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Research Paper

Development and performance evaluation of drive wheel driven boom sprayer

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ABSTRACT

In India, varieties of sprayers (manual or power operated) are typically used for spraying. However, these conventional sprayer types ultimately come with several downsides. Traditional spraying methods have drawbacks such as increased running costs, labor requirements, time consumption, discomfort, fuel unavailability, vibrations, noise, operating costs, water wastage, and health hazards for farmers. A new sprayer has been developed to address these issues and provide better efficiency, safety, economics, and ergonomics. The sprayer was developed at COAE&T SKUAST-K in the year 2021 and the performance of the developed sprayer was evaluated at three levels of forward speed (2.11, 2.55 and 3.44km h^{-1}), three levels of boom height (31, 41and 51 cm) and three levels of pump operating pressure (1.30, 1.50 and 1.75 kg cm^{-2}) with its response parameters being discharge rate (ml min^{-1}), swath width (cm), rate of work (ha/h) and field efficiency (%). Based on optimized operating parameters of forward speed 3.44 km/h, boom height 51 cm and pump operating pressure 1.50 kg/cm^2, the developed sprayer resulted in discharge rate of 392 ml min^{-1}, swath width of 26 cm, effective field capacity of 0.212 ha/h with field efficiency 93.62%. Benefit-cost ratio, Break-even point and Payback period for the developed prototype were found to be 1.54, 0.65 ha and 284.28 h, respectively. The total operating cost of operation per hour was found to be Rs.73.47. Thus, performance of developed prototype of sprayer was found satisfactory and economically viable.

Key words: Spraying, boom, pressure, height, speed, discharge, efficiency, operating cost

India is agriculture based country and it plays a vital role in Indian economy. Approximately 70% of population of India is dependent on farming directly or indirectly. Its contribution to GDP (2020-21) is around 19.9% (Shagun, 2021). More than 82% farmers are belonging to small and marginal land holders (FAO report, 2018). Agriculture sector includes a lot of field work, such as weeding, reaping, sowing etc. Apart from these operations, spraying is also another important operation to be performed by the farmer to protect the cultivated crops from insects, pests, funguses and diseases for which various insecticides, pesticides, fungicides and nutrients are sprayed on crops for protection. Plant protection equipment plays a crucial role in agriculture by enhancing the productivity of various crops. Agricultural pests, which include organisms such as fungi, bacteria, viruses, insects, mites, nematodes, weeds and grain-eating birds, that live on and/or compete with plants determine, to a varying degree, if crops can be grown economically in certain situations. Usually, agricultural pests inflict considerable damage to crops and represent a significant production constraint.

The pesticide/insecticide needs to be applied on plants and soil in the form of spray, dust or mist. Duster and sprayers are generally used for applying chemicals. Dusting, the simpler method of applying chemicals is best suited to vegetables and is usually requires simple equipment. But it is less efficient than spraying, because of low retention of the dust. High volume spraying to some extent overcomes the failings of each of the above two methods while retaining the good points of both. Different designs of spraying equipment have been developed for different types of application and field and crop condition. There are many types of pesticides sprayer available in India. But mostly used sprayer is backpack type sprayer which is used by farmers because it is cheaper, easy to use and main thing about it is less costly. It is suitable for all the crops having standing height up to 1.0 m (Dixit and Khan, 2009). With the help of this machine farmer spray pesticides in their farm, but it requires a lot of time and thus high operational cost. Also, the farmer while spraying pesticides is affected by it as it is harmful to human health and operator also experiences extreme lumbar pain due to weight of equipment. In Jammu and Kashmir also Knapsack sprayers either pressure operated or motor operated are widely and most commonly used sprayers (Dixit *et al*., 2014). Designs with varying tank capacity of 14, 16 and 25 liters are available. The field capacity is about 0.05-0.1 ha/h with an application rate of 250-400 l/ha (Bhuse *et al*. 2014). But knapsack sprayers are to be carried on shoulder for spraying in the field as such they become time consuming, costly and human fatigue with lumbar pain is a major concern. Some researchers designed and developed modified sprayers as a replacement of knapsack sprayer. Dash *et al*. (2020) designed self-propelled intra-canopy boom spraying system for spraying chemicals in small height row crops. Flat fan and hollow cone nozzles were tested to determine the boom volumetric distribution, swath and spray angle at different combinations of pressure and height. The fat fan nozzle gave better volumetric distribution at 2.5 kgf.cm^{-2}, while the hollow cone nozzle gave at 2.0 kgf.cm^{-2} pressure corresponding to 300 mm nozzle height. The spraying system was tested on soybean crop at forwarding speeds of 1.5, 2.0 and 2.5 km.h^{-1}. With an increase in forwarding speed, the mean percentage of coverage decreased significantly (30.30 - 15.37 % for top and 20.01-4.12 % for bottom part of the leaves), and the mean droplet density varied significantly (277.35 - 243.40 no.cm^{-2} for top and 262.87 - 78.44 no.cm^{-2} for the bottom part of the leaves) at 5 % level of significance. The effect of forwarding travel speed, position of tags and nozzle types were significant ($p<0.05$) for mean droplet size, number median diameter, percentage coverage of leaf area and droplet density. The field capacity of the spraying system ranged between 0.22 and 0.36 ha.h^{-1} with an increase in forward travel speed from 1.50 km.h^{-1} to 2.50 km.h^{-1} at an average swath of 1.8 m. Shivarajakumar and Parameswaramurthy (2014) developed wheel and pedal operated sprayer that uses reciprocating pump with an accumulator to provide a continuous flow of liquid to create necessary pressure for the spraying action. This wheel operated pesticide spray equipment consumes less time and avoids the pesticide coming from the front of the nozzles which come in contact of the person who sprays pesticides. Similarly, Raut *et al.* (2013) developed agricultural pesticides sprayer which operates when pushed in forward direction. While pushing by using handles, front wheel rotates and the gear mounted at the axle of wheel starts to rotate and its rotation is then transferred to the pinion though the chain drive. The rotary motion of the pinion is converted into the reciprocating motion by the single slider crank mechanism, due to this arrangement the connecting rod moves upward and downward which then reciprocate the piston of single acting reciprocating pump mounted at the top of storage tank. The existing modified sprayer either animal drawn or power operated are not found suitable for the hilly region due to small and irregular shaped fields and high cost of the machines. Keeping in view of above stated problems, the current study was undertaken to develop and evaluate a drive wheel driven boom sprayer for field crops.

MATERIALS AND METHODS

Methodology: Drive wheel driven boom sprayer consists of main frame, drive wheel, supporting wheel, chain

Table 1. Specification of developed drive wheel driven Boom Sprayer

S. No	Components	Specification
01	Square Pipes	25.4 × 25.4 mm Cross Section
02	Drive Wheel	415 mm D 38 mm W 3mm T No. 01 No. of Lugs 22
03	Supporting Wheel	207 mm D 18 mm W 3mm T No. 02 No. of Lugs 11
04	Sprocket	No. 02 No. of Teeth 18 Steel
05	Chain	No. 01 Steel
06	Storage Tank	Capacity- 18 Litres Plastic 480 x 650 x 390 mm
07	Nozzle	Full Cone No. 02 Plastic
08	Operating Pump	Reciprocating/Piston Pump- Single acting
09	Control Valve	No.02 16mm D PVC
10	Elbow	No.01 16mm D PVC
11	T-Connector	No.03 16mm D PVC
12	Supply Pipe	Length 5m 12mm D Rubber
13	Pressure Gauge	Aluminium ≤ 10 kg/cm2
14	Weight of prototype	27.16 Kg

and sprocket arrangement, crank, connecting rod, sprayer tank, reciprocating pump, supply pipe, spray nozzle, control valve and pressure gauge. The 3-dimensional figure of the prototype was created using AutoCAD 2020 software **(Fig. 1).** The details regarding drive wheel driven boom sprayer are presented in **Table 1**.

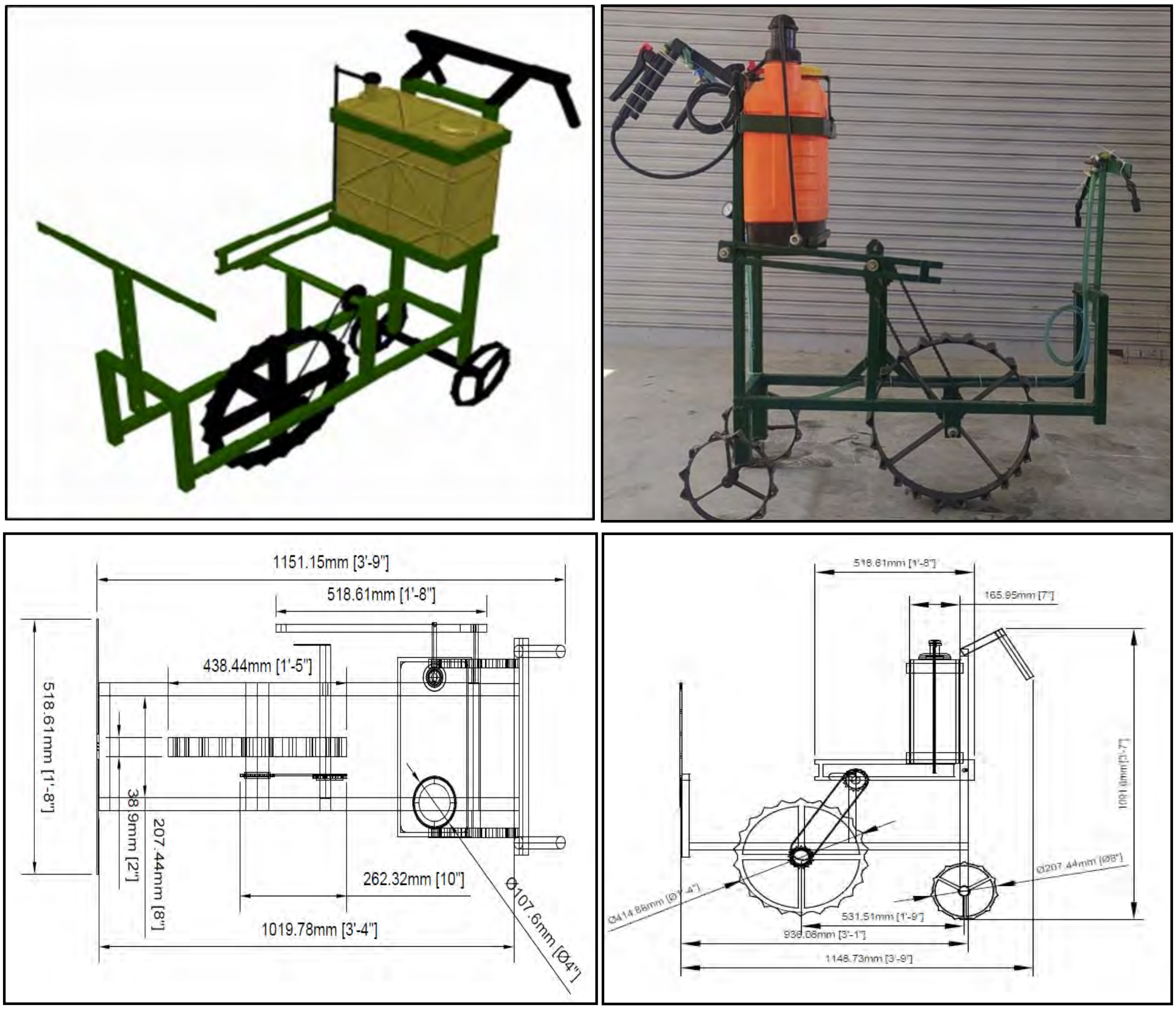

Fig. 1: Conceptual view and an overview of developed drive wheel driven sprayer

Frame: The frame of the machine was made up of mild steel square pipes with a cross-sectional area of 25.4 x 25.4 mm jointed with the help of arc welding. Mild steel Square pipe was chosen for the construction of the frame to keep the sprayer as sturdy as possible.

Drive Wheel: A single drive wheel used to create motion in the developed sprayer was made up of mild steel flat iron with 415 mm diameter and 38 mm width. The wheel is mounted on a 16 mm diameter axle. There were 22 lugs of angle iron of size 25.4 mm and were attached to the wheel surface to reduce slippage losses during operation.

Supporting Wheel: Two supporting wheels used in the developed sprayer were made up of mild steel flat iron with 207 mm diameter and 18 mm width. 11 lugs of angle iron of size 1.27mm were attached to the wheel surface to reduce slippage losses during operation.

Chain and Sprocket Arrangement: The chain and sprocket drive mechanism was used to transmit power from wheel sprocket to sprocket attached to a rotating shaft with no slippage. The name sprocket applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly and differs from a pulley in that sprockets have teeth and pulleys are smooth. Two freewheels and a chain for chain and sprocket arrangement was used.

Crank: A crank was used to transfer motion from the rotating shaft to the connecting rod for further operation**.**

Connecting Rod: The main function of connecting rod was to convert rotary motion into reciprocating/linear motion. Connecting rod converted the rotary motion of the crank to the reciprocating motion of the piston pump.
Sprayer Tank: A plastic tank of 18 liters capacity was placed on the cage fitted on the frame. The chemical solution was drawn from the storage tank through the supply pipe of the reciprocating pump through the trigger which was used to control the spraying and the excess amount was returned to the tank through the bypass valve. The chemical water is conveyed to the tank through the tank lid present at the upper side of the knapsack. The overall dimensions of the tank were 480 x 650 x 390 mm.

Reciprocating Pump: This pump was operated by using a reciprocating piston. The liquid enters a pumping chamber via an inlet valve and is pushed out through an outlet valve by the action of the piston or diaphragm. Reciprocating pumps are generally very efficient and are suitable for very high heads at low flows. The pump delivers reliable discharge flows and is often used for metering duties delivering accurate quantities of fluid.

Supply Pipe: Thick rubber pipes of 10 mm diameter were selected for conveying spray chemicals from the pump to spraying nozzles and bypass solution back into the tank. A total of 5000 mm length rubber pipe was used in the sprayer. The nozzles were fixed at the front end of the sprayer and the sprayer tank was placed at the rear end of the main frame. The pipe was tied along the body of the sprayer, starting from the top of the main frame and then running from the side of the sprayer up to the nozzles. The pipe was kept flexible at the front to adjust the spraying height. Additionally, the pipe was used to bypass any overflow back to the tank.

Spray Nozzle: Two full Cone Type Plastic Spraying Nozzles were fitted on a height adjustment iron strip. These nozzles were joined with a T-Joint with the supply pipe.

Control Valve: Two valves - One bypass valve (16 mm) and one outlet valve (16 mm) were used in the developed sprayer to control the flow rate of the chemical during spraying. The control valves used were light weighted and made of PVC. A bypass valve was used either to carry out excess chemicals back into the tank or release extra pressure generated in the supply line.

Pressure Gauge: A light-weighted aluminum body pressure gauge was used to continuously monitor the generated operating pressure in the supply line of the developed sprayer. The pressure gauge had two dials that measured pressure both in MPa and kg/cm^2. The pressure gauge was fixed just below the bypass valve in the supply line of the sprayer. The pressure gauge used could measure up to 10kg/cm^2 pressure at maximum.

Working Mechanism of Developed Sprayer: The sprayer prototype consists of the main frame, spray tank, reciprocating pump, traction wheel, boom, nozzles and flexible rubber hose pipe. The main frame is mounted on the axle shaft with a single traction wheel and carries the spray tank and pump integration and a boom assembly of 3m length with two sprayer nozzles. The spray tank is connected to the boom with the aid of distributing a flexible rubber hose via the integrated piston pump. The boom frame is attached at the front end of the main frame. The boom frame is designed in a way that the boom height can be adjusted as per the crop height between 62.5 – 72.5cm above the ground. The chemical in the spray tank is pumped to the flexible hose pipe by the piston pump integrated within the tank. The pump is actuated by an offset slider-crank mechanism, which gets the power from the ground wheel. During the operation, the operator simply puts the boom in a horizontal position and pushes the sprayer into the rows of the crop. While pushing using the handles, the ground wheel rotates, transferring power to the attached driving sprocket which in turn drives a smaller sprocket that is attached to a shaft through the chain drive. The rotary motion of the smaller sprocket is then converted into the reciprocating motion by the single slider-crank

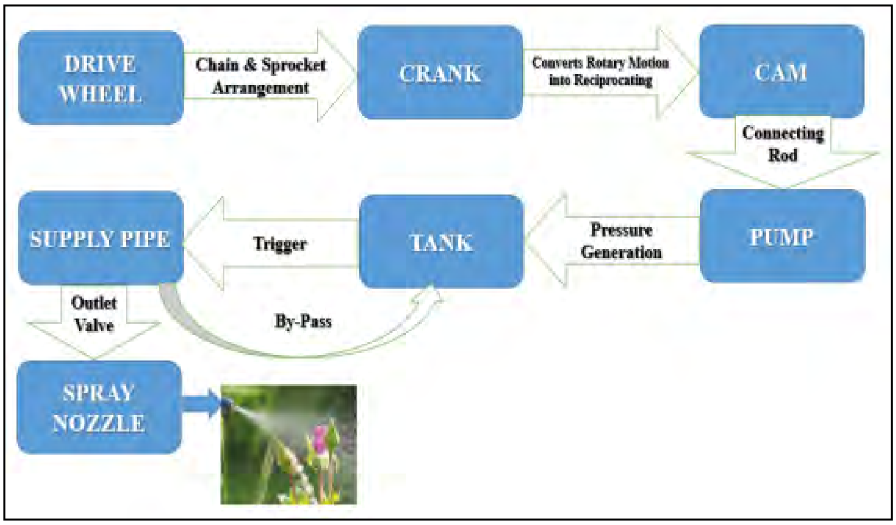

Fig. 2: Flow diagram for working of drive wheel driven boom sprayer

mechanism, which actuates the single-acting reciprocating piston of pump installed in the tank pumping the chemical to the boom **(Fig 2).**

Performance Evaluation of Drive Wheel Driven Boom Sprayer: The developed prototype of the sprayer was evaluated at the Farm Machinery Testing Centre of COAE&T and under actual field conditions at the experimental field of the Division of Vegetable Sciences, SKUAST-K, Shalimar. Different treatment combinations for considered variables with three replications were conducted to evaluate the developed sprayer in the field. The plan of the experiment was decided in terms of the forward speed of the machine, operating pump pressure and boom height of the sprayer which is given in **Table 2**.

Table 2. Plan for evaluating the developed prototype of Sprayer

Machine Parameters	Levels	Responses
Forward Speed (km/h)	S_1=2.11 S_2=2.55 S_3=3.44	• Discharge Rate(ml/min) • Swath Width(cm) • Field Capacity(ha/h) • Field Efficiency (%)
Boom Height(cm)	H_1=31 H_2=41 H_3=51	
Operating Pump Pressure (kg/cm^2)	P_1= 1.30 P_2= 1.50 P_3= 1.75	

Laboratory Test: The developed drive wheel driven boom sprayer was tested in the laboratory to confirm the appropriate working of the components of the sprayer and to establish the relationship between nozzle discharge, operating pressure, boom height and resulting spray pattern **(Fig. 3)**

Fig 3: Determination of discharge, swath width and spray pattern using Spray patternator

Spray Pattern: A spray patternator in Farm Machinery Testing Centre (FMTC), COAE&T was used to study nozzle characteristics. A patternator consisted of 40 channels aligned parallel to each other. Each channel had a graduated glass tube exactly below it for the collection of sprayed chemicals. Each channel had internal dimensions 200×2.5×10 cm. The nozzle of the developed sprayer was placed exactly perpendicular to the channels of the patternator. The nozzle was allowed to spray over channels of patternator for 1 minute (60 seconds) with varying levels of pump pressure 1.30,1.50,1.75 kg/cm^2 and boom heights31,41,51 cm in combination. The total number of combinations examined were 9 with three replications of each. The spray volume pouring from different channels of the patternator was collected in glass tubes. The spray volume of chemicals in different glass tubes was measured and recorded. The spray pattern of the nozzle was examined by plotting values of different channel volumes on a graph.

Swath Width: The swath width for each boom height with three levels of pump operating pressure 1.30,1.50and 1.75 kg/cm^{2}was measured on the spray patternator. A similar procedure as in determining the spray pattern was followed for measuring the swath width of the nozzle. The distance between the outermost channels on the spray patternator filled with sprayed water was measured in cm and concluded as the swath width of a spray of the nozzle.

Discharge Rate: The discharge rates for three levels of pump operating pressure (1.30,1.50,1.75 kg/cm$^{2)}$ at three boom heights (31,41,51cm) were calculated using a spray patternator. The nozzle was allowed to spray for about 1 minute. The total volume of liquid was collected in a beaker and then the collected liquid was measured in a measuring cylinder. Each procedure was repeated 3 times and the relationship between discharge rate and pump operating pressure was studied.

Field Evaluation: The evaluation of drive wheel driven boom sprayer was carried out on Brinjal and Chilli crop in the experimental field of the Division of Vegetable Sciences, SKUAST-K, Shalimar **(Fig. 4)**. Initially, the developed prototype of the sprayer was operated in 45.5×25 m^2 experimental plot at forward speed 2.11 kmh^{-1} with three levels of operating pump pressure (1.3,1.5 and 1.75 kg cm^{-1}) and 3 levels of boom height (31, 41 and 51 cm) independently each replicated three times. Similarly, the procedure was then repeated for forward speed 2.55 kmh^{-1} and 3.44 kmh^{-1} with each level of pump operating pressure and boom height. The operating pressure was regulated using flow control valve. The response parameters were measured for each of the replication comprising 27 treatment combinations in total. Three level full factorial design using Design Expert software version 10 was used for analysis of the developed prototype.

Fig 4: Field evaluation of developed sprayer at the experimental field

Discharge Rate (ml/min): A nozzle discharge test was done to evaluate the amount of liquid discharge from each nozzle and to check the variation between the discharge rates of each nozzle. The liquid was pumped as the sprayer moves and discharge data was collected and the time taken for each trial was recorded. Three replications were undertaken for this test. The discharge from each nozzle was collected by tying a plastic bottle to each nozzle. After each 30 m interval, the sprayer was stopped, as the sprayer stops the pump stops pumping and each liquid collected from the nozzle was measured using a measuring cylinder.

Actual Field Capacity(ha/h): For calculating actual field capacity, the time taken for actual work and that lost for other activities such as turning, filling of the tank were taken into consideration. The time required for actual operation and time lost were measured by stopwatch.

Actual capacity field was calculated by

$$\text{Actual Field Capacity (ha h}^{-1}) = \frac{A \times 36}{T \times 100} \qquad \textbf{(Hunt, 2008)}$$

Where,

A= Area covered by sprayer (m^2)
T=Total time taken (S)
Total Time Taken = Time taking in turning + Time taking in filling +Time taken for actual work

Theoretical Field Capacity (ha/h): Theoretical field capacity was calculated by

$$\text{Theoretical Field Capacity (ha h}^{-1}) = \frac{S \times W}{10} \qquad \textbf{(Hunt, 2008)}$$

Where,
S= Average Speed of the sprayer (km/h)
W=Operating Width of the sprayer (m)

Field Efficiency (%): Field Efficiency was calculated by the following formula

Field Efficiency (%) = $\frac{\text{Actual Field Capacity}}{\text{Theoretical Field Capacity}} \times 100$ **(Hunt, 2008)**

RESULTS AND DISCUSSION

The experiments were conducted in the laboratory and field conditions on the experimental field of the Division of Vegetable Sciences, SKUAST-K, Shalimar for performance evaluation of the developed prototype of the sprayer.

Discharge Rate (ml/min): The discharge rate of the nozzle was determined on the spray patternator at the Farm Machinery Testing Centre of COAE&T. The developed sprayer was allowed to run on a spray patternator for all combinations of pump operating pressure (1.30, 1.50 and 1.75) kg/cm^2 and boom height (31, 41 and 51) cm. The spray pattern of the nozzle was also studied by plotting values of different channel volumes on a graph in excel. At the pump operating pressures of 1.30, 1.50 and 1.75 kg/cm^2, the mean discharge collected was 358.66,388.33 and 411.66 ml, respectively. Results showed only pressure had a significant effect on the discharge rate of the nozzle **(Table 3).** Similarly, by plotting the volumes of spray collected in various channels of the patternator on an excel graph, we analyzed the spray pattern produced by each sprayer nozzle. In all treatment combinations, it was revealed from the graph that the nozzle used in the developed sprayer sprayed more volume at the center of the patternator (channel 16) and the volume of spray decreased both towards the left or right of the center of the patternator where the boom was placed **(Fig 5).**

Table 3. Effect of pump operating pressure and boom height on discharge rate of nozzle (ml/min)

Pressure (kg/cm^2)	Height			Mean (± Standard Deviation)
	H_1 (31 cm)	H_2 (41 cm)	H_3 (51 cm)	
P_1 (1.30)	354	359	363	358.66 (±3.6 SD)
P_2 (1.50)	384	389	392	388.33 (±3.2 SD)
P_3 (1.75)	412	409	414	411.66 (±2.05 SD)
Mean	383.33	385.66	389.67	

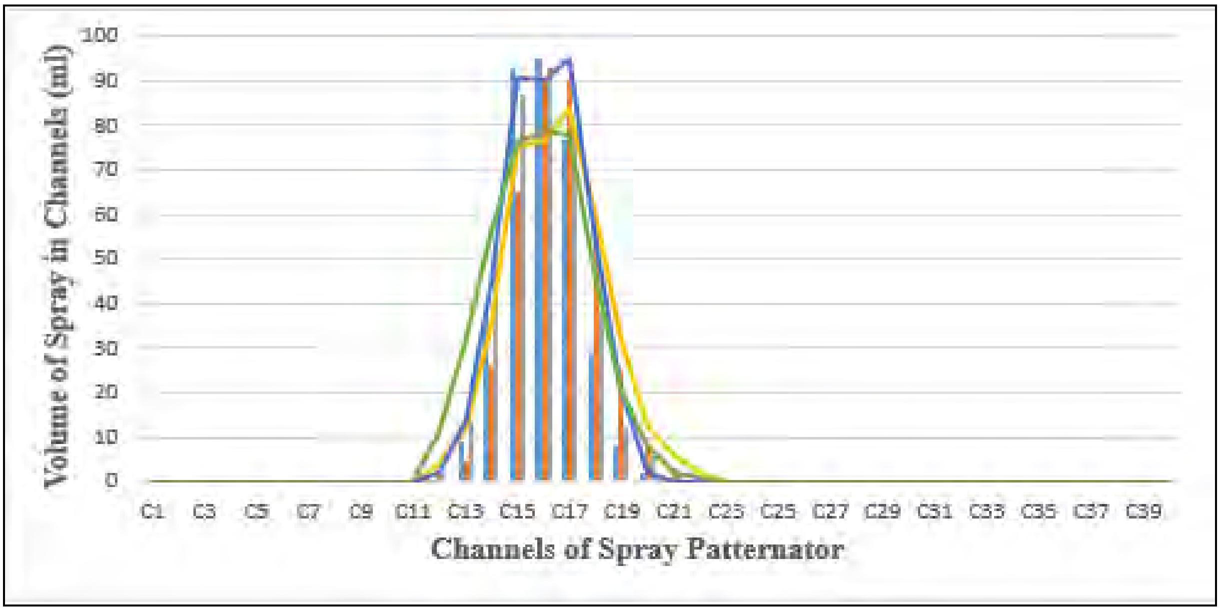

Fig 5: Distribution pattern of spray volumes volume in different channels of patternator in all treatments

Swath Width: The width covered by the spray volume of the nozzle into different channels of the patternator at each operating pressure and boom was termed the swath width of the nozzle. The distance between the outermost extreme Glass tubes on the spray patternator filled with sprayed chemicals on either side of the nozzle was measured in cm and taken as the swath width of a spray of the nozzle. The distance between two consecutive glass tubes was measured as 2.5 cm. The results showed that the swath width achieved was maximum at a higher pressure and higher boom height. At the pump operating pressures of 1.30, 1.50 and 1.75

kg/cm^2, the swath width achieved was 21.93, 24.57 and 27.20 cm respectively. Similarly, for boom heights of 31.0, 41.0 and 51.0 cm, the swath width achieved was 22.86, 24.81 and 26.04 cm respectively. Results showed that both pump operating pressure and boom height independently had a significant effect on swath width. The interaction of pressure and boom height showed no significant effect on variation in the swath width of a spray of the nozzle **(Table 4)**. It clearly showed that greater swath widths could be achieved by increased pressure and boom heights but that would cause higher drift losses.

Table 4. Effect of Pump Operating pressure and boom height on swath width of nozzle (cm)

Pressure (kg/cm^2)	Height			Mean (±Standard Deviation)
	H_1 (31 cm)	H_2 (41 cm)	H_3 (51 cm)	
P_1 (1.30)	19.90	22.60	23.30	21.93 (±1.47 SD)
P_2 (1.50)	22.77	24.95	26.00	24.57 (±1.35 SD)
P_3 (1.75)	25.90	26.87	28.83	27.20 (±1.22 SD)
Mean	22.86	24.81	26.04	

Rate of work (ha/h): The rate of work at the field conditions was independent of all the treatments and treatment combinations. The rate of work was affected by a change in the speed of the developed sprayer irrespective of the change in other independent parameters (pump operating pressure and boom height). The working width for the sprayer was taken as 0.6 m. The three theoretical forward speeds were calculated as 2.47 km/h, 3.10 km/h, and 3.75 km/h by allowing the sprayer to run a 40.5 m distance between two marked points and recording the respective time taken. The theoretical field capacity of 0.153 ha/h, 0.186 ha/h and 0.225 ha/h respectively. The three actual forward speeds of the sprayer were reported as 2.11 km/h, 2.55 km/h and 3.44 km/h considering all the field losses. The rate of work indicates the area covered in the field per unit of time. The rate of work or effective field capacity of the developed sprayer at forward speeds of 2.11 km/h, 2.55 km/h and 3.44 km/h was recorded as 0.130 ha/h and 0.162 ha/h and 0.210 ha/h respectively **(Table 5)** on an average for 3 replications of each **(Fig 6).** It was observed that mean values for field efficiency changed with forward speeds of 2.11, 2.55, 3.44 km/h and were calculated as 85.18 %, 87.27 % and 93.62 % respectively **(Table 6)** for three replications of each **(Fig 7).**

Table 5 Effect of forward speed of sprayer on theoretical and effective field capacity (ha/h)

Forward Speed (kmph)	Theoretical Field Capacity (ha/h)	Effective Field Capacity (ha/h)
S_1=2.11	0.153	0.130
S_2=2.55	0.186	0.162
S_3=3.44	0.225	0.210
MEAN	**0.188**	**0.167**

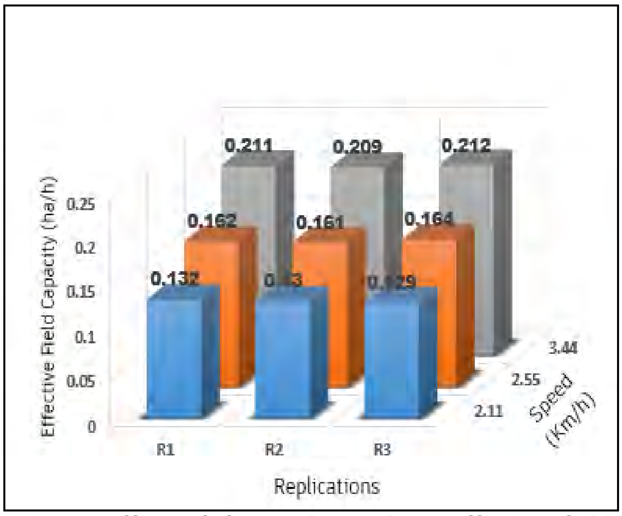

Fig 6: Effect of forward speed on effective field capacity developed sprayer

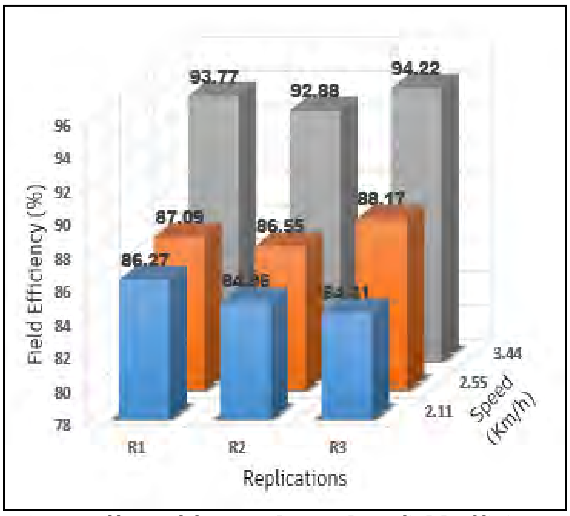

Fig 7: Effect of forward speed on field efficiency of developed sprayer

Table 6. Effect of Forward Speed of Sprayer on Field Efficiency (%)

Forward Speed (Kmph)	Field Efficiency (%)			Mean
	R1	R2	R3	
S_1=2.11	86.27	84.96	84.31	85.18
S_2=2.55	87.09	86.55	88.17	87.27
S_2=3.44	93.77	92.88	94.22	93.62

Cost Analysis: The cost analysis is an important factor that governs the adoption rate of the machinery among the farmers. The Straight line method was used to determine the cost economics of the developed sprayer. The cost analysis revealed that the operating cost of the machine was Rs. 73.74 per hour, breakeven point of 0.65 ha, benefit cost ratio of 1.54:1 and payback period of 284.28 hours. The cost of the developed prototype of sprayer was Rs.8221.

CONCLUSION

Pressure had a significant effect on the variation in the discharge rate of the nozzle of the sprayer. The results showed that the lowest mean discharge of 358.66 ml was obtained for pressure 1.30 kg/cm^2 and the highest mean discharge of 411.66 ml was obtained for pressure 1.75 kg/cm^2. The volume of spray (ml) decreased both towards the left or right from the center of the nozzle. With the increase in pressure and boom height, the swath width (cm) of the spray increased considerably. At a pump operating pressure of 1.75 kg/cm^2, the swath width achieved was 27.20 cm and at a pressure of 1.30 kg/cm^2, the swath width recorded was 21.93 cm. Similarly, for higher boom height (51cm), the maximum swath width achieved was 26.04 cm and for lower boom height (31 cm), the minimum swath width achieved was 22.86 cm. The average rate of work or effective field capacity of the developed sprayer at a forward speed of 2.11 km/h was recorded as 0.130 ha/h. Similarly, the average rate of work or effective field capacity of the developed sprayer at a forward speed of 3.44 km/h was recorded as 0.210 ha/h. It was observed that the mean value for field efficiency was 85.18 % for a forward speed of 2.11 km/h and the mean value of field efficiency for a forward speed of 3.44 km/h was calculated as 93.62 %. The economic analysis revealed that operating cost was 73.74 Rs. h^{-1}with 0.65 ha break-even point, 284.28 hours payback period and 1.54:1 benefit- cost ratio. The developed sprayer applies the pesticide at about 2 m away from the operator, which minimized the chances of exposure of chemicals to the operator, can reduce the drudgery and provide entrepreneurship opportunities to the rural youth of Jammu and Kashmir.

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