PERFORMANCE OF BATTERY OPERATED KNAPSACK SPRAYER

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ABSTRACT

Spraying is one of the important and widely accepted operations in crop production to increase the yield of the crop. The proper selection of pesticides and application of correct dose at proper time are not only the attributes of a good performance in pest control, but in order to obtain maximum returns from their use, it is necessary to select the most efficient equipment for securing uniform deposit of pesticide on the target without any wastage of materials in least time and with minimum labour and fatigue. For achieving this purpose, the modernization of spraying equipment has gone hand in hand with the development of new agrochemical and improved techniques. In this study, deals with BOK design description including test procedures adopted under both laboratory conditions as well as in field condition. Discussed parameters like discharge rate, swath width, spray distribution pattern and droplet size etc. Theoretical field capacity and effective field capacity were measured.

KEY WORDS: Knapsack sprayer, plant protection

INTRODUCTION

The plant protection has assumed great importance today in the context of a national drive to attain self-sufficiency not only in food grain but also in other cash crops. Indian farmers are becoming aware of plant protection measures and the other production techniques and applying pesticides to save their crops from insects and pests. In India, there are about 400 insects and other animal pests, 250 diseases and 40 weeds, which causes varying degree of economic loss to the cultivated plants. There is hardly any crop which can be grown without any attack from insects, pests or diseases. Anonymous (1999a) reported that the various factors affecting crop losses like weed 33%, diseases 26%, insects 20%, Rodents 8%, Birds 35% and other organism 2%. The state wise reports presented at "All India Seminar on Crop Losses from Insect Pest" indicated that the losses were to the tune of Rs. 600 crores in Gujarat. It is claimed that 1 kg of fertilizer is known to produce about 10 kg of additional grain whereas 1 kg of pesticide produces 1 to 2 quintal of additional grains (Mukundan, 1964). Today the use of pesticide is recognized throughout the world as an effective, relatively simple and quick method of pest control. Spraying is one of the important operations in crop production. Battery operated sprayers are pest control

equipment rarely used by Indian farmers. Out of a total of 15 million sprayers in the country, hardly about 10 per cent are of this type. Basically, the battery operated sprayer is an electric energy type; and with appropriate fittings it can apply herbicides, pesticides and other compounds in small or large amounts to areas, strips, spots or individuals targets. Persons with a wide range of physique can use this type of sprayer. Male as well as female can use such a sprayer with minimum effort and have no much physical fatigue. A battery operated sprayer costs about Rs. 4500-5000 and gives service for 3 to 4 years. It requires 6 to 8 hrs of charging time and 3 hrs of working time. It has 12 volt battery with 7 Ah capacity. The controlling parameters for effective spraying of chemicals on crops are spraying pressure, spray height, spray droplets, spray volume, spray application area, leaf area index, etc. Proper calibration of sprayer should be made to obtain the desired results. The care and maintenance of sprayers before, during and after spraying should be made so as to obtain smooth and safe operation.

In India, about 91 percent of the total groundnut area and production, are confined to the states of Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, and Orissa. Out of which Gujarat ranks first in production and is grown in an area of 18.4 lac ha with a productivity of 1335 kg/ha. In Gujarat the region Saurashtra contributes 85 per cent and 81 per cent of area and production, respectively. In Saurashtra, Junagadh district ranks first with the area of 4560 ha and 4133 tonnes of productions (Anonymous, 1999b). Looking to the great importance of groundnut for various purposes, there is desire need to increase the groundnut production in order to meet domestic and industrial needs. Indian farmers understand the need for increasing their agricultural output. To do so, they are progressively adopting better varieties of crops and using fertilizer on a large scale. At the same time, they are becoming aware pesticides to save their crops from insects and pests. The groundnut crop is attacked by varieties of and diseases right from the time of seed sowing to pod harvesting from the field and also during storage. About 55 species of insects and pests are recorded on the groundnut crop. Among all the insects and pests, The aphids and The thrips are the major pest of great concern in Saurastra region. The problem of controlling insects, pests and diseases make it necessary to farmers and orchardists to include in their farm equipments, machines for applying for the application of these chemicals are known as sprayers and dusters most commonly used in plant protection works.

MATERIALS AND METHODS

This chapter deals with the design considerations and design description including test procedures adopted under laboratory conditions as well as field conditions. Measurement techniques and methods for determining various parameters have also been dealt with.

Construction detail of BOK (Battery Operated Knapsack) sprayer

Spraying is one of the important operations in crop production. BOK sprayers are electrically operated pest control equipment widely used by Indian farmers. Out of a total of 15 million sprayers in the country, 30 percent are of this type. Basically, the BOK sprayer is electric energy type; and with appropriate fitting it can apply

herbicides, pesticides and other compound in small or large amounts to areas, strips, spots or individual targets. Persons can overcome the physique with use of BOK sprayer. Mostly male and female workers can operate this type of sprayer. A BOK sprayer cost about Rs. 4000 – 5000 and give service for 3-4 years.

A typical BOK sprayer consists of plastic tank of 15 – 20 liters of capacities, connecting hose with a lance and a nozzle, and an operating lever (Figure 1). Two shoulder straps are attached to the tank for fixing the sprayer on the operator's back. Operation of the sprayer involves walking at a speed 1- 2 km/hr with the sprayer load. One of the hands holds the lance, presses the trigger and directs the spray at any desired location. The schematic view of battery operated knapsack sprayer is as shown in below Figure 1.

Set up of spray patternator

Spray patternator is available in the laboratory of plant protection equipment (FMP, CAET, JAU, Junagadh). The main components of spray patternator are spray table or main frame having dimension 155 × 90 × 160 cm and made of an angle iron (30× 30 × 5 mm and 20 × 20 × 2 mm). Spray channels are 25 ± 2.5 mm wide and 100 cm long made of G.I. sheet. They are 10 cm high vertical columns, which have V – type shape at the lower end and are 52 in number. Test tubes of 25 mm rim diameter and 200 mm in length are fixed on plastic support. Waste water trough was made of G.I. sheet with dimension of 1550 × 380 × 300 mm to collect the water from test tubes. Arrangement was made to mount single nozzle over it to study their pattern at different pressure (Figure 2).

Laboratory testing of nozzle

Following parameters were selected to carry out for laboratory testing of the nozzle.

i. Discharge rate
ii. Swath width
iii. Spray distribution pattern
iv. Droplet size

1. Discharge rate

The nozzle was attached to the sprayer and it was operated at a constant pressure. The liquid discharged for 1 min was collected in the measuring cylinder. Each trial was repeated for three times and average discharge rate was worked out in ml/min. The same process was repeated at the pressure of 3.2 kg/cm^2 to get the discharge rate at different pressure.

2. Swath width

Swath width or working width is the width to which the spray of nozzle extends. To measure the swath width of nozzle at different pressure using the spray patternator the distance between the first tube and last tube in which liquid is collected is measured as shown in Figure 3.

3. Spray distribution pattern

The nozzle was fitted on the tube which was connected to the supply line. The pressure was observed 3.2 kg / cm^2. Then pump was started to observe the spray. Sometime uneven spray was found due to improper fitting or sort of dirt particles remaining inside the nozzle. Such type of difficulties was eliminated to obtain proper spray from the nozzle.

When the spray pattern was properly developed (Azimi, 1985), the runoff from the channels were collected in the vertical glass tubes for a time of one minute at given pressure. This process was repeated for nozzle at 3.2 kg/cm^2 of pressure. Height of liquid column in the test tubes was measured. From the inside diameter of

the test tubes, the volume of the liquid collected in the test tube was worked out. From this data the nature of the pattern was plotted. Parts of nozzle and types of nozzles are also important for spray distribution pattern. The Figure 4 and 5 are for parts of nozzle and types of nozzle, respectively.

4. Droplet size

Droplet is substantially spherical liquid particle with a diameter generally less than 1000 µm.

a) MMD (Mass Median Diameter)

b) VMD (Volume Median Diameter)

The droplet size that divides the spray into two equal parts by volume, One half containing droplets smaller than this diameter, the other half containing larger droplets.

To measure the droplet size, first we have taken one white colored drawing sheet having size of 71 × 66 cm and centre line is drawn. The solution of $KMNO_4$ is sprayed through the given nozzle at the height of 30 cm above the centre line. After drying of sprayed liquid, we have cut the pieces having 5 × 5 cm in size from sample sheet and were evaluated the droplet size and spray distribution on the sample sheet with the help of microscope. Thus droplet size is worked out.

Field testing of BOK sprayer

The performance of BOK sprayer was evaluated in the field also to check its reliability, performance in the field. For field evaluation, field efficiency (F.E.) of the BOK sprayer was worked out with SNSL. A plot size in a field with fixed dimensions as marked. The selected subjects were given information about the experimental requirements. All the trials were conducted between 4.00 P.M. to 6.00 P.M. and the mean ambient condition such as temperature, relative humidity and air velocity were noted down. To calculate the speed of operator distance of 30 m in selected test plot was marked. The time required to cover the distance of 30 m was noted at the optimum pressure in BOK sprayer and covering each crop canopy. Thus the speed of operator was worked out in terms of m/sec. The distance between the two rows was measured by meter tape in order to obtain width. Thus, F.E. was worked out by using equation 1.

$$\text{Field Efficiency, (F.E.) (\%)} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100 \qquad (1)$$

Where,

$$\text{Theoretical Field Capacity } \left(\frac{ha}{hr}\right) = \frac{\text{Width (m)} \times \text{Speed (m/hr)}}{10000}$$

$$\text{Effective Field Capacity } \left(\frac{ha}{hr}\right) = \frac{\text{Width (m)} \times \text{Speed (m/hr)}}{10000}$$

RESULT AND DISCUSSION

The BOK sprayer is available in the department of farm machinery and power, CAET, JAU, Junagadh. The BOK sprayer was evaluated under laboratory condition as well as field condition. The observations of different parameters like Discharge rate, Swath width, Spray distribution pattern and Droplet size are presented and discussed in this chapter.

Laboratory testing of BOK sprayer

1.Discharge rate

The procedure for obtaining the discharge at a pressure of 3.2 kg/cm^2 and the results obtained is 800 ml/min. The discharge rate increased with increased in pressure as discharge rate is directly proportional to the pressure.

2.Swath width

Swath width for SNSL at a pressure of 3.2 kg/cm^2 is worked out 48 cm. Swath width is directly proportional to the pressure as the pressure the swath width also increased.

***3.Spray distribution pattern* (Bisen and Srivastava, 1985)**

The SNSL was tested on patternator for its spray distribution pattern at a pressure 3.2 kg/cm^2. The pattern is shown in Figure 8. The particulars regarding the test are as follows.

Height of nozzle in SNSL: 45 cm
Duration of test : 1 minute
Number of Replication: 3
Distance between two consecutive channels : 2.5 cm
Diameter of test tube : 25 mm (with rim)
Length of test tube : 20 cm

The spray distribution pattern for SNSL is shown in Figure 9. The total discharge rate of SNSL is 800 ml/min. The peak discharge rate of SNSL is 76 ml. The swath width of SNSL is 67.5 cm with increase in pressure, the peak discharge rate for SNSL remain almost remain same but its swath width increases with increase in area of coverage. Here the spray angle is worked out as 73^0.

4. Droplet size

To measure the droplet size and to divide it in category, we have decided the size limit under which different droplets can be categorized. That size limit is shown as below:

LARGE DROPS: More than 1000 µm
MEDIUM DROPS : 200 – 1000 µm
SMALL DROPS : Less than 200 µm

The results obtained for droplet size are presented in the Table 2 and number of droplets on pieces of sample sheet is shown in Table 3.

Field testing of BOK sprayer

1.Speed of the operator

For determining the speed of the operator, the procedure mentioned in the section A.4 is adopted. The trials were carried out at Mechanized Commercial Farm (MCF), J.A.U., Junagadh for groundnut crop. The row to row distance for ground nut crop was 0.71 m. The experimental trials were conducted in the month of September – 2009. The mean ambient conditions were; temperature 34 ^{0}C, relative humidity 42 (±10) % and air velocity 13.2 Km/hr. Speed of operator is calculated by equation 2. Three trials were taken for the ground nut crop and average speed of operator is presented in Table 4.

Speed of operator is calculated as below;

$$S = \frac{L}{T} \quad (2)$$

Where,

S = Speed, m/s
L = Total length of plot, m
T = Time taken to cover L, sec

2.Field efficiency

Field efficiency of BOK sprayer is shown in Table 5. As the speed is more, the field capacity increase and with less time more area can be covered.

$$\text{F.E. (\%)} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100$$

$$= \frac{0.0806}{0.1073} \times 100$$

$$= 75.11\ \%$$

$$\text{Theoretical F.C. } \left(\frac{ha}{hr}\right) = \frac{\text{Width (m)} \times \text{Speed (m/hr)}}{10000}$$

$$= \frac{0.71 \times 0.42 \times 3600}{10000}$$

$$= 0.1072 \text{ ha/hr}$$

Effective F.C. ($\frac{ha}{hr}$)

$$= \frac{\text{Width (m)} \times \text{Speed (m/hr)}}{10000}$$

$$= \frac{0.71 \times 0.42 \times 3600}{10000 \times 1.33}$$

= 0.0806 ha/hr

Here, we have considered 33% more time in case of effective field capacity due to tank filling, pesticide mixing, mounting of sprayer and turning at border of field, so that effective F.C. may always less than theoretical F.C.

CONCLUSION

Development of more effective, less toxic, easier to use, evolution of sprayer technology and a near boom in small plot farming all contributed to a vastly expanded array of small sprayers. Among the more visible classes of sprayers, knapsack sprayer is widely adopted because of its characteristics such as light in weight, durable, strong, corrosion resistance and comparatively low initial cost over larger costlier power spray units. But still knapsack sprayer lacks behind in giving its best performance due to certain constructional and mechanical drawbacks. The major factors influencing performance of the battery operated knapsack sprayer are wind velocity, type of nozzle and discharge.

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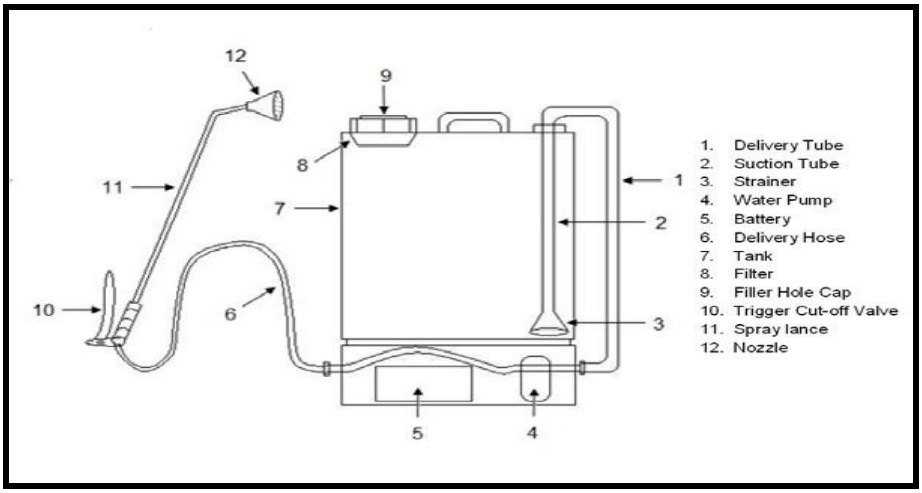

Fig. 1: Battery operated knapsack sprayer

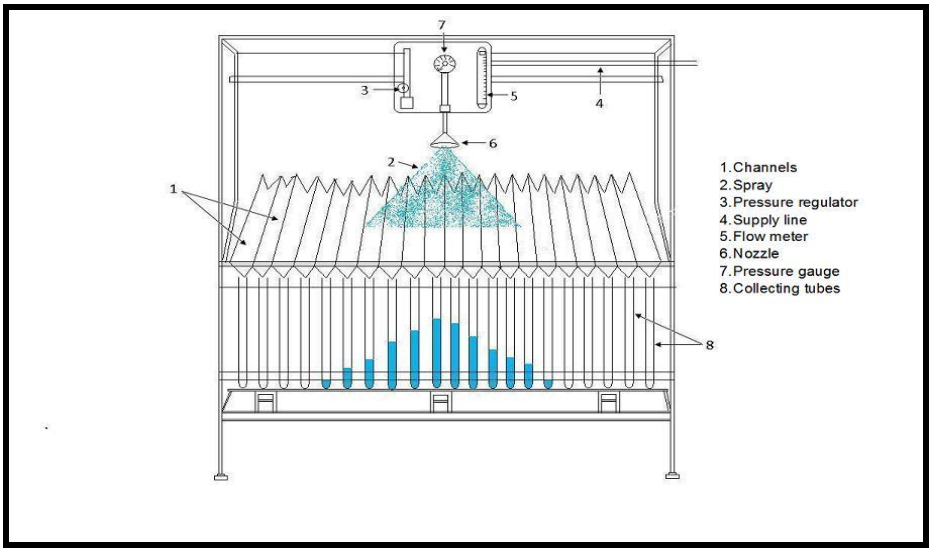

Fig. 2: Set up of spray patternator

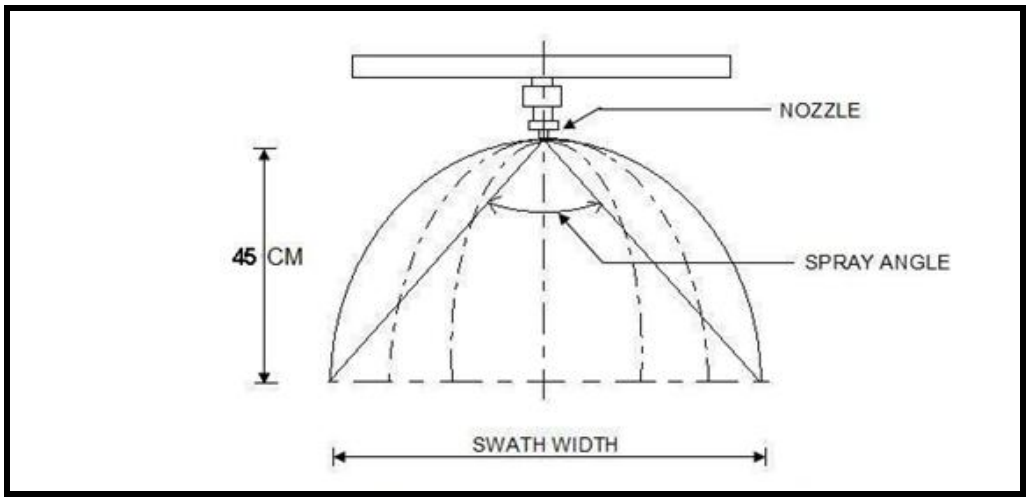

Fig. 3: Measurement of swath width

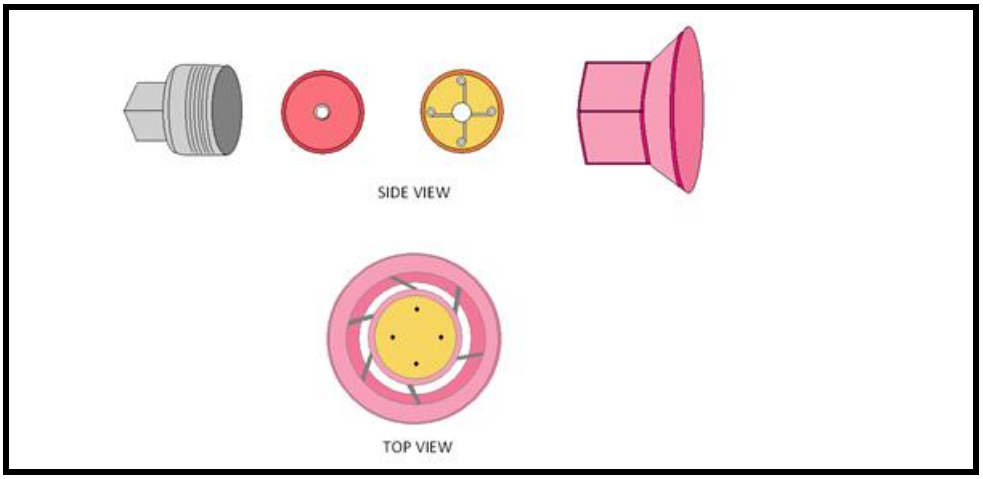

Fig. 4: Parts of nozzle

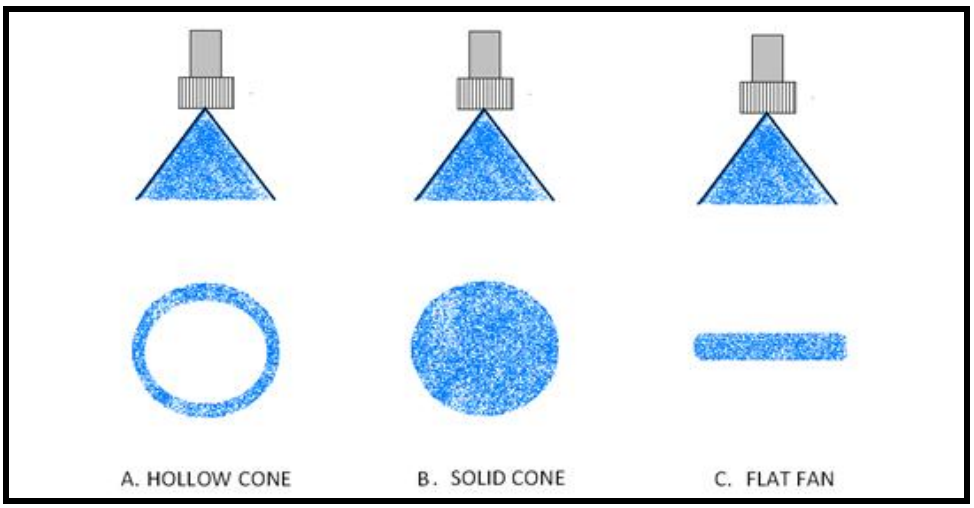

Fig. 5: Types of nozzle

Fig. 6: Set up of spray patternator for nozzle testing

Fig. 7: Spraying of $KMNO_4$ solution on patternator

Fig. 8: Testing of single nozzle spray lance on patternator

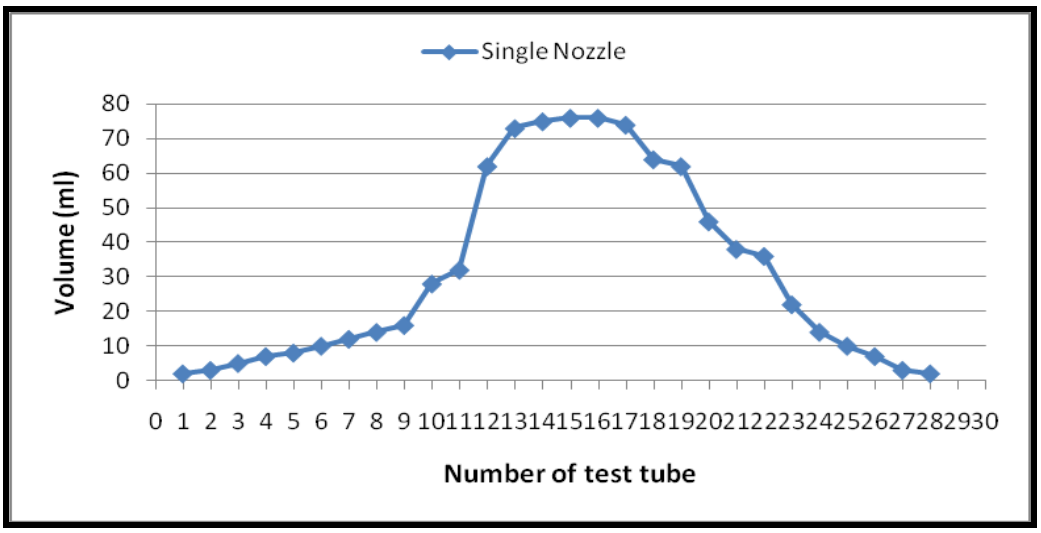

Fig. 9: Spray distribution pattern of nozzle

Table 1: Specification sheet for battery operated knapsack sprayer

No.	Particulars	Specifications/ Dimensions
1	**General**	
	Make	Kisanmitra
	Model	Auto spray pump
	Type	Electrical
2	**Tank**	
	Size (cm)	31.5 × 36 × 19
	Capacity	16 Lit
	Method of mounting	Shoulder Belts
	Safe pressure for spraying operation	3.2 Kg / cm^2
3	**Overall dimensions**	
	Length	36 cm
	Width	19 cm
	Height	40.5 cm
4	**Total mass**	
	With all accessories and without chemical	4.5 Kg
	With all accessories and without chemical tank full	20.5 Kg
5	**Battery specification**	
	Type	Sealed lead-acid battery (rechageable)
	Battery voltage	12 V
	Capacity	7 Ah
	Stand by use	13.6 V - 13.8 V
	Cycle use	14.1 V - 14.4 V
	Max. initial current	1.4 A
	Charging time	6 - 8 hr
	Operation time	5 hr
6	**Material of construction**	
	Spray tank	Polypropylene
	Tank colour	Blue
	Lance	Stainless steel
	Nozzle body	PVC
	Nozzle cap	PVC
	Nozzle disc and tip	PVC
7	**Accessories for operator's safety**	
	Hand gloves	
	Mask	
	Vibration absorbing pad	

Table 2: Droplet size wise distribution on sample sheet

	L5	L4	L3	L2	L1	C	R1	R2	R3	R4	R5
Small droplets (%)	80-85	75-80	55-60	50-55	35-40	25-30	35-40	45-55	60-65	65-70	70-75
Medium droplets(%)	15-20	25-30	35-40	35-40	40-45	50-55	40-45	40-45	30-35	25-30	25-30
Large droplets (%)	0.00	1-2	36-40	10-15	20-25	25-30	41-45	10-15	10-15	10-15	1-2

Table 3: Number of droplets wise distribution on sample sheet

No. of piece / No. of section	L5	L4	L3	L2	L1	0	R1	R2	R3	R4	R5
1	40	65	85	110	135	80	115	120	80	50	55
2	45	60	80	130	140	85	120	140	85	60	45
3	45	90	85	140	110	75	125	130	80	50	35
4	55	110	85	130	135	80	120	150	80	50	35
5	60	100	95	110	120	90	110	115	90	60	25
6	35	60	80	105	155	85	110	130	85	80	50
7	40	50	100	135	160	80	140	120	110	100	60
8	40	70	80	130	145	100	135	110	80	70	40
9	55	80	85	135	135	95	140	130	90	75	40
10	60	130	90	120	130	90	150	140	95	110	45
11	35	70	85	105	115	90	110	90	90	60	60
12	35	55	115	115	110	95	125	110	120	70	40
13	45	80	95	120	125	110	120	120	100	80	45
14	45	90	105	140	120	120	135	100	110	90	45
15	50	110	110	140	130	90	135	150	100	90	40
16	30	80	100	115	110	110	110	120	110	80	60
17	40	60	110	130	120	85	125	120	115	90	55
18	40	85	95	135	125	80	130	150	90	100	45
19	50	90	85	140	135	85	135	110	80	70	45
20	55	110	85	120	125	75	125	150	80	110	40
21	30	90	110	115	125	105	115	150	120	70	60
22	40	100	115	125	135	100	125	100	110	80	55
23	40	60	105	135	140	90	135	125	100	90	50
24	50	95	115	140	125	95	140	120	85	100	50
25	55	100	110	130	115	110	130	110	90	110	45

Table 4: Speed of the operator in field testing

Crop	Distance, m	Time taken, sec	Speed, m/s
Ground nut	30	70	0.42
		73	0.41
		67	0.44
Average			**0.42**

Table 5: Field efficiency of BOK sprayer

Crop	Row to Row distance, m	Speed, m/s	Theoretical F.C., ha/hr	Effective F.C., ha/hr	Field efficiency, %
Groundnut	0.71	0.42	0.1073	0.0806	75.11
		0.41	0.1047	0.0787	75.16
		0.44	0.1124	0.0845	75.17
Average		**0.42**	**0.1081**	**0.0812**	**75.14**

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