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ANALYSIS OF OPTICAL DENSITY OF ELECTROSTATIC SPRAY ON APPLE IN WINTER AND SUMMER SEASON

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ABSTRACT

Wastage of agricultural chemicals and ensuing environmental pollution is an issue, where ineffectivespray deposition is a major concern with conventional pesticide application methods. Electrostaticspraying is known to be one of the most effective methods to improve frontsurface deposition,backsurface deposition, overall deposition, and distribution on the plant targets. Deposition of charged sprays on front and back surfaces with and without electrostatic on apples in winter and summer season was studied in the laboratory. An air-assisted electrostatic induction spray charging system was used toapply charged spray at uniform application (ground) speeds.Spray deposition is determined by using a fluorescent tracer technique. The droplet velocityand charging voltage were the key factors for obtaining desired spray deposition on apples. .A fluorescent tracer powder is used for experimental analysis.After deposition of spray on the apples the samples were observed under the spectrophotometer.After experimental run it is observed thatelectrostatically charged spray improves the deposition on back side surface of appleand overall deposition. The deposition was substantially influenced by factors such as charging voltage, application speed, plant target height, and different seasons in the atmosphere.

INTRODUCTION

Some problems with pesticide spraying exist in agriculture. Often as much as 80% of sprayed pesticide, which is supposed to land on the leaves of crops, acts as a pollutant in soil and water [1]. Electrostatic spraying technology offers a very favorable means to increase pesticide droplet deposition onto biological surfaces of living crops, with more than a doubling in efficiency being a reasonable goal. In this way, management by electrostatic forces offers a solution to the problem. They are thought to provide very significant economic, environmental and energy saving benefits, as well as future potential.

Many toxic pesticides are dispensed to protect food crops from pests in farm fields. Greater than 90% of pesticides are commonly applied as aqueous-based sprays. When dispensed with conventional nozzles, a large portion of the spray is often lost as airborne drifts of droplets. In addition, there is a lack of deposition onto the plants due to the rapid gravitational settling of droplets beneath the soil surface. Thus, target deposition efficiencies poorer than 25% are often encountered in agricultural pesticides. Electrostatic spraying technology offers a very favorable means of increasing pesticide droplet deposition onto biological surfaces of living crops.

Successful development of electrostatic pesticide spraying requires a fundamental Understanding and proper engineering design in three major aspects of the overall process: (a) droplet charging; (b) airborne transport of the droplets from the charging nozzle to target; and (c) actual electrostatic deposition onto the target surface [1]. First, droplet-charging is pertinent to increase deposition efficiency on the target.]. In particular, the electrical and physical properties of an electrostatic spraying nozzle have influenced the induction charging mechanism.

Wastage of agricultural chemicals and ensuing environmental pollution is an issue, where ineffective spray deposition is a major concern with conventional pesticide application methods. Electrostatic spraying is known to be one of the most effective methods to improve leaf abaxial (underside) surface deposition, overall deposition, and distribution on the plant targets. Deposition of charged sprays on leaf abaxial and adaxial(upper) surfaces as influenced by the spray charging voltage.

The enormous wastage of chemicals and the ensuing environmental pollution, due to off-target deposition of conventionally applied pesticides, could be reduced by the use of charged sprays. With conventional sprays, sometimes only 20% of spray liquid reaches the targets (Hussain and Moser, 1986). Increased cost of pesticides and greater concern about environmental pollution necessitate improved efficiency of conventional pesticide spray application methods. Electrically charged sprays for agricultural application can provide greater control of droplet transport, deposition and reduction of wastage. Using electrostatic spraying, the application efficiency can be increased up to 80% with 50% less spray chemical ingredients , Electrostatic forces on small droplets are more prominent than the gravitational forces and therefore, electrostatic charging of spray droplets can provide an improved deposition with reduced drift (Robinson and Garnet, 1984; Sharp, 1984; Almekinders et al., 1992, 1993; Laryea and No, 2003). Moreover, several researchers have shown that electrostatically charged sprays improve the leaf abaxial (underside) deposition.

In most parts of the world, conventional hydraulic atomizing nozzles and especially in large farms, fan nozzles on tractor booms dominate the pesticide spraying systems. Research on agricultural electrostatic spraying started primarily with electrodynamics spraying of charged small oil droplets at ultra-low volume for small farms in the tropics where the scarcity of water was the major concern (Smith, 1988). Meanwhile, a system of induction charging of water sprays from hydraulic nozzles was developed (Merchant and Green, 1982; Marchant et al., 1985; Phillips et al.,1988). Until then, electrostatic spraying of pesticides was not successfully commercialized because of the higher cost of equipment and the relatively small coverage, especially on cereals (Matthews, personal communication, 2007). The latter was due to less penetration in to the crop canopy although the charge on small droplets was effective, which increased deposition and reduced downwind drift (Allen et al., 1983; Lake and Merchant, 1984; Metz and Moser, 1988; Matthews, 2000). Subsequent research has shown that the forces exerted by air jets are needed in addition to those created by electrostatic fields to improve overall spray deposition, distribution, and canopy penetration especially at the leaf undersides (Abdelbagi and Adams, 1987; Law and Cooper, 1988; Almekinders et al., 1992, 1993; Law et al., 1992; Khdair et al., 1994). By the introduction of the air-assisted induction-charging nozzle, the problem of short circuiting in high-voltage power supply due to electrode wetting in the nozzle electrode was overcome (Law, 1978). Requirement of high-voltage power source and its associated shock hazard during the electrostatic spraying was subsequently greatly reduced by the improved designs of induction-charging spraying systems, which require less operating current and relatively low voltage (Law, 1978; Law et al., 1996). Recently, commercially viable and economically feasible safe operating air assisted electrostatic induction charged spray systems are gaining interest among small and large farmers. The following fig.shows the area covered by spray with and without the electrostatic. It is seen that area covered by spray with electrostatic is more than the without electrostatic.

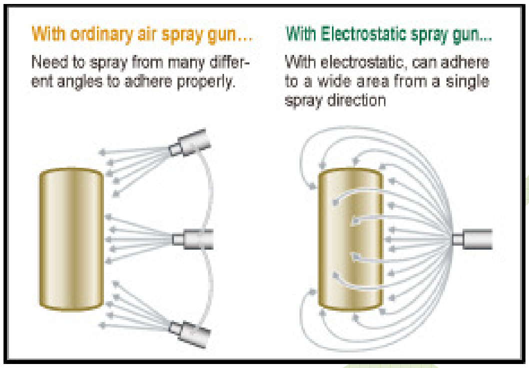


Fig. No.1: Difference between spray deposition on a metal with and without electrostatic spray

The advantages of the electrostatic spray are:Exact control of spray quality, Improved adhesion, Shortened spray and short cycle times., Energyreduction, Cost Savings
Air-AssistedElectrostatic Spraying.
The droplets are electrostatically attracted to plants which are essentially grounded. The science behind electrostatic spraying boils down to two basic principles of charged particles.

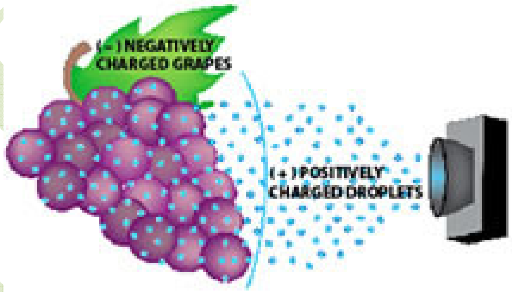


Fig. No. 2: Spray deposition on grapes with charged droplets

Like charges cause the spray to split into even inner particles that repel from one another, pushing the spray deep into the plant canopy. The opposite charges in the plant attract the particles to it, drawing the spray into the plant canopy. The surface charges eventually equal out when the plant is fully covered in spray. This is how electrostatic spraying creates an even coating on all plant surfaces.
ESS offers products with air-assisted, electrostatic sprayers to serve the agricultural, sanitization and industrial markets. The sprayers can effectively apply most common chemicals, pesticides, disinfectants and additives; providing you with a better coverage than a conventional sprayer or fogger.

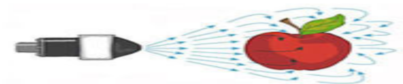


Fig. No. 3: Electrostatic spray on apple

The air-assisted electrostatic sprayers produce droplets 900 times smaller than those or produced by conventional hydraulic sprayers. These tiny droplets are given an electrical charge and they are carried deep into the plant canopy in a turbulent air-stream to coat all of the plant surfaces. The "wrap around" effect causes the spray to cling to the surface rather than being blown past the target, drifting away or falling to the ground.

EQUIPMENTS AND METHODS

1)Nano drop technology nozzle.

A nozzle is designed in such a way that it combines the pneumatic atomization and electrostatic induction charging to provide a stream of electrostatically charged fine droplets.The nozzle having low voltage power supply of 12 to 15 volt battery, electronically raises the voltage up to 5kv to 10kv and applies this high voltage to the electrodes which are embedded in the spray nozzle. The material of the electrode used is brass. The high voltage components are inside the nozzle which is made of an electrically insulating material to minimize the danger of shock and mechanical damage.The NDT nozzle with an embedded induction electrode, offers numerous advantages over conventional spray nozzles.
Specifically the NDT nozzle is capable of incorporating an internal pneumatic atomizing device which produces the smaller size droplets which are desirable for many uses and which can effectively utilize electrostatic forces.

NDT Nozzle Benefits:

- Patented technology
- Design modularity for high and low volumes
- Easy to Disassemble and service
- Engineering material with glass fiber structure.
- Improves life and reliability of nozzle.

- Quick nozzle position adjustment for deep reach
- Integrated fail safe electrode mechanism with 100%safety ensured
- Cleanable nozzle orifice and can be replaced as per requirement.

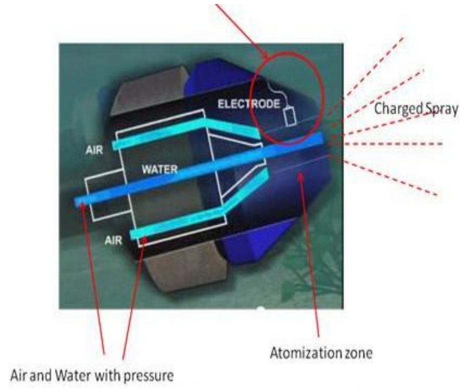


Fig. No. 4:NDT Nozzle

2)High-voltage generator

High-voltage electrode mounted on the nozzle produces high voltage corona which makes droplets charged. In order to ensure the formation of corona field, the high-voltage generator should be supplied with limited voltage and steady current. The highest voltage can be set by a regulating knob. Under steady power supply, stabilized current will decidecurrent density of corona field. Voltage amplitude can be adjusted according to conditions of corona field. In this manner, output current keeps steady and charging equipment can work normally under wider variation range of corona field.
The nonlinear DC high-voltage power supply technique was introduced in the high-voltage power supply equipment, i.e. the typical DC high-voltage switch power supply technique in DC-DC mode. The MOSFET, IGBT, quasi-resonant frequency conversion technique (the frequency of power supply can be 2500Hz) and the silicon voltage multiplier technique were introduced. Compared with the linear power supply, it has outstanding characteristics of high efficiency, small volume, low weight,fast reaction, low power storage and short period of designing and manufacturing.
The ±10～±30kV/5mA DC high-voltage power was generated by the high voltage generator, the regulation and display systems were combined fixed in the same control box. The regulation switchshunt supply insurancetrimmer potfault display LEDtwo ±HV digital display and the power supply of the digital display were included in the control box. The control box has the significant advantage of small volume(only 15cm×10cm×10cm), low weight(only 250g), convenient moved and installed for monitoring and manual adjusting by driver.

3) Test bench

The experimental setup consist of an Air compressor for atomization of droplets, an electric motor, a nano drop technology nozzle, Brass electrode embedded in nozzle, High voltage generator, Table of size 5*3 feet, apples for testing, Filter paper, Water tank of capacity 25 liters.
In the compressor the pressure developed is up to 12 bar. The water is taken from the water tank with the help of electric motor of 0.5 HP power and atomization of water particles takes place with the help of nozzle and compressor. Nozzle is made up of Nylon which is of NDT (Nano Drop Technology) type. The Brass electrode is fixed in nozzle.The amount of water can be control by using valve.The current is applied on electrode by using high voltage generator and hence ionization of atomized particles takes place. These ionized particles are sprayed on the apples

which are wrapped by filter paper. These ionized particles are sprayed by using nozzle with high pressure.

Due to positive and negative charge present in the atmosphere the ionized particles are covered the apple on front as well as back side of the apples.

Fig. No. 5: ExperimentalSetup in Lab.

4) Measurement of Spray Deposit:

Spray deposition on the targets were measured by using a fluorescent tracer method. Ground water having dynamic viscosity 9.14*10^{-3} poise was used as spray liquid. A fluorescent tracer power (Day-GLO Blaze orange, type GT 15-N) weighing2.0 gram was suspended in 1000 ml of ground water, resulting in tracer liquid concentration of 2000 mg/L. This concentration of tracer residue on the target is analogues to pesticide active ingredient of an actual spray mix.Filter papers each of sampling area 12*12 mm^2 were placed at the front and back surface of the apple. 20 samples were drawn for the test purpose or to measure the optical density / absorbance.

After experimental run, all the samples were placed in separate plastic zip locker bags held in an ice chest and then stored in a refrigerator. The samples from each target surface were retrieved into 50ml sample bottles and the samples were allowed to soak in for 30 minutes with complete stirring on a mechanical shaker for 10 minutes to ensure the maximum release of the tracer from the sampling paper to the wash liquid. The recovered tracer concentrations of the samples were analysed for optical density (absorbance) withacomputerisedspectrophotometer.under the visible region of the electromagneticspectrumof wavelength, 555nm.The laboratory experimental result obtained are as follows.

RESULTS AND DISCUSSIONS

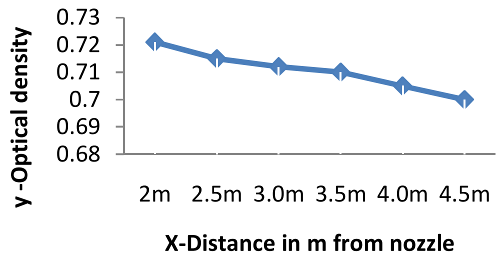
While conducting the experimentation on set up the following results were obtained.

Absorbance analysis in winter season on apple.

A] Absorbance of spray **without** electrostatic at R.H.70% (DBT-24 C, WBT-20)

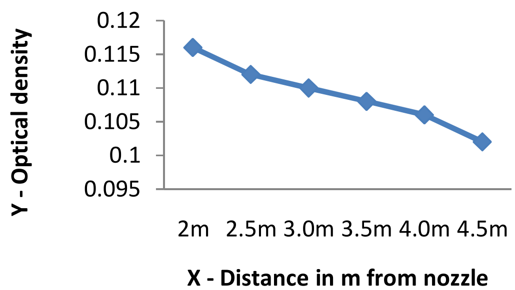
1) At the front face of apple

Distance in m from nozzle	2m	2.5m	3.0m	3.5m	4.0m	4.5m
Optical density	0.721	0.715	0.712	0.710	0.705	0.700



2)At the back face of apple

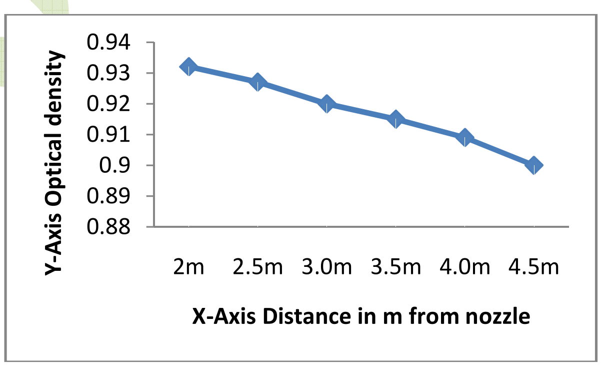
Distance in m from nozzle	2m	2.5m	3.0m	3.5m	4.0m	4.5m
Optical density Observed	0.116	0.112	0.110	0.108	0.106	0.102



B] Absorbance of spray withelectrostatic at R.H.70%

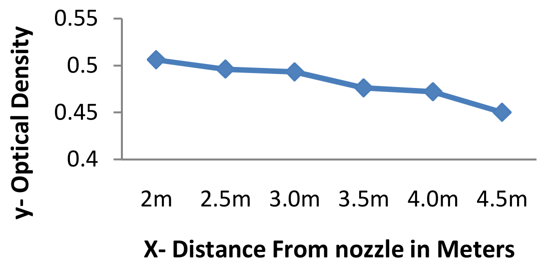
1) At the front face of apple

Distance in m from nozzle	2m	2.5m	3.0m	3.5m	4.0m	4.5m
Optical density Observed	0.932	0.927	0.920	0.915	0.909	0.900



2) At the back face of apple

Distance in m from nozzle	2m	2.5m	3.0m	3.5m	4.0m	4.5m
Optical density Observed	0.506	0.496	0.493	0.476	0.472	0.450

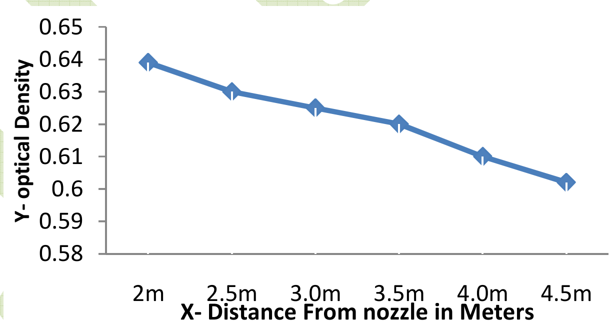


Absorbance analysis in summer season on apple

A] Absorbance of spray withoutelectrostatic at R.H.64% (DBT 32C, WBT 26C)

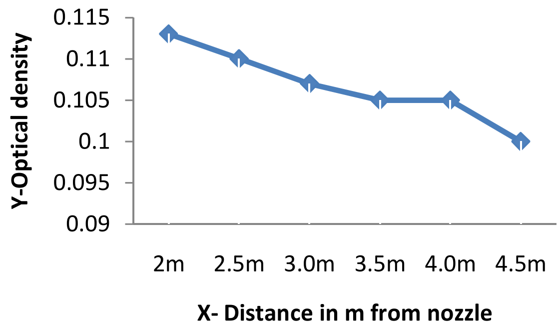
Distance in m from nozzle	2m	2.5m	3.0m	3.5m	4.0m	4.5m
Optical density Observed	0.639	0.63	0.625	0.62	0.61	0.602

1) At the front face of apple



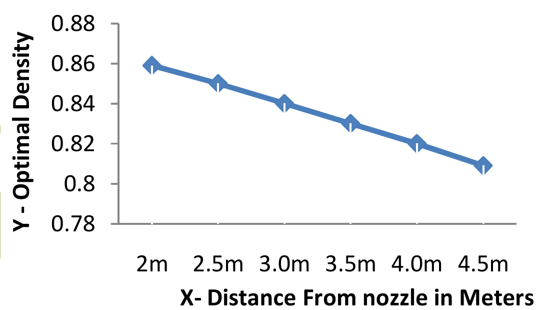
2) At the back face of apple

Distance in m from nozzle	2m	2.5m	3.0m	3.5m	4.0m	4.5m
Optical density Observed	0.113	0.110	0.107	0.105	0.105	0.100



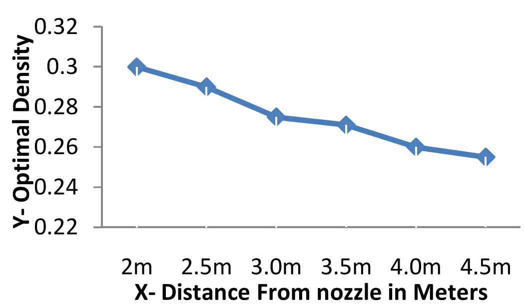
B] Absorbance of spray withelectrostatic at R.H.64%
1) At the front face of apple

Distance in m from nozzle	2m	2.5m	3.0m	3.5m	4.0m	4.5m
Optical density Observed	0.859	0.850	0.840	0.830	0.820	0.809



1) At the back face of apple

Distance in m from nozzle	2m	2.5m	3.0m	3.5m	4.0m	4.5m
Optical density Observed	0.300	0.290	0.275	0.271	0.260	0.255



CONCLUSIONS

1. The experiment is carried out in the laboratory and according to the result obtained we conclude that absorbance of pesticides in the winter season is more than the absorbance in the summer season. The reason behind it is in summer season the droplets which are form through the nozzle they will be evaporated into the atmosphere.

Therefore the deposition efficiency is less in summer season.

Also the experimental results shows that, the absorbance of the spray without the electrostatic is less and absorbance of spray with electrostatic is more by 25-30%.

2.It is also observed that as the distance from the nozzle increases the deposition efficiency or optical density decreases. It is also observed that, due to charging effect spray deposition on the back surface of the apple increases by 20-25%.

3.On the basis of the experimental results in the laboratory, it shows that using air assisted nano drop technology nozzles have high atomization capacity, convenientin operation&give high productivity.

4.It is also observed that the ground loss is very less.This is due to repellent and coalescent behavior of the droplets. Also The quantity of pesticides required is less in case when the pesticides are sprayed with the help of electrostatic charged. The total contribution of the charged spray characterized efficient utilization & pollution control .Translating the laboratory results to field practice results may requires further study.

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