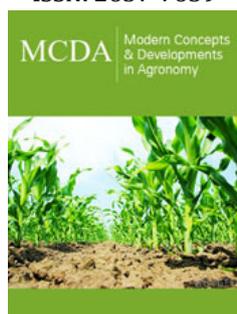


Repellent Solution Precise Application to Cotton Clothes Surrounding Mango Trunk Trees to Avoid Ant Climbing

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Abstract

Leaf-cutting ants (*Atta cephalotes*) cause production losses to mango producers since they take down inflorescences and tender leaves. A repellent fluid was sprayed to an absorbent cloth placed around the tree-trunk to prevent ants from climbing. Eucalyptus oil-water emulsion was manually sprayed into the cotton fabric surrounding the tree trunks and the effect of fabric evaporation analyzed when it was covered or exposed directly to the environment. Manual application of the repellent solution is labour-intensive as each hectare has at least 100 trees. Precise spraying of hundreds of tree fabrics can be done with the orchard irrigation system. Relative humidity measurements were obtained every 3 hours comparing clothes moistened by drip or sprinkler irrigation systems, being the latter more homogeneous. Drippers together with tubing provide better cloth wetting, but the fabric should be thinner. Aroma was sampled by a group of experts and the oil-water emulsion should be applied every two days.

Keywords: Precise spraying; Oil-water emulsion; Ant control; RH fabric drying

Introduction

Worker ants follow trails towards foraging sites where they cut leaves, flowers and buds in fragments. Ants return to their nest with the food collected after establishing bidirectional trails between the nest and the food source. In a study at Brazil, 16.6% of the total coffee plants was attacked by *Atta sexdens rubropilosa* and 1% was defoliated causing production losses [1]. Changes in ant walking speed are also caused by meteorological conditions such as temperature, rain [2] and wind [3].

Precise spraying in agriculture have been studied during this century [4,5]. Timely and accurate precise spraying in orchards and nurseries reduce pesticide residues, saving manpower and material resources [4]. Canopy size and density measured by laser scanning sensors, ultrasound and LIDAR [5] show high variations within orchards.

Some plant extracts repel leaf-cutting ants [6]. Essential oils are composed of complex mixtures of various chemical components including terpenes and repel insect herbivores [7]. Essential oils are degraded rapidly by the environment, being sensitive to oxygen, light and high temperature. In laboratory experiments, concentrations doses over 1% tea tree oil repelled ants, lasting its repellent effect up to four days [8]. Mango growers use micro-sprinklers instead of drippers to produce mulch and cover plants over the orchard floor. Drippers are more water-efficient than sprinklers due to reduced evaporative losses at the soil surface or to direct evaporation of water in the air prior to soil contact [9]. The amount of water that evaporates while water droplets travel from the nozzle to the crop canopy is considerable [10].

Mango orchards suffer up to 30% production losses during the dry season when ants attack tree inflorescences and leaves. CEMANGO a government agency searching to increase mango yield, supported the elaboration and evaluation of a prototype to avoid leaf-cutting ants attacks. Previous laboratory experiments found that an essential oil emulsion applied to a cloth wrapped around the tree trunk decreased ant climbing. In this paper, fabric RH was monitored several hours after liquid application to determine its drying rate; a group of experts analyzed aroma decay with time. New precise wetting techniques to apply

simultaneously a liquid emulsion to a fabric surrounding the trunk of 100 trees with the use of mango orchard irrigation systems were developed and evaluated.

Material and Methods

Different prototypes were installed in fifteen-year-old trees where *Atta cephalotes* ants forage during the night. Mature ant colonies within the orchard contain 10^5 workers approximately, and forage at mango trees, 30m away from their nest. The mango orchard located at Loma Bonita, Guerrero ($17^{\circ} 25' 47''$ N, $-101^{\circ} 11' 19''$ W, 17m ASL) has an automated irrigation system.

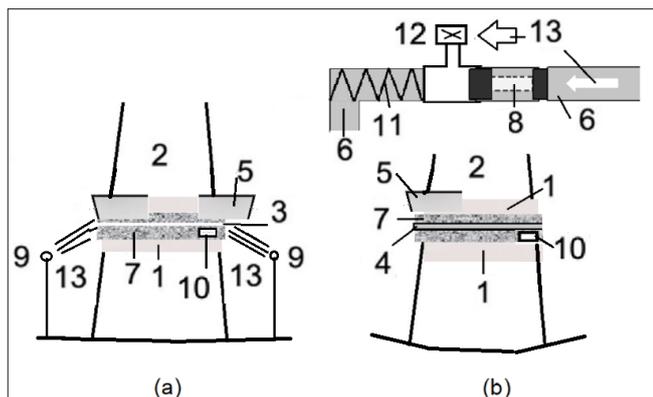


Figure 1: Developed prototypes with

(a) simple cloth, sprinklers, data logger and repellent system, and

(b) hose having integrated drips connected to irrigation system; consisting of

- (1) polyethylene plastic,
- (2) trunk,
- (3) plastic strap,
- (4) hose with integrated drips,
- (5) plastic cover,
- (6) hose,
- (7) absorbent cloth,
- (8) piston,
- (9) micro-sprinklers,
- (10) RH sensor and data logger,
- (11) return spring,
- (12) solenoid control valve, and
- (13) water flow direction.

A prototype patented by Hahn (2020) avoided ants from climbing tree trunks (2; Figure 1). It had a galvanized sheet that holds a plastic container (5; Figure 1), a hose (6; Figure 1) and several micro-sprinklers (9; Figure 1). Water enters the system through a 24 VDC solenoid valve (mod VXE2120-02F-5DO, SMC, USA) connected to the irrigation system (12; Figure 1). Water gets mixed with the pure repellent solution (13; Figure 1) using a venturi

and the resultant solution flows toward the hose surrounding the tree trunk. A sensor (10; Figure 1) monitors the relative humidity nearby the cotton cloth every 30 minutes and stores it in a data logger (Novus, USA). The relative humidity sensor (model HIH-4000, Honeywell, USA) is made of a thermoset polymer capacitor that increases its voltage output linearly with RH.

Wicking represents the capillary movement of moisture within the cloth. As fabric thickness determines how much water can be absorbed, a 4mm thick cotton cloth was selected, being its drying time of 12 hours. A 15-year-old tree has a trunk diameter of 40cm and if the cotton fabric used is 10cm wide and 4mm thick, the cotton cloth weights 86g. If the fabric is introduced into a water tank, its weight increases to 387gr, caused by the absorption of 300ml of water.

In the two experiments the applied emulsion had a 10% of eucalyptus essential oil mixed with 200ml of water. To perform the treatments, a 10% (v/v) solution (10% essential oil, 88% water, 2% Tween 20, Merck) was prepared. On the first experiment the water in oil emulsion [11] was applied with the micro-sprinklers to the cotton cloth surrounding 50 tree trunks. The odor was classified as very strong, strong, medium, just detectable and none. Sampling was taken every 3 hours during two entire days. In the second experiment, a hose (6; Figure 1) with integrated drips was surrounded by the cloth and fixed to each trunk with a plastic strap. After filling the hose and closing the valve, a piston (8; Figure 1) pushed the essential oil solution to the dripping hose, getting the cloth wet; The piston is driven hydraulically by the pumped water. Once the irrigation pump stops, a spring (11; Figure 1) returns the piston to its starting position.

Result

In the first experiment, manual spraying of the 50 tree cloths was very laborious and took over 90 minutes. Relative humidity of the thin cloth fixed around the trunk decreased to $91.1 \pm 1.05\%$ at 8:00 next day, twelve hours after manual spraying (Figure 2).

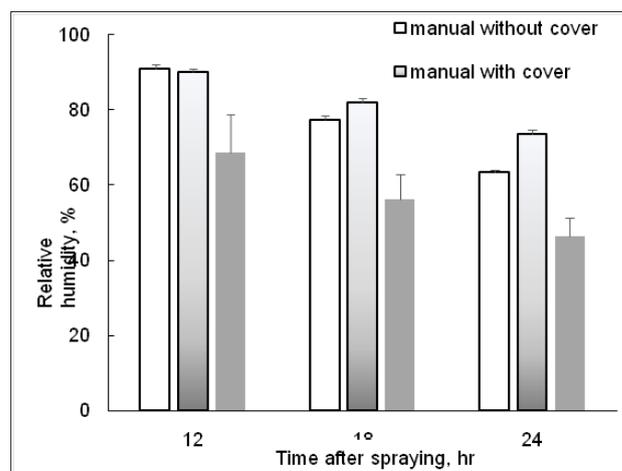


Figure 2: Relative humidity of fifty thin clothes 12, 18 and 24 hours after spraying them manually with and without cover and after sprinkling them.

Cloth wetness decreased slowly during the first 12 hours at night being the water lost between 5-6%. Six hours later at 14:00, the uncovered cloth, reduced its moisture to $77.5 \pm 1.15\%$, meanwhile the covered clothes remained humid at $82.1 \pm 1.1\%$. The cloth without cover presented a RH of $63.3 \pm 0.6\%$ at 20:00, meanwhile the covered cloth remained wet at $73.7 \pm 0.34\%$ at this time; standard deviation in all the cases was close to 1.

In trunks having a plastic container covering the manual sprayed cloth, aroma remained constant during the first ten hours

as shown by the thick continuous line in Figure 3. Eighty percent of the trees remained with a strong odor after 15 hours. When the pointed line intercepts the dark continuous line, the aroma tends to decrease and the panel of experts considered it medium, peaking after 24 hours.

Half of the trees presented a just detectable fragrance after 27 hours (Figure 3). After 40 hours, 50% of the trees did not present any odor, and after 48 hours, aroma was absent in all the fabrics surrounding the trunks.

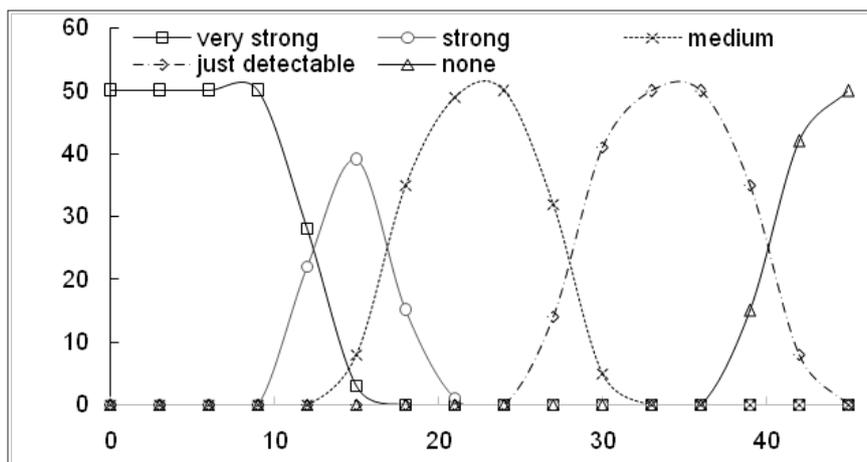


Figure 3: Aroma remaining in a plastic covered cloth after several hours of application.

In the integrated drippers experiment, the drippers are 5cm apart, but the liquid wet the fabric every 2.5cm (Figure 4) as the hose turned twice around the trunk. As roselle was used as colorant it was easy to detect the wet section of the fabric. A peak was found every 2.5cm and only the fabric bottom was wet. If only a liter of

water was applied by the drippers, $50 \pm 3.2\%$ moisture peaks were monitored on the fabric (Figure 4); $88 \pm 2.2\%$ moisture peaks were measured after applying 5 liters by the hose. In Figure 4, the cotton fabric was dry at a 7.5cm linear distance as the dripper clogged. It was found that after 24 hours the aroma in all clothes was absent.

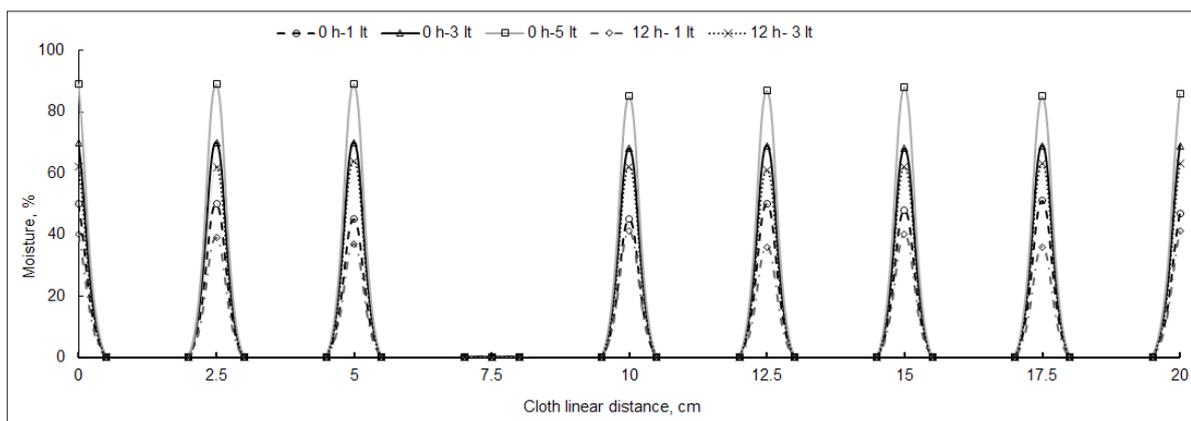


Figure 4: Linear cloth periodic HR caused by drippers applying different flows.

Conclusion

This study compared precise spraying techniques that were connected to the existing irrigation systems to spray simultaneously several hectare of trees. The aroma of the repellent solution applied

to the cloth surrounding the tree trunk should be kept as long as possible, so fabric drying was fundamental. In the precise spraying techniques, the fabric lost its odor-fragrance after 2 days. Fabric wetness status was monitored non-intrusively providing cloth moisture.

As manual application of the repellent solution is labour-intensive, spraying the cloth of 100 trees simultaneously was done by using a pressurized irrigation system; some additional elements were added to moist the fabric clothes. After comparing the results of drip and micro-sprinkler application it was clear that cloth water absorption differed, being water spraying more homogeneous. During the first application of water on dry-new clothes, water impregnates totally in both systems. In the hose dripping system, the fabric is first wetted in the inner surface close to the trunk, meanwhile in the sprinkler system the liquid penetrates the fabric from the outer surface to the interior. When the fabric is covered, a lower quantity of solution (approx. 20%) arrives to the cloth, being the application very inefficient and expensive, but the aroma and fabric moisture lasts longer. If the liquid that requires the cloth is 300ml, a total of 1500ml have to be applied. When no cover is present with a sprinkler-droplet 40% of efficiency, 750ml of liquid is required per tree. It would be advisable to cover only 50% of the fabric and use a deflector to reduce evapotranspiration. In future fabric designs, nanoparticles and new technologies can be used to release the essential oil more slowly.

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