8.1: Ultra-Low Volume (ULV) Sprayers

Ultra-Low Volume (ULV) sprayers are specialized spraying equipment designed to apply pesticide formulations at very low spray volumes per unit area (typically less than 5 liters/hectare, often using undiluted or minimally diluted formulations), by producing very fine, uniform droplets using controlled droplet generation techniques rather than conventional hydraulic pressure alone.

8.2 Concept of ULV Spraying

- Conventional hydraulic spraying typically applies 200–500+ liters/hectare (high volume) or 50–200 liters/hectare (low volume) of dilute spray mixture.

- ULV spraying drastically reduces this to a few liters per hectare, using special ULV-formulated pesticides (often oil-based concentrates designed for direct or minimal-dilution application).

- Because very little liquid is applied, the technique relies on producing a large number of very fine, uniformly sized droplets so that adequate pesticide coverage/deposition is still achieved despite the low volume.

8.3 Droplet Generation Principle

Unlike hydraulic nozzles (which produce a wide range of droplet sizes), ULV sprayers typically use:

1. Rotary atomizers (spinning disc/cage sprayers) – The spray liquid is fed onto a rapidly rotating disc or cage; centrifugal force flings the liquid off the edge, breaking it into droplets of fairly uniform size. Droplet size is controlled mainly by disc/cage rotational speed and liquid flow rate, rather than pressure.

2. Electrostatic-assisted ULV sprayers – In some advanced systems, droplets are given an electric charge as they leave the atomizer, improving their attraction and deposition onto plant surfaces (including undersides of leaves), further improving efficiency at low volumes.

8.4 Main Components of a ULV Sprayer

1. Reservoir/tank – Holds the ULV-formulated pesticide (typically small capacity, since application volume is low).

2. Rotary atomizer (spinning disc/cage) – The core droplet-generating component, driven by a small electric motor or battery.

3. Flow control/metering system – Precisely controls the (very low) flow rate of liquid fed to the atomizer, since accurate metering is critical at ULV volumes.

4. Battery/power source – Powers the motor driving the rotary atomizer in portable ULV sprayers (many are battery-operated hand-held or knapsack units).

5. Boom (for larger/vehicle-mounted ULV sprayers) – Carries multiple rotary atomizer units spaced across a working width for field-scale ULV application.

8.5 Advantages of ULV Spraying

1. Drastically reduces water/carrier requirement, useful in water-scarce areas and saving transport/refill time.

2. Uniform, controlled droplet size improves spray efficiency (less product wasted on oversized droplets that run off, and less ultra-fine drift compared to poorly controlled hydraulic mist).

3. Lightweight, portable equipment (battery-operated types) suitable for smallholder use.

4. Increases field capacity (fewer refills needed) due to low volume per hectare.

8.6 Limitations

- Requires specially formulated ULV pesticide concentrates; not all pesticides are available/suitable in ULV formulation.

- Precise calibration is critical — because chemical concentration is very high (minimal dilution), small errors in flow rate can cause significant over- or under-dosing.

- Fine droplets remain susceptible to drift under windy conditions if not properly managed (though more uniform than hydraulic mist).

- Operator safety precautions are especially important, given the higher concentration of active ingredient handled.

- Higher cost of specialized equipment and ULV formulations compared to conventional sprays in some regions.

9.1: Drone Sprayers

Drone sprayers are unmanned aerial vehicles (UAVs) fitted with a spray tank, pump, and nozzles, used to apply pesticides, fungicides, herbicides, or foliar nutrients from the air. They represent a rapidly growing precision agriculture technology, particularly useful for large fields, tall crops, and areas difficult to access with ground equipment.

9.2 Main Components of a Drone Sprayer

1. UAV airframe – Typically a multi-rotor drone (commonly hex copter or octocopter for higher payload capacity) capable of carrying the spray tank and associated equipment.

2. Spray tank – Mounted on the drone frame; holds the spray liquid (capacity varies, commonly in the range of 10–20 litres for agricultural drones, depending on drone size).

3. Pump and nozzles – A small pump pressurizes the liquid, which is released through nozzles (commonly centrifugal/rotary atomizer nozzles or pressure nozzles) mounted below the rotor arms.

4. Flight controller – Manages flight stability, navigation, and (in autonomous mode) follows a pre-programmed flight path based on GPS/GNSS field mapping.

5. Battery – Powers the drone's flight motors and spraying system; limits flight duration (typically 10–20 minutes per battery charge for agricultural drones) and payload capacity.

6. Obstacle avoidance/terrain-following sensors – Advanced drone sprayers use sensors (radar, ultrasonic, or optical) to maintain a constant height above the crop canopy and detect/avoid obstacles, ensuring uniform application even over uneven terrain.

7. Ground control station/remote controller – Used by the operator/pilot to plan flight paths, monitor spraying progress, and control the drone.

9.3 Working Principle

- The field boundary and flight path are mapped/programmed using GPS-based software (or manually flown by a trained pilot).

- The spray tank is filled with the required pesticide mixture.

- As the drone flies over the crop at a set height and speed, the pump delivers liquid to the nozzles, which atomize it into droplets.

- The rotor downwash from the drone's propellers helps push spray droplets down into the crop canopy, improving penetration compared to simple gravity settling.

- The drone follows parallel flight lines with a set swath width and overlap to ensure uniform coverage across the field, similar in concept to ground boom sprayer passes.

9.4 Advantages of Drone Sprayers

1. Covers large areas quickly, especially useful during narrow disease/pest control windows requiring urgent action.

2. Accesses tall crops (sugarcane, maize) and difficult terrain (waterlogged fields, steep slopes) without crop damage from wheel traffic.

3. No soil compaction, since the machine does not contact the ground.

4. Reduces pesticide exposure risk to the human operator, who controls the drone remotely rather than walking through treated fields.

5. GPS-based flight path programming ensures accurate, repeatable, and uniform coverage.

6. Rotor downwash can improve spray penetration into the crop canopy compared to some ground equipment.

9.5 Limitations

- Limited payload and flight time (battery-dependent), requiring multiple refill/recharge cycles for larger areas.

- Higher initial cost of the drone, spraying attachment, and batteries.

- Requires a trained/licensed drone pilot and adherence to drone flight regulations (airspace permissions vary by region).

- Performance affected by wind conditions, which can cause spray drift.

- Battery life and payload trade-offs currently limit its use mainly to specific high-value applications rather than fully replacing ground/boom spraying for all crops.

10.1: Smart Pest Detection Systems

Smart pest detection systems use sensors, imaging technology, and data analytics (often combined with IoT and AI) to detect the presence, type, and severity of insect pests and diseases in crops, enabling early and precise pest management decisions rather than relying solely on manual field scouting.

10.2 Need for Smart Pest Detection

1. Manual field scouting is time-consuming, labour-intensive, and may miss early-stage infestations, especially over large farm areas.

2. Early detection of pests/diseases allows timely intervention, reducing crop loss and the amount of pesticide needed (compared to treating an already widespread infestation).

3. Supports precision/targeted pesticide application (spot spraying) instead of blanket spraying of the whole field, reducing chemical use and cost.

4. Provides continuous, real-time monitoring, which is not practically possible through manual scouting alone.

10.3 Components and Technologies Used

1. Smart pheromone traps – Traditional pheromone traps (which attract and capture specific insect pests) fitted with sensors/cameras that automatically count trapped insects and transmit data wirelessly, eliminating the need for manual trap-checking.

2. Image sensors/cameras – Mounted in the field, on drones, or handheld; capture images of crop foliage for automated detection of pest damage symptoms or disease lesions using image processing/AI algorithms

3. Environmental sensors – Monitor temperature, humidity, and leaf wetness, since many pests and diseases are strongly influenced by weather conditions; this data helps predict pest/disease outbreak risk (forecasting models).

4. IoT connectivity/data transmission – Wireless modules (as described in Unit II's IoT chapter) transmit sensor and image data to a central server/cloud platform for processing and storage.

5. Cloud-based analytics and alert system – Processes incoming data, applies pest forecasting models or image-recognition algorithms, and sends alerts to the farmer via a mobile app or SMS when pest/disease risk crosses a threshold.

10.4 Working Concept

- Sensors/traps/cameras installed across the field continuously (or at set intervals) collect data related to pest presence and environmental conditions.

- Data is transmitted wirelessly to a cloud-based platform.

- The platform's software analyzes the data — comparing pest counts/images against known thresholds or using AI-based pattern recognition — to determine pest identity, population level, and infestation risk.

- If a threshold is crossed (e.g., pest count in a trap exceeds the economic threshold level), an alert is generated and sent to the farmer/advisor for timely action.

- Historical data builds a pattern over seasons, improving future forecasting accuracy for that specific field/region.

10.5 Advantages

1. Enables early detection of pest/disease outbreaks, allowing timely intervention and reduced crop loss.

2. Reduces labour requirement for manual scouting and trap-checking.

3. Supports precision/targeted pesticide application, reducing overall chemical use and cost.

4. Provides continuous, round-the-clock monitoring not achievable through periodic manual visits.

5. Builds valuable historical pest-incidence data for long-term farm and regional pest management planning.

10.6 Limitations

- High initial investment in sensors, cameras, and connectivity infrastructure.

- Requires reliable internet/wireless connectivity in rural areas, which may be limited in some regions.

- Image-recognition/AI models require adequate training data specific to local pests/crops for accurate detection; accuracy may vary by pest/disease type.

- Requires technical knowledge for installation, maintenance, and interpretation of alerts.

- Sensor/trap maintenance (cleaning, pheromone lure replacement) still needed periodically.