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Economical Way of Appling Pesticides Through Electrostatic Sprayer

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ABSTRACT

One of the downsides of the traditional pesticide spraying is only a part of sprayed pesticide is retained by the crops, however, the rest is saved in undesirable spots, perhaps causing natural contamination. Electrostatic spraying is painstaking to be one of the most appropriate methods of incapacitating these difficulties. These outcomes demonstrated an imminent change in the deposition on leaves. The deposition on the entire foliage was very much enhanced with this type of sprayer, particularly on the rear surface of the leaves. Because of the effectiveness of the electrostatic force with a shower type sprayer is inadequate to shorter plants; to overcome this blowing air type was implemented, it has enhanced performance for taller plants and perform better deposition. These sprayers produce small droplets of highly concentrated pesticide, as compared to conventional or hydraulic sprayer droplets the electrostatic sprayer droplets are 900 times smaller. The electric charge given to the pesticides after they became tiny droplets atomized and is carried deep into the plant canopy in a turbulent air-stream. These charged droplets penetrate foliage and stick to all plant surfaces, including the undersides of leaves due to this more than twice the deposition efficiency of traditional hydraulic sprayers. Better spray coverage equates to lower chemical consumption and farmers can decrease chemical costs by 25-50%, effective results in faster investment profit. The electrostatic sprayer is also helpful in solving the some of the worst agriculture problems like downy mildew, late blight, thrips, aphids, mealybugs, early blight and listeria. Some chemicals are used in the electrostatic sprayer gives an excellent result when trying to control weeds and other unwanted plant growth.

Keywords: *Precision spraying, Automatic target plant detection, Electrostatic sprayer, Mist blower, Air assisted sprayer. Particle size, Electric charges*

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INTRODUCTION

In India, the demand for the plant protection machinery is increasing every year, because of simplicity, ease of operation and inexpensiveness powered knapsack mist blower is one of the unique adaptable pesticide application equipment yet, and these sprayers need to overcome the issues of low target deposition, distribution and penetration into the plant canopies. In the commercial agriculture, plant protection chemicals are vital for profitability, low food prices and for maintaining the adequate food supply. Without them, crop losses could be as high as 50 per cent for field crops and up to 100 per cent for fruit crops and greenhouse ornamentals.

The conventional spraying techniques and equipment's result in many problems such as high volume but low efficiency, only 15% to 20% of the pesticides deposited on the targets,

most of the pesticides lost in the surroundings, causing contamination to the operators, and serious environmental pollution[2]. These issues lead not exclusively to the vicious cycle of pest control but also improve the pest resistance to pesticides. As compared tothe high-pressure gun sprayer, an air-assisted orchard sprayer can decrease pesticide use by 20%, but 40% to 60% of pesticides are still lost because of the continuous spraying between the gaps in tree rows and the drift of small droplets[3].

An electrostatic sprayer is a novel improvement in greenhouse pesticide application technology and it is the most auspicious methods for applying the protective liquid based sprays onto the biological surfaces of living crops and plantations, it can provide greater control of droplet transport with impending reduction of wastage. It made the advance development in the agricultural pesticide spraying techniques and it controls the off-target pest control and increases the deposition efficiency and surface bioefficacy about 80 per cent with 60 per cent less spray chemical [1].Decrease the pesticide loss about 30% [4]. It is responsible for aphid control and superior to conventional spray while using 40 times less water in an equivalent area. In addition to this these provides 3.7 times more foliar deposition compared to conventional full-volume sprays.

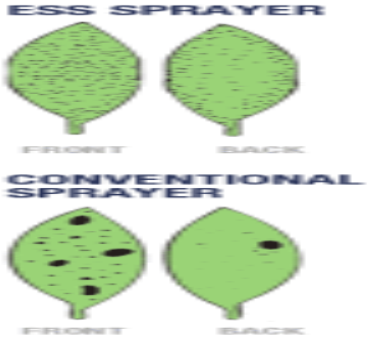


Fig.1. Comparison between ESS sprayer and conventional sprayer

Electrostatically deposited residues were more difficult to remove instinctively. Hence, as compared to conventional full-volume wet sprays an electrostatic application is less hazardous to worker health and safety. These electrostatic spraying processes are helpful in many other applications like thin film deposition, painting, printing etc. According to Agricultural Census Division, in India, the farming is carried out in small scales and the farms land are divided into small pieces of land; it due to the government policy of allocation of farms or geographical and agro-climatic conditions.

The study of static electricity, the surface phenomenon governing electric charges accumulated on a body as explained by Coulomb's law. It has significant potential forthe application of agricultural liquid formulations since charged particles can perform uniform spray coverage with considerably less quantity. The particle size distribution of the uncharged droplet less concentrated then that of the charged droplets and the axial speed of the charged particles is faster as compared to the uncharged particles and also increase the uniform velocity distribution. The deposition was very high irrespective of leaf taxonomy, anatomy and morphology. The photosynthesis activity and the metabolic activity of plant is the main reason for accumulation of static electricity on the plant surface.

This system overcomes the some of the problems like poor distribution, low penetration and low deposition efficiency on the dense plant shade. An air-assisted electrostatic nozzle system is made up ofan air-assisted nozzle and induction based electrostatic mechanism. Since the nozzle is lightweight, more efficient and eco-friendly therefore it decreases the pesticide usage and reduces the human health risk. The power supply of high voltage is generated from the rechargeable dc batter it generates up to a few kilovolts. The formers need some robust pesticides application equipment in order to minimize labour or without any exceptional expertise.

Fig. 2.Application of chemicals using Electrostatic spraying

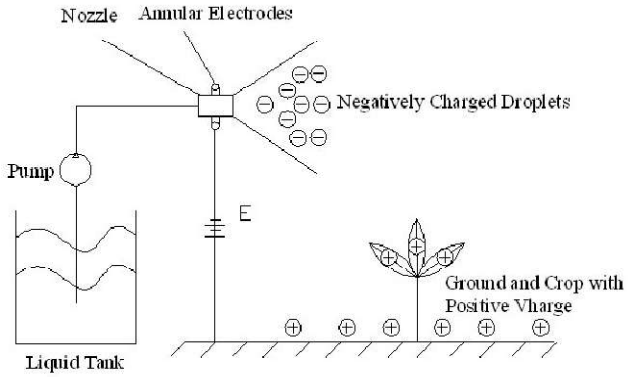
A large number of the cases for these sprayers might be valid, however, but it is necessary to obtain the following objectives:

- More efficient as compared to the full volume wet sprays
- Non- hazards to the operator/ former
- Even deposition of the pesticide to a targeted and non-targeted area

Electrostatic spraying is the process of applying a coating, cleaner, disinfectant, or other liquid, and involves applying an electric charge to a liquid in order to get it to fully cover a surface. The result is a more efficient process with numerous advantages. It is necessary to understand the working principle of electrostatic sprayer and why it is benefit as compared to the conventional method of spraying during implementing.

WORKING PRINCIPLE

Electrostatics deals with the electric forces which involve electrons and ions, and with the related electric fields and potentials. In electrostatic charging, electrons endure relatively stationary with respect to the surface and spread uniformly and concentrated on sharp edges. The particle becomes electrically charge by adding electrons to it, forming “negatively “charge or by removing from it, thus becoming "positively" charged. The same charge repels each other and opposite charge attracts each other. The electrostatic force between two charged particles (F) is given by Coulomb's equation: $F = K(q_1q_2/r^2)$. This force is depending on the magnitude of the charge (q_1 and q_2), the distance between the charged bodies (r), and dielectric coefficient (K).Electrostatic interfaces play a key role in different biological processes including the pollination of plants, both in nature and in agriculture. ideally, plants possess small negative potential during clear fair-day conditions and under uneven weather conditions during the cloudy or rainy day, the electric fields can change their polarity and the surface charges become positive. The magnitude of the electric fields depends in part on the chemical composition of the plant, its height and the environment. The distribution of the electric field around the plant varies with its shape, and the plant's electrical fields should be greatest near sharp points such as plant terminals including flowers.



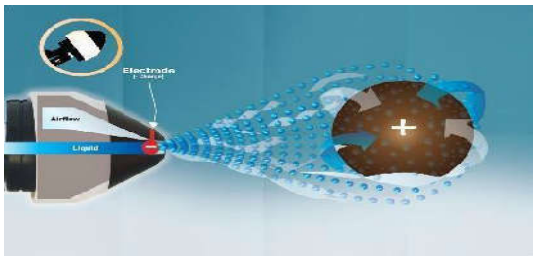


Fig.3. Working principle of the inductive electrostatic sprayer

Electrostatic Particle Charging Methods

The three methods which can be adapted to charge the fluid spray are

- ✓ conduction charging,
- ✓ corona charging and
- ✓ Induction charging.

❖ Conduction charging involves direct application of high voltage potential to the spray fluid by conduction. But this method requires a higher power supply and has the hazard of getting high voltage shock to the operator.

❖ Corona charging uses the corona discharge field to charge the spray particles passing through it, which also has drawbacks of life hazard and may cause chemical changes to the subjected spray material.

❖ Electrostatic Induction charging" (EIC) works on the non-contact charge induction on the subjected spray fluid passing through the high voltage electrical field. As the method has no direct contact with the working fluid, the chances of getting high voltage shock to the operator are negligible and the power consumption is also considerably lower than the other methods. **This made the electrostatic induction charging as the best suitable method for charging agricultural spray liquids.** Hence the method was adopted for this study due to its known advantages over other charging methods like high charge transferability, less hazardous to life and simplicity in construction.

Principles of electrostatic induction spray charging system

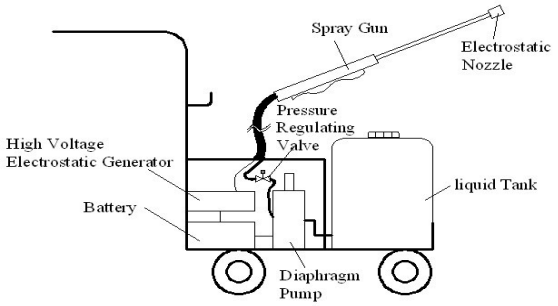


Fig. 4.Configuration of the inductive electrostatic sprayer

The method of electrostatic induction spray charging was adopted for this study by considering its known advantages over other charging methods such as high charge transferability, less hazardous to life and simplicity in construction. Fig. 4 illustrates the schematic arrangement of the components and the working principle of an electrostatic induction spray charging system which has been adopted.

The system consists of a spray nozzle and electrode placed in the vicinity of spray atomization zone concentrically with the spray nozzle. When sufficiently high voltage DC potential is applied to the charging electrode and the spray liquid is grounded, an electrostatic field will be created around the electrode. The position of the electrode is fixed in such a way that it will be exposed to the maximum spray atomization area. According to Gauss's Law, the maximum droplet charging occurs when the droplet formation zone is exposed to the maximum field strength. Therefore, for any liquid having non-zero electrical conductivity, an excess image charge will be accumulated on the grounded spray liquid with opposite polarity.

METHODOLOGY

Appling the positive charge to the pesticides and negative potential to the coating surface is the basic concept for the coating surface and this concept is combined with the process of

atomization. From the basic principle the same charges repel each other, opposite charges attract each other and these particles are certainly repelled by one another, and freely break apart or atomize, in accordingly the pesticides liquids attracted to the surface then it allowed for the full even coating on the surface. This is the primary concept that allows for a more even coating.

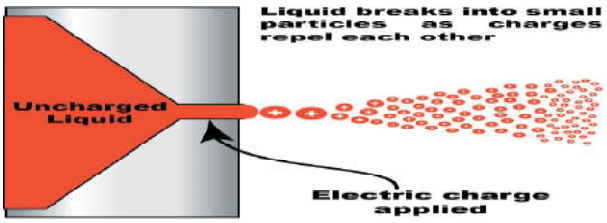


Fig. 5. Working principle of Electrostatic spraying

Majority of agricultural chemicals are applied as water-based formulations. Water has a polar molecular structure and has a large value of electric dipole moment due to hydrogen covalent bonds. The electron-pair forming covalent bond gets attracted towards the oxygen atom and as a result, oxygen side gets slight negative polarity and hydrogen side gets positive polarity and It produce an electric dipole moment inside the water molecule. according to the electrochemistry of polar molecules, fine water droplets can be charged electrostatically. The plants grounded to the earth shall be at zero potential; even though the metabolic processes of living plant body induces a slight positive charge on the plant. But this charge has been found to be distributed asymmetrically on the plant surface, concentrated near the sharp protruding body parts such as leaf tips, spikes and especially floral parts.

There are a few reports of inefficient sprayings, in abundance or with a shortfall of the active ingredient on the object, and at times, over half of the pesticides utilized are squandered in light of the fact that they don't reach the desired targets, causing environmental concerns and inefficiency of spraying. The main objective of this application is to increase the spraying efficiency, decrease the cost and environmental impacts.

The electrostatic sprayer is a system that electrically charges the pesticide particles. The force of attraction between the charge particle and plant resides are divided in two parts. The first is due to the action of the electrostatic field of the particle move towards the plant surface. The second part is the action of the electric field forces of the spray tip and the cloud upon the electric field of the drop. The pesticide partials are projected on surface when electric field is directed to the plant

At present, due to ecological and pecuniary issues, one has wanted to reduce losses in a spray, if the electrostatic spraying is applied properly, optimization of different parameters, deposition study onto actual targets etc., Can definitely decrease these losses and effectively utilizes the pesticides. Hydrodynamics of liquid flow and atomization of the liquid are the parameters required for the designing the nozzle. High voltage generating system consisting of rechargeable dc battery and dc to dc converter it generates the voltage up to few kilovolts. The parameter to be optimized during the designing the nozzles are a charge to mass ratio variation with applied voltage, the conductivity of the liquid, applied air pressure, the flow rate of the liquid and target distance [15] -[18].

Air-Assisted Nozzle

A twin liquid, internal fraternization, air-induced, concentric, the nozzle is made up of the nickel with an annular ring electrode it should make the proper co-axial arrangement between the nozzle and ring electrode. The charge stimulated on the jet is corresponding to the surface area accessible to the electric field and the extent of the ordinary segment of the field. For the given advance of nozzle body which manages the jet separation process, this impact must be accomplished by appropriate determination of the geometry of the charging electrode arrangement

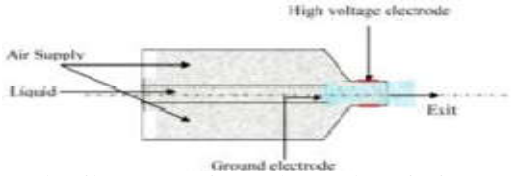


Fig. 6. Schematic diagram of an air-assisted electrostatic nozzle

High Voltage Generation and Droplet Charging

Electrostatic induction based charging has made acceptable method for charging spray pesticide droplets in agriculture. In electrostatic acceptance charging, guide charge-exchange to bead development zone of a fluid stream results from electrostatic enlistment of electrons onto the constant jet and in order to maintain it at ground potential, the nearness of a closely situated electrode of positive polarity is required. The inductive electrostatic process is used for the droplet charging and it decrease the risky and shock operation of the nozzle system

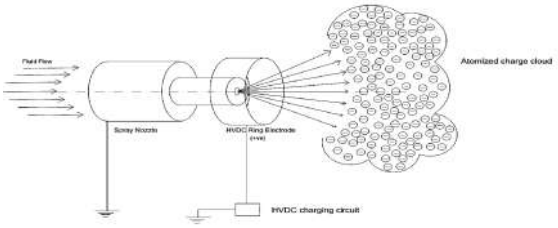


Fig. 7. Electrostatic induction spray charging system

The whole HVDC generator unit was accommodated in an insulated box to avoid arcing, direct contact with the operator or with any other conducting materials to avoid any sort of casualty.

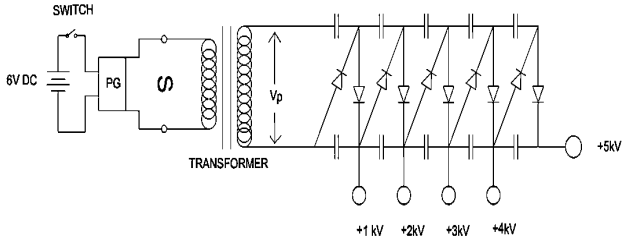


Fig. 8. High Voltage generator

Development of voltage amplification unit for HVDC supply

For charging an aqueous spray electrostatically, a high voltage DC power supply is essential. The basic voltage amplification unit mainly consists of a diode pump voltage multiplier. It has a special arrangement of P-N junction diodes and capacitors with an alternating current input. The voltage amplification depends upon the number of stages of diode and capacitor ladder and the capacitance value.

Voltage Inverter Circuit

In order to convert input DC voltage from the battery into an amplified AC voltage, an inverter circuit is necessary. It consists of a pulse generator and a high voltage transformer, in which the input DC voltage is converted into a pulsating square wave signal through the pulse generator circuit. This pulsating voltage is applied across the primary winding of the high voltage transformer, which then generates a sinusoidal alternating wave in the secondary winding due to mutual induction. This AC voltage can be used as an input source for the voltage amplification circuit.

Diode-Pump Rectification

A diode-pump rectifier circuit was developed as shown in Fig. 9. The figure illustrates the arrangement of diodes and capacitors with an AC voltage input (V). The circuit doubles the voltage output with a cascade arrangement of two diodes and two capacitors. However, the practical output voltage shows a slight reduction due to ripple in the voltage amplification. This voltage double or multiplier circuit is generally known as the Cockcroft-Walton (C-W) voltage multiplier (Fig.10).

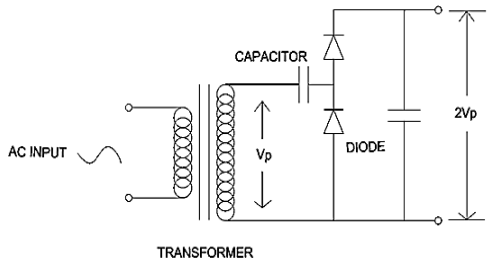


Fig.9. Diode-Pump Rectifier

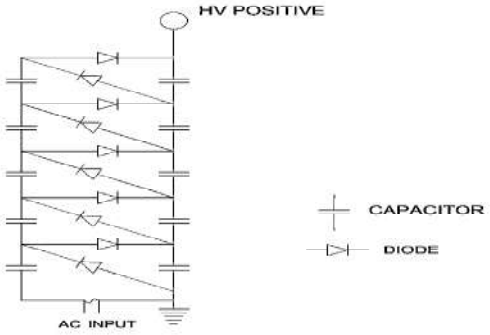


Fig.10. Cockcroft-Walton voltage multiplier

High Voltage Charging Electrode

In order to get high electrical conductivity and low resistance losses as well as ease of workability, pure Copper wire of circular section with the diameter of 2 mm was selected as an electrode material. Copper wire has low electrical resistance with easy workability, which facilitates shaping it into the desired manner.

Spray Head on the mist-blower

The spray head was working on the gravity along with low head centrifugal pump driven by the engine shaft, delivering the radial spray jets into the air-flow generated by the centrifugal blower. The direction of the spray jets and the high-velocity air-flow were right angles to each other, which caused the atomization of the spray fluid. In this mechanism, the size of droplets formed was completely depending upon the velocity of the air-flow. These droplets were then carried away along with the high velocity of continuous air-blow. The developed charging system which consisted of HVDC charging circuit and electrode carrier assembly was fitted as an attachment to the existing engine operated knapsack mist-blower without any modification or alteration with the existing spray nozzle head.

BENEFITS OF ELECTROSTATIC SPRAYER OVER THE CONVENTIONAL SYSTEM

Most conspicuously, the electrostatic spraying gives a more even, full coating over the other methods. The pesticide droplets are strongly attracted to the surface when positive charge particles are sprayed on the negative charge surface. Since the entire surface is negatively charged, the complete surface will be covered by the pesticides. Once the surface is covered to a certain thickness by the chemical particles, the remaining airborne particles become too far away from the surface to be attracted by the negative charge. Remaining pesticide does not stick, leading to an even coat throughout the surface. Another helpful preferred standpoint to electrostatic showering is that it can get to hard-to-achieve regions, similar to cleft, around corners, and rears of surfaces. Conventional sprayers utilize a mechanical atomization strategy, where pneumatic stress is utilized to separate the particles. This stimulates a higher forward spraying speed, and thusly there can be splatter or overspray. This doesn't occur with electrostatic spraying since air pressure isn't utilized in the atomization technique, and consequently there can be splatter or overspray. This doesn't happen with electrostatic splashing since air pressure isn't used in the atomization technique.

Electrostatic spraying has many advantages as compared to conventional sprayers and other coating methods.

Finish Quality: Conventional spray doesn’t provide a fine finish quality and it only covers the surface directly in front of the spray gun to overcome these an electrostatic sprayer are

used and it give an admirable finish quality by covering the material around the part, saving material.

Transfer Efficiency: transfer rate efficiency of the conventional spray applicators have a low which gives you a considerable measure of overspray. The transfer efficiency rate of electrostatic spray is up to 90% and substantially low overspray, due to lot of material gets saved during the spraying.

Investment: Conventional spray applicators have low-cost effective solutions, which provide a low-quality finish. Electrostatic spray applicators may cost more, but they have a quick return on investment from lower spray cost, a reduced amount of clean-up and increased output.

Advantages of Touchless Application: With the use of the water-based arrangement through the electrostatic sprayer, there is no compelling reason to contact/wipe the surfaces (reliant on arrangement splashing) this gives an extraordinary and powerful application technique.

Decrease Cross Contamination: Cross-contamination can be significantly diminished due to the touchless impact of the sprayers. Surfaces won't be contacted by cloth or human hands, therefore, won't be moving the bacteria from one place to another.

Liquid Adhesion: the electrostatic positive charge embedded into the droplet (dissimilar to some other electrostatic application) empowers the drop to stick itself on to the surface by means of the cationic charge. When the droplets fall on the surface they provide an even spread of the liquid in the meantime they hold their cationic charge for approx. 2 - 3 seconds in this manner not making dribbles as two positive charges will repulse from one another.

Dwell Times: Our sprayers allow the water-based solutions to meet their dwell time, in this manner guaranteeing that the arrangement attempts to its full abilities. The 3-waynozzles can be utilized to change the amount of solution applied which, thusly empowers the time you might want the surface to stay moist for.

Electrostatic Wrapping: In basic terms when you shower an answer that is accused of electrostatics, the arrangement will encompass the objective. Electrostatics isn't a development. It is a characteristic condition. We proficiently use this electrical phenomenon and we give a patented framework to more extensive and safer use.

Versatility: automatic electrostatic spray is versatile by providing an excellent atomization and easy adjustment for increased productivity in liquid spray applications. They are lightweight, cordless and come finish with a convey case so they can be taken anyplace.

Easy to Operate: No gauges or compressors, these sprayers have been intended to be utilized by anybody, with the utilization of basic switches and triggers. Simply fill up the tank, turn on the electrostatic switch, and powered the trigger.

Quick and Effective: Using the electrostatic sprayers will empower a fast and effective purification/sanitization. This is due to the electrostatic charge that's applied, allows the solution to cover the hidden and shadowed zones, and it also coversa large area in a small duration of time. The sprayers have additionally been intended to meet dwell times for arrangements so they can work to their full capabilities.

Easy to Implement: Due to flexibility and manageability these units are cost effective and easy to implement.

Eco-Friendly: the electrostatic sprayers are eco-friendly approach also the reducing the amount of pesticide sprayed on the surface of the plant. Surfaces won't be contacted by cloth or human hands, therefore, won't be moving the bacteria from one place to another.

Application of electrostatics sprayer in agriculture:

It is necessary to protect the food and fibre crops against the pest infection and weed bugs use of agronomic chemicals such as insecticides, fungicides and herbicide are indispensable. Entomological investigations have built up that in various cases smaller droplets of pesticide spray give greater biological efficiency per unit mass of pesticide than do the greater drops for accomplishing insect control yet the drift was the significant issue. For proper maintenance and inclusion, it is necessary to select proper optimum droplet size and density. A few cases in rather old information, 95% of the chemical applied can be wasted to the ground or at most half of mass exchange onto the coveted plant. Electrostatic spraying would offer a conceivable solution to those environmental problems; by decreasing spray drift and enhancing inclusion of chemical to target plant. These application zones

extensively incorporate ground equipment for spraying plants of line yields, plantations and nursery, even aircraft spraying.

CONCLUSION

Without proper innovative technology leads to improper utilization of the pesticide in the agricultural field can cause pollution to the earth, leaving residues in food and increase the hazard of poisoning to farm laborers. High-pressure electrostatic can reduce the number and improve the distribution of droplet particles, making them smaller and more evenly distributed. High-pressure electrostatic can also improve and enhance the uniformity of mean velocity distribution. Charge droplets have better deposition rate as compared to the uncharged droplet due to the former adsorb the directional development on the harvests and influence the testimony rate on the underside of leaves. The introduction of electrically charged sprays in the agricultural application has become inescapable for superior control of droplet transference with reduced drift and increased application efficiency with less spray chemical expenditure. The objectives of the paper are to explain the working principle, methodology and benefits of electrostatic sprayer over the conventional system.

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