

PERFORMANCE OF POWER TILLER MOUNTED BOOM SPRAYER

A. K. M. S. Islam¹ M. M. Hossain² M. D. Hussain³ R. I. Sarker³ M. Alam²

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ABSTRACT

A power tiller mounted boom sprayer having six nozzles was tested and evaluated in the laboratory of the Department of Farm Power and Machinery, BAU, Mymensingh. A centrifugal pump driven by the engine flywheel through a V-belt was used to supply the spray liquid to the nozzle. The nozzle pressure was dependent on the speed of the engine. Maximum pressure of 0.8 kg/cm² was obtained at an engine speed of 2000 rpm. A maximum throughput of 174 l/hr was obtained at the pressure of 0.8 kg/cm² and a minimum of 140 l/hr was obtained at a pressure of 0.44 kg/cm². The drift increased with the increase in wind speed. The drift was 1.63% and 7.45% at the wind speed of 2 m/s and 10 m/s, respectively. The spray deposition per unit area was dependent on the forward speed of the power tiller. During the tests, the deposition rates were 400 l/ha and 455 l/ha at the engine speed of 2000 rpm and 1480 rpm, respectively. Deposition rate increased with the decrease in fluid level in the tank. A constant throughput could not be maintained by changing the engine speed because of non-linear relationship between the rate of change of discharge and the forward speed. The cost of construction of the power tiller mounted sprayer was TK. 5000 and the operating cost per hectare was Tk. 135.

INTRODUCTION

The crop losses caused by insect pests sometimes exceed 3.6 million tons/year and this is 25% of the total rice production of Bangladesh (Hussain and Sarker, 1980). It was reported that the yield of paddy could increase up to 31% by spraying pesticide (Alam, 1985). Therefore, minimizing the loss due to pests and diseases may contribute significantly to solve the problem of food deficiency in the country. The concept of crop protection has aimed at the reduction in pest population directly responsible for damage of crops in the field and grains in the storage. Crop protection is most efficient when the pesticide is applied economically on a scale dictated by the area occupied by the pest and the urgency with which the pest population has to be controlled (Joyce, 1977). The most important consideration of applying pesticide is to apply the necessary quantity of toxic materials

at the desired target points with a minimum wastage. Pesticide application has been aimed not only at increasing the efficiency in pest control but also at reducing adverse effects in the environment and farm labour requirement (Richy *et al.*, 1961).

Farmers of Bangladesh are not practicing plant protection measures in a proper way. Equipment is necessary for uniform and effective application of pesticides. Small and portable sprayers like, hand knapsack, compressed air, and lever type are available. Most of the sprayers used are imported, and a few of them are locally manufactured. Farmers are using hand stick or broom to distribute the chemicals which is neither scientific nor efficient and requires more chemicals and energy than the actual requirement. Therefore, it increases the environmental pollution which is very serious to human, fish, animal, birds and plant life cycle. Most of the farmers even can not afford to have any

¹Research Associate ²Associate Professor ³Professor
Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

sprayer. Farmers are generally reluctant to spray their crop fields because of high cost of insecticide and unavailability of spraying machine; evidently the crop yield is lowered.

A power tiller represents a useful productive unit and it is now gaining popularity in Bangladesh. Presently 1,00,000 power tillers are being used in agriculture (Sims, 1994). The use of power tiller for land preparation is increasing day by day. The annual use of power tiller can be increased by using it for spraying and other operations. Therefore, the present study was undertaken to test the performance of power tiller mounted boom sprayer. The specific objectives of the study were to find

- the effect of engine speed on nozzle pressure
- the influence of nozzle pressure on spray discharge
- swath, spray pattern distribution, deposition and drift at different nozzle pressure and field capacity of the spraying machine

MATERIALS AND METHODS

YANMAR YC-7 diesel ES105C water cooled power tiller engine having rated power of 6.71 kW (continuous output at 2200 rpm), was used in the experiment. The boom sprayer was fabricated in the Workshop of the Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh. A tank having 50 litre capacity was used to supply spray solution. The tank was fixed over the wheel axle by four supports. The height of the tank was chosen not to affect the operation of the power tiller. The tank was made of nylon material. A centrifugal self priming type pump (type Kreisel, 6.61 l/min discharge) was used to supply spray-solution from tank to the nozzle. The pump was operated by engine flywheel through V-belt. Gravitational flow was allowed to feed the centrifugal pump. A pressure gauge (0-10 kg/cm²) at the outlet of the pump was used to determine the liquid pressure. The boom was provided with six nozzles at 60 cm apart and mounted in front of the power tiller. The boom length and diameter was 3 m and 1.9 cm respectively. Patternator was used

to observe the spray pattern distribution. The photographic view of the sprayer is shown in Fig. 1. The engine and pump speed were measured by a digital tachometer. Spray discharge was measured by a measuring flask and time was recorded by a stopwatch. Field capacity was determined by using the following formula : $EFC = Swe/100$, where S = travel speed of power tiller (km/hr), W = spray width (m), e = field efficiency. Data were recorded for five different engine speeds at 5 gear positions.

RESULTS AND DISCUSSION

The liquid pressure at the outlet of the pump gradually increased with the increase of the engine speed. Flow rate also increased with the increase in the pressure of the pump. The maximum throughput of 173.74 l/hr was obtained for the pressure of 0.8 kg/cm² and minimum throughput was obtained 139.94 l/hr for the pressure of 0.44 kg/cm² at an engine speed of 2000 rpm and 1480 rpm respectively. The linear relationship between nozzle pressure and nozzle discharge is shown in Fig. 2.

Fig. 3 illustrates the relationship between swath and spray pattern distribution. The spray pattern distribution was observed for five different pressure settings in the patternator. The deposition decreases with the decrease in pressure. The distribution curve flattened with an increase in pressure indicating that the distribution area i.e. the area covered increased with an increase in pressure.

Swath increased as the height of the nozzle as well as the spray angle increased. At 0.8 m height, swath for each nozzle was found to be 0.60 m, 0.65 m, 0.75 m, 0.93 m, 1.02 m for the nozzle angle of 40°, 45°, 50°, 60° and 65° respectively (Fig. 4).

Drift was found to be increased with the increase in wind speed. The drift were 1.63% and 7.45% at the wind speed of 2 m/s and 10 m/s respectively (Fig. 5). The spray drift has exponential relationship with wind speed as shown by the following equation :

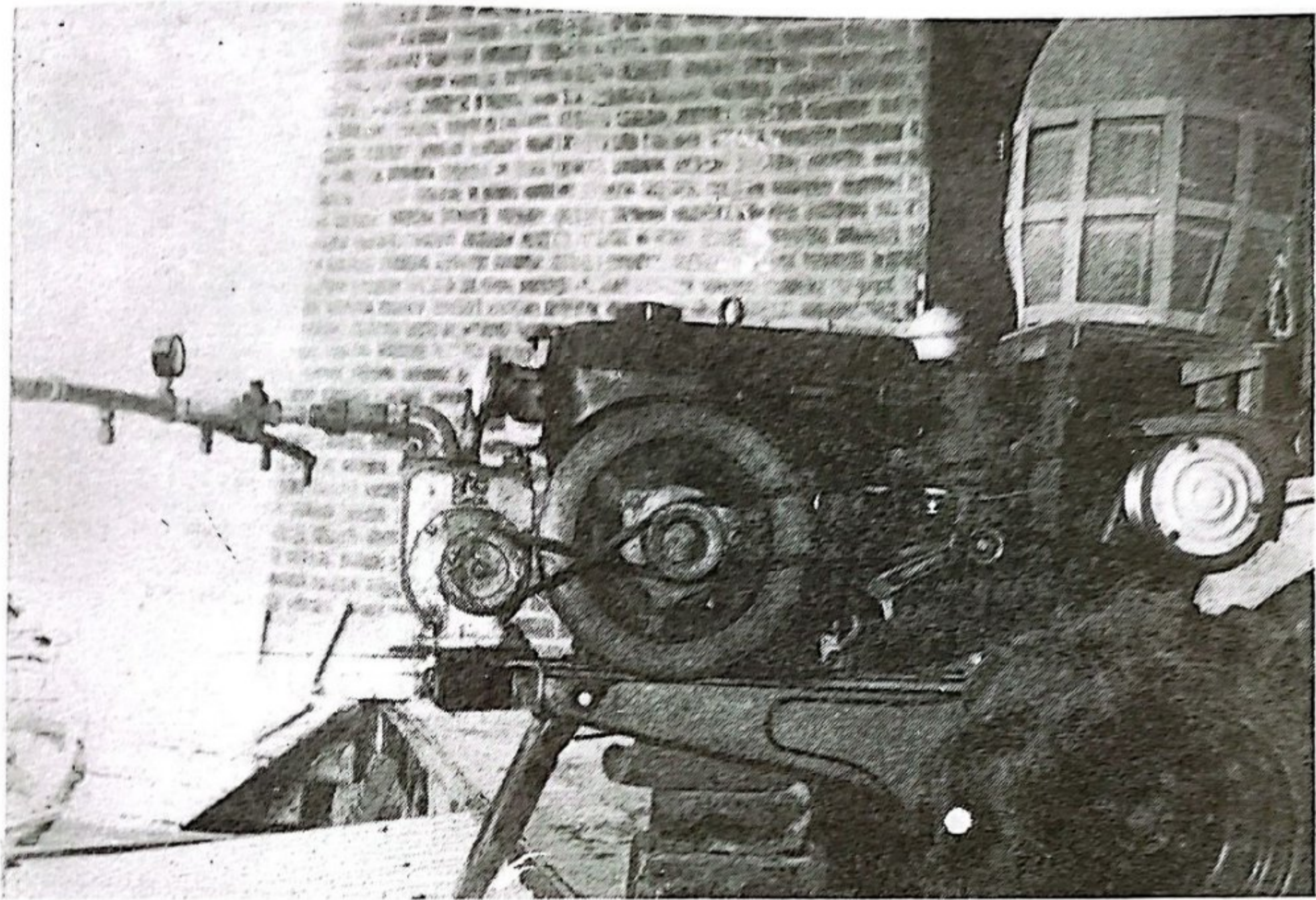


Fig. 1 : Photographic view of the power tiller mounted boom sprayer

$$Y = 1.236e^{0.1908X}$$

where, Y = % drift of output
X = Wind speed in m/s

The excessive drift of pesticides may pollute neighbouring areas or pasture, causing serious toxic hazards to men and animals. The meteorological condition should be observed before the application of pesticides and spraying should be done at low wind speed in the field for obtaining less drift.

Field capacity of the sprayer depends on the engine speed as well as gear position of the power tiller. It also depends on the field condition (i.e., type of soil, soil moisture content etc.). Fig. 6 shows the field capacity varying with engine speed at different gear positions. Maximum effective field capacity was 0.98 ha/hr at engine speed of 2000 rpm at 5th gear and minimum was 0.09 ha/hr at the

engine speed of 1480 rpm at first gear position. For field spraying the power tiller was operated at gear position 4 and the forward speed was 3.6 km/hr. At this gear position and engine speed of 2000 rpm the maximum field capacity was 0.43 ha/hr. The effective field capacity varied from 0.31 to 0.43 ha/hr with the variation of engine speed from 1480 to 2000 rpm respectively.

The spray deposition per unit area increased with the decrease in engine speed of power tiller as well as with the decrease in pressure (Fig. 7). The lowest and highest deposition per unit area was 177 l/ha and 1540 l/ha for the pressure of 0.8 kg/cm² at 5th gear position and for pressure of 0.44 kg/cm² at 1st gear respectively. At gear position 4 the deposition per unit area were 455 and 400 l/ha with the engine speed of 1480 and 2000 rpm, respectively.

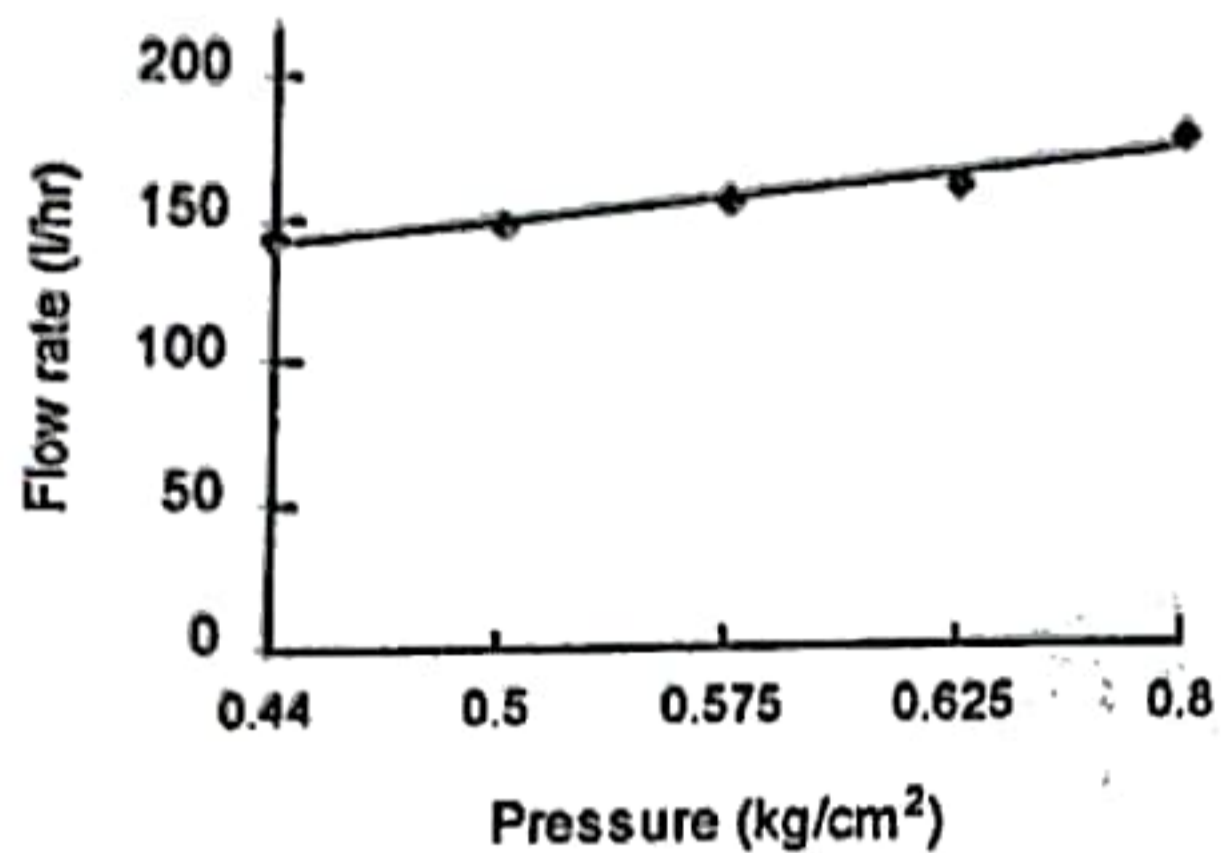


Fig. 2. Influence of pressure on flow rate

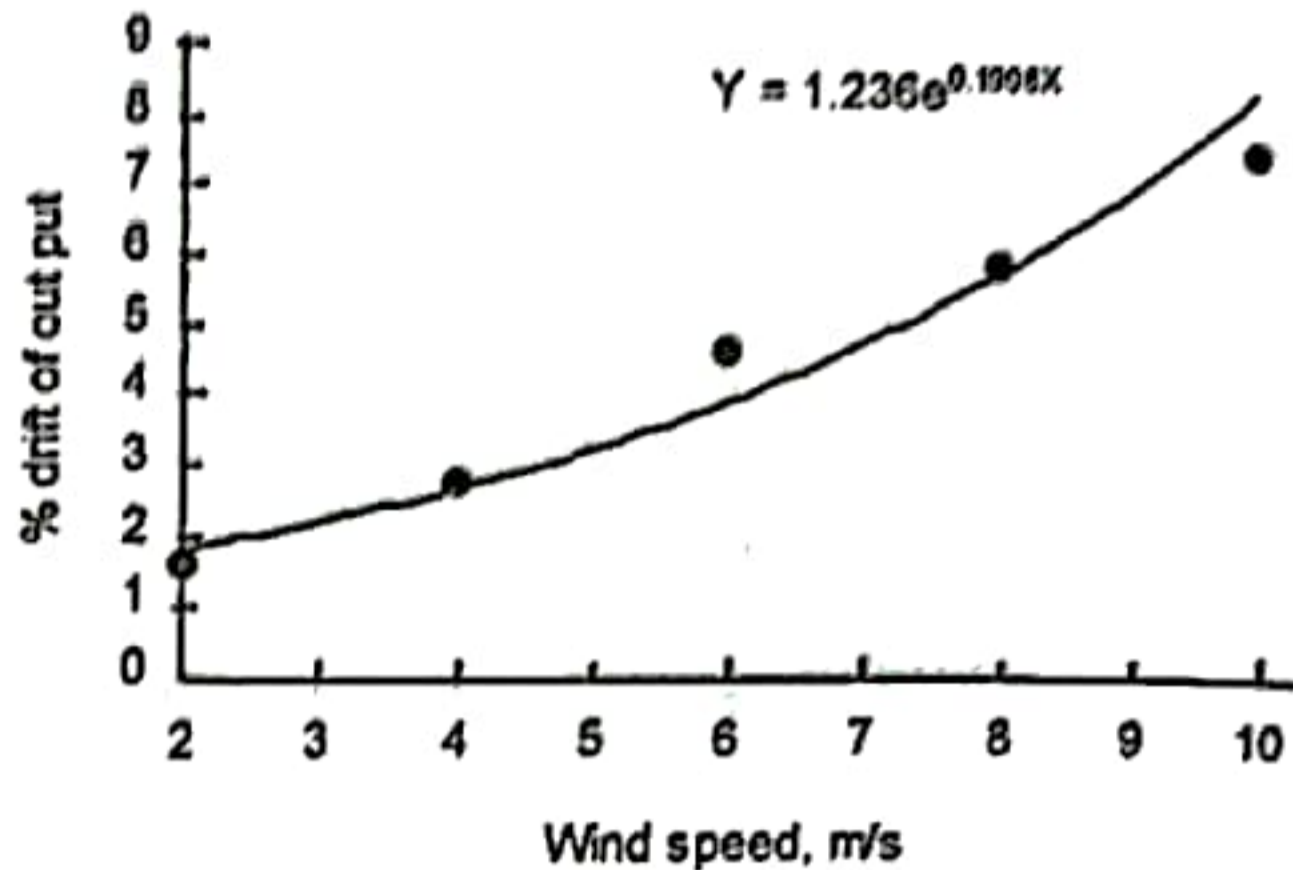


Fig. 5. Relationship between wind speed and percent drift

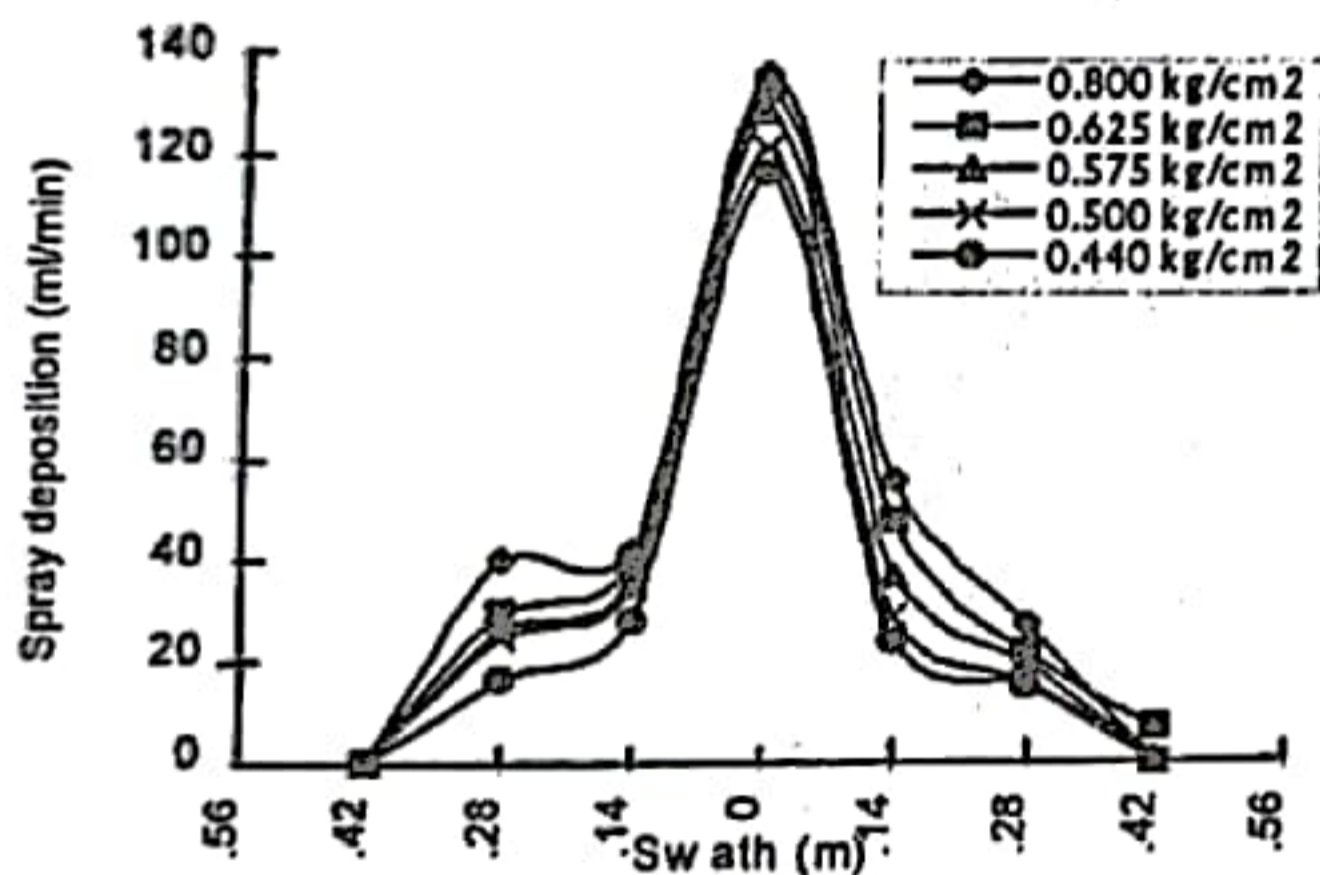


Fig 3. Spray distribution pattern of nozzle at different pressure

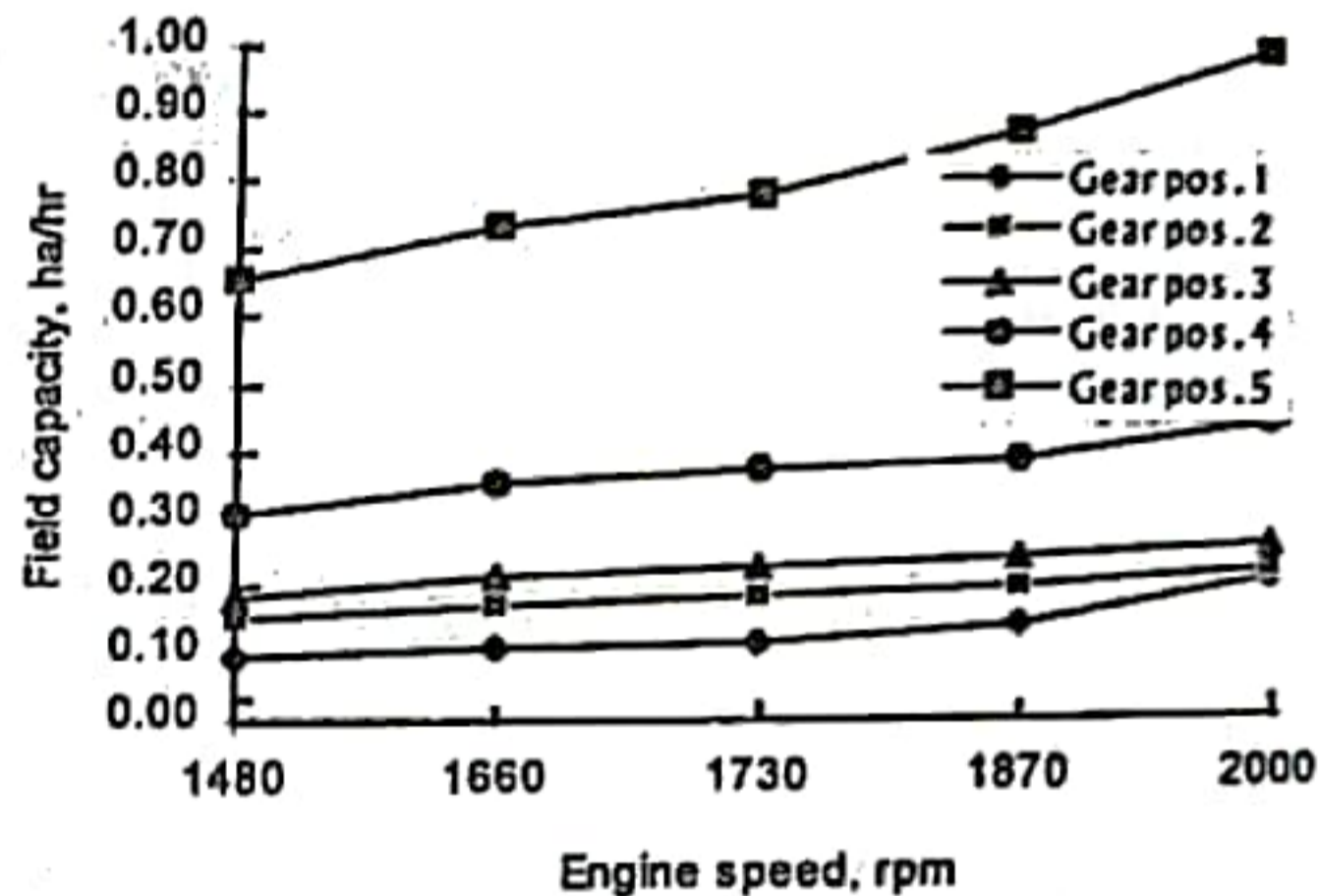


Fig. 6. Relationship between engine speed and theoretical field capacity in different gear position

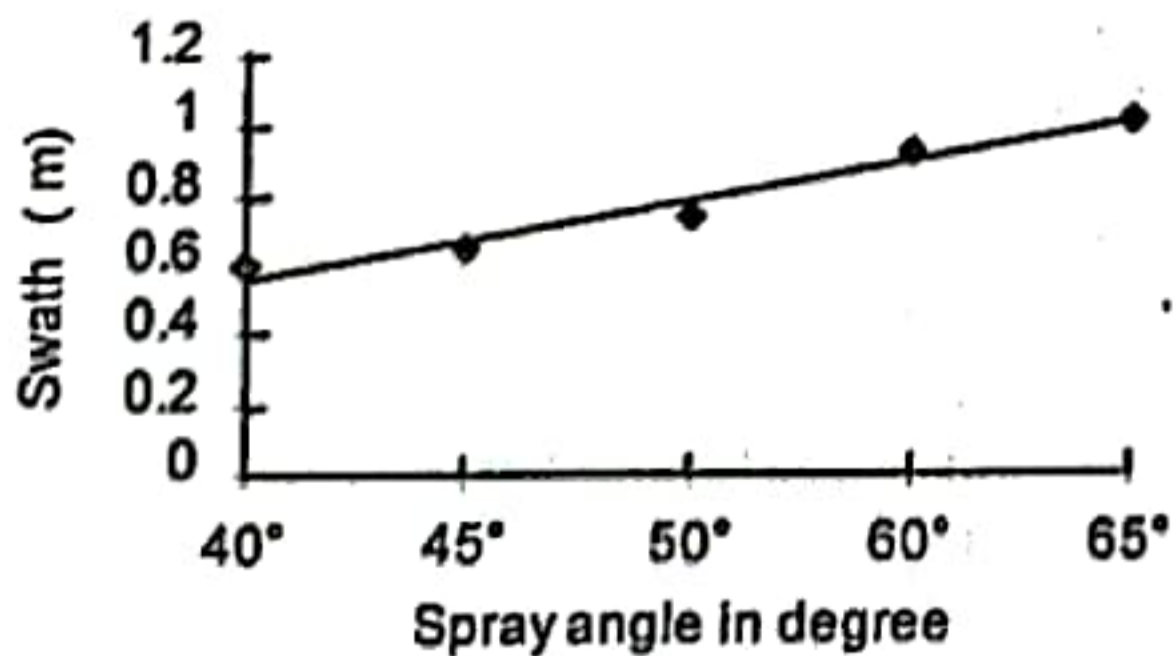


Fig. 4. Relationship between spray angle and maximum swath

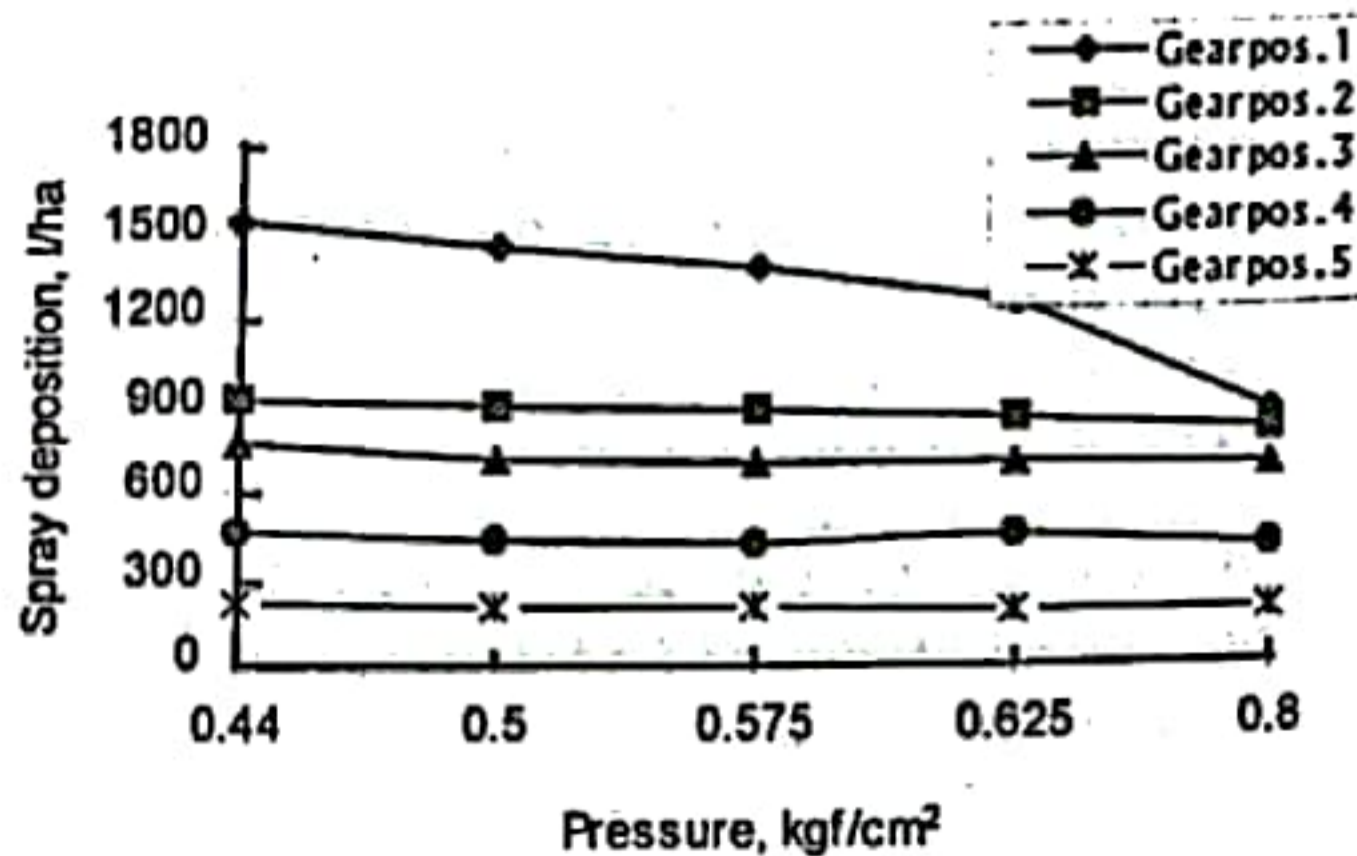


Fig. 7. Relationship between Pressure and spray deposition in different gear position

The total fabricating cost of the sprayer is about Tk. 5000. The operating cost per hectare per year of the power tiller mounted boom sprayer was found

to be Tk. 135.00. Comparative operating cost and spraying time of the five different types of sprayers are presented in Table 1.

Table 1 Comparison of spraying time and operating cost for different sprayers

Sprayer	Knapsack ¹	CDA ¹ sprayer	Spinning ¹ disc type sprayer	Tractor ¹ mounted sprayer	Power tiller mounted sprayer
Application rate (l/ha)	400.0	10.00	4.25	150.00	400.00
Spray tank capacity (l)	15.0	0.60	17.70	200.00	50.00
Mixing refilling time (min)	5.0	2.00	7.00	30.00	17.00
Swath (m)	1.0	1.00	0.80	6.00	3.50
Spraying time (hr/ha)	2.80	2.80	2.50	0.29	2.33
Operating cost (Tk/ha)	168.0	316.65	194.25	180.68	135.00

Source: ¹ Hussain et al., 1993

SUMMARY AND CONCLUSION

The power tiller mounted boom sprayer is a high volume sprayer. The flow rate increased with the increase in pressure. A maximum and minimum throughput of 174 l/hr and 140₂ l/ha were obtained for the pressure of 0.8 kg/cm² and 0.44 kg/cm² respectively. Spray drift increased with the increase in wind speed. Drift of 1.63% was obtained at wind speed of 2 m/s and increased to 7.45% at speed of 10m/s. The effective field capacity was 0.43 ha/hr at gear 4. The spray deposition per unit area depended on the forward speed of the power tiller. Wheel slip reduced the forward speed but increased the spray deposition. The deposition per unit area was 400 l/ha and 455 l/ha at engine speed of 2000 and 1480 rpm, respectively at the gear position 4. The spray deposition can be increased or decreased by varying the engine speed, type of nozzle, diameter of the nozzle orifice. The spraying should be carried out in favourable weather condition.

Deposition increased with the decrease in fluid level. The rate of increase of deposition is almost same in all engine speed. Constant deposition rate can not be maintained for changing speed.

The total fabricating cost of the power tiller mounted boom sprayer was about Tk. 5000 and the operating cost per hectare was calculated to be Tk. 135.00.

Suggestions for future work

1. A high pressure low volume rotary pump may be employed in the sprayer for spraying in different height of targets.
2. Appropriate size of boom for the sprayer should be identified for higher field capacity.
3. A provision should be made to vary height of the boom from the power tiller to ground for spraying different crops in different times.

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