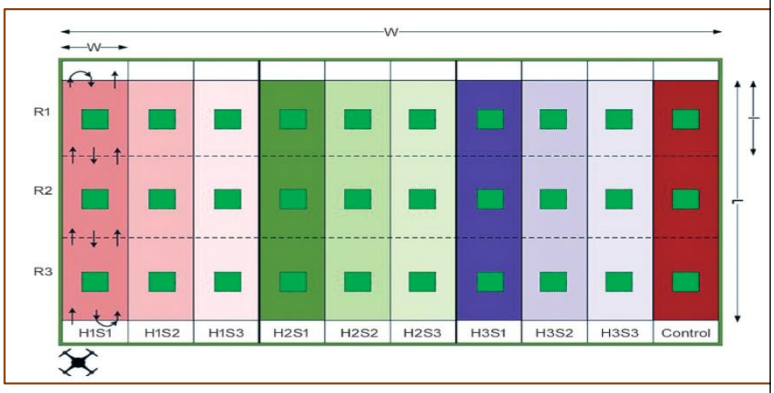
NEW TECHNICAL PROGRAMME -7

01.	**Experiment No. and Title**	:	**19.3.7** **Assessment of Unmanned Aerial Vehicle (UAV) based spraying against pod borer, *Helicoverpa armigera* (Hubner) in gram**
02.	**Budget Head**	:	B.H. 12939 Forecasting weather pests and diseases at Navsari
03.	**Collaborative department, if any**	:	Directorate of Research, NAU, Navsari
04.	**Background information**	:	Gram (*Cicer arietinum* L.) is one of the most important legume food crop after dry bean and dry pea. In India, gram is generally grown as a rainfed crop in the *Rabi* season. Gram pod borer (*Helicoverpa armigera* Hubner) is a key pest of chickpea and responsible for 90 to 95 per cent damage. The young caterpillars of this pest skeletonizes the leaves, while the grown-up caterpillar bores into the pods and feeds on the seeds. The losses can be reduced by the timely application of insecticides. In recent years due to shortage of labor, the pests cross the EILs which results in a severe to complete yield loss. The manual spraying of pesticides by using hand sprayes are quite difficult and creat health hazards to the applicants. it also causes non-uniformly spraying and excess spraying and this may cause reduced crop yields. Now a day's as an alternative to knapsack spraying, Unmanned Aerial Vehicle (UAV) is a boon for the farmers for timely and accurate application of insecticides. The UAVs provides a means of more targeted application of the correct dose, especially by using more persistent formulations, thus reducing the losses of pesticidal chemicals. In present days, there is a need to look for better options other than the traditional spraying methods as the UAVs can cover more than 1.2 hectares in one flight and more than 60 hectares in a day. It can spray two to four liters per minute and can be filled twice for one charge. The UAV is highly efficient and can accomplish the task in 15 minutes which would otherwise take a person 1.5 days of work. Therefore, considering the importance of UAV in plant protection the present investigation is formulated for the management of pod borer (*H. armigera*) infesting gram with the aim to understand the different parameters of spraying with UAV alongwith the efficacy of insecticide

<table>
<tr><td></td><td colspan="2"></td><td></td><td colspan="4">against H. armigera through UAV spraying in gram.</td></tr>
<tr><td>05.</td><td colspan="2">Objectives</td><td>:</td><td colspan="4">1. To study the spraying parameters of Unmanned Aerial Vehicle in gram
2. To study the efficacy of insecticide using UAV based sprayer against pod borer infesting gram</td></tr>
<tr><td>06.</td><td colspan="2">Principal investigator and associates</td><td>:</td><td colspan="4">1. Dr. Abhishek Shukla, Sr. Acarologist (PI)
2. Dr. K.M. Patel, Asstt. Professor (Co-PI)
3. Dr. C.U. Shinde, Assistant Professor (Co-PI)
4. Dr. S.R. Patel, Assistant Professor (Co-PI)
5. Dr.V, Shinde, Assistant Professor (Eng)</td></tr>
<tr><td>07.</td><td colspan="2">Location and Agro- climatic sub-region</td><td>:</td><td colspan="4">College Farm, NMCA, NAU, Navsari, AES-III,
South Gujarat Heavy Rainfall Zone</td></tr>
<tr><td>08.</td><td colspan="2">Year and Season</td><td>:</td><td colspan="4">2023 & Rabi</td></tr>
<tr><td>09.</td><td colspan="2">Crop and Variety</td><td>:</td><td colspan="4">Gram and GG-5</td></tr>
<tr><td>10.</td><td colspan="2">Experimental details</td><td>:</td><td colspan="4"></td></tr>
<tr><td rowspan="13"></td><td>(a)</td><td>Treatments</td><td>:</td><td colspan="4">Different treatment combinations</td></tr>
<tr><td colspan="3"></td><td>Tr. No.</td><td>Treatment</td><td>Flight height (m)</td><td>Forward speed (m/s)</td></tr>
<tr><td colspan="3"></td><td>T_1</td><td>H1S1</td><td rowspan="3">0.55 (H1)</td><td>2.0 (S1)</td></tr>
<tr><td colspan="3"></td><td>T_2</td><td>H1S2</td><td>3.0 (S2)</td></tr>
<tr><td colspan="3"></td><td>T_3</td><td>H1S3</td><td>4.0 (S3)</td></tr>
<tr><td colspan="3"></td><td>T_4</td><td>H2S1</td><td rowspan="3">0.75 (H2)</td><td>2.0 (S1)</td></tr>
<tr><td colspan="3"></td><td>T_5</td><td>H2S2</td><td>3.0 (S2)</td></tr>
<tr><td colspan="3"></td><td>T_6</td><td>H2S3</td><td>4.0 (S3)</td></tr>
<tr><td colspan="3"></td><td>T_7</td><td>H3S1</td><td rowspan="3">1.00 (H3)</td><td>2.0 (S1)</td></tr>
<tr><td colspan="3"></td><td>T_8</td><td>H3S2</td><td>3.0 (S2)</td></tr>
<tr><td colspan="3"></td><td>T_9</td><td>H3S3</td><td>4.0 (S3)</td></tr>
<tr><td colspan="3"></td><td>T_{10}</td><td>Knapsack Spray</td><td>0.1</td><td>-</td></tr>
<tr><td colspan="3"></td><td>T_{11}</td><td>Control</td><td colspan="2">No spray application</td></tr>
</table>

<table>
<tr><td></td><td>(b)</td><td>Experimental Design</td><td>:</td><td colspan="3">Split-plot design without randomization
 

The field will be divided into equal size plots for each treatment and replication depending upon the size for conducting the bio-efficacy experiment. The experimental plots plots without having the electrical wires and trees will be selected. A minimum plot size of 100 m² (10 m x 10 m) per replication per treatment will be maintained. The plots will be well separated by maintaining buffer zone of five meters between the treatments.</td></tr>
<tr><td></td><td>(c)</td><td>Replications</td><td>:</td><td colspan="3">Three</td></tr>
<tr><td></td><td>(d)</td><td>Plot size(If applicable)</td><td>:</td><td>Gross</td><td>-</td><td>10 m x 10 m</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Net</td><td>-</td><td>10 m x 10 m</td></tr>
<tr><td></td><td>(e)</td><td>Spacing</td><td>:</td><td colspan="3">45 cm x 10 cm</td></tr>
<tr><td></td><td>(f)</td><td>Seed rate (kg/ha)</td><td>:</td><td colspan="3">65 kg/ha</td></tr>
<tr><td></td><td>(g)</td><td>Manures and fertilizer</td><td>:</td><td colspan="3">10 t/ha; N : P : K (kg/ha) 20: 40: 00</td></tr>
<tr><td></td><td>(h)</td><td>Any other detail, if required</td><td>:</td><td colspan="3">Insecticide details:
<table>
<tr><th>Tr. No.</th><th>Treatment</th><th>Conc. (%)</th><th>a.i. (g/ha)</th><th>Qty. of formulation g/ha</th><th>Qty. of req. water lit./ha</th></tr>
<tr><td>1.</td><td>Emamectin benzoate 5 SG application with UAV based sprayer</td><td>0.04</td><td>11</td><td>200</td><td>25</td></tr>
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				2.	Emamectin benzoate 5 SG application with Knapsack sprayer (As per CIB)	0.002	11	200	500
11.	**Observations to be recorded**		:	**Spray quality parameters:** Droplet coverage (%) Droplet density (No./cm^2) Droplet size (µm) Uniformity coefficient No. of larvae/ plant Pod damage (%) Natural enemies, if any					
12.	**Methodology (if necessary)**		:	**Methodology for testing droplet deposition parametres**: The testing of droplet deposition will be carried out for Knapsack sprayer and UAV based sprayer (drone). **1. Flying speed and flight height of drone**: For the evaluation of droplet deposition flying speed of drone will be operated at 2 m/sec at 1.5 m above the crop canopy level (SOP, GOI, 2022). Further, the field spray will be carried out on lesser windy days *i.e.* when wind speed was less than 5.4 km/hour. The average (Weekly) wind speed more than 5.4 km/h was recorded from last week of April to end of August during previous year. **2. Droplet size (um):** It is a proven fact that pest incidence mostly occurs on leaves. As such, it will be decided to find out the droplet deposition on the leaves. It was observed on five randomly selected plants with the crop canopy divided into three equal portions (top, middle and bottom) according to the plant's height. To achieve this, use of glossy paper/mylar sheet will be made. Glossy photographic paper of size 7.5 × 2.5 cm selected because it has low spreading factor and will be placed on upper side of leaves. They are fixed to leaves at location horizontally. The dye Methylene blue MS dye mixed @ 5 g per litre mixed with water sprayed on the crop. When the sprayed material dried, the glossy paper strips will be collected for analysis in the laboratory with DepositScan software.					

			3. Droplet density (No/cm^2): The droplet density is also important along with droplet size for the quality of the spray since droplet density directly affects the volume of spray applied depending on the droplet size. By using image J, the number of droplet spots on one square centimeter area of photographic paper will be obtained. The number of droplets per square centimeter area will be termed as droplet density. The droplet density will be measured in DepositScan software. **4.Spray drift:** The drift area will be measured by placing the mylar sheets, which will be arranged at 2 to 4 m away from the spray area to collect the droplet drift on the ground.
			Methodology for evaluation of insecticide spray against borer: The evaluation of insecticidal efficacy against *H. armigera* will be carried out. The recommended insecticide (Emamectin benzoate 5SG) will be used for spraying purpose against *H. armigera* in gram. First spray of insecticide will be given at initiation of pest and need based spray will be carried out after 15 days by using manually and automatically operated drone. Observation on number of pod borer larvae will be recorded from 20 randomly selected plants from each treatment at before spray and 3,7,10 and 14 days after each spray. Number of damaged pods will be recorded by observing 100 pods from each treatment from five randomly selected plants at harvest from each treatment.

Knapsack electro battery sprayer: In the bio-efficacy studies, drone aerial spraying will be compared with the locally popular manual spraying equipment, knapsack electro battery sprayer manufactured by ASPEE with a fluid tank capacity of 16 liters. The nozzle type will be flat fan nozzle. The spraying height of the knapsack sprayer is 0.1 m above the crop canopy, operated at spray pressure of 3.45 bar (50 psi) and flow rate of 3.0 L/ min. Under these application conditions, the spray volume will be close to 500 L/ha with a field coverage capacity of 2.0 ha/day.

Technical specifications of drone used in the experiment:

Sr. No.	Particulars	Details/ Specification
1.	Model Should be DGCA Certified (Type Approval Certificate)	Mandatory (Copy of Type Approval Certificate downloaded from digital sky portal with digital signature to be enclosed with the proposal)
2.	Type of Drone & Category	Multi-Rotor Drones & Hexa copter (6 rotors)
3.	Flight modes	Manual, Autonomous, A-B mode
4.	Maximum takeoff weight	25 Kg
5.	Folded Size	800 mm X 750 mm X 500 mm

6.	Maximum flying speed	10 m/s
7.	Flight altitude range, (Above Ground Level), (m)	10.0 (Minimum)
8.	Flight Time (With payload) (Minutes)	16 to 20 (Minimum)
9.	Hovering time (without payload)	25.0 min (minimum)
10.	Detection Range (M)	Minimum 10 meter
11.	Tank capacity	10 litre
12.	Operating Payload (Kg)	10.0 (minimum)
13.	Material of Tank	HDPE
14.	Material of Tube	PVC or better
15.	Nozzle	1 set each of electrostatic centrifugal and high pressure flat spray (Must be below propeller and compatible with the spraying system)
16.	No. of nozzles	4
17.	Material of Nozzle	Polypropylene housing with Ceramic tips
18.	Spray flow (Maximum Spray Speed)	1.2 to 4.0 lit/min
19.	Spray width/swath	3.0 ~ 5.0 m
20.	Battery Capacity	16000-22000 mAh
21.	Battery Voltage	More than 40 V
22.	Battery Charging time	Max. 60 min
23.	Battery Cycle	200-250 minimum
24.	Camera	Integrated with 2 MP MIPI Camera on GCS
25.	Wind speed tolerance	Minimum 30 Km/Hr. (=8m/sec)
26.	Remote Controller (1) Operating Frequency (2) Max Transmission Distance (Communication distance between GCS and flying Drone (KM) (3) Display (4) System (5) Operating Temperature Range :	 (1) 5.725 GHz to 5.850 GHz (2) More than 2 km (3) 5.5 inch screen 1920×1080, 1000 cd/m² (4) Android (5) 0° to 50^0 C
27.	Control Unit	Suitable flight controller CPU, compatible to be above specifications and as per DGCA guidelines Intel Core i5 v Pro processor or advanced Storage: Minimum 500 GB Memory: Minimum 4GB RAM Display: 14 inch or larger more with touch screen. Battery: Min.12 hours' backup Interfaces: USB, HDMI/VGA, Ethernet etc. should conform IP 65 norms or as per recent norms Max Transmission Distance (Communication distance between GCS and flying Drone (Km)- more than 2 km Inclusive of charger