UDC: 631.348
original scientific paper

Acta Agriculturaae Serbica, Vol. VI, 11 (2001) 19-27

Acta Agriculturae Serbica
FACULTY OF AGRONOMY • ČAČAK •

CDA Method Technological Assumptions and Technical Solutions Conceptions

P. Nenic, M. Urosevic, M. Zivkovic
Faculty of Agriculture, Zemun, Yugoslavia

R. Koprivica
Faculty of Agronomy, Cacak, Yugoslavia

Abstract: The paper focuses on CDA plant protection method and on the technical solutions for the sprayers to help realize this method. CDA method enables excellent distribution of the chemical to be sprayed, effective active matter utilization and a lower environmental contamination, thereby protecting plants for a much shorter time. It also reduces treatment rate from 300-400 l/ha, thereby increasing working speed by 50% and the machine output, too.

Keywords: CDA method, rotating nozzles, Airtec sprayer

Introduction

It is evident that a much better approach to the total, differential, integrated protection as well as to that of pesticides themselves has been made over the last 25-30 years. The consumption dose of the working liquid is thought to be decisive, especially from the point of view of its specific use. Thus, great efforts are being made towards higher protection means effectiveness using as lower chemical amounts as possible. Protection mode "LV" (low volume) is featured with markedly low water use. In relation to the conventional modes, the pesticide amount used per unit area remains unchanged while the diluter one is diminished (being water in most cases).

In recent times, there is a tendency to reduce the norm, jet drift and pesticides hazards in the nature. When used in just as small quantities, new plant

protection chemicals may achieve high effectiveness in the plant treatment, requiring that their application be performed and the uniformly distributed droplets jet targeted with high accuracy at a constant treatment rate used.

Lower amounts of liquid to be sprayed enable smaller but more numerous droplets.

Thus, an equal ratio between the sprayed and the total surface and therefore a better biological effect due to a possibility that, when sprayed, the droplets may occupy even up to 15 times higher area than being their cross section.

However, conventional procedures often overlook pesticide quantities applied to plant surfaces and therefore the losses due to drift. Their determinations are also very costly and solely based on the reduced treatment norm, which may be attained by drift reduction. With these methods, jets are precisely directed, the droplets uniformly distributed and efficiently received.

With usual procedures, the number of superfluous pesticides is hardly determinable. The researches have shown that with, say, insecticides and fungicides application, one-tenth of the total active matter is enough for the therapy effectiveness. Therefore, the crops are more and more often treated with considerably small chemical amounts.

Materials and method

Technological assumptions of the CDA method. The experiments were performed with the CDA (Controlled Droplets Application) method aimed at the optimal treatment norm reduction and utter drift elimination. This method enables producing of the highly uniform size droplets, with diameter averaging from 150-350μm with the possibility that the droplets below 100μm in diameter are used in less than 1 per cent. Unlike the ULV and ULD procedures with smaller size droplets causing serious losses due to drift, the CDA one ensures high efficiency with small treatment norms. Therefore, the directed and controlled pesticide application with spraying method along with its complexity and a promising content was developed some 20 years ago.

In general, this concept is based on two criteria and on their interaction.

The first one refers to the mono-dispersion system production, with jet of the highly uniform size droplets.

The second one means controlled droplet transport to their destination.

All this assumes automation ancillaries (sprayers) to produce a narrower droplets size spectrum comparing to the conventionally used hydraulic sprayer. This primarily refers to reducing the number of small prone to drift droplets to the minimum.

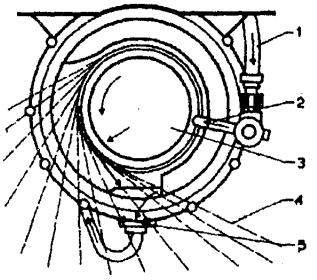
Droplet size uniformity is relatively feasible and objectively higher with higher diameter values (200-250μm) and relatively big nozzle wholes. This application mostly refers to the herbicides. The spraying uniformity diminishes gradually with the lower droplet size values (80-180μm) being similar to the conventional sprayers.

Results and Discussion

Sprayers technical solutions for CDA method application. By introducing rotating nozzles with droplets produced to be of the nearly identical dimensions (mono-dispersion droplets) has made an advance in liquid disintegration. In this sense, the variants of rotating automation ancillaries with vertical and horizontal axle have been developed.

Working liquid is, by means of force of gravity, lowered through the finely calibrated measurement instrument onto the highly precise tilting disc. The disc is most often rotated at around 7.000 min^{-1} producing centrifugal force enabling 5 x 10^6 droplets from 1 cm^3 of the working liquid for one second.

This type of nozzle is also called centrifugal one, consisted of supply pipe (1) for the liquid, which, through the batcher (2), directs the liquid to the center of the disc. Tilting disc and centrifugal force enable the liquid to diminish and eject droplets at the angle of around 140°. Thus, an encircling width of 1.2 m analogous to that in the two or three classic nozzles seems to be pretty meritorious. Liquid excess from the other part of the disc is collected into the collector and reversed to the tank (5) by the micro-pump's return lead. This is enabled by the upper disc segment, which collects all the droplets falling onto its interior surface at 220o directing them to the pump reversing the liquid to the tank. The liquid running from the bottom segment of the disc (at140°) is able to form the liquid jet being 40% of its total quantity. There are simpler devices in which water amounts are batched by the natural fall onto the tilting horizontal disc. Noticeable changes in the droplet size spectrum can take place thanks to the centrifugal force intensity so that the water flow is easily adjusted by means of the flow valves.



Drawing 1. Cross-section of the vertical centrifugal sprayer:
1) working liquid supply hose; 2) working liquid supply pipe
3) rotary disc; 4) arch (angle) of the jet 140°; 5) Micro pump returning unused liquid

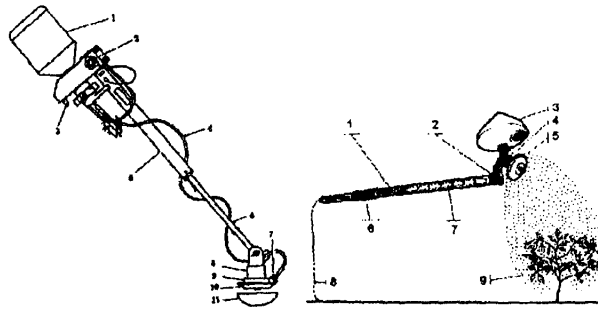
The nozzle is mounted on the drive spindle supplied with magnetic clasp for easier mounting with each disc driven by the electric motor fed by the collector current. The droplet size is adjusted by changing the rotation number from 1.700-7.000 min^{-1} and in some cases up to15.000 min^{-1}. Rotating nozzle capacity is dependent on the amount of liquid supplied, droplet size on the speed of disc rotation and on its shape, too.

Rotary disc with vertical disc for the CDA method low volume treatment norm, is outlined in drawing 1. This sprayer efficiently accelerates droplets airborne flight, resulting in their being well permeated by the plants as well as in a lower drift and jet dispersion.

Alternative mechanism rendering more uniform droplets basically consists of the plastic rotary disc of the high rotary speed (3.500-7.000 min^{-1}) with finely toothed edges.

Manual nozzles to use the extremely small amounts (ULV - ultra low volume) fed from dry batteries placed in the handle resting on the only one rotary disc, are being used worldwide. This method is likely to suit CDA method in pesticide application. Typically, this device is provided with plastic flask for working liquid to protect 1-5l volume and render droplets 70μm in size. In order that droplets jet may be airborne and "entered" easier the plants to be protected, the wind of 5-25 km/hour speed is desirable. This application is also called drift spraying as the droplets are let in into the prevailing wind. After being ejected, droplets emission depends on whether they appear in large amounts, on wind speed and direction, air turbulence and release, which altogether further determines droplets movement. The quantity of liquid to flow from the tank to the disc is regulated with the flow jet nozzle as well as with the density of liquid to perform protection. By addition of 20% adequate oil and by mixing it with protection means, too quick droplets jet evaporation is prevented. In other words, particularly formed pesticides with the minimal evapotranspiration potential used with ULV regime towards achieving residual effects, is preferred.

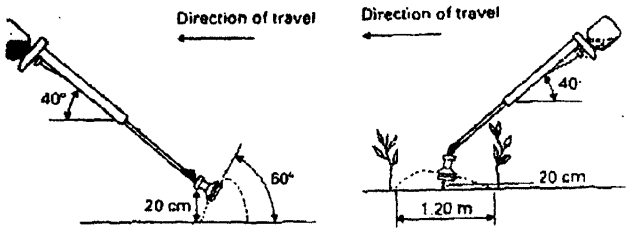
Similar device with 2.5 l flask is provided with adjustment of jet nozzles and a rotary one designed for pesticide application with 250μm droplets (drawing 2). This unit is adjusted so that one can easily handle it while spraying 1.2 m wide path and efficiently spray around 1 hectare of land for 2.5 hours (without stoppages during tank filling). The head of the sprayer, adjusted at the right angle, is held at around 1m above the target surface (drawing 3).



Drawing 2. Manual battery sprayer ULV with rotation nozzle producing 250 μm

a) 1-droplets 2- electric circuit switch; 3-spare flow nozzle 4-supply pipe; 5-battery housing 8x1.5 V by size; 6-extended pipe; 7-eeding nozzle; 8-electric motor housing; 9-electric motor bearing plate; 10-sprayer; 11-setting cover;

b) 1-high volume generator-3000V; 2-by one-fourth circle rotation switch-off; 3-tank; 4-electric motor; 5-tilting disc; 6-steering handle and user safety belt 7-batteries (eight 1.5 V pieces); 8-earthling chain; 9-liquid jet



Drawing 3. Operation mode of the manual rotation sprayer vs. wind direction

Technological drift spraying systems may be different: aircraft, tractor as well as those described as the manual sprayers. Therefore, the major precondition is to produce 40-80μm droplets to be released in the wind air current.

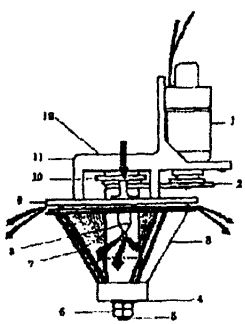
This application, however, has so many limitations in view of the environmental contamination, not being the treatment goal in this case. This suggests how important measuring speed, wind direction determination and spraying speed are.

More complex CDA method sprayers, some of which are provided with several discs, are usually able to adjust the motor rotation speed and, on principle, may produce a wide range of droplet size, i.e. 70-300μm in diameter. Constructional details are highly differing, and it is necessary to carefully compare them by the user.

The type outlined in the drawing 4., is widely used and provided with electric drive with three-speed belts enabling droplets sizes as given below:

Table 1. Droplet size depending on the rotary sprayer speed

Rotation speed (min^{-1})	Droplet size (μm)	Application
Low 2.000	250-300	Herbicides
Medium 3.500	130-160	Herbicides, fungicides
High 5.000	70-100	Insecticides, fungicides



Drawing 4. The Scheme illustrating manifold sprayer work mode
1-12 V motor; 2-three-level drive belt; 3-external conus (disc); 4-Bottom bearing; 5-Central axle; 6-Blockage nut; 7-Internal conus; 8-Feed jet unit; 9-Upper plate; 10-Three-speed belt disc ; 11-Main support 12-upper bearing

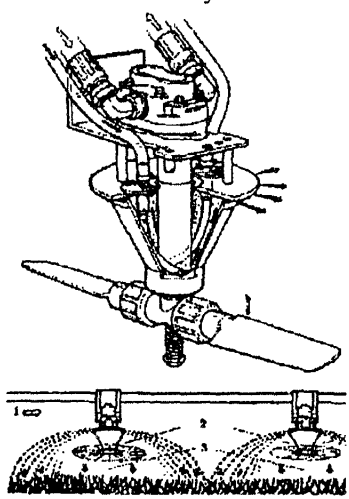
The nozzle, situated inside the conus, controls the jet "throwing"it between this conus and the external rotary one. The external one is provided with crown-wheel forming droplets or partial jets depending on the speed (amount) of supplied liquid as well as on that of disc rotation. The higher diameter smooth ring is positioned under the crown-wheel, protecting it properly.

The three-level belt enables three rotatary speeds and three droplet sizes, too.

The utilization of adjustable air current with rotation nozzles can meet specific needs. This rotation sprayer with turbo system is constructed in order to eject and direct the jet on to the crop according to the required permeation depth mainly by adjusting the fan positioned on the rotary nozzle central axle. The rotor speed and the amount of liquid supplied per unit time seem to be highly essential for droplet size, while the amount of air within the current (rotation speed) of the fan is suitable for the droplet permeation into the crops.

These sprayers are efficiently used with liquid mineral fertilizers in the amount of 400 l/ha all of up to 10l/ha protection means with the extremely tiny droplets produced.

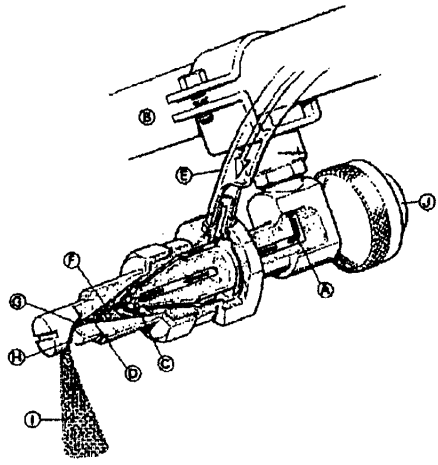
Time saving method relies on the rotation sprayers mounted on the farming ones since the former are not likely to need too frequent tank fillings.



Drawing 5. a) Rotation sprayer with hydraulic drive performance with one of the two protection means supply pipes. The fan wings' turning angle may be adjusted after the edged nut has been released. Full arrows indicate liquid flow; b) Droplets path from the low pressure zone via the sprayer to the high pressure one produced by the fan's wings.

The newest constructions of the rotary nozzles are even able to perform conversion from the sprayer itself with the typically conversed jet into the sprayer with the "controlled droplets". Such a sprayer is provided with the three-level feeding motor positioned in the conus with the control switch with 7, 9 or 12 V. By exchanging many-colored jet nozzles for liquid supply, adequate pressure and liquid amount are obtained as well as the number of disc rotations and droplet sizes.

Airtec sprayer (drawing 6) makes possible that a high permeation level into the plant structure and a narrow droplet size range (certain droplet sizes equally present) are attained.



Drawing 6 Airtec sprayer

A-working liquid lead; B-dispatch system; C-replaceable stopper; D-cross plate; E-lead under pressure; F-conus passage (channel); G-round passage; H-secondary automation and jet forming positions; I-liquid jet; J-control valve with membrane against dripping

In order to fulfill condition, airtec sprayer uses compressed air with threefold functions: to help initial automation, to speed up droplet passing through the sprayer pitch and to function as an additional transmitter. The sprayer onto which airtec sprayers are positioned uses conventional pump for liquid supply through the replaceable flow stopper towards harrow-disc blockage positioned at the end of the sprayer in the spinning chamber. All this makes it possible that liquid current is developed into a jet composed of droplets. So partly made automatic jet is mixed with a higher air amount in the spinning chamber.

Compressed air presses (pushes) the jet through the opening towards the internal side of the flow nozzle. Secondary automation takes place with fan like jet directed at the angle of 115°.

Air current is used in order to automatically regulate weight relationships between the air and liquid. This ratio ranges from 1 : 50 to 1 : 20 for the air current regime of 50-150 m/s. Variations in this ratio have been utilized for the airtec sprayer development variants aiming at a greater range of droplet sizes.

The third role of the compressed air, as the supplementary transmitter, is to improve jet distribution inside the plant pattern.

Treatment norms, applying these sprayers, range from 30-125 l/ha and droplet size varies with diameter averaging from 100-450 μm.

Droplet size and liquid flow through the sprayer are adjusted by setting the stoppers of a certain size (one of the three) on to the sprayers and by setting the air and chemical pressure as prescribed by the producer.

The sprayer can be rotated related to the pipeline in order to obtain the best possible sloping angle.

The possibility of selecting the optimal diameter for particular chemicals and utilization of the air as a supplementary transmitter are the reasons for minimizing drift in these sprayers. All this contributes to the minimal possible treatment norm as well as to the differently distributed droplets on the surface being treated.

The absence of the movable parts inside the sprayer and application of the circular passages (corridors) for jet transport (flow) as well as the specific shape of the outlet opening are considered the main features of this sprayer contributing to its longer age and easy maintenance.

These sprayers are highly suitable for applying of all the chemicals, liquid fertilizers and may be easily built in in all the other classic sprayer types.

Conclusion

It has been confirmed that fuller liquid spraying to the target surface, better utilization of the active matters, less use of water as diluter and a largely reduced droplet drift accordingly, are some of the major merits of the technique mentioned above. Lower number of large droplets and more efficient use of the smaller ones are also favoring this technical solution, so enabling much lower costs of the chemicals.

One of the strongly approved advantages of CDA method using 40l-ha compared to the usual average amount of 300-400l-ha is that working speed can be increased even by 50% with treatment norm decrease. This may be highly beneficiary aiming at essential target areas and avoidance of spraying during unsuitable weather conditions. However, some activities, such as weed control are likely to be more efficiently performed, using greater chemical amounts and the equipment being already used for these purposes.

References

Bode, L.E., B.J. Butler, S.L. Pearson and L.F. Bouse: Characteristics of the Micromax rotary automyzer, Transaction of the ASAE, No-2, 1993

Law, S.E.:Embedded-electrode electrostatic induction spray charging nozzle: Theoretical and engineering design, Transaction of ASAE, No-2, 1991.

Matthews, G.A.: Pesticide Application Methods, London: Longman Group Limited, 1989.

Rider, A.R., Dickev, R.P. Harris, P. Lee, P. Jasa, R. Schneider and E. Nelson: Field evaluation of calibration accuracy for pesticide application equipment ASAE Paper No-1, 1990.

TEHNOLOŠKE PRETPOSTAVKE CDA METODE I KONCEPCIJE TEHNIČKIH REŠENJA

-originalni naučni rad-

P. Nenić, M. Urošević, M. Živković
Poljoprivredni fakultet, Zemun

R. Koprivica
Agronomski fakultet, Čačak

Rezime

U ovom radu su iznete tehnološke pretpostavke CDA metode zaštite bilja kao i tehnička rešenja rasprskivača sa kojima se može realizovati navedena metoda. Primenom CDA metode stiču se prednosti koje se sastoje u potpunijem nanošenju raspršene tečnosti, shodno tome bolje iskorišćavanje aktivnih materija i manje zagađenje životne sredine. Ovo omogućava realizaciju zaštite bilja u kraćem vremenskom periodu. Pored toga, primenom CDA metode smanjuje se norma tretiranja sa 300 na 400l/ha čime se ostvaruje povećanje radne brzine za 50% a time i produktivnost mašine.