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Research Paper :

Design and testing of suitable boom for power tiller operated sprayer for bower type pattern of grape vineyard

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ABSTRACT

Grape (*Vitis Vinifera* L.) is a world wide popular fruit due to its taste and juicy nature. Grape crop is more susceptible to pests and diseases as such normally need 25 to 38 applications of pesticides or insecticides in a year. Conventional methods of spraying in grape vineyards are labor intensive and time consuming. Average farmer cannot afford larger tractor for spraying. Planting of grape and training to the grown vineyards are the very much important aspects. For proper growth and for maintaining proper shape to facilitate the interculturing, spraying, harvesting activities, proper training to the grape vineyard is to be given. Bower or pedal system is the best training system, which is commercially followed in Maharashtra. Two wheel tractor is most suitable for spraying in country like India. So it was decided to design and test suitable boom for hydraulic sprayer operated with power tiller for bower type pattern of grape vineyard. Considering the shape of the grape vineyard layout pattern, the boom for bower type vineyard system was fabricated in the workshop. Two booms of inverted L shape were designed and tested in the laboratory. There were eight nozzles, four on each boom. HTP pump was driven by the flywheel of the power tiller. Booms were fitted on a frame. The frame was fixed on the backside of the trailed type unit. The control panel was used to control the discharge to the boom to regulate the pressure. Discharge required through each nozzle was calculated to design the booms. The laboratory test results indicated that spray cone angle of the nozzle increased with increasing system pressure. Maximum droplet density (31droplets/cm^2) during the field trials was found for the travel speed 1.0 kmph and system pressure 9.0 kg/cm^2, which was most suitable for spraying in grape fields. The value of uniformity coefficient was found to be 1.96 for the treatment combination of N_1P_3, which showed more uniform size of droplets.

Key words : Swath width, Boom, Bower, Uniformity coefficient, Droplet density

Fruits have been grown in India for thousands of years and occupy today a position of considerable importance. Fruits are the chief source of vitamins, without which the human body can not maintain proper health and resistance to diseases. Grape is one the most delicious, refreshing and nourishing fruits rich in minerals, sugar and vitamins. Share of Maharashtra state in total production of grape of India is almost one third. Spraying is one of the most important operations in crop protection from the point of view of pests and diseases control. Grape is highly susceptible crops to pest and diseases. Hamid (1973) suggested that two-wheel tractor was most suitable in India for promoting economic development, employment and better income distribution. Verma *et al.* (1988) found that power tiller with its matching equipment for different operations was an appropriate and economic source of power. Considering difficulties of conventional spraying methods and incapability of Indian farmers to have costly tractors for mounting and operating plant protection equipments, it was decided to design and test a suitable boom for bower type pattern of grape vineyard mounted on trailed type unit with power tiller as a power source.

Kelkar *et al.* (1994) revealed that bower or pergola system is the best training system, which is commercially followed in Maharashtra. Normally 25 to 38 applications of pesticides or insecticides are required to control the pest and diseases of grape crop in a year (Vevai *et al.*, 1964). Chemical control is the only effective method of controlling most insects, pests, weeds and diseases (Smith, 1970). In India, two wheel tractor is most suitable which unlike large tractors would replace animal labor but not human labor and would be consistent with countries objective of promoting economic development, employment and better income distribution (Hamid, 1973). The present study was, therefore, undertaken to design and test suitable boom for bower type pattern of grape vineyard and accordingly develop a suitable sprayer for bower type grape vineyards.

METHODOLOGY

Bower or pedal type of training system is most popular stem among the farmers of Maharashtra. Boom design is one of the most important factors in sprayer development. The spray lance carrying more than one nozzle is called boom. The pendal is a system in which grape vines are spread horizontally parallel to ground over the wires or wooden frame. Some of the grape vines are in hanging position along the length of main stem of grape tree. Considering the shape of grape vineyard layout pattern, the boom for bower type was fabricated in the workshop. The sprayer suitable for bower type of grape training practice, as shown in Fig.1, was designed and fabricated at ASPEE Research Institute, Mumbai. It was trailed type consists of two booms and a pesticide tanks. These two booms of inverted L shape were designed by giving due consideration to grape vine canopy shape. Boom of sprayer is a spraying bar carrying more than one nozzle. The pressure that can be developed by HTP pump was 20 to 25 kg/cm^2, nozzle pressure for effective spraying was 5 to 15 kg/cm^2, discharge from each boom was 1.79 lit/min. Therefore, 16 mm diameter G.I. pipe was selected for boom. The plant canopy of grape vine was of pendal shape, therefore, for complete and uniform spraying, inverted 'L' shaped booms were designed and two adjustable nozzles were fixed on vertical portion of boom on either side. The effective swath width requirement of boom was 2.4 m considering spray cone angle. In view of central distance for adjustment, the total length of one boom was decided 2.125 m and that of two booms was 4.25 m. Four nozzles on each boom were fixed. Total requirement of liquid for spraying one hectare of grape vineyard was in the range of 900 to 1200 liters, plant canopy swath per row was 2.4 m. and average speed of power tiller in grape field was considered as 1 kmph. Considering these parameters, discharge required through each nozzle was determined as 450 cc/min. Therefore, eight nozzles of NMD/S 60450 (cone angle 60^0, discharge 450 cc/min) on equal spacing of 310 mm each considering 29.5 % overlap were selected. Boom was fabricated as per design and tested in the laboratory. Patternator was used to study the spray distribution of nozzle in the laboratory (Fig. 2). Spray angle and nozzle discharge were measured in the laboratory as shown in Fig. 3 and Fig. 4, respectively. The trailed type unit was consisted of chassis for hitching and tank carrier on which plastic tank was fitted. Horizontal Triplex Piston (HTP) pump was used to develop required pressure (20 Kg/cm^2) and discharge (36 lit/min at 950 rpm) to force the chemical through nozzles. Horizontal Triplex Piston (HTP) pump was driven by the flywheel of power tiller through belt and pulley arrangement. The field testing of sprayer was conducted at Central Campus, M.P.K.V., Rahuri, Dist. Ahmednagar. The purpose of field testing was to know the performance of developed booms to have proper coverage, ideal application of pesticide and increase particular utility of sprayer in grape vineyard.

Experimental design of field trials:

Field testing of sprayer was conducted for three travel

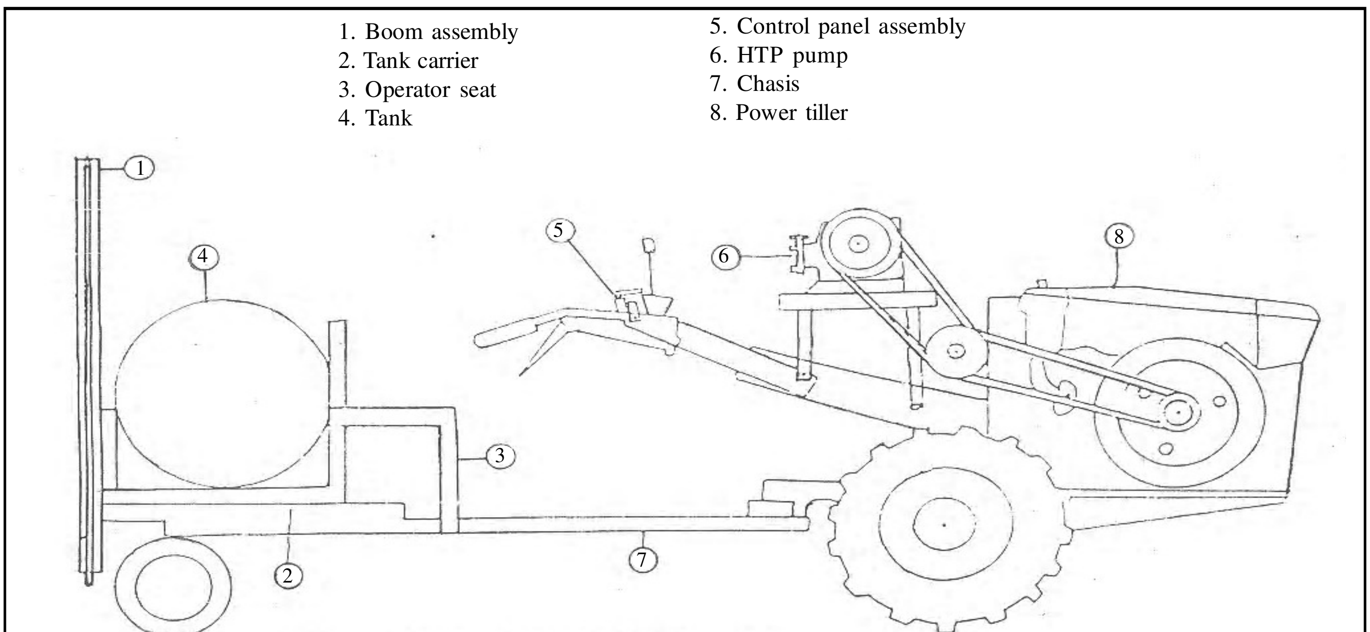

Fig. 1 : Power tiller operated sprayer

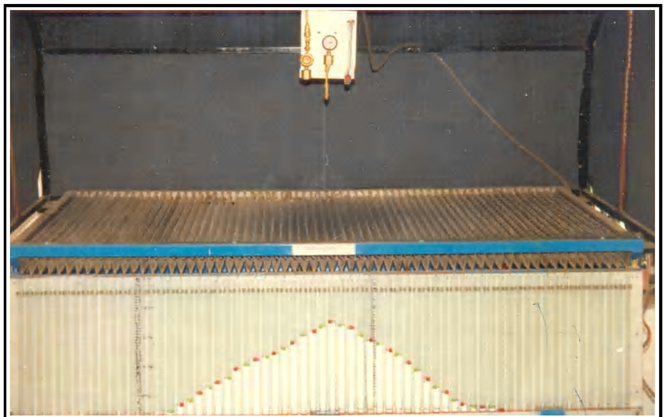

Fig. 2 : Patternator for study of spray distribution of nozzle

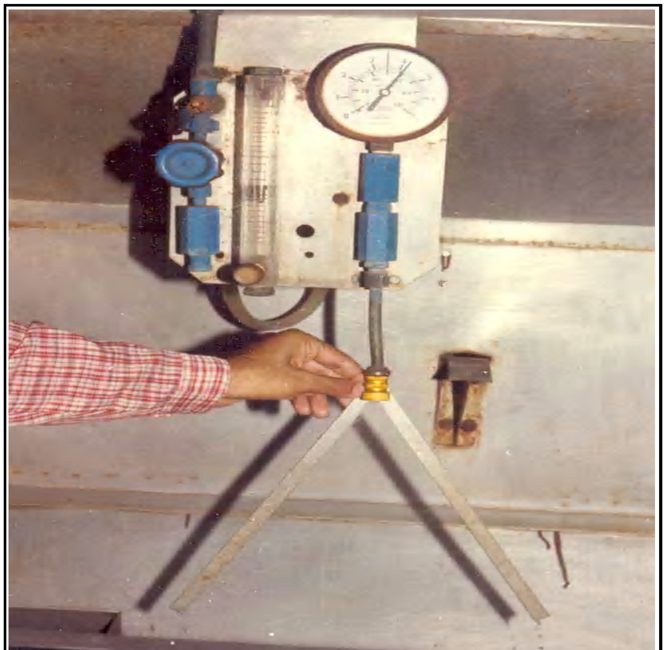

Fig. 3 : Measurement of spray angle

speeds (N_1=1.0 kmph, N_2=1.5 kmph, N_3= 2.0 kmph) and three system pressures (P_1=3 kg/cm^2, P_2=6 kg/cm^2, P_3=9 kg/cm^2). Spilt plot design with nine treatments each with three replications was used to evaluate the performance of field trials with minimum experimental error and maximum precision. White colored glossy papers were fixed to the grape leaves for collecting the spray droplets. After applying all treatments, glossy papers fixed on the grape vines were analyzed with the help of computerized Particle Size Image Analyzer for droplet size, droplet density and uniformity coefficient , which is the ratio of volume mean diameter (VMD) to number mean diameter (NMD).

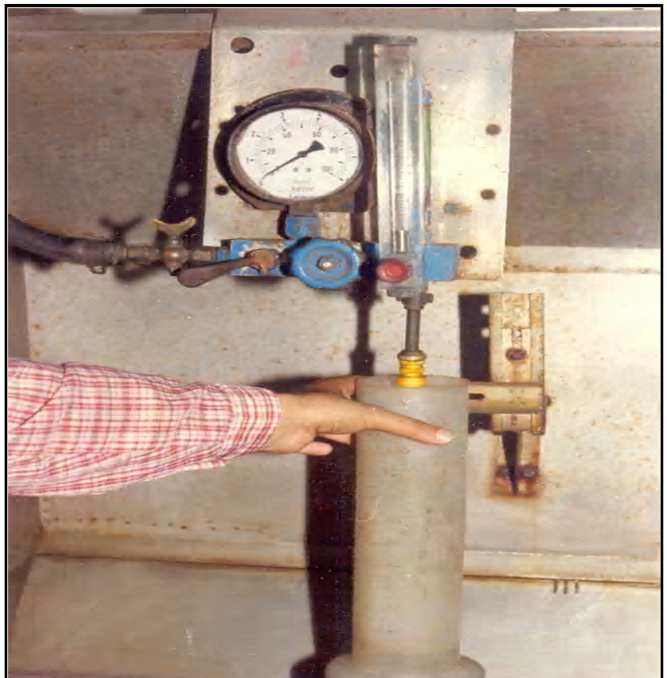

Fig. 4 : Measurement of nozzle discharge

RESULTS AND DISCUSSION

Laboratory performance of the sprayer with designed booms indicated that spray cone angle of the nozzle increases with increase in system pressure. As the pressure of sprayer increased, the distribution of spray became uniform,. The field performance of the sprayer in terms of droplet density at different combinations of the travel speed and system pressure at various portions of grape bower type training system was studied.. Average droplet density of three replications with the mean of front and back of leaf is reported in Table 1 and these data were considered for statistical analysis. Effect of system pressures on droplet density at various travel speeds was studied. It was found that droplet density was increased with increase in system pressure. Droplet deposition was higher at system pressure of 9 kg/cm^2, which was higher than that of 3 and 6 kg/cm^2. It was also found that droplet density at travel speed of 1.0 kmph was higher than that of 1.5 and 2.0 kmph. Thus, droplet density increased with decrease in travel speed. Maximum droplet density (31 droplets/sq.cm.) was found at treatment combination of N_1P_3 *i.e.* travel speed 1.0 kmph and system pressure 9 kg/cm^2. The average VMD, NMD and UC (uniformity coefficient) at different treatment combinations are presented in Table 2. The value of uniformity coefficient (UC) was found to be 1.96 at treatment combination of N_1P_3 *i.e.* travel speed 1.0 kmph and system pressure 9 kg/cm^2. This value was quite nearer to 1.0 indicating more uniform size of droplets.

Table 1 : Droplet density at left, centre and right portion of grape pendal

Travel speed, kmph	System pressure, kg/cm^2	Droplet density (No./Sq.cm)* (Average of 3 replications)					
		Left		Centre		Right	
		Bottom	Top	Bottom	Top	Bottom	Top
1.0	3.0	20	15	21	14	20	16
1.0	6.0	23	17	28	19	23	20
1.0	9.0	30	27	31	24	30	22
1.5	3.0	14	11	15	12	15	12
1.5	6.0	19	16	19	14	21	15
1.5	9.0	29	19	30	21	29	19
2.0	3.0	13	10	12	08	11	09
2.0	6.0	15	10	12	10	15	12
2.0	9.0	19	15	20	16	18	16

* Average density of front (F) and back (B) side of the leaf.

Table 2 : Average VMD, NMD and UC at different treatment combinations

Travel speed, kmph	System pressure, kg/cm^2	VMD, µm	NMD, µm	UC
1.0	3.0	246.09	91.08	2.70
1.0	6.0	237.89	90.04	2.64
1.0	9.0	184.78	94.30	1.96
1.5	3.0	300.41	126.74	2.37
1.5	6.0	245.07	120.37	2.45
1.5	9.0	269.95	101.84	2.65
2.0	3.0	313.15	143.22	2.19
2.0	6.0	291.72	142.44	2.05
2.0	9.0	280.73	120.67	2.33

Conclusion:

Treatment combination of N_1P_3 *i.e.* travel speed 1.0 kmph and system pressure 9 kg/cm^2 is suitable for spraying in grape vineyards than other treatment combinations, since it meets the minimum requirement of 20 droplets per cm from the bottom portion to top portion of grape pendal and for reduced drift and uniform coverage. The range of VMD should be 100 to 200 µm which gives fine droplets at all combinations of system pressures and travel speeds. The droplet density at top of grape canopy was less, but due to sunlight, attack of most of the insects and pests on top portion was somewhat minimum as compare to the middle and bottom portion of grape pendal. The value of uniformity coefficient was found to be nearer to unity which indicated more uniformity of spraying.

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