

Preparation Analysis on Effect Factors of Spraying Quality for Boom Sprayer

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Abstract. In the agricultural production system, protecting crops against weeds, insect pest, and germ is an important part of farming process. The most main method of crops protection is applying agricultural chemicals at present. Theoretically, the quantity of agricultural chemicals could be limited to a few kilograms per hectare applying with modern highly effective agricultural chemicals. But the consumption of agricultural chemicals is much more than theoretical quantity in real spraying application because of the factors affecting spraying quality. Main factors affecting spraying quality of boom sprayer, including weather condition, character of droplet, performance of nozzle, spraying methods, and pesticide resistance, are analyzed in the paper to provide technical reference for reasonable spraying application of agricultural chemicals.

Keywords: Spraying Quality; Nozzle; Agricultural Chemicals; Droplet

1 Introduction

Effectiveness of agricultural chemicals depends on whether the droplet of agricultural chemicals is sprayed appropriately to the target to be protected. The factors affecting spraying quality of boom sprayer include weather condition, character of droplet, performance of nozzle, spraying method, pesticide resistance, and so on. Proper chemicals and time should be chosen for minimum consumption of agricultural chemicals and operation of spraying application. With the developing of high technology like GPS and GIS, new advanced detecting method and equipment, which optimize the factors affecting spraying quality, are researched to improve spraying quality.

Spraying application can be resolved to a series of correlative dynamic process where chemicals can be lost. The chemicals loss could be caused by improper use of equipment, drift and evaporation of droplet, dilution, high temperature, washout, volatilization, hydrolyzation, photochemical degradation, absorption and drainage of soil, bacterial degradation, dissolution, and so on. And furthermore, the effectiveness of agricultural chemicals could be reduced as the trait of plant leaves. It's very important for plant protection to find out the reason of chemicals loss and the way of improving spraying quality.

2 Index of Spraying Quality

Uniformity of droplet distribution, drift and coverage rate are the most important index of spraying quality that can be known by studying the droplets of spraying operation[1-2].

The uniformity of droplet distribution, represented by the coefficient of variation in quantity, is uniformity coefficient of droplet distribution on target. Distance, height and droplet pattern of nozzles, which cause miss or overlap of spray, are main effective factors of uniformity of droplet distribution[3-6]. Uniformity of droplet distribution can be affected by unexpected air flow too. The drift, represented by the ratio of deviated droplets to total spraying droplets, means the deviation trend of droplets from targets. The most immediately reason of drift is crosswind. Droplets sprayed from some special nozzle (anti-drift nozzle) provide low drift for their larger initial speeds and more uniform and bigger size than from general nozzles.

Three spraying quality indexes are related and constrained. More intensive spraying patterns provide low drift and bad uniformity of droplet distribution. Although uniformity of droplet distribution will be good spraying with small size droplets, more drift will come on. Uniformity of droplet distribution could be improved by increasing vertical distance between nozzle and target, but more drift would come on inevitable. So it is very hard to get the most optimal parameters for all spraying quality indexes at the same time[7-9].

3 Factor Affecting Spraying Quality

3.1 Weather Condition

Proportion of droplets reaching the target is influenced by environment temperature, relative humidity, wind speed, and wind direction. The evaporation of droplet and adhesion of plant leaves, which affect the movement of droplet directly, are related to environment temperature and relative humidity. In high environment and low humidity condition, most droplet from nozzle will fall down from the middle zone of low adhesive leaves. When humidity is enough excess droplets beyond the limit that leaves can hold will converge into stream and flow to the soil.

Wind speed and direction are important factors affecting spraying application. Blew by unexpected wind, droplet might deviate from the target and contaminate adjacent plant and soil. Spraying application will fail when the deviation of droplet, is too much especially in band or point spraying application. Reducing deviation as possible is required in spraying application, through it cannot be avoided completely in field spraying application. Spraying quality of boom sprayer is more affected by wind direction than other sprayers. When wind direction and boom of sprayer are parallel or the angle of them is small missing and overlap of spraying will come on[7-10].

3.2 Droplet Size

The quantity of droplets deposition on the plants yields significant influence on the agricultural chemicals effect. Therefore, it's necessary to know about the effect of droplets size to droplets flow and deposition on the target. Considering coverage rate only, the smaller droplets are, the better coverage rate is. But smaller droplets will cause much more drift especially in herbicide spray.

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3.3 Droplet Density

The droplet density is an important factor of coverage rate. The droplet density is related with insect pest density and mobility, active ingredient of agricultural chemicals and redistribution of active ingredient on target. For same droplet size, different droplet density means different consumption of agricultural chemicals.

3.4 Spraying Volume and Distribution of Droplets

Most agricultural chemicals were developed on the hypothesis that spraying volume (dilution) of agricultural chemicals is larger than 10L (or much more than 10L for some plants). More diluent will reduce the poison of agricultural chemicals, but the distribution of droplets is affected for the drift.

Lethal dose is presented with the number of mean droplets that reach to the insect pest. For specific agricultural chemicals, the requirement of minimum size of droplet is related to the quantity of agricultural chemicals that droplet contain. If droplet size is too small the droplet cannot reach the target because of evaporation. In theory, droplet size is required to be larger than 50 μm . To reduce drift, droplet size should be controlled to be larger than 200 μm in real spray application.

There are various size droplets in the spraying cone. The droplet size spectra can be detected quickly by the measurement system based on laser and computer or other technology. Classification of droplet size usually includes very fine, fine, medium, coarse, and very coarse.

In many case, pest can be considered as the certain area of the plant canopy. Droplets should reach the middle zone of the plant canopy by nozzles or assistant airflow when the area is on the back of leaves. The spraying volume is 2.5L per hectare as ultra-low volume spraying application if there are ten 100 μm diameter droplets per square centimeter area on the leaves whose leaf index is 5. The spraying consumption applying the spraying method will be less than recommended amount of the instruction pesticide. Compared with spraying application of pesticide and bactericide, droplet size and spraying volume should be larger in spraying application of herbicide for more effect of wind.

3.5 Nozzle

As the most important component of spray equipment, spray nozzle is related with droplet size, droplet density, and distribution directly. Pressure type and centrifugal nozzle are widely used in spray equipment now. Application history of pressure type nozzle is longer than centrifugal nozzle especially in large volume spray operation. For larger initial speed and size spectrum of droplet from pressure type nozzle, the performance of pressure type nozzle is better than centrifugal nozzle in preventing drift and worse in precise spray. There are many types pressure type spray nozzle including flat fan, hollow cone spray nozzle and twin fluid spray nozzle, etc. Droplet spectrum of centrifugal spray nozzle is smaller than pressure type spray nozzle, so it's easy to get different size droplet from same spray nozzle. Spray flow is related with spray pressure and size of spray nozzle. Generally, different spray performance can be gotten by adjusting spray nozzle size, spray pressure, movement of spray equipment and height of spray nozzle to the ground. Proper spray nozzle is one of an essential factor of good spray performance because of different characters of droplet from different spray nozzle and the difference of spray nozzles in principle, application condition.

Interval and height of spray nozzle are the same important parameter as the type of spray nozzle in droplet distribution. Interval of spray nozzle depends on spray cone angle and height of spray nozzle is related with interval of spray nozzle. Overlap and miss could be induced by mismatch of the two factors in whole area spray operation which need droplets distribution is uniform in whole area. In band spray, interval of spray nozzle depends on the row space of row spacing and height of spray nozzle depends on height and width of plant. It's advisable to cover the plant completely for band width of spray. The installation angle of nozzle is another factor affecting distribution of droplets in spraying application.

3.6 Spraying Quality and Effectiveness of Agricultural Chemicals

The efficiency of agricultural chemicals in real spraying application is very low for various reasons. Tests revealed that efficiency of pesticide for aphid in pulse crop protection is 0.02%. At present, the best efficiency of spraying application is 6% which is gotten in spraying application for locust. The age of most locust lied on the upside of leaves is same in the spraying application with best efficiency. Furthermore, hit rate of droplet was improved flying movement of locust.

The efficacy of agricultural chemicals is decided by spraying quality when agricultural chemicals is sprayed to leaves and stems of plant by sprayer. Effect of crop protection is affected if any index of spraying quality is not proper. Chemicals droplet will miss the target in the spraying application with high drift and nonuniform distribution of droplet which can caused phytotoxicity. It cannot control the insect pest, weeds, and germ. Spraying quality is significance for agricultural chemicals application.

3.7 Choice of Spraying Method

Spraying technology is very important in agricultural chemicals application since more than 100 years ago when mixture chemicals applied 50-2 000L. Most agricultural chemicals is sprayed as liquid droplet with nozzle of sprayer. The range of spraying volume is very large between 50L per hectare and 2000L per hectare because of different requirement of dilution. More than 40% of chemicals will fall down to the ground in spraying application to plant leaves. It will be greater when the spraying volume is large. If rain comes soon after spraying environment will be contaminated greater. Moreover, some droplets missing the target or floating in air will harm the environment and other creatures.

3.8 Resistant to Drugs

Resistant to drugs grows up gradually because the same or similar chemicals is used in the same field by farmer. To solve the resistant to drugs, most farmers increase the dosage and times of spraying operation. The right method is applying the other chemicals with different active ingredient, decreasing time and times of spraying application, and confining the use of the chemicals inducing the resistance in certain time period and place. The resistant to drugs can be reduced by optimal spraying method which can optimize the coverage rate of droplet and chemicals dose per unit area. Chemicals dose per unit area is related to the lethal dose.

4 New Technology for Improving Spraying Quality

4.1 Electrostatic Spraying

The first electrostatic spraying application was applied for cotton field in Africa. The application of electrostatic spraying proved quite effective, which can reduce the spraying volume to 1L per hectare. This method is invented for severe drought area. A little chemical can be used in electrostatic spraying because the ingredient of farm chemicals is required strictly by the method.

4.2 Assistant Air Technology

It's hard to penetrate the canopy of plant for droplets in spraying application with regular pressure nozzle. Spraying application was suggested to be applied without wind before to reduce drift. At present, new research show the distribution of droplets can be improved by proper wind speed which upper limit of wind speed is 1.5 m/s (3 m/s for herbicide). Initial assistant air system of sprayer with tube-axial fan was designed to apply in spraying application for trees. The best effect of assistant air is from natural wind comparing various kinds of assistance air system design.

4.3 Other Development

Now, some electrical and computer system are applied to monitor and control sprayer that is not widely used because of the cost and requirement of working condition in the field. Spraying application is improved by GPS which can record the geographic information instead of mark on ground. Prescription map can be presented by the new technology to instruct spraying application.

5 Conclusions

Uniformity of droplet distribution, drift and coverage rate to target are the main indexes of evaluation of spray quality. Wind speed is direct reason of droplet drift; environment temperature and relative humidity are indirect reason of droplet drift. Droplet size, uniformity and drift are related each other closely. Droplet size is related directly to type of spray nozzle, height of spray nozzle and spray pressure. Assistant air technology can reduce drift and improve penetration and distribution of droplets. The management on training of spraying application will be reinforced in the future, especially in the country where the agricultural chemicals is confined.

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