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DEVELOPMENT OF A MANUAL OPERATED SPRAYER FOR FIELD AND HORTICULTURE CROPS

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ABSTRACT

A manually operated sprayer was developed and its performance studies were carried out in the department of Farm Power and Machinery. It can be used in the ground crops and as well as in the horticultural crops by changing only the nozzles. By this sprayer a maximum pressure of 20 kg/cm^2 can be developed. The maximum field capacity for ground crop application was 0.186 ha/hr at 5 kg/cm^2 pressure and for orchard application was 0.826 ha/hr at 10 kg/cm^2. The maximum horizontal distance covered by the spray drops produced by orchard nozzle was 11.43 m at 4 kg/cm^2 and the vertical distance covered by the same nozzle was 5.7 m at 60° spray angle. The cost of fabrication of the sprayer was 200 US$.

INTRODUCTION

Timely application of pesticide in ground crops and in horticultural crops is needed in Bangladesh. The annual losses of food crops due to insect and pest attack is about 1.5 to 2.0 million tons (Krishi Diary'92).

No survey was done over pest diseases complex in High Yielding Variety (HYV) of rice in Bangladesh but Bangladesh Rice Research Institute (BRRI) found that yield increased upto 31% in paddy by spraying insecticide (Alam, 85).

Pest control by chemical application is an indispensable operation on orchard management for both small and large farms. Timely and appropriate chemical applications ensure the quantity and quality of fruits (Kozo Hirata, 1980). BARC(1985) reported that the farmers of Bangladesh mostly used traditional methods of chemical application such as (i) distribution by flicking a boom or broom dipped into the solution, (ii) by using coconut leaf and (iii) with single plunger made of bamboo.

Hand sprayer, knapsack sprayer, small power operated sprayer are increasing in numbers in Bangladesh agriculture and most of them were imported in past. Presently some locally made sprayers are available in the country but they operate at a very low pressure and for specific use and their life is very short (Hussain and Alam, 1991).

Considering the above mentioned points an attempt was made to design and develop a manually operated sprayer to spray both the field and the horticultural crops.

Objectives

(i) To develop a hand powered push type sprayer suitable for ground and horticultural crops.

(ii) To study the performances of the sprayer such as strokes Vs pressure rise, time elapse Vs pressure release, pressure Vs flow rate, pressure Vs Horizontal & vertical travel.

(iii) To study the spray distribution pattern.

MATERIALS AND METHODS

Locally available materials were used for the fabrication of the sprayer.

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Pump unit

The pump used for the sprayer is a reciprocating type(Fig. 1). A steel pipe of 50 mm internal dia, 5 mm thickness and 300 mm long was used as the cylinder of the pump. A flat plate of 2 mm thickness with a hole of 25 mm at the middle was welded at the lower end of the cylinder. The pump unit is connected with the liquid direction control chamber with a socket of 25 mm internal dia.

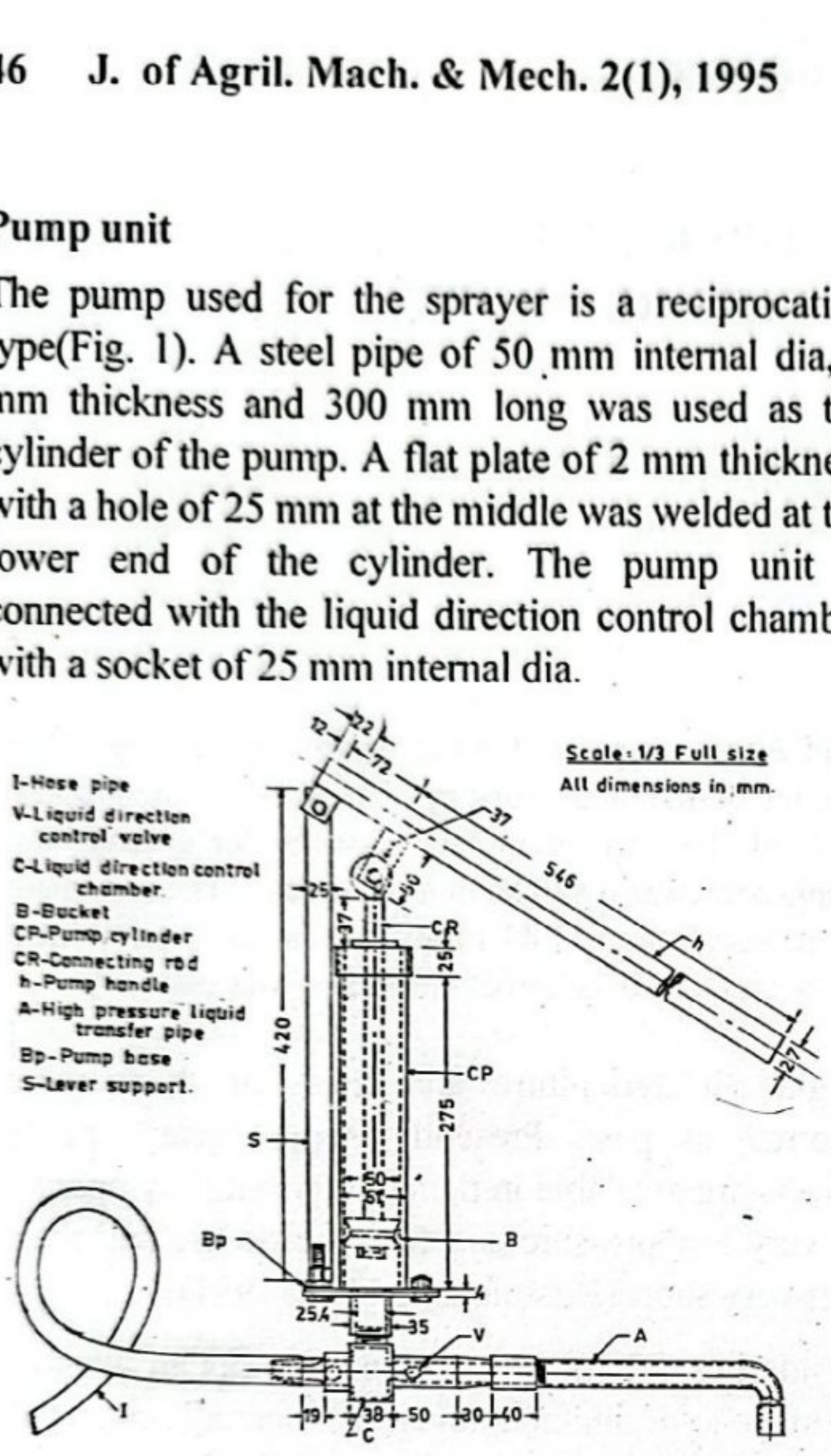

Fig.1 Details of pump and valve system.

A mild steel rod of 16 mm dia and 340 mm long, used as connecting rod, was attached with a leather bucket to act as piston. A steel pipe of 25 mm dia was used as pump handle (Fig. 1). The pump acted as lever type reciprocation pump which worked with the up and down action of the handle. The maximum stroke length was 140 mm. A maximum pressure of 20 kg/cm^2 could be developed with this pump.

The liquid direction control chamber

The liquid direction control chamber was made of mild steel sheet with three openings: one at the top to connect with the pump unit through socket and the other two at two sides of which one (intake side) to the reservoir by the hose pipe and the other (discharge side) to the high pressure chamber.

To control the flow of liquid in one direction from reservoir to the high pressure chamber two control valves were used at the two sides of the control chamber: one at the intake side and the other at the discharge side (Fig. 2).

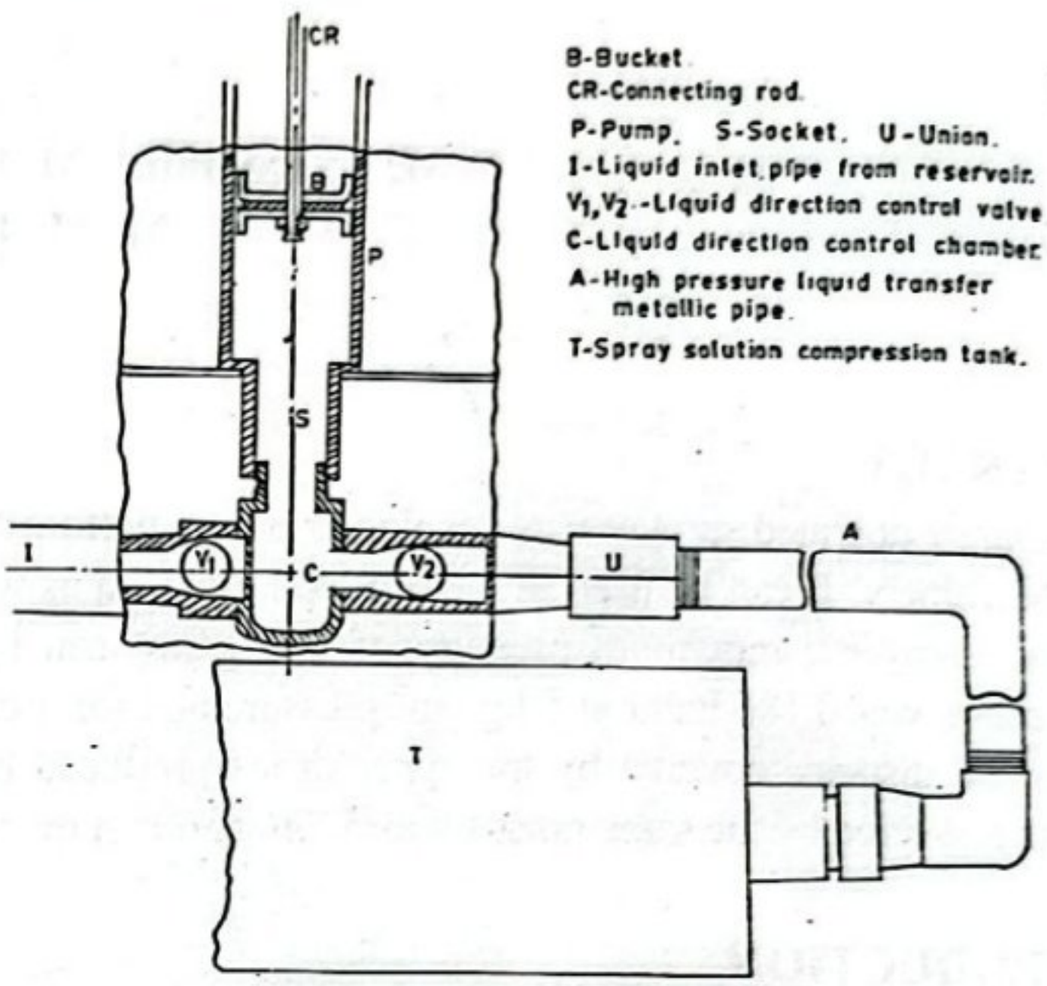

Fig. 2 Arrangement of valves and bucket with pump cylinder sectional view.

Nozzle

Two types of nozzles were made, one (nozzle type 1) for field crop spraying and the other (nozzle type 2) for orchard spraying (Fig. 3).

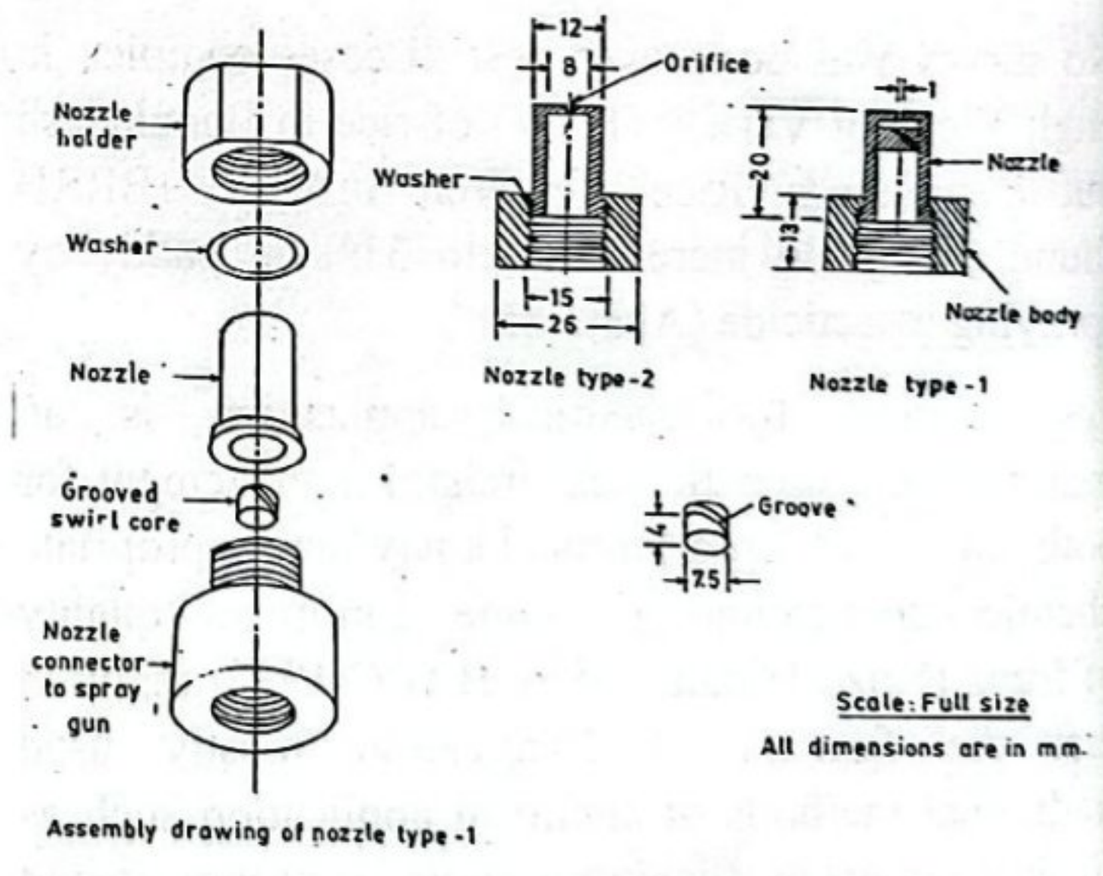

Fig.3 Cut away view of nozzles with their arrangement.

The nozzle type 1 was designed to give rotary motion in the spray solution. The spray pattern formed a solid cone of angle 55° at 5 kg/cm^2 pressure. The nozzle type 2 was designed to give jet flow for spraying fruit trees. Copper was used as a nozzle material for antirusting and anticorrosive property.

Operating principle

The whole sprayer unit in shown in fig. 4. The high pressure chamber together with pump is fixed over a base frame to give stability in operation. With the upward stroke, the valve 1 opens and suction occurs inside the pump. During the down stroke valve 1 closes and the liquid inside the pump is pressurized and under pressure valve 2 opens and the pressurized liquid enters into the high pressure chamber. With repeated strokes pressure increase in the high pressure chamber. This high pressure causes the liquid to flow through the nozzles for distribution.

Fig. 4. Photographic View of Multipurpose Sprayer

Measurement

The temperature and relative humidity were measured by a digital thermo-hygrometer. The wind speed was measured by a portable type anemometer. The flow rate of spray liquid through the nozzle was measured by using graduated cylinder and stop watch. The spray distribution was measured by patternator. Pressure gauge was used to record the pressure in the pressure chamber and in the nozzle.

Two men were required to operate the sprayer: one man to operate the pump and the 2nd man to hold the spray gun for spraying.

RESULTS AND DISCUSSION

Influence of stroke length on pressure rise

The smaller the stroke length the higher the number of strokes were required to attain the desired pressure (Fig.5). The Fig.5 also indicates that for a certain stroke the pressure increases with the increasing rate.

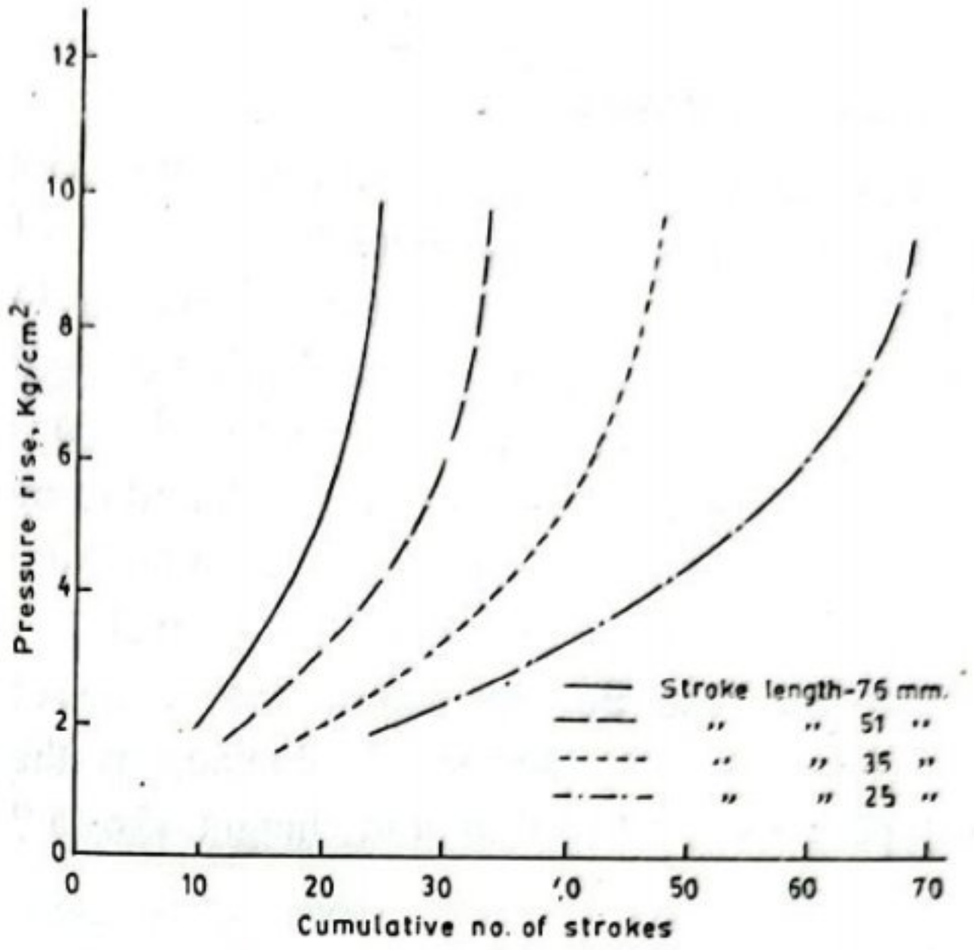

Fig. 5 Pressure rise as a function of no. of strokes

Pressure release with time

Table 1 shows the pressure releases at higher pressure level with higher rate than at lower pressure level. Nozzle type 1 release pressure more slowly than that of type 2. This advantage of nozzle type 1 is due to the grooved swirl core present in this type. It is necessary to mention here that pressure can easily be maintained almost constant by adding only a few number of strokes (Fig. 5) during operation.

Table 1. Pressure at the nozzle with time and corresponding flow rates through the two nozzles

Time(sec)	Pressure(kgf/cm^2)		Flow rate(ml/min)	
0(start)	10.00	10.00	1190	1950
40	2.80	3.20	400	1200
80	2.00	2.50	380	700
120	2.10	2.30	350	650
160	1.95	2.20	250	450
200	1.80	2.10	240	375
320	1.75	1.80	200	300

Effect of pressure on flow rate

Flow rate increased with the increase of pressure. Almost straight line relationship was followed by the nozzle type 1 and exponential relationship by that of type 2 (Table 1). High flow rate was observed with nozzle type 2 than type 1 at the same pressure.

Spray pattern and swath

Swath was measured after 60 secs of spraying. The swath was found to increase with the increase of nozzle height upto 1.2 m and then it started to decrease. Again for a certain height swath increased with the increase of nozzle pressure up to 5 kg/cm^2. At the nozzle height of 1.2 m swath was found to be 0.91 m, 1.35 m, 1.4 m, 1.25 m and 1.21 m at pressure levels of 3, 4, 5, 6 and 8 kg/cm^2 respectively. A desirable swath can be obtained in the range of pressure 4 to 6 kg/cm^2. The swath obtained by the nozzle type 2 was 0.5 to 1.0 m at the height of 6 to 7 m.

The distribution of spray drops produced from nozzle type 1 upto height of 0.9 m is shown in Fig. 6. The highest deposition was found just under the nozzle i.e, at thc zero position. At pressure of 5 kg/cm^2 swath was observed to be 0.64 m, 0.96 m, 1.0 m and 1.4 m at nozzle height of 0.3, 0.6, 0.9 and 1.2 m respectively.

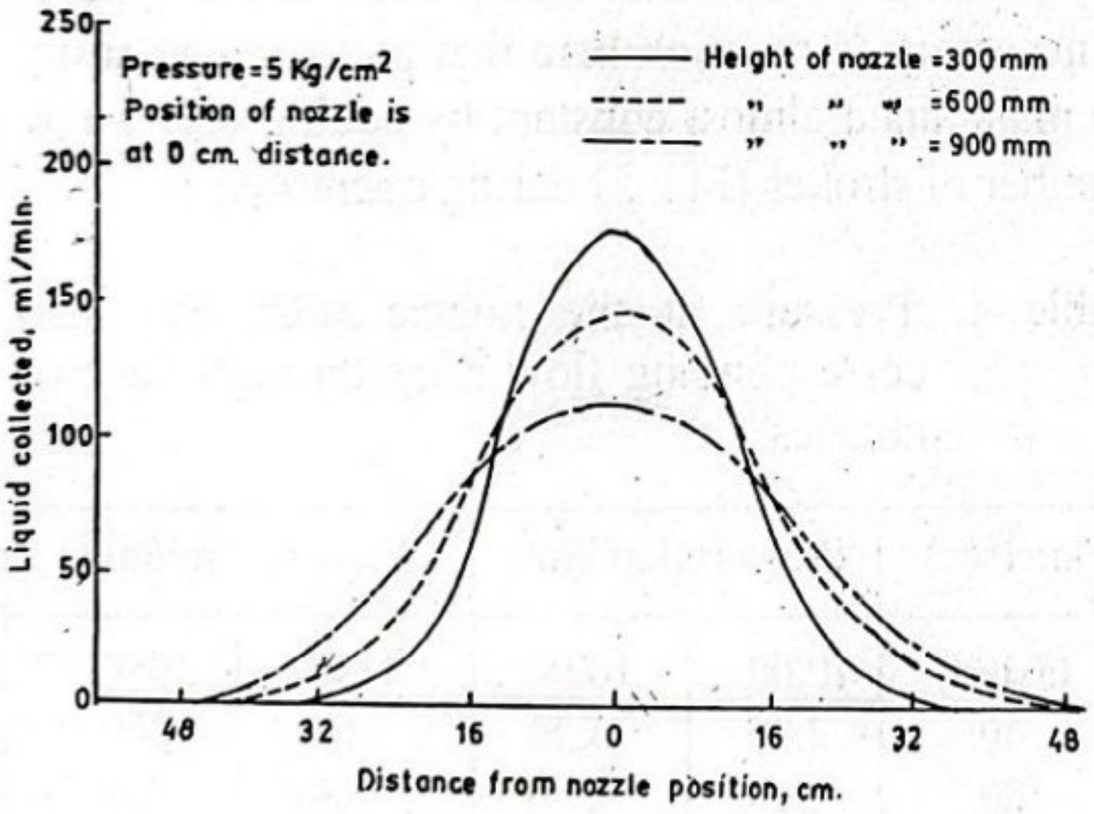

Fig. 6 Spray pattern distribution of nozzle type-1 at different height.

Spray drops travel

The horizontal and vertical distances travelled by the spray drops was found to be decreased at higher spraying pressure (Table 2). Normally higher pressure produces smaller droplets. The smaller the droplet sizes the smaller the mass and the velocity of the droplet and in turn lowers the kinetic energy. This is the cause for the low travel at the high pressure.

Table 2a. Maximum horizontal distance travelled by droplets produced from orchard sprayer's nozzle type 1 under different pressure and angle of spray

Pressure kgf/cm^2	Horizontal distance travelled			
	0°	30°	40°	60°
0	0	-	-	-
2	8.2	9.1	10	10.3
4	8.8	9.7	11.1	11.2
6	8.5	9.2	11.7	11.3
8	8.1	8.7	10.6	10.6
10	7.1	8.5	10.2	10.4
12	6.5	7.9	9.8	10.1

Table 2b. Maximum vertical distance travelled by droplets produced from orchard sprayer's nozzle type 1 under different pressure and angle of spray

Pressure kg/cm^2	Vertical distance			
	30°	45°	60°	90°
0	-	-	-	-
1	3.2	3.7	4.4	6.9
2	3.3	4.2	4.7	7.3
4	3.6	4.8	5.4	7.4
6	4.2	5.0	5.3	6.7
8	4.6	5.4	5.4	6.4
10	4.4	4.7	5.0	5.7
12	3.9	4.1	4.8	5.3

The maximum horizontal distance covered by the spray drops with nozzle type 2 was 11.43 m at 4 kg/cm^2 and vertical distance covered by the same nozzle was 5.7 m at 60° spray angle.

Field capacity

The field capacity (F.C) was observed to be varied with the change of spraying pressure. For nozzle type 1 the F.C was 0.439 ha/hr and 0.15 ha/hr at spraying pressure of 4 kg/cm^2 and 6 kg/cm^2 respectively. The F. C. for nozzle type 2 was 0.408 ha/hr, 0.563 ha/hr and 0.784 ha/hr at the spraying pressure of 6, 8 and 10 kg/cm^2 respectively. The fabrication cost of the prototype was 100 US$.

CONCLUSION

(1) Manually lever operated push type sprayer is suitable for use in ground crops and horticultural crops.

(2) Two men are required to operate the sprayer: one man for pumping & pushing and 2nd man for spraying and holding the spray gun.

(3) Trees upto a height of 5.7 m and 6 m can be sprayed using nozzle type 1 and 2 respectively.

(4) This sprayer is suitable for spraying in different pressures ranges from 4 to 10 kg/cm^2. This makes the sprayer suitable for various purposes. Different size of nozzles can be used with the spraygun.

(5) Locally available materials can be used for its manufacture in any small scale workshop.

(6) For commercial purpose, its fabrication cost will be around Tk. 4000.00 only.

(7) The field capacity for ground crop spraying is 0.449 ha/hr & for orchard spraying is 0.508 ha/hr.

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