The Andhra Agric. J 71 (4): 425-433, 2024
doi :10.61657/aaj.2024.156

Evaluation of hexacopter UAV (ANGRAU PUSHPAK) spraying in management of sugarcane whitefly *(Aleurolobus barodensis* Maskell)

A Sambaiah, M Sudha Rani, Ch Madhuri and K Purna Chandra Rao
Centre for Andhra Pradesh Sensors and Smart Applications Research in Agriculture (APSARA),
Acharya N G Ranga Agricultural University, Regional Agricultural Research Station, Lam,
Guntur- 522 0434, Andhra Pradesh, India

ABSTRACT

The whitefly, *Aleurolobus barodensisis* is recorded to be major constraint in sugarcane production especially in low-lying, water-logged areas and in semi dry alkaline soils. A field experiment with cane Co V 09-356 (2003 V 46) (Bharani) was conducted at operational research project (ORP) area, Penamakuru Village, Krishna District, Andhra Pradesh during *kharif* 2021 and 2022. In 2021, 100% recommended dose of Imidacloprid 17.8 SL @ 50 ml/acre by drone was highly effective in reducing the incidence of whitefly (94.41%) compared to untreated control and produced the highest single sugarcane yield (1.17 Kg Cane wt), percent sucrose (19.5%) and purity of juice (94.3%) as against untreated control (0.89 Kg, 20.67%, 93.7%). This treatment was statistically equivalent in reducing whitefly population (92.74%) with 75% recommended dosages of imidacloprid 35 ml/acre by drone and 100% dosage with manual spraying.Whereas, 50% dosage with imidacloprid 25 ml/acre showed least. In 2021, qualitative parameters in 75%, 50% and manual spraying i.e. single cane wt was about (1.16 Kg,1.09 Kg, 1.09 Kg), percent sucrose (18.5%,20.4%,19.6%) and purity of juice (94.1%,88.4%,89.7%). In 2022, highest reduction of whitefly population, 92.93% with a cane yield (1.18 Kg), percent sucrose (20 %) and purity of juice (98.9%) with 100% recommended dosage of imidacloprid by drone as against untreated control (87.1%) and equivalent with 75%, 100% human back sprayer and lowest was in 50% recommended dosages. Moreover, the spray efficiency of UAV treatments was more compared to knapsack sprayer. The results showed the high potential use of UAV spray of insecticides for management of sugarcane whitefly was found in flight parameters of 1.0 m height and 4.5 m/s forward speed.

Key Words : *Bio Efficacy, Imidacloprid 17.8 SL, Phytotoxicity, Whitefly and UAV sprayer.*

Sugarcane is a major crop in Andhra Pradesh in about 0.050 million hectares of land, which is about 3.5 percent of the total area under sugarcane cultivation in India. Sugarcane is a long duration crop of 10 -12 months and therefore is liable to be attacked by a number of insect pests. According to an estimate, sugarcane production declines by 20-25% by insect pests. As per estimates, sugarcane production declines by 20.0 % and 19.0 % by insect pests and diseases (Shukla *et al.*, 2017). Sugarcane whitefly, *Aleurolobus barodensis*, *Neomaskellia bergii*, only these two species have been recorded damaging sugarcane in India. Both nymphs and adults suck sap from leaves and turn them yellow and/or pinkish in case of severe infestation. It's attack in the early stages of crop growth results in a serious setback to the crop and at the later stages causes deterioration in the quality of juice. The sugarcane crop raised in low-lying, water-logged areas and below in semi dry alkaline soils suffers more due to whitefly. Infestation is seen from August – October. Due to attack by this pest, cane juice becomes diluted and the jaggery (gur) quality is adversely affected. A loss of 30-40 per cent in sucrose and 20-25 per cent in total solids was estimated due to its attack. It is reported the loss to be of 15-20 per cent in yield and 1-2 units in sugar recovery due to the pest attack on crop.

Application of chemicals is very significant to control pest infestation than cultural practices. The available sprayers (wide swath spray boom for tall crop, self-propelled boom sprayer, bucket type sprayer, knapsack sprayer and aerial spray) are being used in grand growth phase, maturity and ripening phase and operational difficulties are faced by workers with physical and mental overload and exposure to chemicals (Singh *et al.*, 2020). Drones can be valuable tool for sugarcane farmers to improve their productivity and profitability in a way of crop climate inspections, with accurate and efficient feild applications. Considering the above concern, the present research was done to know the standard operating protocols, bio efficacy, phytotoxicity and standardisation of UAV sprayer at Centre for Centre for Andhra Pradesh Sensors and Smart Applications Research in Agriculture of Acharya N G Ranga Agricultural University, Guntur, in Sugarcane farmers field in k*harif* 2021 and 2022.

MATERIAL AND METHODS

The present research was conducted at operational research project (ORP) area, Penamakuru Village, Krishna District, Andhra Pradesh during *kharif* 2021 and 2022. The phytotoxicity, bio-efficacy, plant and yield parameters were studied during the UAV spraying of Central Insecticides Board and Registration Committee recommended chemicals against whitefly *Aleurolobus barodensis*.

Design of Plant Protection UAV for Spraying

A hexacopter UAV was designed and standardized specifically for plant protection spraying in agricultural crops by Acharya N G Ranga Agricultural University. The UAV built by ANGRAU was designated as "ANGRAU-Pushpak-01", a model RPAS (Remotely Piloted Aircraft System). The registration approval pertaining to the "ANGRAU-Pushpak-01" was obtained based on guidelines issued by Directorate General of Civil Aviation (DGCA) for its usage in agricultural operations for research purpose. The specifications pertaining to technical parameters and payload data of ANGRAU – PUSHPAK -01 drone for spraying are detailed below (Table 1).

Standardization of spraying height, time, direction of spray, drift, ambient temperature, time taken for drone flight, spray fluid volume and regularity of distribution of droplet deposition (vertical distribution) with ANGRAU Pushpak-01-UAV were done following the procedures given by DGCA, New Delhi.

Details of crop, soil, climate characteristics and experimental design

Imidacloprid 17.8% SL tested for its efficacy against whitefly *Aleurolobus barodensis* by imposing five treatments with different dosages . The treatments were imposed on Co V 09-356 (2003 V 46) (Bharani), variety was selected which is high yielding, sucrose rich, erect, early maturing, non-lodging, with excellent ratooning ability. It is suitable for waterlogged and irrigated conditions as well as uplands. The crop was raised during 2020 -21 and 2022-23 (Transplanted in 2021-22 & Ratoon from January, 2022) and ratooned for 2 years. The experiment was designed and laid in 5 acres with RRBD (Restricted randomized block design) with total 5 treatments and 4 replications. Treatments T1-100% RDP with drone spray 1.0m above crop canopy, T2-75% RDP with drone spray 1.0m above crop canopy, T3-50% RDP with drone spray 1.0m above crop canopy. T4-100% RDP with human back motorized sprayer and T5-Control (Water Spraying with drone). Imidacloprid 17.8 SL was 50 ml/acre at 180 days after planting (50 ml in 100% UAV, 30 ml in 75% UAV).

Bio efficacy studies on Sugarcane whitefly

Figure 1. An UAV spraying of recommended chemicals for bio-efficacy and phytotoxicity studies

Data collection and measurements Pest assessment

The population of whitefly at peak infestation levels was observed during II fortnight of July and treatment were imposed. The population of nymphs and puparia of whitefly per 10 sq.cm was recorded from randomly selected 25 leaves per plot at 1,3,7 and 10 days after spray and the percent reduction over control was calculated by Flemming and Retnakaran (1985).

Cane yield and Cane juice Quality parameters

Cane yield per hectare was estimated as a product of average single cane weight, and the total stalk population was counted in each experimental

Table 1. Technical parameters of Model Remotely Piloted Aircraft System (MRPAS) ANGRAU-Pushpak-01 for Plant Protection research.

SI. No.	Classification	Parameters
1	Official Designation	Model Remotely Piloted Aircraft System (RPAS) approved by DGCA.
2	Size (mm)	1495 mm X 1308 mm X 500 mm (Arms unfolded with motor and without propellers)
3	Category of drone	'Small' category with all up weight of 24.8kg
4	Motors Type and Specification	BLDC (Brushless Direct Current) with 180 KV rating; Input Current: 80A; IPX7
5	Maximum Thrust of each Motor	12kg/Axis (48V, Sea Level)
6	Battery Specification	16,000 mAH capacity with charging C rating 5C and discharging C rating :15 C and Burst Discharge rating: 30C; 6S1P; 22.2 V and 355.2 Wh
7	Spray width	2.8 m
8	Pay Load capacity	10-12 kg or Litres
9	Field Capacity	2.5 ha/hr
10	Spray system	Hydraulic
11	Flight mode	Autonomous
12	Navigation System	GNSS
13	Forward speed of the UAV	5.5 m/s
14	Nozzle type	Flat fan (VP 110015)
15	Number of nozzles	4 Numbers
16	Nozzle flow rate	0.42 to 0.45 lpm
17	Spraying direction	Vertically down
18	Spray angle	110 degrees
19	Spray fluid volume	25L ha^{-1} (Low volume and high concentration)
20	Radio communication frequency	2.40 GHz - 2.4833 GHz
21	Energy Source	2 No.s (1 Set) of 16000 mAh Li-Po battery with 15C rating.

unit at a crop age of 10 months. The juice was extracted from 12 stalk samples using a Jeffco mill for cane quality analysis. The quality parameters determined include Brix percentage (%), purity percentage (%), and recoverable sucrose percentage (%). The Brix % of the juice was measured by the Brix hydrometer. Purity (%) was determined by the percentage of sucrose or pol in the juice based on its brix.

Statistical Analysis: The data were transformed to " x+ 0.5 transformation before analysis and subjected to one way ANOVA using OP STAT software package. The treatments effect was compared by following Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Percentage reduction of *Whitefly* population over control (% ROC)

$$\% ROC = 1 - \frac{Post\ Treatment\ population\ in\ the\ treatment}{Pre - treatment\ population\ in\ the\ treatment} X \frac{pre\ treatment\ population\ in\ the\ untreated\ check}{post\ treatment\ population\ in\ the\ untreated\ check} X\ 100$$

Phytotoxicity Studies

Observations for phytotoxicity were taken on 1, 3 and 5 days after the insecticide application for the specific parameters like chlorosis, necrosis, wilting, scorching, hyponasty and epinasty by using following scale (Table 2).

RESULTS AND DISCUSSION

The results of the experiment conducted to control whitefly through UAV spraying and human back pack sprayer equipment with recommended chemicals is presented as detailed below.

Standardisation of UAV flight parameters with respect to Sugarcane crop.

The standard operating procedures (SOP's) (Table 3) for drone spraying in sugarcane crop using

Table 2. Grading scale for phytotoxicity measurement

Score	Phytotoxicity (%)	Score	Phytotoxicity (%)
0	No phytotoxicity	6	51 – 60
1	0 – 10	7	61 – 70
2	11 – 20	8	71 – 80
3	21 – 30	9	81 – 90
4	31 – 40	10	91 – 100
5	41 – 50	--	--

ANGRAU – PUSHPAK -01 (Figure 2) developed as the part of this experiment from elongation stage were used for imposing the spraying treatments. At the time of operating the drone in field conditions of sugarcane crop, which was at grand growth stage *i.e.*, at 180 days after planting, the plant heights were ranging from 189.0 cm – 199.0 cm at respectively.

Figure 2. ANGRAU PUSHPAK- 01; An UAV standardized for agricultural spraying.

Bio-efficacy of Imidacloprid 17.8 SL on sugarcane whitefly nymph + puparia

The incidence of whitefly in sugarcane during the study period 2021-22 had ranged from 13 to 179 number of nymph+puparia per 10 sq.cm in randomly selected 25 leaves. All treatments were found superior over control in reducing the whitefly population. The highest efficacy was recorded in 100 percent recommended chemical sprays with drone exhibiting 94.41 per cent reduction over control. The treatments 75 % recommended chemicals spray with drone and 100 % manual spraying had registered 92.74 % reduction over control as against 67.59% with 50%. (Table 4).

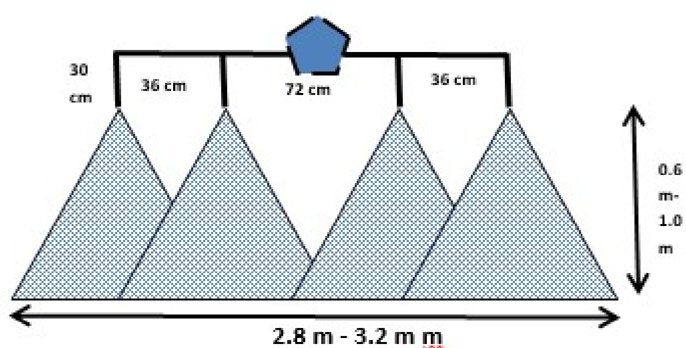
During the season 2022-23, the incidence of whitefly in sugarcane during the study period had ranged from 13 to 184 number of nymph+puparia per 10 sq.cm in randomly selected leaves. All treatments were found superior over control in reducing the whitefly population. The highest efficacy was recorded in 100 percent recommended chemical sprays with drone exhibiting 92.93 percent reduction over control. The treatments 75 % RD with drone and 100 % manual recommended chemicals spray with drone had registered 90.76 and 89.67% reduction over control respectively as against 68.47 % with 50% drone spraying.(Table 4).

The results obtained in the present investigation are in agreement with Bhavani and Rao (2013) where lowest number of whitefly population with highest per cent mortality of whitefly (84.47%) was recorded in the treatment with removal of infested leaves + application of imidacloprid 17.8%SL @ 0.3 ml /lt along with 2% urea which was significantly efficient than neem based and other cultural practices. Yallappa *et al.*, 2022 who noticed there was higher droplet deposition rate (1.79 µL cm^{-2}), area coverage (16.17%) and droplet density (48.00 droplets cm^{-2}) with UAV sprayer in the target area as compared to the non-target area (deposition rate: 0.39 µL cm^{-2}, coverage 3.54% and droplet density 10.00 droplets cm^{-2} respectively), studies by Yallappa *et al.*, 2023, in rice showed the average droplet densities cm^{-2} on upper and bottom layers as 36 and 30 droplets cm^{-1} respectively for UAV sprayer and 41 and 13 droplets cm^{2} for the knapsack sprayer in rice and this may be due to different crop canopy and heights. Sambaiah *et al.* (2022) who reported the chemical deposition (mg kg^{-1}) with drone with 100% RDP upper leaf (3.2 mg kg^{-1}) was nearly three times more than (0.9 mg kg^{-1}) in upper leaf of Knapsack sprayer 100% RDP. Zhang *et al.* (2019) reported the spray efficiency of UAV treatment was recorded 14.37 times more than that of Knapsack sprayer treatment in sugarcane.

Cane yield

The data presented in Table-5 indicated that all the insecticidal treatments produced superior cane yields 1.09 – 1.17 Kg, 1.09-1.17 Kg during 2021-2022, 2022-23 compared with the untreated control 0.81 Kg in 2022-23 and 0.89 Kg 2021-22. Among the treatments, 100% recommended insecticide spraying recorded 1.18 Kg cane yield in 2022-23 (31.38 per cent increase over the control) 1.17 Kg in 2021-22. The next best treatments were 75% RDP UAV sprayer, 100% manual, 50% RDP UAV sprayer with 1.16 Kg, 1.09 Kg, 1.09 Kg cane yields respectively which all are at par with each other in 2021-22.

Table 3 SOP of drone spraying in Sugarcane

Sl.No.	UAV Spraying Parameter / Condition	SOP's	Results Observed
A.	**Standardised parameters for UAV and spraying system**		
1.	Weight of the Drone	Small Category – 24.8 to 26.8 kg for spraying	The plants did not lodge, leaves, flowers and fruits did not drop
2.	Spray Fluid Volume	25 L ha^{-1} or 10 L $acre^{-1}$(Low Volume Spraying)	This volume is arrived based on relative reduction of the droplet size (100 -250 µm) from the conventional technology (300 -750 µm) and phytotoxicity studies.
3.	Nozzle Type & Specifications	Flat Fan & VP 110015	Manufacturer specifications
4.	Droplet size of the Nozzle	100-250 µm	Through water sensitive paper studies
5.	Discharge of each nozzle	1.42 to 0.45 lpm	Measured through Discharge test
6.	No. of Nozzles in Hexacopter	4 Nozzles	
7.	Arrangement of Nozzles	Beneath the rotors and strictly avoid boom arrangement to avoid formation of vertices which cause non-uniform spraying.	
8.	Spacing, vertical distance and arrangement of 4 nozzles on the drone. (Under 5 Kmph wind speed and 35^0C- static condition at 0.6-1.0 m height above crop canopy).	• Beneath the rotors at 30 cm from the arms axis. • Distance between nozzles from each other on either side at 36 cm. • The nozzle flow fan should be vertically downwards without any obliqueness. The nozzles should be adjusted accordingly. • All the nozzle tips must be aligned to be in horizontally parallel 	

<table>
<tr><th>B.</th><th colspan="7">Standard Flight parameters</th></tr>
<tr><td rowspan="3">9.</td><td rowspan="3">Optimal flight height (above crop canopy), Optimal drone forward speed and corresponding width of spray coverage</td><td>Sl. No.</td><td>Item</td><td>Drone Flight Height, m above crop canopy</td><td>Width of Spraying, m</td><td>Forward Speed of UAV, m/s</td><td rowspan="3">Arrived by studying the iterative operations to match 10 L delivery with speeds, widths and corresponding heights of spraying with no crop damage and with 10-15% drift losses</td></tr>
<tr><td>1.</td><td>Vegetative stage to Before Flowering stage</td><td>0.6-1.0</td><td>2.8</td><td>5.5</td></tr>
<tr><td>2.</td><td>From flowering stage onwards</td><td>1.0-1.5</td><td>3.2</td><td>4.5</td></tr>
<tr><td>10.</td><td>Recommended diurnal Schedule of drone spraying</td><td colspan="4">8-11 A.M. & 3.00 P.M. to 6.00 P.M.
(Avoid Rainy periods)</td><td colspan="2">Arrived based on the wind speeds & prevailing temperatures and corresponding spray coverage</td></tr>
<tr><td>11.</td><td>Optimum wind speeds recommended</td><td colspan="6">3-10 kmph wind speeds are good for insecticides, fungicides and foliar nutrients, PGR, PGI’s etc. and for herbicides, <5 kmph wind speeds are recommended with reduced flight height.</td></tr>
<tr><td>12.</td><td>Drone flight direction for spraying</td><td colspan="6">The direction of drone travel must be parallel to the longest side of the field. During exigencies, if wind speeds >10 kmph are prevailing, direction of drone travel must be parallel to the direction of the wind.</td></tr>
<tr><td>13.</td><td>Drift</td><td colspan="6">0.5-1.5 m effective drift on either side at 5-10 kmph wind speeds and temperature of about 35-40 ^{0}C is found.</td></tr>
<tr><td>14.</td><td>Optimal ambient temperature envelope</td><td colspan="6">35-40 ^{0}C. Drone spraying above 40 ^{0}C results in excessive vapour drift causes low bio-efficacy.</td></tr>
<tr><td>15.</td><td>Time for Drone spraying</td><td colspan="6">1. Net Time of 15 min. ha^{-1} and
2. Gross Time of 24.71 min. ha^{-1} (Including chemical filling, nozzle checking, battery replacement and pilot instructions to the farmers).</td></tr>
<tr><td>16.</td><td>Field Capacity of recommended 10L payload spraying drone</td><td colspan="6">2.43 ha hr^{-1}</td></tr>
</table>

Table 4. Bio-Efficacy of various treatments against whitefly infesting sugarcane during the season 2021-22 & 2022-23.

Treatments		Population of sugarcane nymphs and puparia per 10 cm-2 in 2021-22 & 2022-23.									
		2021-22					2022-23				
		1DBS	3DAS	7DAS	10 DAS	Per cent mortality	1DBS	3DAS	7DAS	10 DAS	Per cent mortality
T_1	100 per cent recommended chemicals with drone	122	59	35	10	94.41	140	65	37	13	92.93
		-11.05	(7.68)[a]	(5.92)[a]	(3.16)[a]		-11.83	(8.06)[a]	(6.08)[a]	(3.61)[a]	
T_2	75 per cent recommended chemicals with drone	131	60	41	13	92.74	148	68	48	17	90.76
		-11.45	(7.75)[a]	(6.40)[a]	(3.61)[a]		-12.17	(8.25)[a]	(6.93)[a]	(4.12)[a]	
T_3	50 per cent recommended chemicals with drone	117	87	64	58	67.59	151	93	70	52	68.47
		-10.82	(9.33)[a]	(8.00)[b]	(7.68)[b]		-12.29	(9.64)[b]	(8.37)[b]	(7.28)[b]	
T_4	Manual spraying of recommended chemicals	120	65	45	13	92.74	135	71	57	19	89.67
		-10.95	(8.06)[a]	(6.71)[a]	(3.61)[a]		-11.62	(8.43)[a]	(7.55)[a]	(4.36)[a]	
T_5	Untreated control	128	157	170	179	-	148	159	173	184	-
		-11.31	(12.53)[c]	(13.04)[c]	(13.38)[c]		-12.17	(12.61)[c]	(13.15)[c]	(13.56)[e]	
CD(p=0.05)		NS	2.01	1.57	1.74		NS	1.54	2.04	1.87	
CV (%)		11.57	18.57	21.54	10.98		13.99	16.54	10.57	13.58	

Mean of four replications; DAP: Days after planting; DAS: Days after spray Figures in parenthesis are square root transformed values Mean with same letter are not significantly different at 5% level by Duncan's Multiple Range Test. ROC: reduction over control Treatments imposed: Foliar spray of Imidacloprid 17.8 SL @ 0.25 ml/l at 180 DAP.

Cane juice Quality parameters

The results presented in Table 5 showed that all the insecticidal treatments recorded higher juice wt (0.59 Kg), higher sucrose content (19.5%), higher brix (%) 21.75 % and juice purity values (94.3%) as compared to the untreated control (19.7%, 20.67%, 93.7%). Among the test treatments, 75% RDP UAV sprayer recorded superior Juice wt (0.58Kg), percent sucrose (18.5%) and purity of juice (94.1%), manual sprayer (0.56 Kg, 19.6% and 89.7%) and 50% RDP UAV sprayer (0.57 Kg, 20.4% and 88.4%) were the best compared to other treatments and were significantly on par with each other.

Phytotoxicity due to spraying of chemicals with UAV sprayer at low volume

The results of phytotoxicity study (Table 6) that includes the scaling of yellowing/Chlorosis, stunting, necrosis, epinasty, hyponasty, wilting and scorching at 1, 3 and 5 days after spraying revealed that Imidacloprid 17.8 SL @ 50 ml acre^{-1} imposed on cotton crop from flowering stage to fruiting stage across all treatments did not show any phytotoxicity.

CONCLUSIONS

UAV spraying to control sucking pests is found effective and among treatments 100% recommendation of UAV sprayer as effective in controlling and produced the highest cane yield with both high sucrose content and juice purity. This was not significantly difference from applying, Imidacloprid 17.8% SL @ 35ml/lit with UAV and 50ml/lit with Knapsack motorized sprayer.

Though the droplet density with different dosages may not be different but deposition of chemical varies among different layer of plant. The

Table 5. Influence of various treatments on quality parameters of sugarcane crop during 2021-22 & 2022-23.

Treatments		2021-22					2022-23				
		Single Cane Wt (Kg)	Juice wt cane (Kg)	Brix (%)	Sucrose (%)	Purity (%)	Single Cane Wt (Kg)	Juice wt cane (Kg)	Brix (%)	Sucrose (%)	Purity (%)
T_1	100 per cent recommended chemicals with drone	1.17[a]	0.59[a]	21.75	19.5	94.3	1.18[a]	0.58[a]	20.21	20	98.9
T_2	75 per cent recommended chemicals with drone	1.16[a]	0.58[a]	21.71	18.5	94.1	1.17[a]	0.58[a]	20.74	19	91.6
T_3	50 per cent recommended chemicals with drone	1.09[a]	0.57[a]	20.11	20.4	88.4	1.09[a]	0.56[a]	20.59	19.5	94.7
T_4	Manual spraying of recommended chemicals	1.09[a]	0.57[a]	20.11	19.6	89.7	1.13[a]	0.57[a]	21.7	19.3	88.9
T_5	Untreated control	0.89[b]	0.47[b]	20.67	19.7	93.7	0.81[b]	0.47[b]	21.71	18.9	87.1
CD(p=0.05)		0.34	0.07	-	-		0.34	0.07	-	-	
CV (%)		11.58	25.88	-	-		11.58	25.88	-	-	

Mean of four replications; DAP: Days after planting; DAS: Days after spray. Figures in parenthesis are square root transformed values. Mean with same letter are not significantly different at 5% level by Duncan's Multiple Range Test. ROC: reduction over control Treatments imposed: Foliar spray of Imidacloprid 17.8 SL @ 0.25 ml/l at 180 DAP.

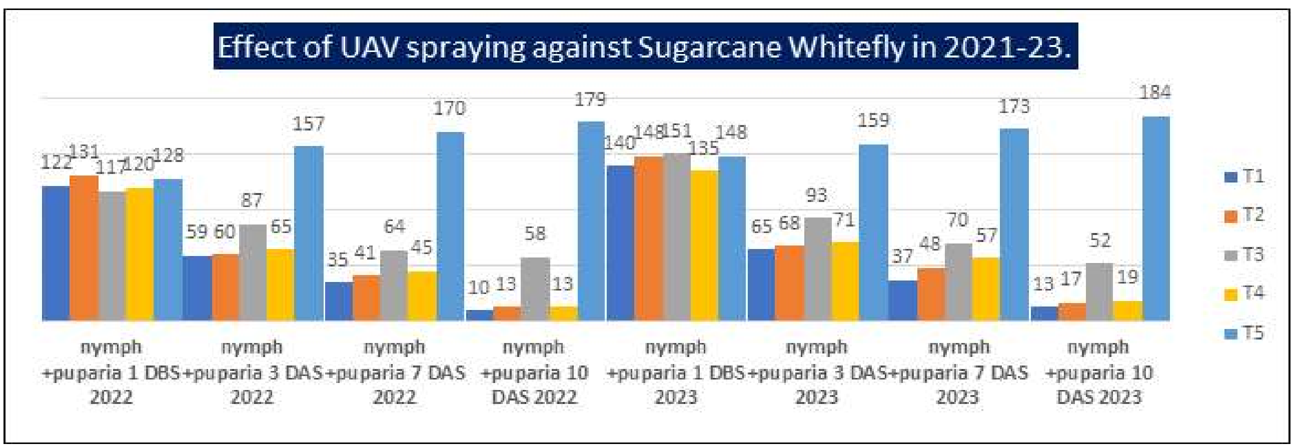


Fig.3 Effect of UAV sprayer against Sugarcane Whitefly in 2021-2023.

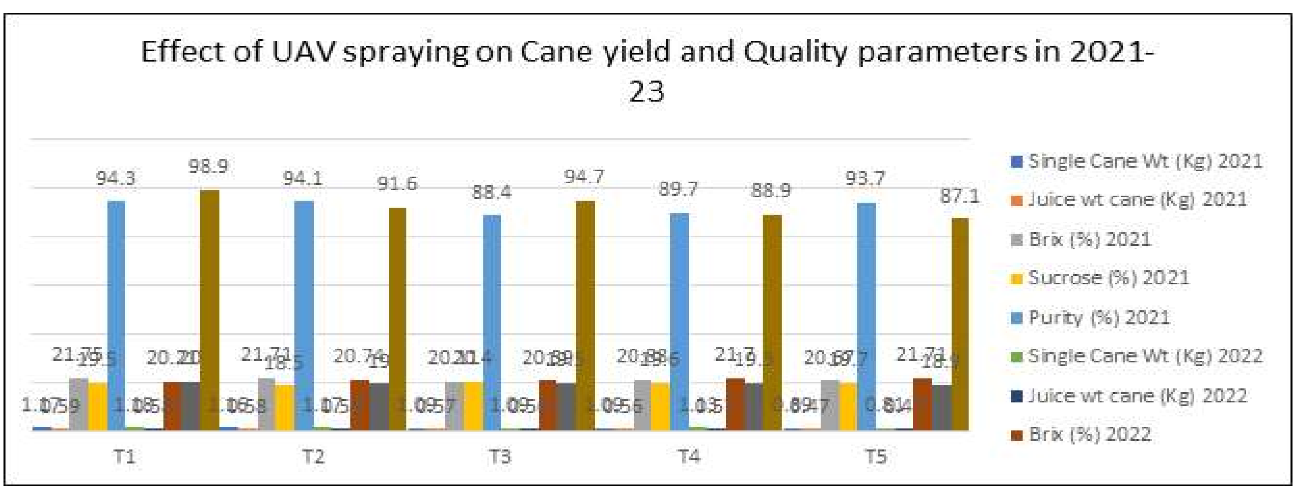


Fig.4 Effect of UAV sprayer Sugarcane whitefly in 2021-2023

Table 6. Phytotoxicity in Sugarcane with spraying of Imidacloprid 17.8 SL.

Treatments	Dosage / ha			Equipment for Application	Yellowing (DAA*)			Stunting (DAA)			Necrosis (DAA)			Epinasty (DAA)			Hyponasty (DAA)			Wilting (DAA)			Scorching (DAA)		
	a.i.(g)	Formulation (ml ha^{-1})	Water volume L ha^{-1}		1	3	5	1	3	5	1	3	5	1	3	5	1	3	5	1	3	5	1	3	5
T1	22.5	125	25	10 L Pay load Drone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T2	16.7	93.75	25		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T3	11.3	62.5	25		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T4	22.5	125	200	Human Back pack Sprayer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T5	Water		25	10 L Pay load Drone		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0

*DAA – Days after application

chemical deposition rate was higher in UAVs than knapsack sprayers and control efficacy found better and at par with conventional sprayers. The working efficacy was found higher than knapsack, knapsack motorised sprayers. This is the greatest advantage of the UAV sprayer. UAVs spraying has significant effect on reduction by 25% of recommended chemicals for Knapsack sprayers for controlling whitefly on sugarcane as the control efficacy with 100% RDP (50 ml/acre) and 75% RDP (35 ml/acre) are at par at field conditions. After assessing spraying effect, control effect, and the control effects of insecticides, a flight height of 1.0 m with forward speed of 4.5 m/s and spray volume of 25 L/ha are optimal parameters for UAV spraying to control sugarcane sucking pests.

LITERATURE CITED

Bhavani B and Rao C V N 2013. Management of sugarcane white fly (*Aleurolobus barodensis* Mask.) in North coastal districts of Andhra Pradesh, India. *International Journal of Social Science & Interdisciplinary Research*, 2; 112-115.

Ganiger P, Yeshwanth H M, Muralimohan K, Vinay N, Ranjith Kumar V and Chandrashekara K 2018. Occurrence of the new invasive pest, fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), in the maize fields of Karnataka, India. *Current Science*.115, 621–623. doi: 10.18520/cs/v115/i4/621-623.

Sambaiah A, Reddy A V, Prasanthi L, Reddy A S, Mahalakshmi M S, Reddy K G, Kumar G S, Reddy G R and Kumar K V K 2022. Development of a plant protection UAV and evaluating its efficacy in managing rice leaf folder (*Cnaphalocrocis medinalis* Guenee.).*The Pharma Innovation Journal.* 11 (10); 1155-1163

Shukla S K, Sharma L, Awasthi S K and Pathak A D 2017. Sugarcane in India. Package of practices for different agro–climatic zones, All Indian Coordinated Research Project on Sugarcane, IISR Lucknow, Uttar Pradesh, 1-64.

Singh S P, Kumar A and Kushwaha H L 2020. Sugar cane canopy spraying: A perspective solution with ergonomics and mechatronics approach. *Sugar Tech*, 22, 203-207.

Yallappa D, Kavitha R, Surendrakumar A, Suthakar B, Kumar A M, Kalarani M K and Kannan B 2023. Effect of downwash airflow distribution of multi-rotor unmanned aerial vehicle on spray droplet deposition characteristics in rice crop. *Current Science*, 172-182.

Zhang X Q, Liang Y J, Qin Z Q, Li D W, Wei C Y, Wei J J, Li R Y and Song X P 2019. Application of multi-rotor unmanned aerial vehicle application in management of stem borer (Lepidoptera) in sugarcane. *Sugar Tech,* 21(5); 847-852.

Received on 28.09.2024 and Accepted on 19.10.2024