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SELF PROPELLED RIDING TYPE HIGH CLEARANCE SPRAYER



A SUCCESS STORY



ALL INDIA COORDINATED RESERCH PROJECT ON
FARM IMPLEMENTS AND MACHINERY
CENTRAL INSTITUTE OF AGRICULTURAL ENGINEERING
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HIGH CLEARANCE SPRAYER**

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Introduction

Cotton is a major *Kharif* crop of Punjab State. It is cultivated on an area of 7.54 million hectares with production of 130 lakh bales. Average yield of American cotton (890 kg lint./ha) and *Desi* cotton (265 kg lint./ha) in Punjab is significantly more than the national average of 292 kg lint/ha, but it is much below the yield levels in developed countries of the world. One of the reasons for the low yield is attack of insects and pests which adversely affects the crop. Average loss of cotton due to poor insect and pest control varies from 10 to 17 per cent. In case of severe attack, the loss is much higher. Thus an efficient high clearance power sprayer was required for spraying in cotton crop even in its advanced stage of growth.

Traditional Practices for spraying of chemicals in cotton crop

At present to control insects and pests, insecticides and pesticides are being applied by manually operated knapsack sprayers and tractor mounted sprayers. The use of manually operated sprayer is hazardous and tiresome, in addition to non-uniform spray and low output. Also these are not suited to tall crops like cotton and sugarcane especially at the later stages of crop growth. Tractor mounted sprayers modified in the Department of Farm Power and Machinery, PAU, Ludhiana for use on tall crops has become very popular in Punjab for spraying insecticides and pesticides on cotton.

Salient Features of the Machine Developed

The machine (Fig. 1) consists of a 20 hp diesel engine, gear box, a 1000 litre tank, seat for the operator, spray pump and a boom with 16 nozzles. The pump is of piston type and nozzles of hollow cone type. The engine is mounted on the chassis which has a ground clearance of 120 cm. The front wheels are narrow in width (20 cm) and are commercially available. The two rear wheels are steering wheels. A ladder has also been provided on the sprayer for riding on the machine. The gear box provides four forward speeds and one reverse speed. The 1st and 2nd gears are for field operation while the 3rd and 4th gears are for road transport. The field speed is upto 5 km/h and the road speed is upto 25 km/h. The boom height can be adjusted from 31.5 cm to 168.5 cm to suit different crops. The nozzles are spaced at 67.5 cm and total boom length is 1080 cm while swath of sprayer is 1200 cm. The drive to the pump is given directly from the engine with the help of a V-belt drive. A clutch is provided to engage or disengage the power to the spray pump. Provision has also been made to supply the liquid insecticide from the spray pump independently to three sections of the boom namely the central, left and right. Left and right sections of the boom can be folded during transport. A relief valve has also been provided with the pump to adjust the spray pressure. The machine has been provided with the steering wheel on the top of the platform. The steering wheel steers the rear wheels with the help of mechanical linkages. Left and right front wheels can be braked independently. Guards have been provided in front of the drive wheels to deflect the crop branches away from the wheels. This feature reduces the crop damage. The wheel tread is 135 cm and

during operation 2 rows of cotton crop come under the machine chassis. Seat for the operator on the chassis is provided above the highest boom position to provide safety to the operator against chemicals. Machine weighs 1900 kg with full tank. Specifications of the machine are given in Appendix-1.

Evolution of the Design

A tractor mounted sprayer was developed in the Department of Farm Power and Machinery, PAU, Ludhiana for use in tall crops which became popular. However, there was crop damage in cotton as it comes directly under the tractor tyres and chassis. Moreover, tractor operated sprayers can be used effectively for only first 3-4 sprays on cotton crop due to low ground clearance. Self-propelled High Clearance Sprayer (tri-cycle type) developed in the Department of Farm Power & Machinery, PAU, Ludhiana had a 6.5 hp diesel engine. The ground clearance was 147 cm and tank of 220 litre capacity. The machine was found to have traction problem under adverse field conditions. Difficulty in crossing the irrigation bunds was experienced during testing. The bunds on field boundaries had to be leveled while taking the machine from one field to another.

Keeping the above problems in view, technical guidance was provided to a manufacturer M/s Standard Agricultural Works, Haudiaya, Distt. Sangrur (Punjab) to fabricate a new Self-propelled High Clearance Sprayer with four wheels. The developed sprayer would also be used to spray insecticides and weedicides on other crops like sunflower, maize, wheat, potato, vegetables in addition to cotton because of the adjustable boom height. Economics of operation through high field capacity and low crop damage was also a design criterion.

Performance of the Machine

The detailed testing of the riding type self-propelled high clearance sprayer was carried out under actual field conditions from fourth spray onwards at the Regional Cotton Seed Farm, Faridkot which lies in the cotton growing area of the Punjab state. A total of 6 ha area was sprayed four times. A comparison was made regarding the crop damage that came under the chassis for both the tractor mounted as well as riding type self-propelled sprayers. Plant was considered to be damaged when either the plant stem was broken or when the branches were broken from the main plant.

Sprays from fourth stage onward are more critical as in the earlier stages, the crop is not tall and is without mature bolls. The height of the crop at the fourth stage of crop spray was in the range of 140-144 cm. This height is close to the height corresponding to fully matured crop. The field did not have any bunds as the area was canal irrigated by free flooding. At the time of spraying, the soil was loose and had ruts in the field because of interculture operation performed in the field by tractor operated specially designed tillers. The crop was row planted with drills at a row spacing of 67.5 cm. The crop variety was F-846 and the crop stand was average and it was not lodged at the time of spraying. The machine was operated in 1st or 2nd gear in the field and to adjust the spray discharge rate according to the travel speed, relief valve was manually adjusted. To provide a spray rate of 500-600 l/ha, relief valve has to be adjusted normally in the range of 0.5-0.7 MPa when the machine is operated in the 1st gear. It should be about 1.4 MPa when operated in 2nd gear. In addition to the above research trials the

machine was extensively used at the farmers fields on custom hire basis. The hire charges varied from Rs 50-65/ha. A total of more than 125 ha area was sprayed by this machine during the season. Data on slippage, field performance, mechanical breakdowns and crop yield in comparison to tractor operated sprayer were recorded.

Results and Discussion

Field performance results in Table 1 indicate that the machine can cover an area of 1.5-2.0 ha/h. The tank is required to be refilled after spraying about 4 ha area. The tank refilling time is 40 min. The ground speed varied from 2.2 km/h to 4.2 km/h depending upon the field condition. In a moist field where the soil was loose, the machine was operated in 1st gear as engine power seemed to be inadequate. Also 6.94 per cent slip that was observed, was on the higher side. In hard soil, the machine did not face any problem during its operation even in the 2nd gear. Fuel consumption of the engine was 1.25-1.50 l/ha. Water application for spraying varied from 200 to 250 l/ha depending upon the pump speed and pressure. In general, the pump was operated at 0.7 MPa. It was observed during the trials that complete plant damage was almost nil in both tractor, as well as self-propelled sprayer. Few plants were completely damaged when there was some problem in the steering which could happen in both types of sprayers. However, since the tyres are narrow in self-propelled sprayer, the chance of complete plant damage was relatively less. Data recorded in Table 2 show that there were more branches broken in case of tractor operated sprayer as compared to self-propelled sprayer both under the chassis and adjacent to the tyres. This was mainly because of two

reasons. Firstly, the ground clearance in high clearance sprayer was more (120 cm) which allowed most of the plants to pass under the chassis. The crop height was 145 cm and top 25 cm of the plant portion had to be deflected. In case of tractor operated sprayer, the ground clearance is generally 45 cm. In this case more than 100 cm plant is deflected which also carries more flowers and bolls. During the movement of the tractor, some of the bolls/flowers get detached. To get an estimate about the damage caused to pickable bolls, data was recorded which is given in Table 3. It may be observed from Table 3 that average pickable bolls per plant were 2.25 more as compared to tractor operated sprayer. This represents about 10 percent increase in the average pickable bolls as compared to the tractor operated sprayer. This will result in corresponding increase in yield of cotton.

Economics of machine operation is an important factor governing its adoption. Details of the comparative economics of the developed machine in comparison with tractor operated sprayer is given in Table 4. The calculations are based on the assumption that the annual use of the machine is 500 h. Based upon a machine capacity of about 1.6 ha/h, the annual crop area to be sprayed is 800 ha. If all the seven sprayings in cotton crop are done with the sprayer, area on which the machine is to be used is about 120 ha per season. It is also assumed that the sprayer is used only for cotton. With its high field capacity, the machine is suitable for custom hiring.

The machine is suitable for spraying weedicides in wheat also as the wheels of the machine are narrower than the conventional tractors. With its use in wheat also, its

economic viability is further improved. Its initial cost is Rs 1,80,000/-. The cost of machine operation is Rs 65/ha as compared to Rs 100/ha for the tractor operated machine. The current custom hiring rate is in the range of Rs 125-185/ha for commonly used knapsack or tractor operated sprayers. If it is assumed that for a tractor owner who wants to make a decision regarding the sprayer to be purchased, the cost of machine operation will be less considering operational cost only. However, with the tractor operated sprayers, there is damage to the crop which will result in decrease in yield as discussed earlier to the extent of about 10 per cent. Thus, if this factor is also taken into account, the machine operation will be economical even to a tractor owner.

Table-1: Field Performance Data of 4-wheel Self-propelled High Clearance Sprayer

Field speed corresponding to 3/4th of throttle, km/h	2.2 in 1st gear 4.2 in 2nd gear
Average nozzle discharge rate, l/min	1.43 at 0.35 MPa pressure
Tank filling time, min	40
Field capacity, ha/h	1.6 to 2.0
Water requirement, l/ha	200-250
Engine fuel consumption, l/ha	1.25 to 1.50
Slip in freshly ploughed field, % a) under optimum moisture condition b) under very high moisture condition	3.30 6.94

Table-2: Comparison of Crop Damage Caused by Self-propelled High Clearance Sprayer and Tractor Operated Sprayer During 4th Spray in Cotton Crop

Average plant height = 144.5 cm

Sl. No.	No. of plants in 5 m row length	Damaged branches in the 5 m row length directly behind the chassis		Damaged branches in the 5 m row length adjacent to the wheels	
		Tractor sprayer	Self propelled sprayer	Tractor sprayer	Self propelled sprayer
1.	17	8	1	5	0
2.	18	1	0	4	2
3.	10	3	0	6	1
4.	16	0	1	0	2
5.	09	0	0	3	2
Avg	14	2.4	0.4	3.6	1.4

Table-3: Advantage of High Clearance Sprayer over Tractor Operated Sprayer in Terms of High Yield of Cotton Crop

Sl. No.	Particulars	Tractor operated sprayer	High Clearance sprayer
1.	Attached bolls left per plant at the time at harvest	3.5	2.3
2.	No. of larvae found per plant at the time at harvest	0.3	0.4
3.	Left over bolls per plant that did not mature	3.0	6.8
4.	Average bolls collected per plant from the area not under the chassis and tyres (71.4% sprayed area)	22.5	23.1
5.	Average bolls collected per plant in the rows adjacent to wheels i.e. 2 crop rows (14.3% sprayed area)	19.6	21.6
6.	Average bolls collected per plant in the rows directly under the chassis i.e. 2 crop rows (14.3% sprayed area)	10.4	21.2
7.	Average pickable bolls per plant through weighted mean	20.36	22.61
8.	Loss in pickable bolls per plant in tractor sprayer in comparison to self-propelled sprayer.	2.25	-
9.	Yield loss in tractor operated sprayer in comparison to high clearance sprayer kg/ha at the rate of 3.0 g per boll and with 60,000 plants/ha.	405 kg (about 10%)	

Table-4: Economics of Self-propelled High Clearance Sprayer in Comparison to Tractor Operated Sprayer

Sl. No.	Description	Self-propelled High clearance sprayer	Tractor operated sprayer with hiring charges of tractor
1.	Price, Rs	1,80,000.00	8,000.00
2.	Life, year	10	10
3.	Annual use, h	500	500
4.	Annual interest on average cost, %	16	16
5.	Depreciation	St. line method	St. line method
6.	Salvage value, %	10	10
7.	Annual repairs & Maintenance	5% of price	5% of price
8.	Labour rate, Rs/h	10	10
9.	Fuel consumption. l/ha	7.0	-
10.	Fuel consumption. l/h	1.5	-
11.	Oils and lubricants	20% of fuel cost	-
12.	Average machine capacity, ha/h	1.6	1.6
Cost calculations:			
1.	Interest, Rs/h	36.68	1.40
2.	Depreciation, Rs/h	32.50	1.44
3.	Repair and maintenance cost, Rs/h	18.00	0.80

Sl. No.	Description	Self-propelled High clearance sprayer	Tractor operated sprayer with hiring charges of tractor
4.	Fuel cost, Rs/h	10.50	-
5.	Oil and lubricants cost, Rs/h	2.10	-
6.	Labour cost, Rs/h	10.00	10.00
7.	Hiring charges of tractor Rs/h	-	150.00
8.	Total cost of spraying, Rs/h	104.68	163.64
9.	Total cost of spraying, Rs/ha	65.40	102.30

Present Status of Technology

Mechanical damage caused by the movement of high clearance sprayer was found to be less in comparison to tractor operated sprayer. Average yield in a field sprayed by high clearance sprayer was more by 400 kg/ha than the field sprayed by tractor mounted sprayer. The performance of high clearance sprayer was found to be highly satisfactory. M/s Standard agricultural works, Haudiaya, Distt. Sangrur, Punjab is manufacturing riding type self propelled high clearance sprayer designating it as "Standard super delux spray pump model 5-2000 cc". Total 25 machines have been produced and supplied by the manufacturer.

Appendix-I

**Specifications of Riding Type Self-propelled High Clearance
Sprayer (4-wheel Type)**

Sl. No.	Specifications	
1.	Source of power	20 hp diesel engine
2.	Engine rpm	1440
3.	Crops for which machine is useful	Cotton, wheat, maize, vegetables, sunflower.
4.	Overall machine dimensions :	
	Length, mm	4300
	Width, mm	1950 (With folded boom)
	Height, mm	2650
5.	Ground clearance, mm	1200
6.	Wheel tread, mm	1350
7.	Total machine weight, (With full tank), kg	1900
8.	Cost of machine, Rs	1,80,000
9.	Number of gear box speeds	4 forward and one reverse
10.	Number of drive wheels	2
11.	Width of drive wheels, mm	200
12.	Number of toed wheels	2
13.	Maximum Road speed, km/h	25
14.	Maximum field speed, km/h	5

Sl. No.	Specifications	
15.	Type of boom	Folded from two sides
16.	Outer diameter of boom, mm	25
17.	Length of boom, mm	10800
18.	Width of boom coverage, mm	11500
19.	Number of Nozzles	16
20.	Nozzle spacing, mm	675
21.	Type of Nozzles	Hollow cone
22.	Boom height adjustment, mm	315-1685
23.	Type of pump	Piston type
24.	Pump pressure, MPa	1.4
25.	Type of pump drive	V-belt and pulley
26.	Tank Capacity, l	1000

Name of manufacturer : **M/s Standard Agricultural Works, Haudiaya, District Sangrur, Punjab**

Number of units produced : 25