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Effect of Spraying using Sprayer Robot for Cotton Crop

AJAY MAKWANA* AND PRAMOD MOHNOT

ABSTRACT

Chemical pesticides have played and continue to play a major role in the rapid advancement of agricultural production. Farmers are continuously spraying the growing crop economically and profitably. Cotton crops are grown above human shoulder height at that time spraying operation is impossible to penetrate the canopy over shoulder height with manual spraying. At such stages overhead spraying was not given proper spray distribution. Mostly the chemicals do not hit actual target and cause wastages of spray material to the environment. It is necessary to apply pesticide in such manner that the maximum droplets are deposited on the target. Exposure to pesticides and poisoning is an also problematic among farming communities for their health due to side effects of pesticides. Therefore, this study was taken to solve spraying problem. First developed sprayer robot for cotton crop and it was run between two rows at constant speed by remote without any driver. The sprayer robot was evaluated for cotton crop in term of spray deposition (VMD, NMD, UC, spray coverage percentage) on top and bottom side of leaf at different height of crop. During evaluation, observed that VMD was increased with height of cotton crop and it varied from 149.73 μm to 426.93 μm, NMD was also increased with height of cotton crop and it varied from 70.60 μm to 215.99 μm, UC varied from 1.67 to 2.70 for cotton crop, coverage percentage varied from 4.54 % to 39.71 % for cotton crop.

Keywords: *VMD, NMD, UC, Coverage Percentage, Height.*

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INTRODUCTION

Agriculture is an important sector of Indian economy as it contributes about 17-18% to the total GDP and provides employment to over 50% of the population. India is the world's largest producer of milk, pulses and jute, and ranks as the second largest producer of rice, wheat, cotton, sugarcane, groundnut, vegetables, and fruits (Anonymous, 2020).

The yields apart from the variety mainly depend on the crop management like chemical spraying: plant protection is very important in cotton crop and farmers spray very high concentrated pesticides for several times (6 to 8 times) with manual spraying. The chemicals are highly toxic and cause lot of operational discomfort sometimes detrimental secondly intercultural operation. Cotton grown mainly under rain fed conditions where in intercultural operation is highly essential, for reducing nutrient competition from weeds, moisture loss from capillary pores and need to be destroyed and also to prune shallow roots so as to force the plant to develop deep roots and explore deep layers of soil for both moisture and nutrients (Suresh *et al.*, 2013). Due to urbanization and changed life-style of rural population in India, the dearth of agricultural labour-force has emerged and the cotton farmer is in compromise between taking up intercultural operation and loosing of yield (Shahare *et al.*, 2010). Since both intercultural operations in cotton are labour intensive and without which normal yields cannot be achieved, it is necessary to reduce the dependency on the human labour and perform operations efficiently mechanizing the operations is only the way-out.

Cotton crop plant height is more than plants width, making it almost impossible to penetrate the canopy at over shoulder height with manual spraying. At such stages overhead spraying was not given proper spray distribution. Mostly the chemicals do not hit actual target and cause wastages of spray material to the environment. It is necessary to apply pesticide in such manner that the maximum droplets are deposited on the target.

MATERIALS AND METHODS

This study was conducted at Junagadh Agricultural University. In this study developed a sprayer robot for a cotton crop was designed basis of engineering consideration and it was evaluated in term of spray deposition (VMD, NMD, UC, spray coverage percentage) on top and bottom side of leaf at different height of crop.

Developed Sprayer Robot

The developed sprayer robot for field crop view is illustrated in Fig.1.

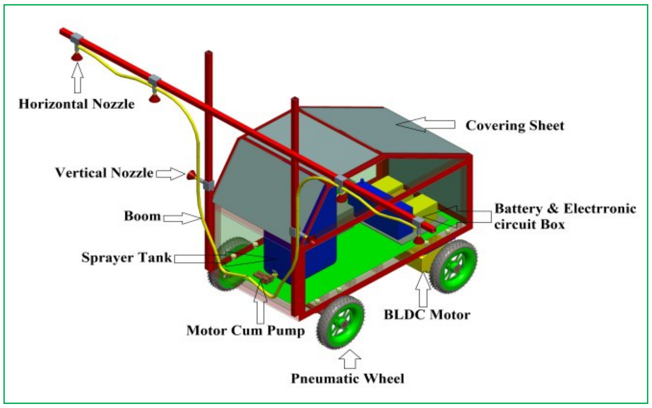

Fig. 1: View of sprayer robot

Deptt. of Farm Machinery and Power, Collage of Agricultural Engg. & Technology, Junagadh Agriculture University, Junagadh, Gujarat, India
*Corresponding Author E-mail: ramvaibhav.13492@gmail.com

Specifications of sprayer robot

Specifications of the developed machine are shown in Table 1.

Table 1: Detailed specifications of developed sprayer robot for field crop

Sr. No.	Particulars	Specifications	
A.	**Name of the equipment**	**Sprayer Robot**	
1.	**Overall Dimensions**		
i.	Length, mm	1080	
ii.	Width, mm	800	
iii.	Height, mm	900	
iv.	Weight, kgf	126	
2.	**Main Frame**		
i.	Material of fabrication	Mild Steel (Square pipe 40 × 40 mm)	
ii.	Length, mm	1080	
iii.	Width, mm	540	
3.	**Sprayer Unit**		
i.	Spraying Tank	Capacity	50 litre
		Material	High density plastic
ii.	Nozzles	Hollow Cone	
iii.	Hose Pipe		
iv.	Motor cum Pump	Electric diaphragm water pump	
v.	Pressure Control Valve	Type	Ball valve
		Material	UPVC
vi.	Boom	Horizontal	3000 mm
		Vertical	2200 mm
4.	**Power Transmission Unit**		
i.	BLDC Motor	Rated Voltage	48Volt
		Rated Power	500Watt
		Number of BLDC	2
ii.	Lithium-ion Battery for BLDC Motors	48 Volt 11 Ah	
iii.	Lead acid Battery for Sprayer	12 Volt 12 Ah	
iv.	Lead acid Battery for Transmitter	12 volt 1.3 Ah	
v.	Transmitter (Remote)	Frequency	433 MHz
		Power Supply	10Volt, 1.3 A
		Range	Up to 50m
vi.	Microcontroller	8 bit (Atmega 16)	
vii.	Voltage Regulator IC	12 to 5Volt Controller (IC 7805)	
viii.	Realy	4-Channel	
5.	**Transport Unit**		
i.	Type	Pneumatic	
ii.	Nominal Rim Diameter, mm	203.2	
iii.	Material	Rubber	
iv.	Number of Wheels	4	

Working of sprayer robot

The sprayer robot was be used in field crop for spraying purpose. Sprayer will run by remote without any driver and all components of this machine i.e. all motors are controlled by programmed based electronic circuit so farmer is free to handle this spraying operation in field and also free from toxic effect during spraying operation. As well as increases spraying uniformity and efficiency.

Droplet Size

Spray contains a large number of very small spheres of liquid known as droplets. Droplet size is an important factor for the pesticides to be applied effectively with minimum contamination to the environment. The droplet size requirement depends upon the pest, the pesticide, its mobility and mode of action. Droplet size influences the efficiency of catch of sprays by crop surfaces and insects. It also affects the uniformity and completeness of coverage on crop surfaces and drift of the material from the treated area. The considered unit for measurement of droplet diameters in the present study is micron (μm) which is equivalent to 0.001 mm; usually droplet size is presented as volume median diameter (VMD), number median diameter (NMD), uniformity coefficient (UC) and coverage percentage.

Droplet Size Determination

Digital image analyser was used to determine the droplet size in the present study. Collected samples of card from the field were analysed after 24 hours of application to ensure that droplets had stopped spreading 'ImageJ' most powerful electronic imaging program was used for analysing the sample card. ImageJ is a Java-based image-processing program used for the acquisition and analysis of images. It was developed by the National Institutes of Health and is now freely available to public (Zhu et al., 2011). ImageJ can be used to measure an area and count number of spots in the user-defined areas or throughout the entire image. The shape of selected areas could be rectangular, elliptical, or irregular. The program supports any number of images simultaneously and is limited only by the available random-access memory. Sample cards were scanned with high density pixels to JPG format for better analysis. These images were then processed in a computer with the help of ImageJ software to get the values of droplet size, droplets count and percent area covered.

RESULTS AND DISCUSSION

Cotton (RCH 2 BG II) was sown at 120 cm row to row spacing and 60 cm plant to plant spacing at village of Sanatha in Junagadh district. The performance evaluation of the sprayer robot was evaluated at different heights H_1 (< 50 cm), H_2 (50-100 cm) and, H_3 (> 100 cm), by determining droplet diameter, uniformity coefficient, coverage percentage for both manually (M_1) and remote operated methods (M_2). Results of these parameters for manually and remote operated methods are depicted in Table 2.

Table 2: Average values of manual sprayer for cotton crop in the field

Sr.No	Height	Position	VMD (µm)	NMD (µm)	UC	Coverage (%)
1	H1 (< 50 cm)	Top	308.66	164.18	1.88	26.93
		Bottom	133.66	91.64	1.45	6.73
2		Top	299.00	100.24	2.98	27.27
		Bottom	240.66	89.10	2.70	6.13
3		Top	385.00	138.43	2.78	36.85
		Bottom	226.33	101.52	2.22	8.16
4		Top	374.00	98.47	3.79	35.57
		Bottom	250.33	94.67	2.64	5.85
5		Top	346.33	167.39	2.06	33.91
		Bottom	142.66	86.76	1.64	4.87
6	H2 (50-100 cm)	Top	358.33	165.04	2.17	35.98
		Bottom	134.33	63.15	2.13	3.07
7		Top	310.67	108.17	2.87	31.04
		Bottom	205.33	86.32	2.38	6.26
8		Top	387.67	160.85	2.41	40.28
		Bottom	128.67	67.04	1.92	3.72
9		Top	314.00	121.51	2.58	26.57
		Bottom	122.33	68.02	1.80	4.55
10		Top	352.00	157.06	2.24	34.08
		Bottom	158.00	76.55	2.06	5.11
11	H3 (> 100 cm)	Top	348.33	135.18	2.58	37.26
		Bottom	161.00	78.16	2.06	7.90
12		Top	540.33	290.46	1.86	42.11
		Bottom	269.00	97.63	2.76	7.56
13		Top	383.67	178.17	2.15	29.93
		Bottom	113.67	47.36	2.40	4.06
14		Top	435.00	222.09	1.96	36.21
		Bottom	154.00	67.14	2.29	6.25
15		Top	427.33	207.21	2.06	35.12
		Bottom	168.00	62.73	2.68	3.54

Effect of different heights on VMD

The results of the effects of different heights on VMD at top and bottom side of leaf are graphically presented in Fig. 2 and Fig. 3 respectively.

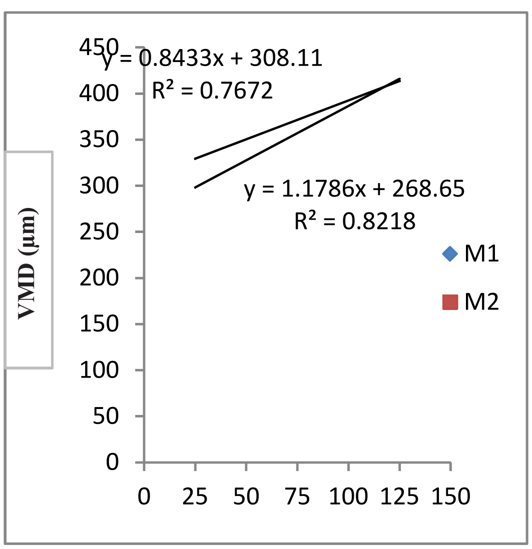

Fig. 2: Effect of different heights and both spraying methods on VMD at top side of leaf

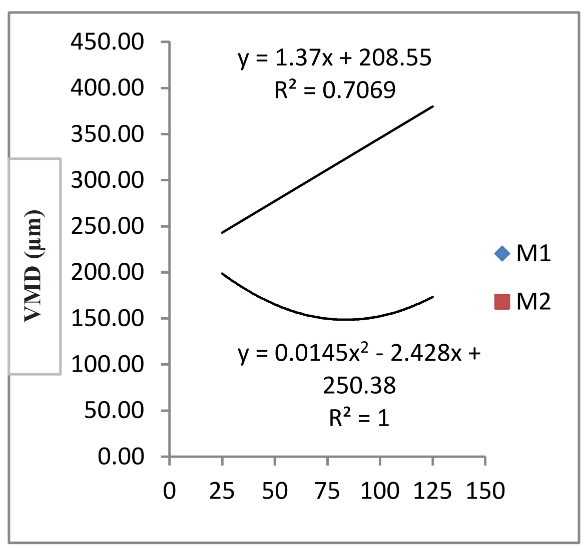

Fig. 3: Effect of different heights and both spraying methods on VMD at bottom side of leaf

Effect of different heights on NMD

The results of effect of different heights on NMD at top and bottom side of leaf are graphically presented in Fig. 4 and Fig. 5 respectively.

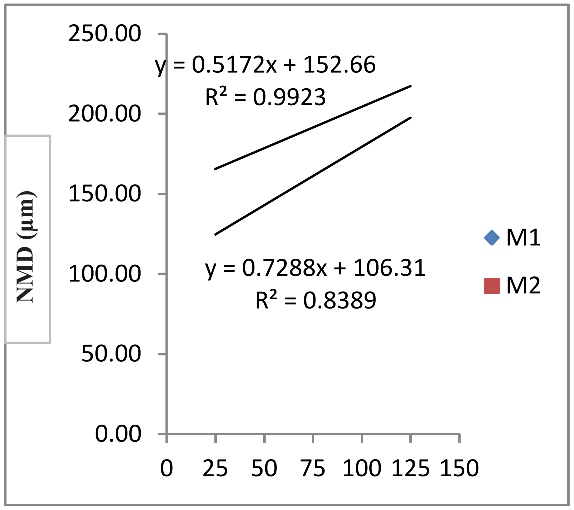

Fig. 4: Effect of different heights and both spraying methods on NMD at top side of leaf

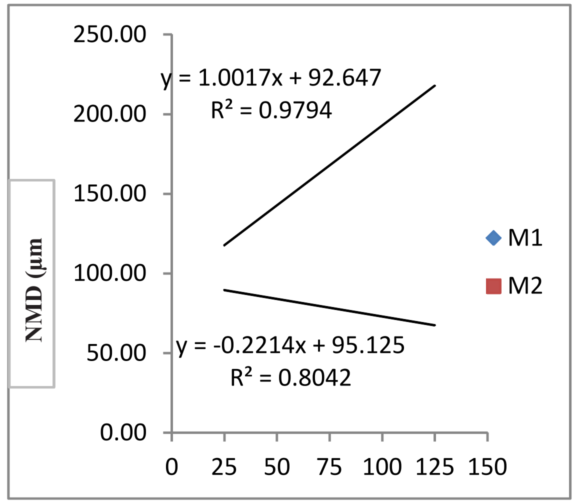

Fig. 5: Effect of different heights and both spraying methods on NMD at bottom side of leaf

Effect of different heights on UC

The results of the effects of different heights on UC at top and bottom side of leaf are presented in Table 2 & Table 3 respectively and effect of different heights on UC at both sides of leaf were found non-significant.

Table 2: Mean values of UC for different heights at top side of leaf

Height	H_1	H_2	H_3
UC	2.26	2.25	1.99

SEM 0.14 $CD_{0.05}$NS

Table 3: Mean values of UC for different heights at bottom side of leaf

Height	H_1	H_2	H_3
UC	2.08	2.10	2.05

SEM 0.13 $CD_{0.05}$NS

Effect of different heights on coverage percentage at bottom side of leaf (Cotton)

The results of the effects of different heights on coverage percentage at top and bottom side of leaf are graphically presented in Fig. 6 and Fig. 7 respectively.

CONCLUSIONS

VMD was increased with height of crop, maximum VMD was found 426.93 µm at (>100 cm) height of M_1 (manually) method on top side of leaf and minimum VMD was found 149.73 µm at H_2 (50-100 cm) height of M_1 (manually) method on bottom side of leaf. NMD was increased with height of crop, maximum NMD was found 215.99 µm at H_3 (>100 cm) height of M_2 (remote operated) method on top side of leaf minimum NMD was found 70.60 µm at H_3 (>100 cm) height of M_1 (manually) method on bottom side of leaf. Maximum UC was found 2.70 at H1 (< 50 cm) height of M_1 (manually) method on top side of leaf and minimum UC was found 1.67 at H_3 (> 100 cm) height

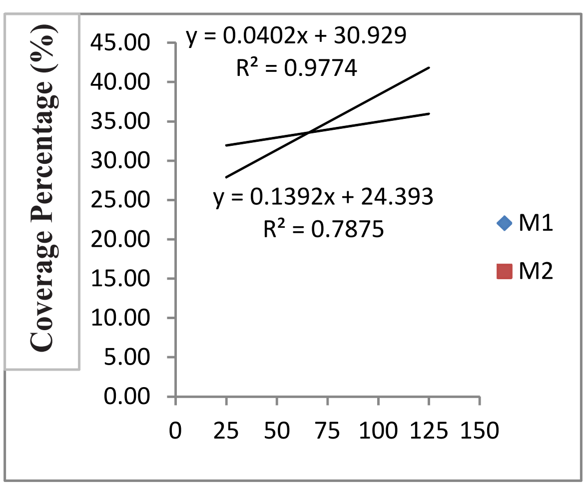

Fig. 6: Effect of different heights and both spraying methods on coverage percentage at top side of leaf

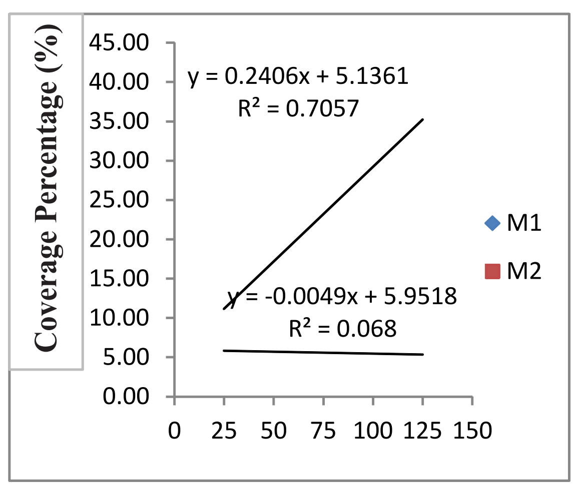

Fig.7: Effect of different heights and both spraying methods on coverage percentage at bottom of leaf

of M_2 (remote operated) method on bottom side of leaf. Maximum coverage percentage was found 39.71% at H_3 (>100 cm) height of M_2 (remote operated) method on top side of leaf and minimum coverage percentage was found 4.54 % at H_2 (50 - 100 cm) height of M_1 (manually) method on bottom side of leaf.

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