Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

An air-assisted electrostatic sprayer was developed for the management of sucking pest in coconut palms. The palm architecture including the palm height, leaf length and angle of leaf orientation was studied prior to the design of the electrostatic sprayer unit. The average height of the palm trees was observed as 9.12 ±1.88 m. The average length of leaf (fronds) and canopy diameter was recorded as 3.54 m and 7.09 m respectively. The angle of leaf orientation relative to the vertical axis was observed between 36º to 82º, which may vary throughout the lifespan of a leaf frond. The study employed electrostatic charging of the spray droplet by induction charging with the help of a ring electrode made of 43 mm diameter copper wire.

Experimental prototype of a backpack type rechargeable battery powered electrostatic sprayer with air blower assistance mounted on a telescopic pole was thus developed and evaluated for the performance parameters. The major components of the prototype include a High Voltage DC (HVDC) generator unit, nozzle, liquid delivery unit, and an air-assistance unit. The HVDC generation unit was developed based on a variable output power MOSFET (IRFZ44E) driven fly-back transformer (LOPT1010A) for the induction charging of the spray droplets. A solid cone hydraulic nozzle of 0.5 mm orifice diameter with an operating pressure of 3-5 $kg \cdot cm^{-2}$ and discharge of 4.7 – 7.5 $L \cdot h^{-1}$ was selected for the study. A double stage diaphragm pump with cutoff pressure and open discharge was selected as the liquid delivery unit. A high-capacity Electric Ducted Fan (EDF) was selected as the air assistance unit at an optimum air flow velocity of 17 $m \cdot s^{-1}$.

A The backpack frame of dimensions 404 × 367 × 239 mm was constructed using of 25 mm PVC pipes and 3 mm thick plywood sheets, houses the spray solution tank, pump, valve, pressure gauge, 12 V DC battery, and HVDC generation unit, Electronic Speed Controller (ESC) of the EDF, and control switches. The spray gun housed the spray nozzle and EDF unit was a 280 mm length conduit made of cast nylon. The spray gun was attached to the top end of the 8 m long telescopic pole of carbon fiber. The

major operation parameters including diameter of the ring electrode (40, 60, and 90 mm), position of the electrode with respect to the nozzle (5, 10, and 15 mm towards the front), applied voltage, operating pressure were optimized under laboratory conditions. Whereas, the position and speed of the EDF unit was optimized under actual field conditions. Considering the challenges to reach the top of the canopy, the filed studies were conducted on the palms with a maximum of 6 m height.

A specially designed Faraday cage apparatus was fabricated for the measurement of Charge-to-Mass Ratio (CMR). The Faraday cage comprises two inverted conical structures made of a 4.3 mm thick copper wire frame and a copper wire mesh with a 1 mm aperture. The bottom section of the cage was fabricated in a truncated conical shape, while the top section was fully conical, both with a base diameter of 500 mm and a cone angle of 45º. This structure was suspended on a cantilever beam at the top end of a 4.0 m long telescopic pole. A sliding cantilever beam was positioned below to hold the spray gun, ensuring that it place exactly below at the centre point of the cage. The CMR measurements were at different combinations of electrode potentials (4 to 10 kV with 1 kV measuring interval), electrode diameter, horizontal position of electrode, and at two vertical distances between spray gun and Faraday cage (1 and 2 m). The optimization of operating pressure and the determination of spray droplet spectrum was done using Water Sensitive Papers (WSPs). The operating parameters of the EDF unit including the air velocity (10, 15 and 17 $m \cdot s^{-1}$) and position with respect to the canopy (1, 1.5, and 2 m below the lower most leaf) was conducted at the actual field conditions.

The salient conclusions drawn from the study are as follows:

- The electrode with 90 mm diameter at 10 mm horizontal position in front of the nozzle obtained the highest CMR of 3.458 $mC \cdot kg^{-1}$ at 9 kV electrode
- The charging efficiency of the developed electrostatic charging system was estimated as 18.626 per cent
- The VMD or DV50 of the spray spectrum when operated at 5 $kg \cdot cm^{-2}$ was 156 µm, while DV10 = 103.33 µm and DV90 = 217 µm. Also, the NMD was found

to be 107.49 µm with a uniformity coefficient Uc of 1.45 and Relative Span Factor of (RSF) 0.67

- An adequate spray pattern (17-25 per cent) and droplet density (115 -150 deposit·cm^{-2}) in all the canopy layers was recorded when the EDF was positioned at 1.5 meters and operated with 17 m·s^{-1} air velocity.
- Spraying with electrostatic charging ON has 20.69, 27.23, and 63.95 per cent more adaxial surface spray deposition in the lower, middle and upper middle layers respectively compared to the Electrostatic OFF spraying (ai-assisted)
- Similarly, 39.05, 22.7, and 84.33 per cent more adaxial surface spray deposition in the lower, middle and upper middle layers respectively when compared to the conventional rocker sprayer
- Spraying with electrostatic charging ON resulted in 1.20 times more droplet density than air assisted and 1.81 times more droplet density than rocker sprayer
- Total normalised spray deposition with electrostatic charging ON was 1.57 and 1.93 times higher than the air-assisted and rocker sprayer respectively
- The deposition efficiency was observed as 69.77, 43.09, and 33.86 per cent for electrostatic charging ON, OFF and rocker sprayer respectively
- The spray drift with electrostatic charging ON was majorly observed at the point of spraying, however it was detectable up to 3 m and 4 m for air-assisted spraying respectively
- Spraying with ESS ON was able to reduce the RSW incidence, severity and RSW live colony per leaflets by 32.76, 64.17, and 74.91 per cent respectively.
- The total cost of the developed air-assisted electrostatic sprayers was estimated as Rs. 22,120/-, which is around 38 times less costly than a commercially available electrostatic sprayers (tractor operated) suitable for orchards costs approximately Rs. 8,50,000/- (Gursukh Agro Works, Ludhiana, Punjab)
- The operational cost of the developed electrostatic sprayer was calculated to be ₹151 per hour, significantly lower than that of the conventional rocker sprayer, which stood at ₹231 per hour.

In future the prototype can be fine-tuned by providing the control unit in the telescopic poles, along with a provision to detect the location of spray gun with respect to the crop canopy with the help of wither camera or ultrasonic distance sensors. Wearing safety goggles and gloves while operating the equipment can be recommended for enhanced safety of the operator. Moreover, an ergonomic study is recommended to assess the physical strain and handling difficulty associated with the system, especially due to its weight and the use of a telescopic pole. This will help evaluate user comfort and inform design improvements for better usability.