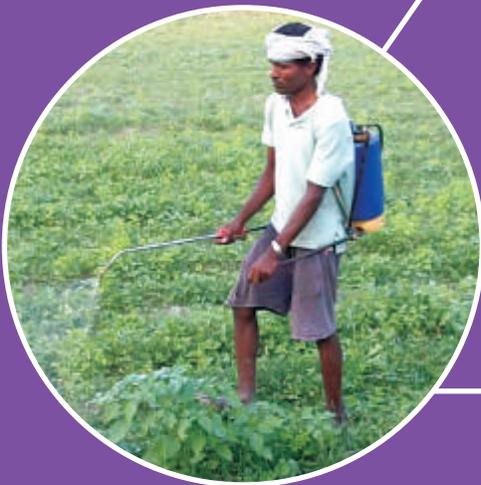


Sprayers and Spraying Techniques

A Manual



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Sprayers and Spraying Techniques

A Manual

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Sprayers and Spraying techniques

- A Manual

Timely application of herbicides, pesticides and fungicides (collectively called **Crop Protection Products-CPP**) at peak periods plays a vital role in ensuring better yields from a crop. The magnitude of this problem is further amplified due to shortage of labour during this time. Hence, mechanization of application is the only viable option in this scenario.

Correct Equipment selection for CPP application is the most important issue we need to address for effective pest and weed control. The choice of equipment depends on its specific use and the need for a particular pest-weed control measure. Studies indicate that seventy percent of the success of CPP depends on the effectiveness of its application.

In India, improper and ineffective methods of application have resulted in a tremendous waste of CPPs. This has led to the damage of non-targeted plants and has decreased CPP effectiveness while posing extensive health hazards for humans and animals alike. This makes a call for the need of a manual on CPP application technologies. This manual intends to work as a practical guide to extension workers and farmers. It aims to answer the following questions

- i. What is the best way to apply a CPP?
- ii. How do I know what nozzle to use?
- iii. How do I calibrate my equipment?
- iv. What are the precautions I should take before spraying?

- v. Why is it important to clean and maintain my sprayer?

Components of Sprayers

CPPs are largely applied as sprays. The important components of a sprayer are:

1. Pump
2. Power source
3. Tank
4. Agitator
5. Distribution system
6. Pressure gauge
7. Pressure regulator

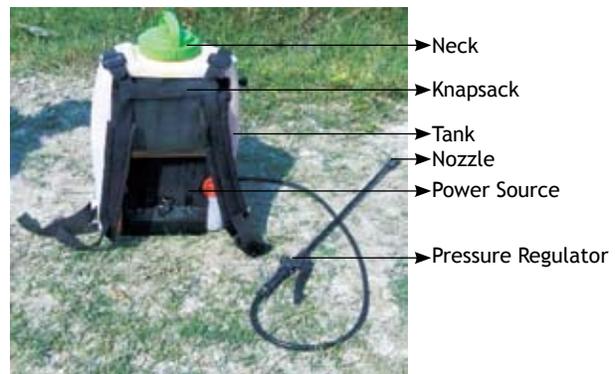


Fig 1. Parts of a Sprayer

1. Pump

Any spray liquid must be atomized before it leaves the spray nozzle. The pump facilitates the necessary pressure for this purpose.

Types of Pumps

a. Air Compression or Pneumatic pumps:

These pumps force air into an airtight tank containing spray liquids thus moving the spray liquid under pressure through the nozzle for its atomization.

b. Hydraulic or Positive Displacement Pump:

These pumps take in a definite volume of spray liquid and force it through the delivery system under pressure. The pumps differ in pressure they produce.

2. Source of Power

It is a prerequisite to operationalize the spray pumps. The source of power may be either:

- a. Manual
- b. Traction
- c. Motor
- d. Tractor and air craft engines

3. Spray Tank

A sprayer may have either a built in tank or a separate tank to carry spray liquid. The tank need be large enough to avoid frequent refilling but not cumbersome to carry. The tank is equipped with a large opening with a built-in strainer and cap to fill in the liquid. Small openings pose difficulty in filling and cleaning the tank.

4. Agitator

In order to maintain the homogeneity of the liquid spray, it may be either of mechanical or hydraulic purpose. Mechanical agitators may be of metal fan or rod etc. Hydraulic agitator consists of a pipe with several side holes and closed at its free end. It is placed in the tank and fed with spray liquid with the help of pump. Liquid jets emerge from these holes, further initiating the agitation

to the complete of the liquid. This is known as 'By pass system'. Hydraulic agitation is not thorough but is more convenient in power sprayers used in large tank size. Using sprayer without agitator should be avoided to apply CPP emulsion and suspension.

5. Distribution System:

It includes

- i. Nozzle
- ii. Spray lance
- iii. Spray boom

i. Nozzle

The function of spray nozzle is conversion of pressurized spray liquid into droplets for application on the target. Nozzles are identified by

- a. Droplet size
- b. Delivery and
- c. Type of Nozzle

ii. Lance

It is a brass or steel rod, 90 cm in length, attached to a delivery hose pipe of sprayer and fitted to its free with a replaceable nozzle. A CPP spray lance is bent at its nozzle forming a goose neck. At the hose end it is provided with a trigger mechanism to control flow of liquid for a specific purpose. We may fix the spray lance with plastic shield to prevent chemical from drifting.

Box 1 : Considerations when choosing a nozzle

When choosing the nozzle think about

- Size of the droplet needed
- Spray pattern wanted
- Rate of application

iii. Spray bar or Boom

It is composed of a horizontal pipe on which 2 or several nozzles are fitted spaced 50 cm apart. Boom length varies from 1 to 15 m. Short boom with 2-3 nozzles is used with manual sprayers, while longer ones are accessed with tractor sprayers. The main advantage of spray boom over spray lance is the wide swath that it covers in each trip on the field. Total width of land wetted by a boom can be adjusted to get either (i) Uniform spray (ii) Directed spray or (iii) Band spray

Droplet size

Droplet size plays a significant role in CPP application by minimizing environmental

Box 3 : Classification of sprays according to droplet size

Volume medium diameter of droplet (µm)-1	Classification of droplet size
<50	Aerosol
51 - 100	Mist
101 - 200	Fine spray
201 - 400	Medium spray
>400	Coarse spray

The most widely used parameter of droplet size is volume medium diameter (Vmd) which is measured in micrometers (µm) . 1 mic = 1/1000 mm.

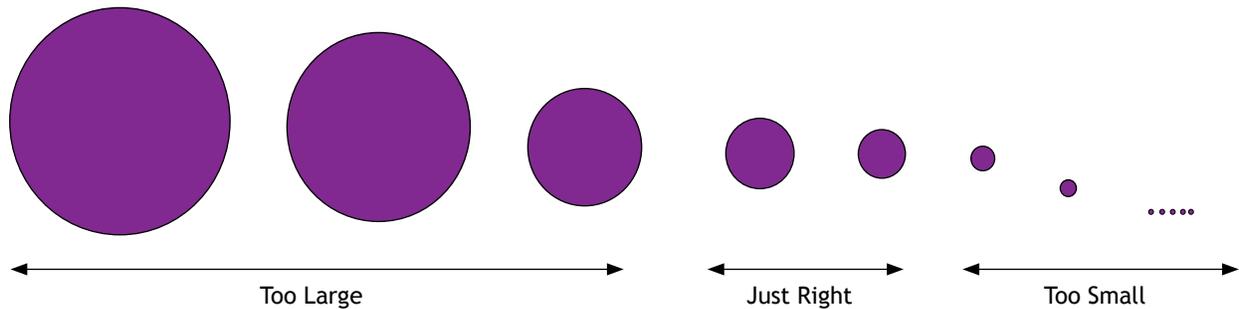


Fig 2. Droplet size

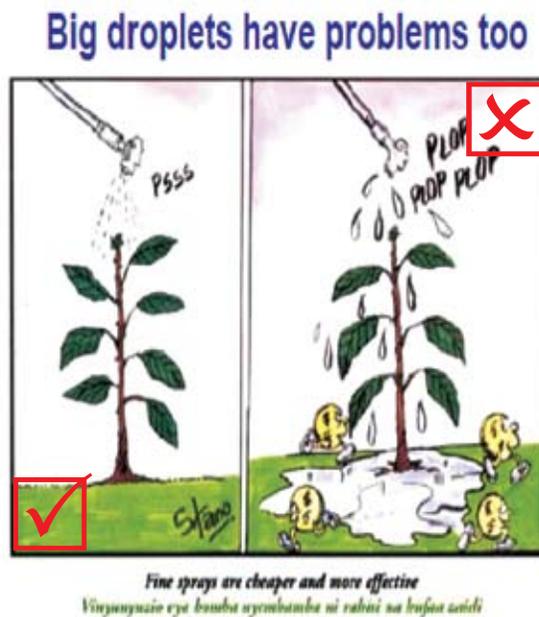


Fig. 3. Pictorial representation of the effect of droplet size on spray and crop, (Source: Graham Mathew)

contamination. CPP sprays are generally classified according to droplet size. When drift is to be minimized, a medium or coarse spray is required irrespective of the volume applied.

Droplet size will influence coverage and drift. The nozzles typically used to apply CPPs produce droplets that vary in size to a great extent. Large droplets, which will facilitate in mitigating spray drift, may not provide good coverage. Very small droplets lack the momentum needed towards the target and are prone to drift under windy conditions. Flow rate of liquid (size of nozzle orifice), liquid pressure, physical changes to nozzle geometry and operation are the factors determining the range of droplets from a nozzle.

Why is droplet size important?

If droplet is too small in size too then it may lead to evaporation and drift.

Spray drift

The movement of spray droplets onto nearby susceptible crops and environs is a grave risk when using CPPs.

Factors contributing to drift are:

- ❖ Weather conditions during and immediately after application
- ❖ Droplet and particle size. This is determined by the application method and equipment used with large nozzles at low pressure, reducing drift danger
- ❖ Nature of the spray mixture; that is, its volatility
- ❖ Height and distance. Greater the height and distance from the target plant at which CPPs are discharged, greater is the risk of drift
- ❖ Direction of application. Spraying upwards or in wind increases the risk of drift.

6. Pressure regulator

Fitted to heavy duty sprayers and tractor driven sprayers, it aids the operations of the sprayers at a constant pressure. Pressure gauge is provided to check pressure.

Types of Sprayers

A. Knapsack Sprayers

Loaded on the back of worker during operations. Tanks may be of plastic or metal. Common Knapsack sprayers are

- i. Hydraulic
- ii. Manual pneumatic and
- iii. Motorized pneumatic

i) Hydraulic Knapsack Sprayers

Manually operated, tank capacity is 15 liters, mechanical or hydraulic agitation, worked with a hand lever to maintain constant pressure, particularly used for spot treatment by small holding farmer and hand treatment. Equipped with a boom. It is good for blanket application.

Drawbacks : These sprayers are mounted on the back of a man. One hand to lever sprays 0.4 ha/day and with a boom 0.8 ha/day. It is a high volume spray but low volume nozzles can also be fitted. Spray potential is 12 kg/cm². It is sprayed at 3 to 4 kg cm² to prevent spray drift.

ii) Pneumatic or compressed system Knapsack

Does not require pumping during operation / spraying. The tank is pressurized after filling the liquid to 2/3rd capacity with a built in hand pump. Undesirable for weedicide as spraying pressure declines after some time resulting into uneven spray. Tank cleaning is a challenging task. It is used in limited amount to spray on weeds in paddy and jute.

iii) Motorised Pneumatic sprayers

As a low volume sprayer, it is suitable for spraying concentrated spray liquid. A blast of air flows through spraying jet of delivery hose and nozzle tube and ejects spray liquid in this blast. Air blast atomizes spray liquid into fine droplets. Air acts as carrier, faster the air is pressured, more the atomization. These sprayers are also used as blowers. Mist blower causes considerable loss of CPP by winds. The main advantages of Knapsack blower are:

1. Low volume spray. Saves time in refilling tanks.
2. Portable working.
3. Fast spraying. Suited to post emergence translocated type. CPPs as low volume

Spraying is not so uniform with Knapsack blowers. Liquid - 60 liters/ha swath 7 to 8 m.

B. Foot Sprayer/Pedal Pump Sprayers

Popularly applied for CPP application and is operated with foot. It has provision of 1-2 long delivery hoses. Fitted with either lance or 2-6 nozzle booms. Its potential spray pressure is 17 to 21 kg/cm² output and with lance is 1 ha/day. It can spray high volume spray and covers more area.

C. Traction Pneumatic Sprayer

Indian Institute of Sugarcane Research, Lucknow has developed bullock drawn sprayer with size nozzle boom, that is powered from the wheels of the frame. It is efficient, easy to operate and simple in its construction. It uses two pneumatic pumps and develops maximum pressure of 2-8 cm² which is suited to minimize spray drift. Area covered is 2-3 ha/day equipment.

D. Tractor mounted sprayers

With spray pressure of 1.4 to 2.8 kg cm² and fitted with multi nozzle boom are very useful in CPP application for large holding of farmers. Tractor mounted sprayer fitted with booms are used to spray road side vegetation. Tractor run sprayers have.

1. High uniformity of sprayers.
2. High working efficiency.
3. Full utilization of tractor during idle time.

E. Aerial sprayers

CPP application from air is limited to treat aquatic weeds like water hyacinth, paddy fields and large sugarcane plantation. Presence of obstacles like trees and diversified farming in India are bottle necks in its use.

When do I use which sprayer?

The selection of a sprayer is governed by several factors

- i. Frequency of CPP application,
- ii. Availability of diluent (water, oil, kerosene, etc.),
- iii. Availability of labor (human or animal power),
- iv. Area requiring treatment,
- v. Characteristics of area (machine equipment)

Box 4 : Considerations when choosing sprayer equipment

When choosing the equipment ask

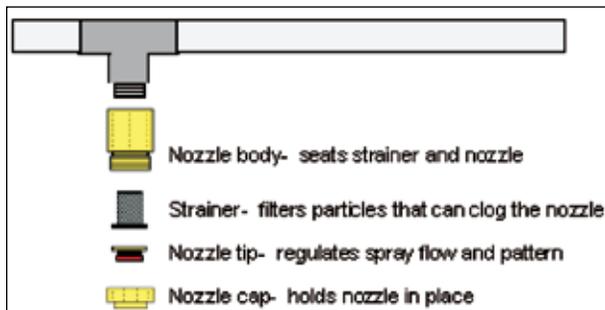
- will it apply the CPP effectively?
- will the application cause effective drift?
- Will it do the job at a reasonable cost?
- Is it easy to operate and clean?

for large areas, hand-operated equipment for smaller areas),

- vi. Durability of equipment,
- vii. Cost of equipment,
- viii. Availability of after sales service,
- ix. Operating cost, and
- x. Speed required to treat an area (this will depend on type of crop, stage of crop growth, and volume of spray solution to be applied).

Nozzle

Nozzles are comprised of a spray tip, a filter/strainer, a nozzle body and a cap.



(Source: Rice Knowledge Bank, IRRI)

Fig. 4. Parts of a Nozzle

Nozzle tip

The nozzle tip is the prime component of nozzle. It determines the flow and distribution of the spray. There are many different types of tips, each designed for a certain type of spray application.

Nozzle selection

Selecting the correct type and size of spray nozzle is essential for each application. The nozzle determines the amount of spray applied to an area, the uniformity of the application, the coverage of the sprayed surface, and the amount of drift. Although

nozzles have been developed for practically every kind of spray application, only a few types - extended range flat-fans, flood jets, etc. are commonly used in the application of crop protection products.

Eight kinds of spray nozzles are common e.g.

- 1. Flat fan
- 2. Solid cone
- 3. Flooding
- 4. Tripe action



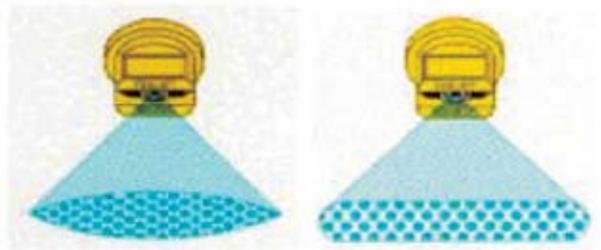
Fig. 5. Types of nozzles - (a, b) : Hollow cone nozzle, (c) : Flat fan nozzle, (d) : Flood jet nozzle

- 5. Broadcast fan
- 6. Blast
- 7. Low volume
- 8. Centrifugal (Sprinkler rotary)

Flat Fan nozzle tips are designed specifically for multiple nozzle booms. The spray pattern is tapered from the centre (full flow) to the edges (lighter flow) and is designed to overlap with adjacent nozzles, creating a uniform pattern across a spray boom

Even Fan nozzle tips are designed for single pass sprays over crop rows or between rows. The spray pattern is uniform (full flow) from edge to edge. Even fan spray tips are not made for use on multiple nozzle booms

Flood nozzle tips are designed to have a wide spray pattern at low pressure, making them popular with knapsack sprayer operators. They are best suited for defoliants and

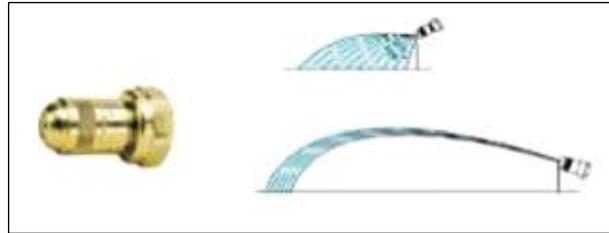


(Source: Rice Knowledge Bank, IRRI)

Fig. 6. Spray from a flat fan nozzle

herbicides. The spray pattern is tapered from the center to the edge, however is it not as uniformly tapered as that of the flat fan. The spray is heavy towards the very edges and coarse throughout the spray pattern. Using this nozzle in a “swinging” pattern across a field will normally result in poor application results. Overlapping by fifty percent can help eliminate the inherent unevenness in the spray pattern.

Variable Cone nozzle tips have a cone-shaped spray pattern that is adjustable from a fine mist to a solid stream. The adjustable pattern makes variable cone spray tips versatile tools. Calibrating these nozzles is not easy due to the difficulty of adjusting the tip to the same pattern and flow time after time. While not ideal for most applications, they are useful



Source: Rice Knowledge Bank, IRRI

Fig. 7. Spray from a Variable Cone nozzle

for many insecticide, fungicide and herbicide sprays.

Hollow Cone nozzle tips produce a fine spray that is concentrated on the outside edge of



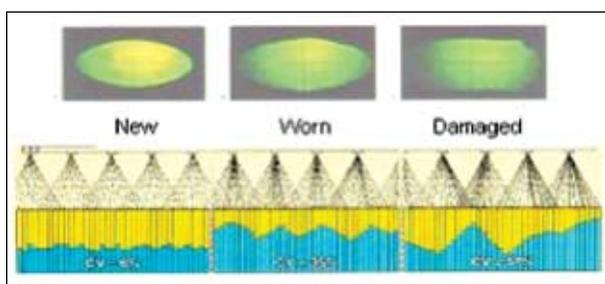
Source: Rice Knowledge Bank, IRRI

Fig. 8. Spray from a Hollow Cone nozzle

the pattern. The spray approaches the target from different angles increasing the coverage area. They are designed for fungicide and insecticide applications where excellent coverage is needed. The fine spray pattern increases spray drift potential

Worn tips

Worn and damaged nozzle tips lose the ability to properly regulate the spray pattern and should not be used. Worn tips have a greater output with the spray concentrated beneath the tip. Damaged spray tips have an erratic



Source: Rice Knowledge Bank, IRRI

Fig. 9. The effect of the condition of Nozzle on spray pattern

output, over-applying and under-applying. Spray tips and spray patterns should be checked at regular intervals and be replaced when found worn or damaged.

Multiple nozzle booms

Multiple nozzles are used to enhance application efficiency and accuracy. Any type of plumbing material suitable in strength and weight are used to assemble hand booms. Aluminum, steel, brass, copper and plastic tubing with brass or plastic fittings are utilized to create boom sprayers.

Flat fan nozzles are spaced on the boom keeping in consideration that the spray pattern of adjacent spray tips will overlap by thirty percent. Spacing will depend on boom height

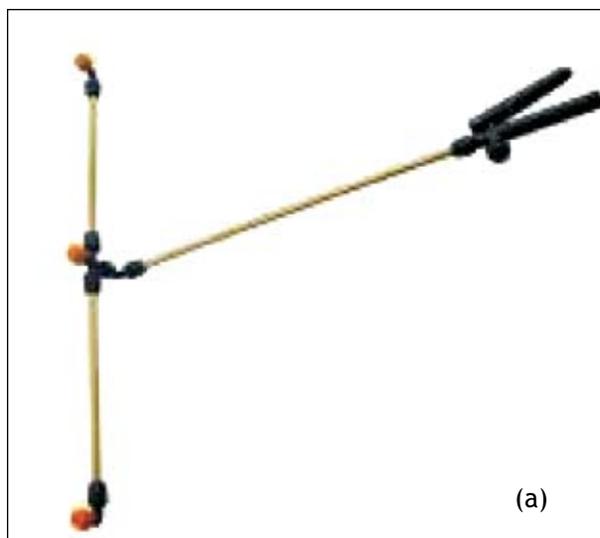


Fig. 10. (a) 3 boom nozzle, (b) Spray using a 3 boom nozzle

and the angle rating of the spray tips. Larger angle tips have a wider spray pattern and may be spaced further apart on the boom when the height remains constant.

Spray Applications

Uniformity in application of pesticides is essential. Areas of over- or under-application will result in undesired application results. Problems include crop injury, poor pest control and crop injury in the following crop when using residual pesticides.

Single Lance

Pesticide applications can be made using a single nozzle lance, however spraying a straight swath with appropriate overlapping is



Fig. 11. Spray with a single lance

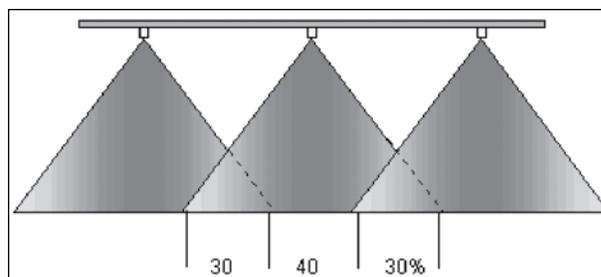
extremely difficult. If the single nozzle lance is swung from side to side while walking, the resulting application will have large areas of under- and over-application. To avoid such indiscretion Multi nozzle booms should be preferred

Multi nozzle boom

Using a boom sprayer over swinging single flood jet nozzle, will increase the uniformity of spray applications. The width of pass may be smaller using a three or four nozzle boom, but each pass will have very standardized herbicide distribution. Spray swaths of three meters or more can be obtained by fitting a knapsack with appropriate nozzles and



Fig. 12. Spray using a 3 boom nozzle



Source: Rice Knowledge Bank, IRRI

Fig. 13. Pattern overlap from a 3 boom nozzle

adjusting the spray pressure of the system to provide adequate output.

When a single flat fan nozzle is sprayed, only the middle third of the spray pattern of the nozzle can be considered to have a full rate application. When two or more are spaced to overlap by 30%, the tapered pattern of adjacent nozzles creates a consistent spray distribution. On the boom ends, where there is no adjacent nozzle, the outside edge of the spray will still be having a light application.

The two most common spray tip angles are 800 and 1100. This refers to the size of the angle of the spray pattern from side to side. Nozzles should be spaced 50 cm apart on the boom and boom height need to be maintained at approximately 50 cm for 1100 and 70cm for 800. Adjacent passes of multiple nozzle booms must overlap by approximately thirty percent, similarly adjacent nozzles on the same boom should overlap. Height is crucial factor when using a boom sprayer. If the boom is too low to the ground, the nozzles will not overlap resulting in bands of concentrated spray with little or no spray in between.

To determine the spray swath width of multiple nozzle booms, multiply the nozzle spacing by the number of nozzles. When the boom is used at the appropriate height, this will give the spray swath width for that boom when multiple passes are made across a field. For example: 4 nozzles \times 50 cm spacing = 200cm swath width.

Nozzle Height

Booms and nozzles need to be set sufficiently high above the target so as to ensure that the spray output across the swath is even. To ensure that this occurs, the following table provides approximate heights for each fan angle at 50 cm spacing, which should provide single coverage. The effect of variations in boom height can be further minimized if these heights are doubled or the distance between the nozzles halved. This is often referred to as double overlap or double coverage. If at all in doubt, it is best to set the boom too high rather than too low.

Table 1 : Effect of Spray Angle on spray overlap

spray angle	Single overlap Nozzle height (cm)	Double overlap Nozzle height (cm)
60°	56	112
70°	53	108
80°	46	92
110°	25	50

Approximate height (cm) of taper fan nozzle to produce single coverage with normal overlap when spaced 50 cm apart.

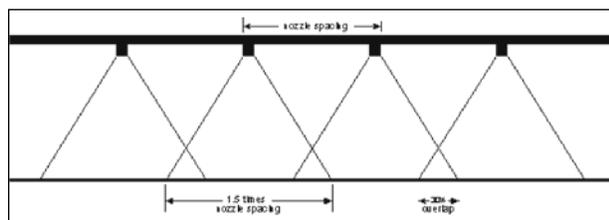


Fig. 14. Single coverage spray pattern showing the approximate 30% overlap between adjacent nozzles

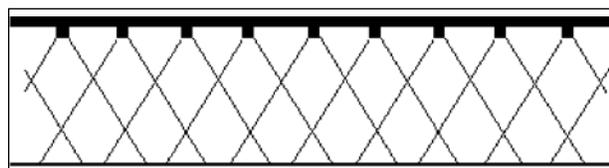


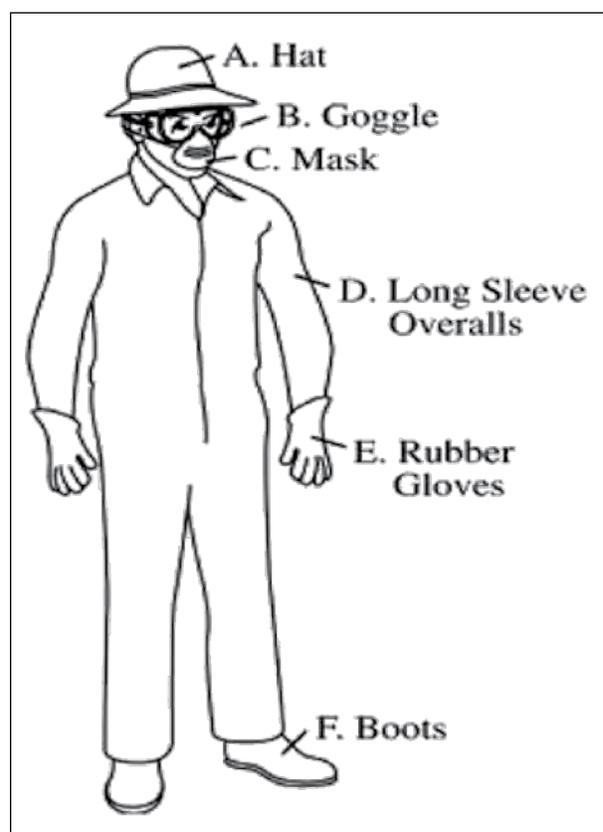
Fig. 15. Double coverage spray pattern to minimize effects of boom height variation

Table 2. Factors affecting choice of Nozzle

	Nozzle guide for broadcast spraying.							
	Herbicides				Fungicides		Insecticides	
	Sub-irrigated	Pre-emerge	Post-emerge		Contact	Systemic	Contact	Systemic
Extended range flat fan	Good	Very good	Good	Very good	Very good	Very good	Good	Very good
Standard flat fan		Good	Good	Good	Good		Good	
Soft pencil fan	Very good	Very good		Very good		Very good		Very good
Taper fan			Very good				Very good	
Turbo floor wide angle	Very good	Very good		Very good		Very good		Very good
Wide angle full cone	Very good	Very good						
Flood nozzle wide angle	Good							
Windrow™ hollow cone	Good	Good		Good				

Body wear

Overalls - Overalls made of cotton are the most advised ones but additional protective



Source: Rice Knowledge Bank, IRRI

Fig. 16. Diagrammatic representation of required Protective Gear for spraying

clothing should also be worn. For wet sprays, large sleeves with cuff buttons and pants with buttons at the bottom deliver good protection.

Aprons - Waterproof rubber or plastic aprons are proven effective. Light weight water resistant chaps could also be used. Fabricated chaps made out of urea bags have been tried and tested in Punjab; and are verified as easy to make and very cost effective.

Head Protection

Wide brimmed hats that are water resistant should be adopted to prevent mist and dust settling on hair. Helmets with attachments for face shield and goggles can also be a good option. Goggles are used to protect eyes from splashes, spills, mists and droplets. Wide plain goggles covering maximum possible eye area are preferred. Face shields provide protection to face from splashes and dust and also allow for air circulation and guarantees wider coverage than goggles.

Hand and feet protection

Gloves - The hands are the most prone to chemicals. Hence gloves dressing while handling chemicals and equipment are advised. The gloves should be made of rubber or some synthetic material like PVC or latex and should cover the arm till little below the elbow. They should be kept at distance from water bodies, children and animals after use.

Foot wear - Leather and fabric shoes should never be worn as they absorb chemicals. Damages like leakage should be checked for before shoes are worn.

Factors affecting the efficacy of the CPP

There are many factors that affect CPP efficacy. The CPPs must be applied accurately and uniformly. Improved accuracy can be achieved by proper calibration and operation of the equipment. Agricultural CPP equipment is required to deposit the plant protection products as accurately as possible on the

Table 3. Protective gear required for spraying with justification.

Pictogram	Principle	Comments
	Cover as much of the body as possible, especially the neck, chest and forearms. Use washable fabric overalls, disposable overalls and waterproof clothing if coming in contact with large quantities of CPPs	Under hot conditions beware of perspiration -this can increase the rate of entry into the body
	Use aprons mostly while mixing	An apron worn on the back helps protect from leaks when using knapsacks
	Never use leather or cloth materials because they absorb CPPs and provide a constant source of contamination. Gloves should be unlined for this reason	

Pictogram	Principle	Comments
	Never use leather or cloth materials because they absorb CPPs and provide a constant source of contamination	Wear the trouser leg outside the boots
	Hard hats, washable hats Goggles shields Spray helmets	Important when handling concentrates. Avoid splashes
 	Dust mask for particles and larger droplets Types of filtration available include mechanical, electrostatic and chemical. Choose the correct type and have the correct cartridge fitted	Use a mask that matches the class of CPP to be used. Replace cartridges regularly and write the date on each cartridge. Ensure there is an adequate fit on the face
	Sprayers, protective equipment must be cleaned after application. People exposed should wash immediately	

(Source: Rice Knowledge Bank, IRRI)

target. The aim is to deliver the amount of chemical required to control the pest and minimize contamination of the operator and of target losses to the environment.

It is believed that worldwide only 1% of the CPPs used worldwide actually reach their target, and because of this, CPP application equipment and methods are two important factors increasing CPP efficacy and human safety. Overdosing, uneven application, unintentional spread of the CPP into the surrounding environment and the exposure risks for the users are the three main problems that can be solved by better application technology. This necessitates a good understanding of the weed, CPP method, equipment and operator.

The efficacy of a CPP in any application technique is mainly influenced by the following three factors:

1. Mean level of deposit (dosage): This refers to the total amount of toxicant (active ingredient) used in treating a unit of the target area;
2. Distribution of deposit: The surface of the leaf may be completely covered by a chemical (active ingredient) deposit in the case of runoff (high volume) spray, but the deposit may be unevenly distributed; and
3. Wetting agents tend to decrease droplet size and increase spreads, and low-volatility carriers help prevent the evaporation of

small droplets (low and ultra low volumes) and ensure better distribution.

Sprayer Calibration

Sprayer calibration aims at obtaining a spray pattern and droplet size that will ensure optimum coverage of the target area with uniform sized droplets without causing runoff. Calibration should therefore be taken into account

- i. **Target Area** - area to be sprayed (large area would require higher quantities)
- ii. **Droplet size** - fine droplets cover a large area with less volume and reduce run off, but can cause more drift and evaporation losses
- iii. **Nozzle size and spacing** - once the volume of the spray and droplet size is determined, the nozzle size and spacing on the boom should be decided keeping in view the height between the boom and the crop.
- iv. **Nozzle capacity** - Nozzle capacity is a manufacturer's rating that depicts what output a nozzle will have at a given pressure. At constant pressure and speed, nozzle capacity is directly proportional to sprayer output. Output becomes greater as nozzle capacity increases. When multiple nozzle booms are used on knapsack

sprayers it may be necessary to keep the nozzle capacity ratings low to avoid exceeding the output capacity of the knapsack pump. Typical nozzle sizes are 700, 800 or 900 ml/minute. Smaller nozzle sizes are manufactured by some companies but may not be universally available. A 1000 ml/minute nozzle will have twice the output as a 500 ml/minute nozzle at the same pressure. The angle rating of a spray tip is not related to output.

- v. **Speed** - keeping boom output constant Speed is inversely proportional to spray application. As you walk faster, less spray is applied to a given area.
- vi. **Pressure** - As pressure increases, sprayer output increases. However, this relationship is not direct. Pressure must increase four times in order to double nozzle output. Variable pressure will cause variable output. Pressure may also affect the spray angle of different nozzles. The nozzle angle rating is for a specific pressure. The spray angle of a nozzle will decrease when pressure drops below the recommended minimum pressure for that nozzle. Low pressure nozzles (nozzles that have spray angles maintained at low pressures) are manufactured, however, they may not be universally available.

Calibrating a multiple boom nozzle

Step 1



- ❖ Make sure that the boom is aligned in a straight line.
- ❖ Make sure nozzle interspacing is equal. This is usually 50 cm.
- ❖ Measure the length of the boom. This is usually 1.5 m.

Step 2



- ❖ To check nozzle output, tie equal sized containers to the nozzles and measure the output of water.
- ❖ The water outputs from the three nozzles should be at the same level, if not, adjust the nozzle output.

Step 3



Measure out a ml of water in a bucket and fill into the knapsack sprayer

Step 4



- ❖ Mark out a rectangle that is 33 m long and 3 m wide i.e. approximately 100 square m in area using a tape
- ❖ Start spraying from one end of the rectangle in a straight line and make one full pass. Turn around and make the second pass such that the entire area is sprayed
- ❖ Measure out the quantity of water (a_1 ml) left in the knapsack after spraying the area

Step 5

Calculations :

Initial volume of water taken = a ml

Water left after spraying $100 \text{ m}^2 = a_1$ ml

Area sprayed = 100 m^2

Volume per unit area = $(x - x_1)/100 = a_2$

Volume required for spraying 1 acre = $a^2 \times 4000 = a_3$

In terms of Knapsack tanks

One tank capacity = b l

No. of tanks required for 1 acre = a_3/b l

No. of tanks required per katta = $(a_3/b)/17$
(assuming 17 kattas = 1 acre)

Numerical example

Initial volume in sprayer	= 10 l
Volume left	= 8 l
Volume consumed	= 2 l
Area sprayed	= 100 sq m
Volume per unit area	= 0.02 l
Per acre	= 81 l
One tank capacity	= 12 l
No of tanks per acre	= 6.7 l

Volume required per katta	= 0.4 l
(17 katta = 1 acre; 1 acre = 4047 sq m)	

Stock solution preparation

A stock solution is defined as a concentrate, that is, a solution to be diluted to some lower concentration for actual use. Although it is never absolutely necessary to use a stock solution, it is often impractical not to use them. Stock solutions can save a lot of time, conserve materials, reduce needed storage space, and improve the accuracy with which we prepare solutions and reagents.

Determining the Amount of Herbicide to Use

Once the sprayer output per area is known, the applicator can begin to prepare to spray the field. With a sprayer output of 300 liters/hectare and a herbicide rate of 1 liter/hectare the rate of mixing can now be calculated.

If each tank holds 15 liters then

$$\text{Rate of mixing} = 15/300 \times 1 \times 1000 \text{ mls.} \\ = 50\text{ml/tank}$$

Mix the chemical with the water prior to pouring into the knapsack tank.

Spraying techniques

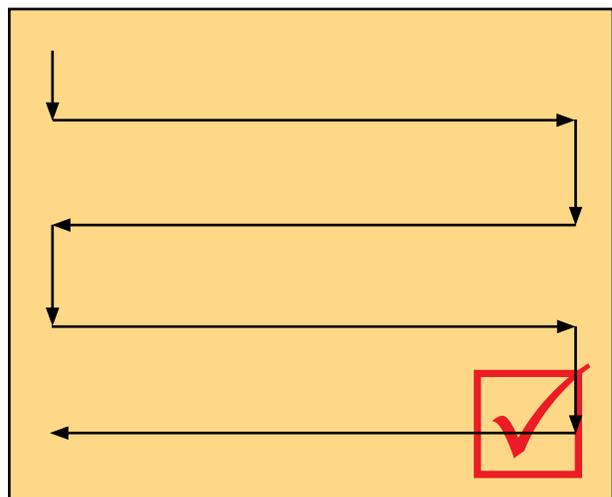
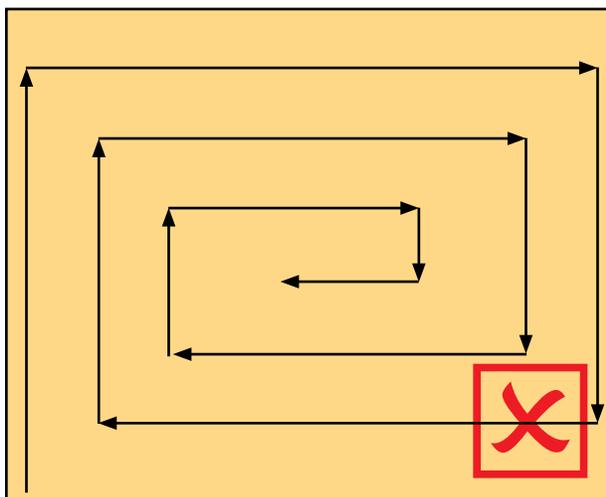


Fig. 17. The right and wrong spraying techniques

Operational Efficiency

Operational efficiency will improve if stoppages in the field are minimized and filling times reduced. Blocked nozzles are the greatest setback when spraying, thus proving the importance of effective mixing, agitation and filtration to overcome the hindrance.

Filtration

The importance of use of an effective filtration system cannot be over emphasized. There are several filters and filter kits available which have helped to alleviate the problems of blockages. A double system is best, using 100 mesh washable filters for tank filling and in-line screening. A second in-line 100 mesh filter can be fitted between the pump and nozzle. Use fine filters early in the system to support the nozzle filters. In-line filters should be cleaned regularly, preferably at each filling, and should not be left to dry out without cleaning.

Filling

Concentrate siphon probes decrease the risk of chemical contamination and, when calibrated, simplify formulae mixing. They are commercially available for both standard 20 l metal containers as well as PVC type containers. Probes are available as part of the filling system on some sprayers (for example, computer sprayers). Homemade versions fitted into the filling pump line are also effective. Contractors tend to use separate concentrate filling systems. Electrically driven gear pumps and a flow meter mounted as part of the spraying unit provide satisfactory performance and life.

Flushing

The fitting of a flushing out system allows stationary washing out of lines and fittings with clean water. Also it offers safer unblocking and changing of nozzles as well as stationary calibration of computer sprays. Checking of nozzles is made much simpler with its usage. If used regularly, nozzle blockages are tend to reduce

Maintenance and storage of Sprayers

Maintenance of Sprayers

- a. Use of clean water only
- b. Use of the screen at the inlet spray
- c. Use of metal object for cleaning the nozzles
- d. Flush new sprayers before their use
- e. Clean each sprayer thoroughly after each period of use.

Cleaning of Sprayers

It is necessary to remove all residues of CPPs completely after completion of spraying. It is essential for prevention of following:

- a. Damage to crop plants subsequently sprayed with different CPPs
- b. Undesirable action between CPP residue and new CPP used
- c. Corrosion of sprayer parts

Procedure for Cleaning of Sprayers

1. Remove and clean all screens and boom extensions with kerosene and a small brush.
2. Clean the tank with detergent.
3. Flush with two tanks full of clean waters spraying through the boom with the nozzle removed.

Storage of sprayers

1. Store the sprayer away from sunlight and protect from frost
2. Generally keep the sprayer away from children

Do's and Don'ts

1. Exercise caution at all times

- i. Do not work with CPPs if you feel unwell before you start
- ii. To avoid dehydration consume adequate amount of drinking water before you start
Do not eat, smoke or drink whilst handling the CPP

2. Read and understand the CPP label

- i. Check for expiry
- ii. Transport CPP separately from food stuffs, animals and children

3. Use CPP only as stated in the label

- i. Follow label instructions for use in terms of target pest, application doses and water volume rates
- ii. Do not exceed maximum spray concentration
- iii. Use label specific equipment and methods especially with regard to nozzle types and pressure
- iv. Do not exceed the label stated dose and frequency of use
- v. Apply the CPP on time when crop, pest, weather conditions are as stated
- vi. Use integrated pest management methods as advised
- vii. Keep CPP safe under lock and key and away from the reach of animals and children
- viii. Keep the CPP in the original container as supplied by the manufacturer

4. Wear appropriate Personal Protective Clothing (PPE)

- i. Different products and application methods require different PPE

- ii. Hand and eye protection is definitely required
- iii. Protective gear - cap/hat, long sleeved shirt, long trousers, non - absorbent footwear, gloves

5. Spray only during optimum time

- i. Do not spray during the hottest part of the day
- ii. Do not spray on windy days
- iii. Ensure good personal hygiene, wash yourself and your clothes before eating or drinking anything
- iv. Dispose CPP container after use - do not reuse

6. Before Spraying

- i. Check spraying equipment with water before use
- ii. Check if nozzle is working properly, replace if necessary
- iii. Calibrate equipment at least once a season

7. Clean and Maintain your sprayer well

- i. Clean sprayer after use as it has to be used for subsequent seasons as well
- ii. Do not store sprayer in sun
- iii. Protect from frost
- iv. Keep away from reach of children and animals

Environmental Protection

The spraying environment is important in deciding what CPP to put in use and how the CPP should be applied. The environment consists of:

- ❖ People carrying out the spraying
- ❖ People surrounding the spraying
- ❖ Plants and animals in the field to be sprayed and surrounding it
- ❖ Soil in the field and adjacent to it
- ❖ Water in the field and in surrounding areas (above ground and underground)
- ❖ Air surrounding the application
- ❖ Use application techniques that maximize the amount of product that reaches the target and minimizes the amount that moves off target
- ❖ Dispose of CPPs and waste products in a safe manner.

Disposal of CPP and Waste containers

The spray operator must ensure that any action associated with the application of CPPs has minimal effect on all of the above

Environmental Risk

The product toxicity and exposure to the environment determine the risk that a CPP poses to the environment.

Exposure

Exposure is a combination of the amount of product used and the number of times it is used. To minimize exposure, chemicals must be applied in accordance with the label directions and applied through properly calibrated equipment. This should avoid overdosing and minimize wastage by over mixing.

Minimizing Environmental Contamination

All actions associated with the use and application of CPPs must be carried out in a manner to minimize degradation of environment. The important issues to minimize degradation are:

- ❖ Store CPPs safely with appropriate emergency procedures in place
- ❖ Select and use products that have a minimal effect on the environment.
- ❖ Read the label and follow the safety directions

Waste CPPs and containers should be disposed in a manner that reduces the risk to people, animals, crops, water supplies or the environment, both now and in the future. Indiscriminate dumping of excess CPPs into water drains, streams and fields is entirely unacceptable and can have detrimental effects on many down stream users The rules for disposal are:

- ❖ The user should read the label for specific advice on waste disposal.
- ❖ The local supplier of the chemical should be asked if he would accept the waste
- ❖ Where possible waste should be disposed through a company or individual licensed to handle waste disposal.
- ❖ Waste should be disposed of as soon as possible. Avoid accumulation, as this often intensifies the risk of contamination through spillage.
- ❖ Empty CPP containers should never be reused except for the transfer of the same product from a leaking container
- ❖ All containers should be drained, cleaned and punctured after emptying and before disposal

Containers may be buried on the premises owned by the user or a site designated by the local authority. The burial site must be chosen so there is no risk of contamination to surface or underground water. The containers should

be buried at a depth greater than 1 meter and below any land drains. Fencing and marking of area with warning signs should be practiced and a record of the number of containers kept need to be maintained

When liquid wastes need to be disposed, soak-aways or evaporation pits may be a good

option. Soak-aways must be environmentally acceptable for the type and quantity of CPPs to be disposed. The user need to consult the local authorities and seek the advice of the chemical suppliers to determine where a soak away is appropriate for the chemicals being used.

