray cone. This was clearly a hollow cone type of

nozzle. Spray of two nozzles overlaps after some distance from nozzle and this degree of overlap was calculated in terms of percentage. It was observed that degree of overlap was 0, 100, 200 and 300% at nozzle height of 25, 50, 75 and 100 cm, respectively. Thus degree of overlap increased with increase in nozzle height. The relationship was linear in nature.

Table.1 Specification of the power tiller operated tall tree sprayer

Parameters	**Specifications**
Power requirement, kw	3.73
Tank	
(i) Capacity, litre	200
(ii) Shape	Cylindrical
(iii)Diameter, mm	500
Power transmission	Belt pulley system
Type of agitator	Propeller type
Type of device for controlling discharge	Regulating valve
Pump	
(i) Type	Reciprocating
(ii) Size	37.5 mm x 25 mm
(iii)Weight, kg	55
Boom	
(i) Number	3
(ii) Length, mm	1600
Length of boom holding alluminium pipe, mm	3670
Nozzle	
(i) No. of nozzle in each boom	5
(ii) Distance between two nozzle, mm	420
(iii)Type of nozzle	Hollow cone
Delivery pipe	
(i) Length, mm	14500
(ii) Diameter, mm	6.5

Table.2 Comparative performance of tall tree sprayer with gutor sprayer

Parameters	Power tiller operated tall tree sprayer	Gator sprayer
Working capacity of sprayer, tree/h	80	6
Application rate of chemical, l/h	288.8	49
Average chemical solution required, l/ tree	3.63	8.06
Average time required per tree, min	0.76	9.86
Fuel consumed, l/h	0.636	Nil
Maximum height of reach, m	7.2	6
Cost of operation, Rs/h	245.0	80.0
Cost of operation, Rs/tree	3.0	13.4
Labour requirement	5	3
Number of trees covered	68	5

Fig.1 Power tiller operated tall tree sprayer during operation

Fig.2 Pressure vs included angle of nozzle

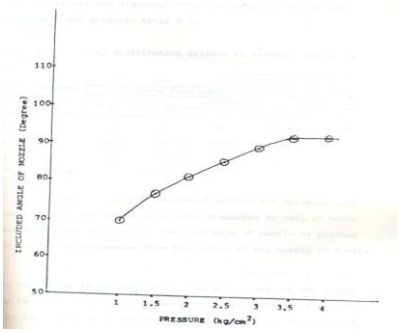


Fig.3 Spray distribution pattern at various pressures

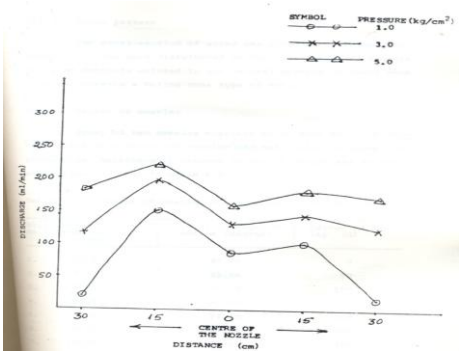
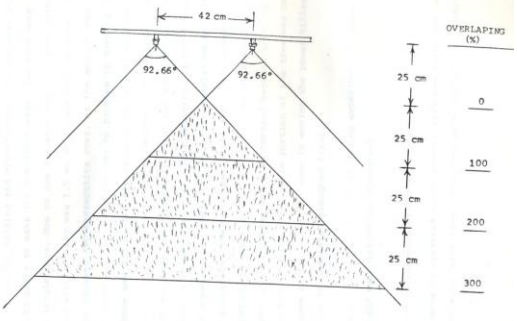


Fig.4 Relationship between height of nozzle and degree of overlap



Field performance of power tiller operated tall tree sprayer

Spraying was done in the field of lichi orchard with power tiller operated tall tree sprayer and its performance was as shown in Table 2. Two rows were covered in single pass. Row to row distance was 12 m and width of power tiller with trolley was 1.5 m. So it was easy to move the power tiller between two consecutive rows. At the end of rows sufficient space was left so that there was no problem in turning. The height of boom was 5.5 m. Bottom portion of the boom was tighten with the belt and fixed with waist and shoulder and thus hold the boom in balance position. Tank capacity was 200 litre and rate of chemical was 288.8 l/h. So after completion of 41.55 minutes of operation, the tank was filled again with chemical solution. Height of the tree was 8 m and height of reach was 7.2 m. The rest portion of the tree was also covered because spraying was done in the form of mist. Thus whole portion of the tree was covered. Only some difficulties had come in moving the power tiller in the field due to undulated ploughed field. Time taken and chemical required to spray one tree completely were 9.86 minutes and 8.06 litres respectively. The cost of operation by power tiller operated tall tree sprayer was Rs 245/h and Rs 3.0 /tree whereas, by Gator sprayer the cost of operation was Rs 80.0 /h and Rs 13.4 /tree. Thus spraying by power tiller operated tall tree sprayer was economical than Gator sprayer, because cost of use to spray one tree was less in this method.

Summary and conclusions of the study is that the working capacity for power tiller operated tall tree sprayer and Gator Sprayer was 80 and 6 trees/h respectively. The cost of operation for power tiller operated tall tree sprayer and Gator Sprayer was Rs. 3.0 and Rs 13.4 per tree respectively. The performance of power tiller operated tall tree sprayer was satisfactory.

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