

Herbicide application in agriculture:

nozzle selection and effective application

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Herbicides can be applied by a variety of means including boom sprayers, aerial spraying, misters, blanket wipers, rope wick applicators, weed seekers and back-pack sprayers. Boom sprayers are most common type of apparatus used for applying herbicides in broad-scale farming. The nozzle is the only component in the boom sprayer that directly determines the efficacy of the herbicide and effectiveness of spraying. All other components are necessary to position the nozzles and provide them with a continuous supply of herbicide at the correct pressure. The ideal nozzle-pressure combination should maximize spray efficiency by increasing deposition and transfer of a lethal dose to the target, while minimizing residues, off-target losses such as spray drift and user exposure. The droplet size and velocity distribution, volume distribution pattern, entrained air characteristics, spray sheet structure, and structure of individual droplets are such spray parameters, which influences efficiency of application of system. Spray droplet size is one of the most influential factors in spraying system, which affects crop coverage, biological efficacy of the applied herbicide and spray drift risk. Moreover, the size distribution of droplets in agricultural sprays is not homogeneous and depends on the position within the spray nozzle. Further, increasing the spray liquid pressure with most nozzle designs not only results in a finer spray but also increases the velocity of droplets leaving the region of spray formation. In general, increasing the initial downward droplet velocity decreases drift distances. Since spray becomes finer as pressure increases, the risk of drift tends to increase, however, some researchers found that a further increase in pressure does not result in a further increase of drift and may even, with some nozzle designs, result in a decrease in drift at high pressure due to the dominance of the droplet velocity effect.

Key words: Agriculture, Herbicide, Nozzle selection

THE problems of weeds and methods of controlling them were with farmer since the early days of agriculture. The relatively labour-intensive and less effective methods of weed control were replaced by the improved weed management techniques such as cultural, mechanical, chemical and biological weed control methods. Out of all controlling methods, growing labour scarcity and increasing cost of manual weeding, making the chemical weed control as a popular method because of their cost-effectiveness and higher weed control efficiency. Herbicides were applied as pre-planting (before planting the crop); pre-emergence

(after planting, but before emergence of the crop); and post-emergence (after crop emergence) depending on the crop and weed situation in the field. Most of the herbicides are applied in liquid form, where the formulation is mixed with water. Obviously, different types of sprayer are available for the application of herbicides. But a few number of granular formulation is also available in Indian market. These are generally applied in the field by hand. The continuous application of same herbicide repeatedly for several (4 to years 10) in a row and the improper doses of the chemical may lead to development of herbicide resistant in

weeds.

Nozzle selection

The proper selection of a nozzle type and size is essential for proper pesticide application. Nozzles break the liquid into droplets, form the spray pattern, and propel the droplets in the proper direction. Nozzles determine the amount of spray volume at a given operating pressure, travel speed, and spacing. It is important to select a nozzle that develops a desired spray pattern and spray volume. The efficacy of the herbicide application depends on the nozzle type, size, height and liquid pressure, which affects the amount

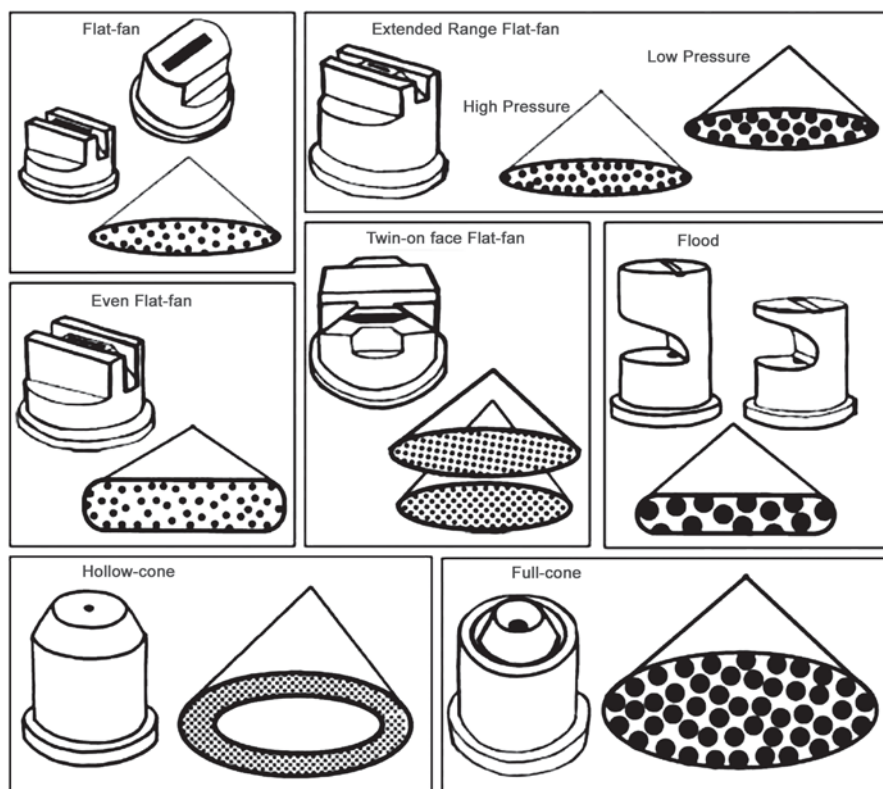


Fig. 1. Hydraulic nozzles used in agricultural sprayers
Source: Johnson and Swetnam, University of Kentucky

and effectiveness of herbicide reaching the target area. The main types of applicators available are hydraulic nozzles, twin fluid nozzles, controlled

droplet applicators, air induction nozzles and air assisted nozzles. Hydraulic nozzles are the main type of nozzles used on boom sprayers

designed to treat large areas (Table 1.). Before selection of the right nozzle we must know spray application rate, in litre/ha, travel speed when spraying, in km/h and nozzle spacing in meters. The required nozzle discharge rate for a spraying system is used to calculate as:

$$\text{Nozzle output (litre/min/nozzle)} = \frac{\text{Spray application rate (litre/ha)} \times \text{travel speed (km/h)} \times \text{nozzle spacing (m)}}{600}$$

The shape and accuracy of a spray pattern can become faulty over a time and the nozzle should be replaced, if the flow exceeds its factory rating by 10%. The main aim of the correct nozzle function is to get the least coefficient of variation. New spray nozzles generally have a 6% coefficient of variation, producing a uniform spray distribution when properly overlapped. But the coefficient of variation may go up to 35 to 57% in worn out and damaged nozzles. This leads to higher discharge rate with very erratic spray and thus the uniformity of herbicide application could not be obtained. Further more, a proper spray overlap of 30 % in flat fan nozzle and 50 % in flood jet nozzle is essential for

Table 1. Different types of hydraulic nozzles of boom sprayers for herbicide application

Spray pattern	Nozzle type	Common use	Operating pressure (kPa)	Droplet size D (v,0.5) μm	Remarks
Flat fan	Standard	Herbicides	200-400	Fine-medium <144-340	Main nozzle used in broad-scale spraying
Flat fan	Low pressure	Broad-leaved weed or pre-emergence herbicides	100-250	Medium-coarse 236-403	Large droplets result in less drift. Good control of broad-leaved weeds.
Flat fan	Extended range	Herbicides	100-400	Fine-coarse <144-403	Designed to operate over a large pressure range. Droplet size between standard and low pressure nozzles
Flat fan	Air induction	Herbicides and fungicides	200-800	Coarse-extremely coarse 341-502	Large droplets result in less drift but have relatively good coverage. Good application on broad leaves
Flat fan	Air assist (twin fluid)	Herbicides and fungicides	200-600	Medium-coarse 236-403	Ability to change droplet size by changing air pressure
Flat fan	Twin	Post-emergence herbicides, fungicides	250-400	Fine <144-235	One fan is angled $\sim 30^\circ$ forwards and the second is angled $\sim 30^\circ$ back for better leaf coverage
Flat fan	Wide angle	Banding between rows	150-400	Fine <144-235	Two outlets project either side of the nozzle to produce one wide angle fan
Flat fan	Flooding	High volume pre-emergence herbicides	100-250	Coarse 341-403	Large droplets result in less drift. High volume application
Even fan	Standard	Banding between rows	150-250	Medium 236-340	Produce a uniform distribution across the fan pattern
Hollow cone	Whirl	Herbicides	100-400	Fine-coarse <144-403	Nozzles available for the application of pre-emergence and post-emergence herbicides. Large passage way minimizes clogging
Solid/Full cone	Full	Pre-emergence herbicides	100-300	Coarse 341-403	Large droplets result in less drift

Source: Department of Agriculture and Food, Government of Western Australia, Australia

Table 2. Different materials used for nozzles manufacturing

Material used in nozzle tips	Remarks
Ceramic tips	Superior wear life and are highly resistant to abrasive and corrosive chemicals.
Stainless steel tips	Good wear life, excellent resistance to chemicals, and a durable orifice.
Polymer tips	Good wear life and resistance to chemicals, but the orifice can be damaged if not cleaned properly.
Hardened stainless steel tips	Very good wear life and good durability and resistance to chemicals.
Brass tips	Poor wear life and are susceptible to corrosion.

Source: *Farmer's Weekly* Lloyd Phillips, 2010.

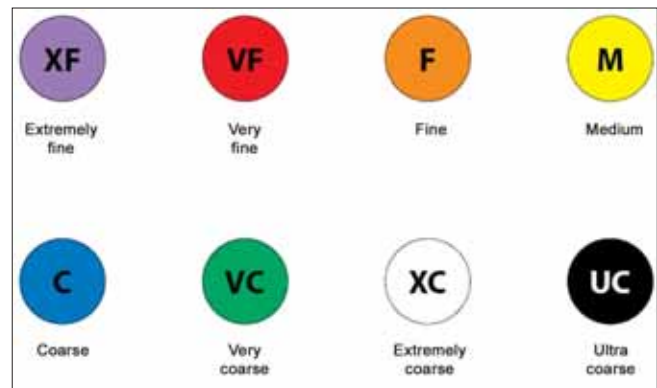


Fig. 2 Droplet size classification
Source: Teejet technologies

spray uniformity and uniform chemical distribution to the target. Material used for nozzle manufacturing determines the life of the nozzle. The wear and tear of the nozzle tip depends on the quality of spray liquid and type of material used for manufacturing. Different materials used for nozzle manufacturing are discussed in Table 2. To minimize the mechanical damage of spray nozzles, clean them with the soft brush or by a compressed air.

Droplet as a key factor for nozzle selection:

- Nozzles with finer droplets are used for post-emergence contact applications, because of its excellent coverage on leaf surfaces.
- Nozzles with mid-range droplets are used for contact and systemic herbicides.
- Nozzles with coarser droplets are used for systemic and pre-emergence soil applied herbicides.

Spray drift

It is defined as the movement and deposition of spray particles through air in non-targeted locations. Spray drift occurs in two forms: (i) particle drift results from physical movement of droplets to non-targeted locations via air currents, and (ii) vapor drifts, results from evaporation and redeposition of spray particles to

Table 3. Droplet size distribution classification (ASABE Standard S 572.1)

Droplet category	Symbol	VMD range (i)*
Extremely fine	XF	< 60
Very fine	VF	61-144
Fine	F	144-235
Medium	M	236-340
Coarse	C	341-403
Very coarse	VC	404-502
Extremely coarse	XC	503-665
Ultra coarse	UC	>665

*Estimated from sample reference graph in ASABE/ANSI/ASAE Standard S 572.1
Source: College of agriculture and life sciences. University Arizona

non-targeted areas. Droplets having the dia of < 150 μ are more prone to be getting drifted.

Factors responsible for drift

- *Environmental factors:* Wind speed and direction, temperature and relative humidity.
- *Spray characteristics:* Formulation of the chemical being applied, additives added to the chemical, spray droplet size and evaporation.
- *Equipment and application factors:* Nozzle type and size, operating pressure, and the height of the spray boom.

Drift control tips

- Increase the droplet size by reducing the pressure. Flow rate will be reduced so it may be necessary to go to a larger nozzle

size to stay within the labeled application rate.

- Use nozzles that produce larger droplets such as drift reducing nozzles or nozzles of larger capacity.
- Lower boom height to reduce drift with proper overlapping for spray coverage.
- Adjustment of application methodology according to the weather conditions.

SUMMARY

The extensive use of a fixed set of herbicides and herbicide tolerant cropping systems has led to the emergence of numerous herbicide resistant weeds and may create costly consequences, if not managed properly. Every year, global seed and chemical industries are launching the next generation of herbicides cropping systems to address the problem. Hence, improved spraying management and smarter spray nozzle selection is of the need. Further, products like 2,4-D, glyphosate, glufosinate, dicamba and others have different modes of action and different potential for drift. Thus, proper droplet size management and proper tip selection is of the higher priority in controlling the weeds.

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