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A study on biometric and equipment parameters to develop portable knapsack boom power sprayer for chilli crop

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Abstract
The insect pests cause significant damage to the chilli crop. There are 39 genera and 51 species of insects attacking chilli in the field and during the storage. Pesticides are critical inputs for crop production worldwide and are expected to continue to play a major role for the foreseeable future to protect most crop systems from the infestation of insect pests and diseases. A study was conducted in in research farm, UAS, Raichur, to study biometric and equipment parameters influencing development of portable knapsack boom power sprayer. The type and variety of crop influence the quantity of chemical solution recommended per unit area. The height of crop varied from 909 to 985 mm with an average value of 957 mm. leaf area index of crop varied from 1.41 to 1.52 with an average value of 1.48. The row to row spacing varied from 855 mm to 927 mm with an average value of 900 mm. The plant to plant spacing varied from 285 mm to 309 mm with an average value of 300 mm. The equipment parameters such as pump capacity, pressure setting, tank capacity, rated power and weight of sprayer without solution were considered for development of portable knapsack boom power sprayer.

Keywords: Chilli, biometric parameters, equipment parameters, portable knapsack boom power sprayer

Introduction
India is the world largest producer, consumer and exporter of chilli. In India chilli occupies an area of 3.09 lakh hectares with an annual production of 35.92 lakh tonnes. In India, major chilli producing states are Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and Madhya Pradesh (Agriwatch, 2018) [1]. Karnataka stands third in area (1.02 lakh hectares) and production (1.03 lakh tonnes), while in productivity it ranks 12th in position (Anon, 2018) [2].
The chilli (*Capsicum annuum* L.) is an important vegetable cum spice crop grown in almost all parts of tropical and subtropical regions of the world. It belongs to the family solanaceae and originated from South and Central America where it was domesticated around 7000 BC. The genus capsicum includes 30 species, five of which are cultivated: *Capsicum annuum* L., C. *frutescens* L., *C. chinense jacq*, *C. pubescens* and *C. baccatum* L. (Bosland and Votava, 2000; Wang and Bosland, 2006) [4, 8]. *Capsicum annum* is cultivated either for pungent fruited genotypes called chilli (synonyms: hot pepper, American pepper, azi, cayenne, paprika *etc*.) or non-pungent fruited genotypes called sweet pepper (synonyms: Capsicum, paprika, bell pepper, Shimla mirchi). Chilli has many culinary advantages. It comprises numerous chemicals including steam-volatile oils, fatty oils, capsaicinoids, carotenoids, vitamins, proteins, fibres and mineral elements (Bosland and Votava, 2000) [4]. Capsicum fruits may serve as a source of natural bactericidal agents to use in food and medicinal systems.
The Commercial cultivation of chilli is mostly confined to the tropical regions of the world, since it requires long and warm season for its growth and development. Chilli is known from prehistoric remains in Peru and was widely cultivated in Central and South America in early times. Chilli crop is raised over 1798 thousand hectares in the world, with a production of 3918 thousand tonnes. Highest production per unit area of 6615 kg per ha was recorded in China. The top ten chilli producing countries are India, Thailand, China, Pakisthan, Bangladesh, Vietnam, Nepal, Turkey, Laos and Cambodia. All Asian countries accounted for about 65% of the world production in 2017, the lion‘s share (chilli) is taken by India with 35.45% share in global production, followed by Thailand (9.7%), and China (7.8%) (Anon, 2018) [2].

One of the factors for low yield of chilli fruits is incidence of various insect pests. The insect pests cause significant damage to the chilli crop. There are 39 genera and 51 species of insects attacking chilli in the field and during the storage (Jadhav *et al.* 2004) [5]. The pest and diseases infestation is serious problem during the plant growth. In the present context, the spraying operation on field crops have been carried out using different types of spraying machinery like manually operated knapsack sprayer, motorised power sprayer and tractor drawn high clearance sprayer. A manually operated knapsack sprayers can cover 0.4 ha day^{-1} for 6 working hours and a motorized knapsack sprayer fitted with petrol engine can cover 1.2 ha day^{-1} for 6 working hours.
Normally motorised knapsack sprayer has been fitted with single nozzle and its improvement in covering the more area is possible by designing a suitable spray boom length fitted with multiple nozzles. The increase in width of boom fitted with nozzles generally covers more area of spraying within short period of time. This article presents the various biometric and equipment parameters which influence the development of portable knapsack boom power sprayer.

Material and Methods

Portable knapsack boom power sprayer was developed by considering the crop and equipment parameters which harbours the detailed investigation. Some of the important crop and machine parameters are discussed below.

Crop parameters

The kind of chemical solution to be sprayed on crop as per the dosage requirement is essential to control the pest and diseases. Thus it is necessary to understand the biometric parameters of the chilli crop, so that effective spraying can be achieved. The biometric parameters of the chilli crop were measured by using standard techniques. The following crop parameters were considered for the development of the portable knapsack boom power sprayer.

Type of crop

Based on type of crop, quantity of chemical solution recommended per unit area was calculated. The type of crop selected for spraying operation was chilli crop.

Variety of crop

Karnataka state is one of the important chilli growing area of the country. Some of important varieties of chilli dominant in market are Byadagi, Jwala, LC-334 *etc.* In the northern part of Karnataka Gulbarga (37.36%), Raichur (24.85%) and Bijapur (27.99%) are the top three areas covered under chilli. Majority of the crop are infested by the attack of pests like thrips and mites due to inefficient spraying of pesticide chemicals. Chilli crop variety, JCH-42 grown in research farm UAS, Raichur was selected for spraying operation.

Height of crop

Plant height is one of the key parameter to be considered in designing the sprayer. The adjustment of height of boom or height of nozzles depends on height of crop. It was measured from ground surface to height attained by leaf tip for randomly selected plants by using steel tape (Figure 1). Average of plant height was calculated by averaging all plant heights measured in the field. The data were noted and recorded for further assessment.

Fig 1: Measurement of plant height using steel tape Leaf area index (LAI)

Leaf area index influence the deposition of spray material. It is an area of one side of the leaves divided by the corresponding ground area. It is dimensionless parameter and considered to be gauge to assess the growth of plant. In order to calculate the leaf area index of crop at a particular stage, leaf area of three plants were randomly selected. In that total three leaves were selected randomly per plant and area of each was calculated using square method technique (Mathew, 1999) [6] from which the average leaf area of plant at that stage of the crop grown was calculated. With the known area of the plot and with known number of plants in a plot, the leaf area index can be calculated using the formula.

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Total ground area alloted for particular crop}}$$

Row spacing

Row spacing plays an important role for deciding the number of nozzles to be fitted on boom according to the distance between two rows. Row to row spacing of chilli crop was measured as distance between two centres of crop rows by using steel tape (Figure 2).

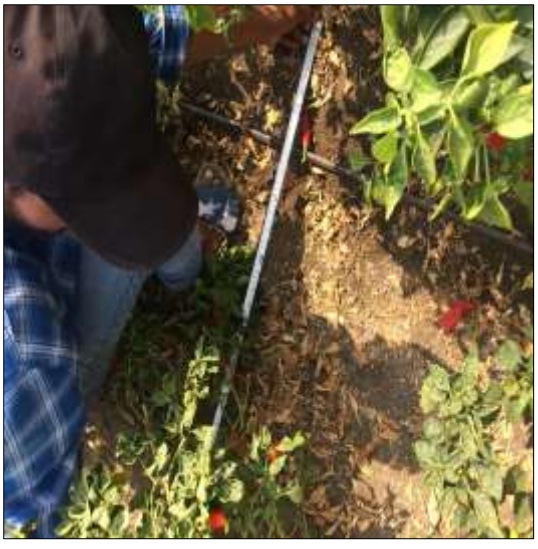

Fig 2: Measurement of row to row spacing using steel tape

Plant to plant spacing

Plant to plant spacing determines the plant canopy per unit area. It is the distance between centres of two adjacent plants in a row measured by using steel tape (Figure 3). at three different locations. Average was calculated and noted for further study.

Fig 3: Measurement of plant to plant spacing using steel tape

Stage of crop

The height of crop and its density increases with the stage of crop growth. In the early phenological growth stages a dynamic growth of leaves and densification of plant canopies takes place. Their retention ability increases considerably. Walklate *et al.* (2000) [7] proved that the level of deposition is inversely proportional to the density of tree canopies. Height of boom can be adjusted as per height of crop which increases with increase in stage of crop and also number of spraying operation depends on stage of crop. Stage of crop was noted down by considering the date of sowing.

Equipment parameters

The sprayer parameters considered for developing portable knapsack boom power sprayer include the pump capacity, pressure setting, tank capacity, rated power of engine, weight of the sprayer (Figure 3).

Fig 3: Measurement of weight of the sprayer without solution on weighing balance

Results and Discussions

Crop parameters

The biometric parameters of the chilli crop were measured by using standard techniques. The following crop parameters were considered for the evaluation of the portable knapsack boom power sprayer.

Type of crop

The type of crop selected for spraying operation was chilli crop.

Variety of crop

The Chilli crop variety, JCH-42 grown in plot size of 30 m × 55 m (width × length) at research farm UAS, Raichur was selected for spraying operation.

Height of crop

The spraying operation to be carried out by the machine mainly depends upon the height of the crop. At different places in the chilli field, height of crop was measured randomly and observations are presented in Table 1. The average plant height was found to be 957 mm. This height was considered for the adjustment of spray boom height in the portable knapsack boom power sprayer for uniform application of pesticide solution over the entire crop.

Table 1: Height of chilli plants

Sl. No.	Plant height (mm)
1	909
2	985
3	976
4	937
5	977
Average	957

Leaf area index

The leaf area index is dimensionless parameter and considered to be gauge to assess the growth of plant. It is an area of one side of the leaves divided by the corresponding ground area and the observations are furnished in the Table 2. The average value of leaf area index for chilli was found to be 1.48.

Table 2: Leaf area index of chilli plants

Sl. No.	Leaf area index
1	1.51
2	1.41
3	1.52
Average	1.48

Row spacing

The row to row spacing for chilli at different positions in the field was measured and average row spacing was found to be 900 mm and the observations are presented in the Table 3.

Table 3: Row spacing of chilli plants

Sl. No.	Row spacing (mm)
1	927
2	918
3	855
Average	900

Plant to plant spacing

The plant to plant distance of chilli crop within the row at different positions was measured and the average plant to plant distances was found to be 300 mm and the observations are furnished in the Table 4.

Table 4: Plant to plant spacing of chilli plants

Sl. No.	Plant to plant spacing (mm)
1	309
2	285
3	306
Average	300

Stage of crop

Number of spraying operation depends on stage of crop. Stage of crop was noted down by considering the date of sowing. The stage of crop was 114 days during the spraying operation. The details of biometric parameters of chilli crop is presented in Table 5.

Table 5: Details of crop parameters

Crop parameters		
Sl. No.	**Particulars**	**Details**
1	Plot size (L×B)	55 m × 30 m
2	Area (m^2)	1650
3	Type of crop	Chilli
4	Variety of crop	JCH-42
5	Height of crop (mm)	957
6	Leaf area index	1.48
7	Row to row spacing (mm)	900
8	Plant to plant spacing (mm)	300
9	Stage of crop (days)	114

Equipment parameters for development of knapsack boom power sprayer

The spraying criteria mainly depend upon the machine parameters which decide the quality of the spray during spraying operation. The machine parameters considered for the development of portable knapsack boom power sprayer include the pump capacity, pressure setting, tank capacity, rated power, weight of the sprayer. Equipment parameters considered for the development of portable knapsack boom power sprayer were measured using standard techniques and instruments. The data on machine parameters are presented in Table 6.

Table 6: Details of equipment parameters

Equipment parameters		
Sl. No.	**Particulars**	**Details**
1	Pump capacity (l min^{-1})	8
2	Pressure setting (kg cm^{-2})	15-25
3	Tank capacity (litre)	20
4	Rated power (hp)	1.0
5	Weight of the sprayer without solution (kgs)	14

Conclusions

This study was conducted in the research farm, UAS, Raichur, Karnataka, India. The crop and equipment parameters which influence the development of portable knapsack boom power sprayer were studied. The crop parameters such as type of crop, variety of crop, height of crop, leaf area index, row to row spacing, plant to plant spacing and stage of crop were studied. The type and variety of crop influence the quantity of chemical solution recommended per unit area. The height of crop varied from 909 to 985 mm with an average value of 957 mm. leaf area index of crop varied from 1.41 to 1.52 with an average value of 1.48. The row to row spacing varied from 855 mm to 927 mm with an average value of 900 mm. The plant to plant spacing varied from 285 mm to 309 mm with an average value of 300 mm. The equipment parameters such as pump capacity, pressure setting, tank capacity, rated power and weight of sprayer without solution were considered for development of portable knapsack boom power sprayer.

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