BEST PRACTICE GUIDELINES
for
EXTENSION WORKERS

HOW TO USE KNAPSACK SPRAYERS TO APPLY HERBICIDES

A technical manual for field staff for use as a training guide in the operation of knapsack sprayers for herbicide use

Natural Resources Institute

CPP
Crop Protection Programme

DFID Department for International Development

AREX

BEST PRACTICE GUIDELINES FOR USING KNAPSACK SPRAYERS FOR HERBICIDE APPLICATION

Contents

An introduction to knapsacks and herbicides

Herbicides can provide effective weed control when applied using manually operated knapsack sprayers provided

- The correct herbicide is used
- The correct rate of herbicide application is used
- The correct nozzle is fitted

Hydraulic nozzle lever-operated knapsack sprayer

Herbicides can be used to make hand and animal weeding more effective

Key steps

1.Choose the recommended herbicide for the problem.

2.Read the instructions and label carefully

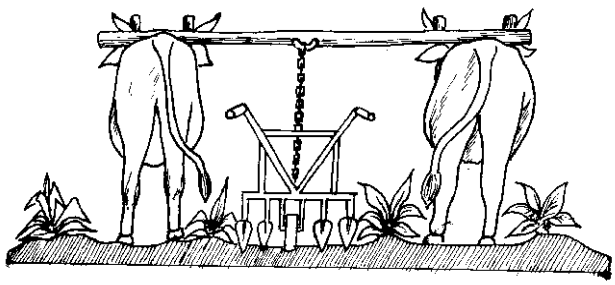
3.Calibrate the sprayer

- Use the steps shown in this leaflet

4.Mix the herbicide and water in the sprayer tank as follows:

- Half fill the tank with water
- Add the measured amount of herbicide to the water
- Shake to mix
- Add the remaining water and shake again

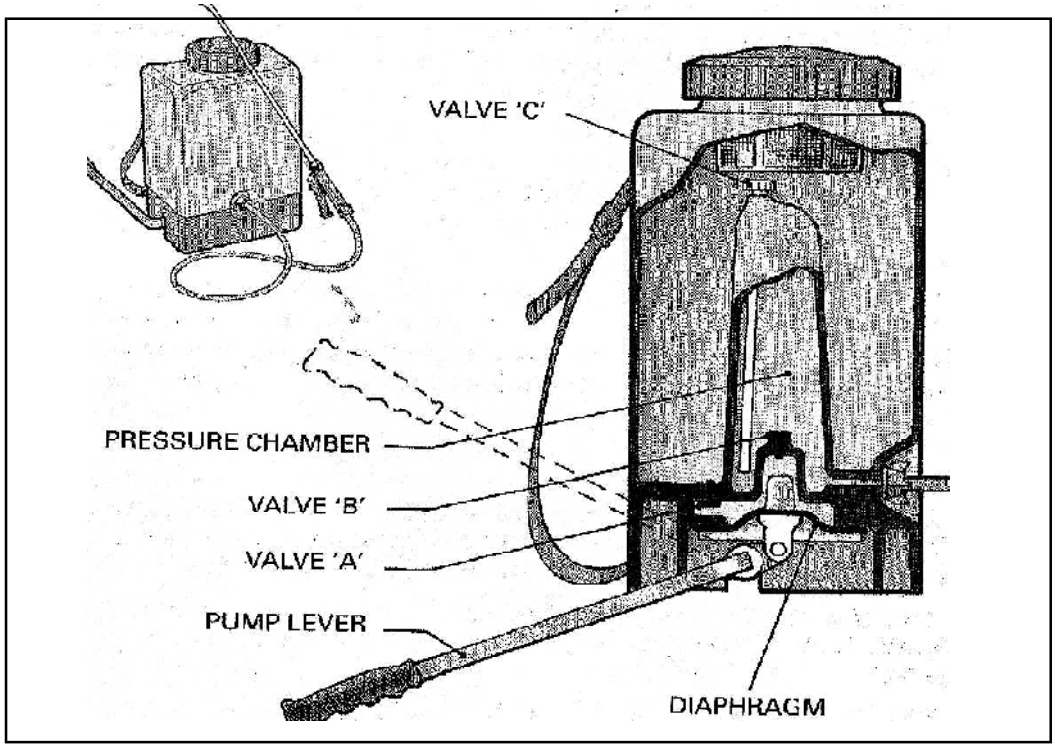
Relying on hand weeding alone can mean that weeds grow faster than the crop



Weeding with animals can be combined with the use of herbicides

The knapsack sprayer

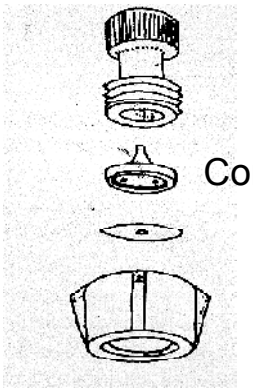
The most commonly available sprayers are those using a diaphragm pumps like the one shown below



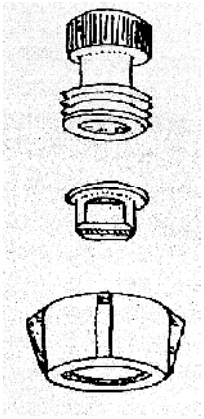
Nozzles

Three commonly used nozzles are available,

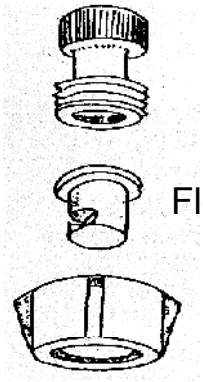
- A cone nozzle
- A fan nozzle
- A floodjet (flat fan or deflector) nozzle



Cone nozzle



Fan nozzle



Flood jet nozzle

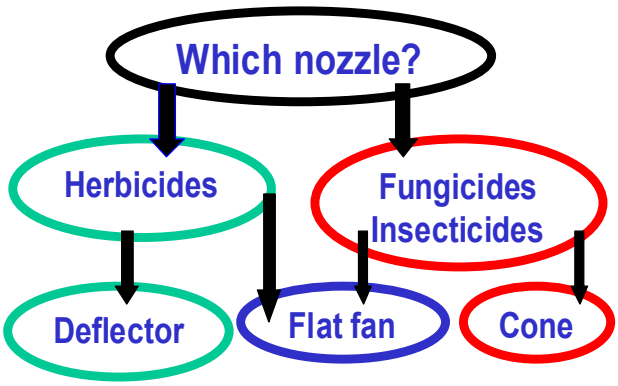
For herbicide application floodjet nozzles are the best and are available to spray 0.75 m, 1.0 m, 1.5 m and 2.5 m wide swaths. Floodjet (flat fan or defector) nozzles operate under low pressure, with the lance positioned so that the nozzle directs the spray downwards with an equal swath width on each side of the lance.

Nozzle selection for herbicides

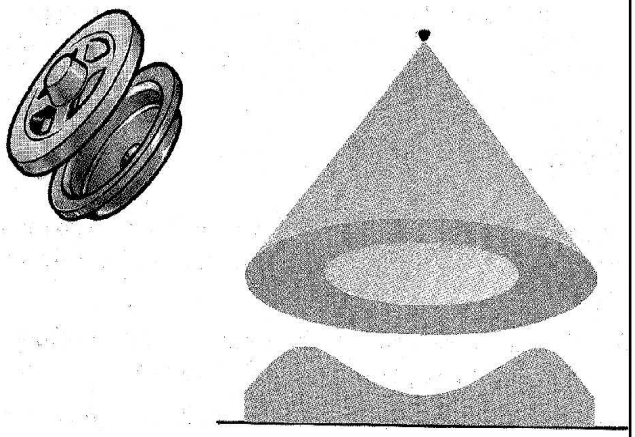
When a farmer purchases a new sprayer it will be supplied with a cone, deflector or fan nozzle

Cone nozzles produce a fine spray and are good for applying insecticides or fungicides to the leaves of plants. They should never be used to apply herbicides as the fine spray produced will drift on even a slight breeze away from the field being sprayed.

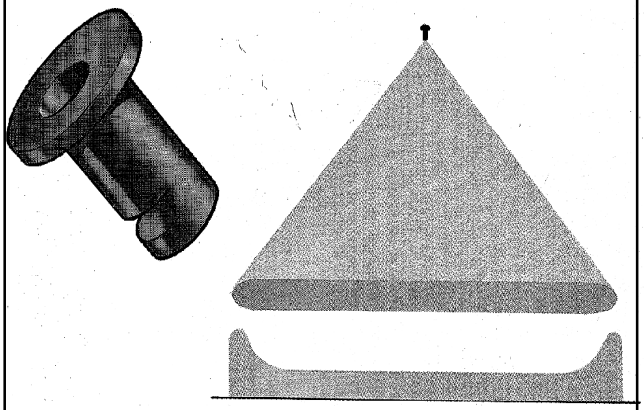
For herbicides it is necessary to use a deflector nozzle or a flat fan nozzle. The best type is called the "Even spray" flat fan as this produces an even distribution of spray liquid on the target.



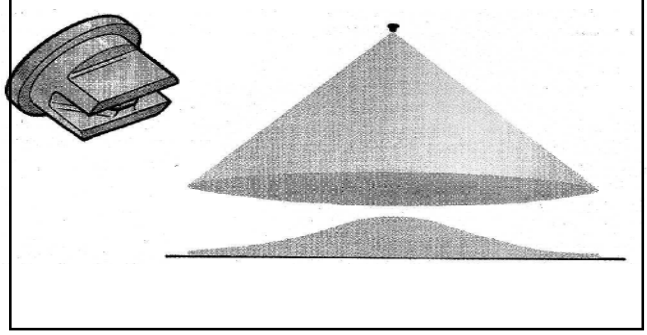
A cone nozzle



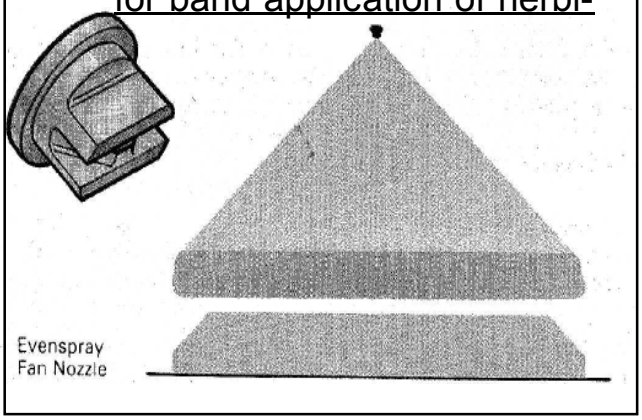
A deflector nozzle, suitable for post emergent interow herbicide application



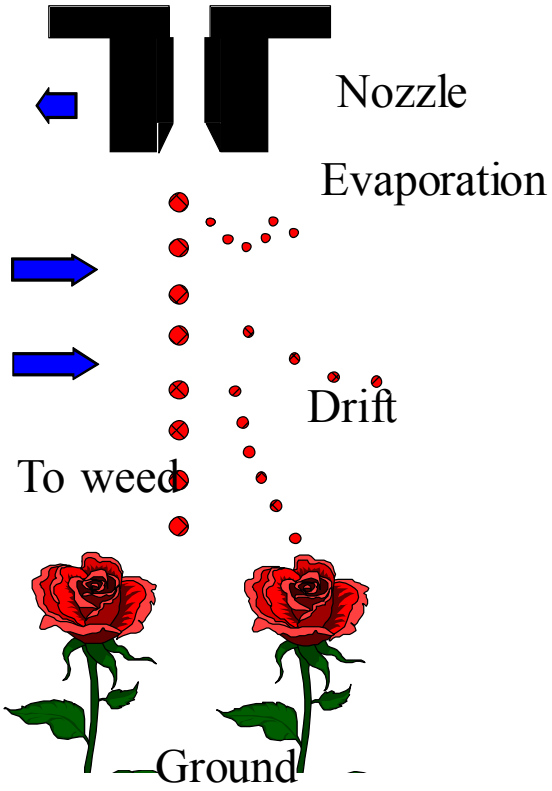
A regular fan nozzle, suitable for overall herbicide application



An even fan nozzle, suitable for band application of herbi-



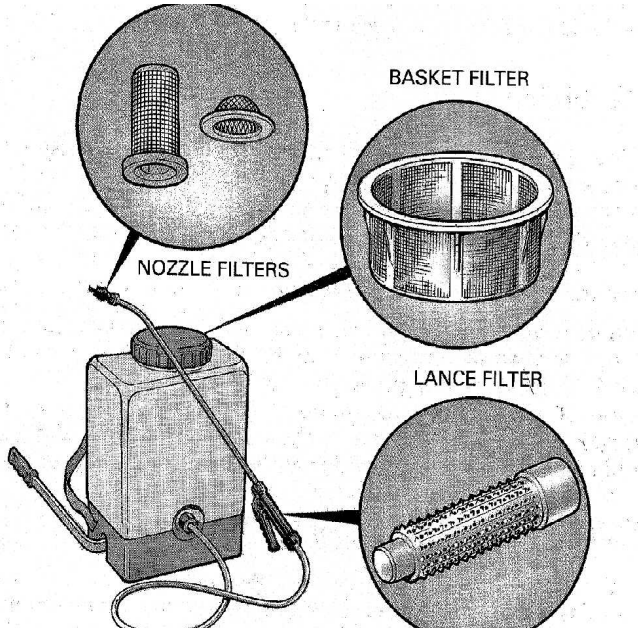
What happens to the spray?



Spray is made up of many droplets

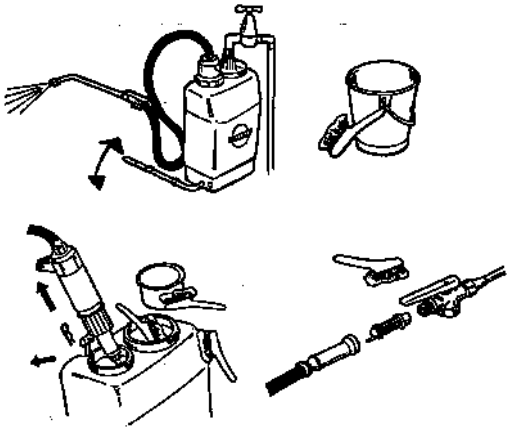
Some droplets hit the weeds
Some droplets may drift to other areas
Some droplets may evaporate
Some droplets may hit the ground

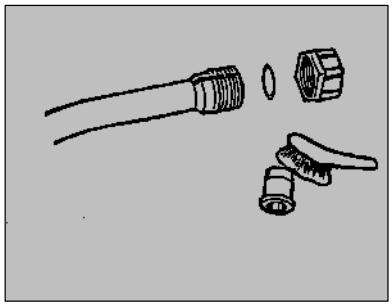
<u>Therefore : Use good quality, new nozzles</u>



Cleaning the filters

It is important to always use clean water for spraying and to thoroughly clean the sprayer after it has been used. Never store the sprayer with pesticides in it, as parts will become corroded and the sprayer will not operate properly. After spraying and washing make sure the tank has been depressurised and then clean the filters.





Preparing to spray

Every time a farmer sprays he/she should first make sure that the sprayer is safe to use. First check it is empty ensuring that there are no breaks in pipes or the tank and that the straps are secure.

Then add some water and check that there are no leaks.

Finally pump to operating pressure and again ensure there are no leaks.

Assessing field conditions

Before deciding to spray the field where a herbicide is to be applied check that conditions are suitable. Answer the following questions:

- Is soil moist enough for pre-emergence herbicide? Soil moisture is needed to activate or move the herbicide into the soil so that it can kill weeds.
- Have enough weed seedlings emerged to justify post-emergence spraying? Are they stressed? If weeds are suffering from drought, the herbicide may not work well and spraying may be a waste of money.
- Are there any susceptible crops next to the plot to be sprayed? In light wind the herbicide may drift to neighbouring plots. Check the label on the herbicide container for the crops in which the herbicide is safe to use and do not allow the herbicide to fall onto other crops.
- Is there a water- course adjacent to the plot? If so never spray closer than 1 m to any water course.
- Is wind speed too great for spraying? Always plan to avoid drift of the spray away from the field. Never spray when the wind is moving small branches of trees and bushes.
- Are conditions too hot for spraying? Under these conditions the herbicide will be lost (evaporate) to the air.

Try to spray early in the morning before it becomes very hot and when there is little wind.

Ensure safety and protection of the person spraying

All pesticides including herbicides are poisonous and may harm humans.

NEVER PUT ANYONE AT RISK INCLUDING YOURSELF

Rubber gloves or plastic bags should **always be used** to protect hands and arms from herbicide concentrate when measuring out herbicide or any pesticide from the bottle and adding it to a sprayer.

Knapsack Sprayer Calibration

What is calibration?

Calibration is the process of determining sprayer output and adjusting the sprayer output by changing the speed of walking and/or nozzle size to match a specified sprayer output that is recommended for a particular herbicide on the herbicide label.

When we look at a herbicide label we find that there are two figures, one which relates to the dosage in mls or litres, grams or kgs of herbicide that should be applied per hectare of land. The second relates to the amount of water into which that recommended dosage of herbicide is mixed and applied to a hectare. For example, a herbicide like atrazine, the label can say that 4 litres of the herbicide be applied in 200 litres of water to a hectare. When you calibrate the sprayer then, you are adjusting the sprayer to give out an output of 200 litres of spray mixture per hectare. That spray mixture will be made up of atrazine mixed in 200 litres of water.

Why is this done?

To ensure that enough herbicide is applied to kill weeds and to avoid spraying too much which would be a waste of money and may damage the crop or soil.

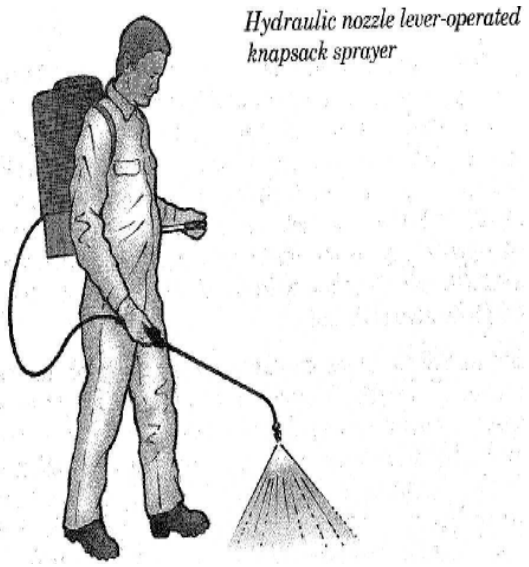
What determines sprayer output?

Changing the walking speed of the person spraying, the hole size in the sprayer nozzle and the height of the nozzle above the ground will all change the output of the sprayer

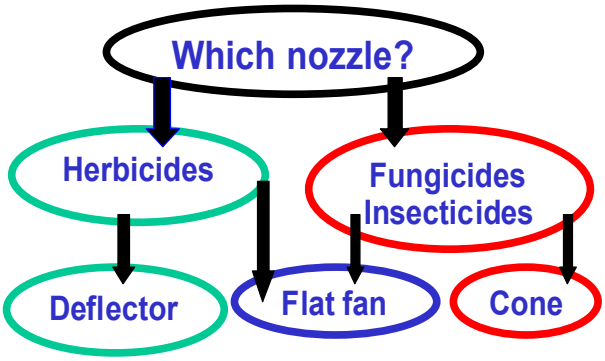
When the speed of walking is increased, sprayer output will decrease because you would have reduced the time of sprayer discharges for each unit of land area. Therefore if speed of walking is doubled, sprayer output per hectare will be halved. Similarly, if speed of the sprayer is halved, sprayer output is doubled.

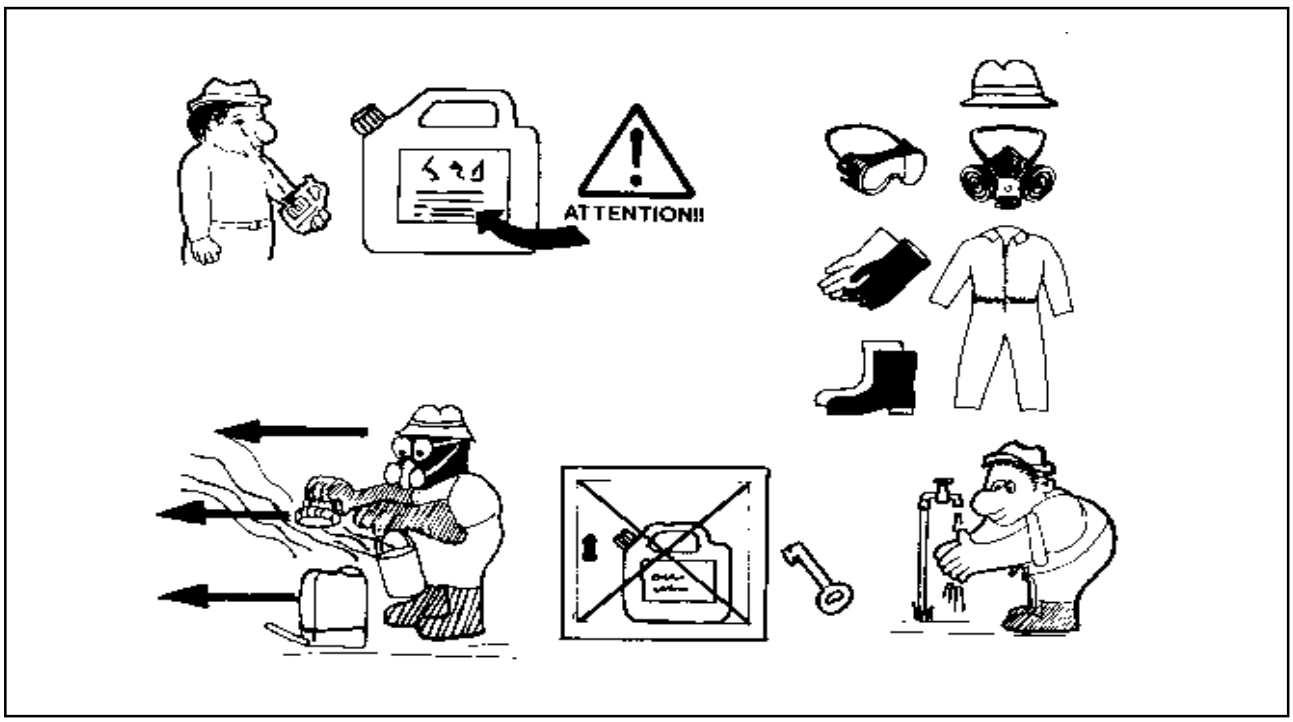
The nozzle orifice is the hole through which the spray solution is discharged. An increase in the size of the nozzle means an increase in the amount of herbicide spray mixture discharged by the nozzle. The nozzle orifice size can be read in conjunction with the angle of discharge of the sprayer on the surface of the nozzle tip eg. 01-F80, 01-F110, 02-F80, 02-F110, the first number indicating the size of the orifice and the second the angle of discharge. The F indicates that the nozzle is a flat fan nozzle that requires overlapping when spraying.

The nozzle orifice sizes can be 01,015, 02, 03, and 04 in reflecting the rate of discharge of spray from the knapsack sprayer. Bigger nozzle orifices are available for specialised applications.


Hydraulic nozzle lever-operated knapsack sprayer

The wider the angle of the nozzle eg. 110° versus 80°, the more one is able to achieve a wide swath width without raising the nozzle too much. When the nozzle is raised too high, there is likely to be higher losses of the spray mixture due to wind assisted drift. It is recommended that the swath width should be similar to the row width of the crop to which the herbicide is applied so that the spraying is on a row by row basis to avoid marking for each spray run. For narrow row crops, the swath width can be twice the row width.





Determining sprayer output

The method of determining spray output described below is called the stationery calibration method owing to the determination of the spray output once the sprayer is stationery, after timing the length of run. This method can be used to determine sprayer output of any sprayer as long as the swath width of the sprayer can be determined and the sprayer can be timed, moving at constant speed over a measured distance

When you calibrate the sprayer the first thing that you have to do is to determine its output at a known walking speed and the height of the nozzle above the ground. Height of the nozzle over the ground affects the sprayer output by affecting swath width of the spray pattern on the ground. The closer the nozzle is to the ground, the narrower the swath width, and the greater the dosage of chemical applied. The higher the nozzle height the wider the swath width and therefore lower dosage.

Calibration method to determine sprayer output		**Example**
Read the LABEL	Fund the recommended spray volume	200 litre per hectare
Set nozzle height and measure swath WIDTH	Adjust nozzle height until sprayed swatyh is 90 cm wide (crop row spacing) and fix with piece of string and weight. Ecord swath in metre	0.9 metres
Determine TIME to spray 100 metres	Measure a distance of 100 metres, using a comfortable walking speed (1metre per second). Spray oer the 100 metres. Record the time in seconds. Repeat three times	95 seconds
Determine OUTPUT per run	For equivalent time taken to spray over the 199 metre distance, discharge sprayer into a measuring cyolinder or graduated jug	1500 mls (1.5 litres)
Calculate spray OUTPUT per ha in litres	Area of 1ha (10,000 m^2)x spray output per run (litres) / swath width (m) x length of run (m) (10000 x 1.5)/(0.9x100)	167 litres per ha

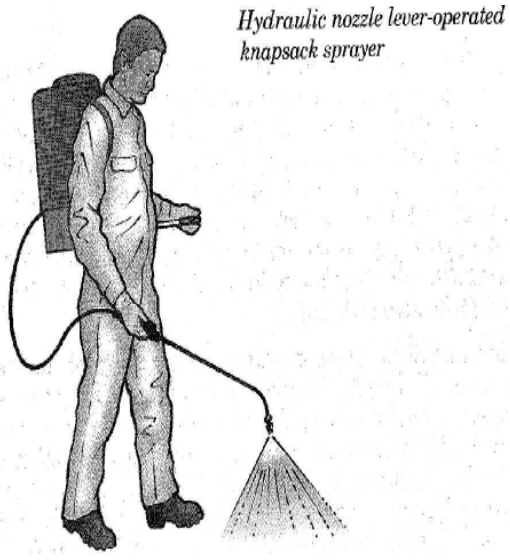
Steps to be followed in calibration

Step 1.
Mark out the width row on a dry piece of ground or concrete floor and then spray on the ground until the swath width that you obtain is equal to the marked out row width. Fix this swath width by tying a bolt, piece of wood or stone on a string onto the lance of the knapsack sprayer so that the bolt, wood or stone just touches the ground.

Step 2
While maintaining the nozzle at the height set in 1, spray in a straight line for a distance of 100 m, walking at an even speed and pumping at an even stroke. Record the time in seconds required to spray the measured distance. This exercise may need to be repeated two or three times until the operator displays a constant walking speed by achieving approximately equal times (seconds) over the measured distance. A good starting point for calibrating is to walk at approximately 1 m per second. Take the opportunity when a tape measure is available to check the pace. This is achieved by counting the number of paces that one needs to cover 100 m and then simply use simple proportion to convert number of paces to distance. For example if a short person needs 125 paces to cover a distance of 100 m, then he needs to multiply his number of paces by 100/125=0.80 to convert the number of paces to distance in metres. If a tall person needs 80 paces to cover a distance of 100 m, always multiply the number of paces by 100/80=1.25 to convert them to distance in metres. What needs to be remembered is the conversion factor to allow easy conversion of any distance while counting the paces and then converting the number of paces to distance in metres

Step 3
Say that the distance over which the extension worker is timed spraying is 100 m, this distance is called the length of run. The length of run x the swath width gives us the area of run. The area of run is theoretically the area in m^{-2} to which the herbicide is applied in step 2.

Step 4
For the equivalent time taken to spray a distance of 100 m in seconds, at the same even stroke of spraying as in 1, discharge the sprayer into a measuring cylinder or graduated jug. What you are doing here is determining the spray output for the area of run that you have determined in step 3.



Hydraulic nozzle lever-operated knapsack sprayer

Step 5

To determine spray output per hectare, you need to find out how many runs (area of run x swath width) they are in a hectare. A hectare is 10 000 sq m. The number of runs per hectare is 10 000 sq m divided by area of each run in sq m.

For example a swath width of 90 cm (the row width in maize and cotton), and length of run of 10 m, the area of run would be 0.9 m x 100 m =90 sq m.

The number of runs per hectare would be 10 000 sq m/45 sq m = 111 runs per ha.

Step 6

Output per hectare of the sprayer is obtained by multiplying the number of runs per ha with the output per run determined in step 5 when you discharged the sprayer for the equivalent time taken to spray the length of run.

For example if the discharge into the measuring cylinder was 1500 mls (1.5 litres) then the sprayer output for the chosen nozzle size, swath width and sprayer speed would be 111 runs in a hectare x 1.5 litres per run output = 167 litres of spray solution discharged per hectare

Step 7

Since nozzle supply is erratic in the smallholder sector, it is advisable to use speed as the main weapon to change the spray output to match a recommended output for a particular chemical

n the case above if the sprayer was moving at 1 m per sec and achieved an output of 167 litres per ha, then the sprayer needs to slow down enough to achieve the desired target output of 200 litres per ha Over a 50m distance, at 1 m per sec, the operator would take 50 seconds and needs to slow down to take 200/167 = 1.19 x 50 sec = 60 seconds to spray the 50 m distance and give an output of 200 litres per hectare.

The operator then practices this speed of walking and uses it for the herbicide spraying operation. Where nozzles of different orifice sizes are available, spray output can be increased in this case by using the next bigger nozzle orifice size. It is pertinent to note that the volume of spray solution in which herbicides are applied are not precise amounts. If your calculations show that you are missing the intended target application discharge volume by 20 litres either way, it is recommended to commence spraying without any further adjustments.

Calculating the amount of herbicide to be added into the knapsack sprayer

The amount of chemical to be mixed into a 15 litre knapsack sprayer can be calculated using simple proportion. Taking our example of atrazine when applied alone to very heavy soils at a dosage 4 litres of commercial product per ha in 200 litres of water, let us calculate how much atrazine you would add to the knapsack sprayer.

Since a knapsack sprayer is 15 litres in capacity, it will need a 15/200 proportion of the 4 litre atrazine dosage calculated thus

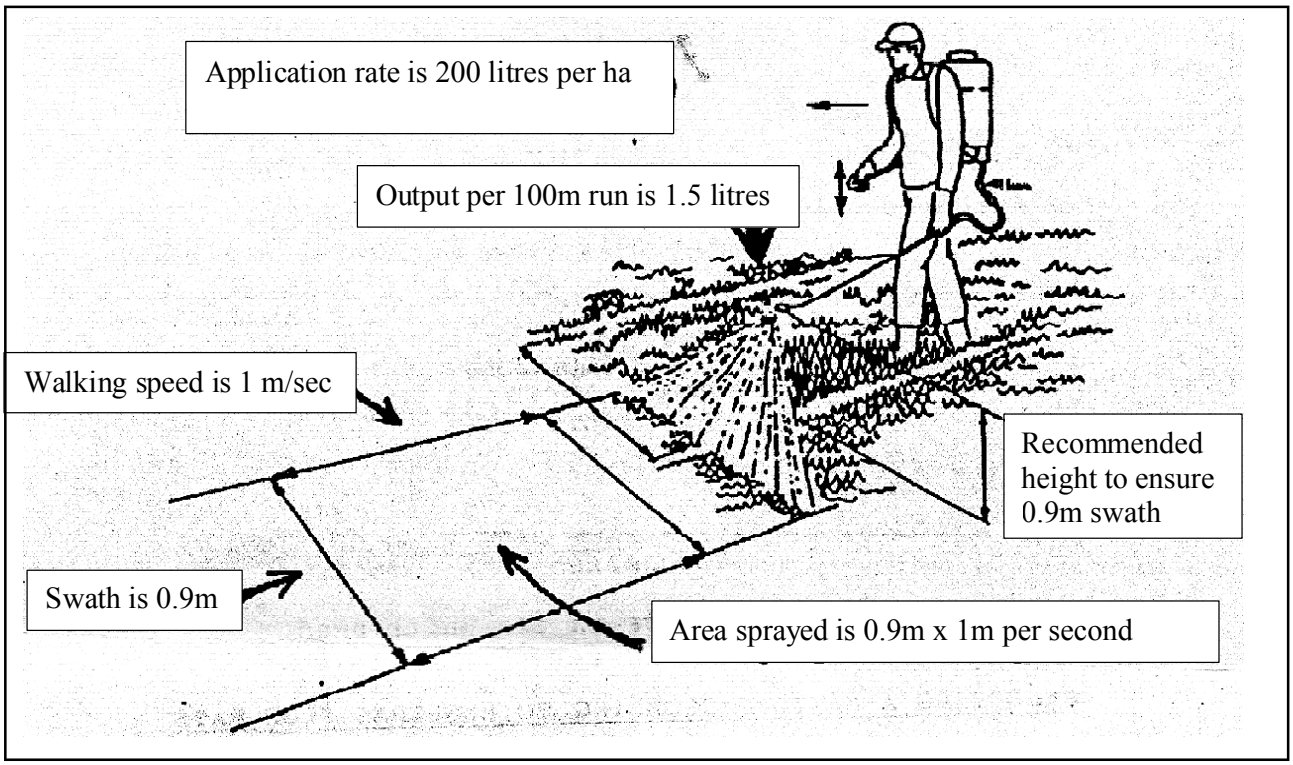
15/200 x 4 000 mls (4 litres) = 300 mls.

Therefore 300 mls of atrazine will be mixed into 15 litres of water to produce a similar concentration as 4 litres of atrazine in 200 litres of water. Remember that you would have calibrated (adjusted your walking speed when spraying and/or nozzle size) for the sprayer to give a spray volume output of 200 litres of spray volume per hectare.

As long as you maintain your calibration walking speed and nozzle height and do not change the nozzle, once you mix the herbicide into the knapsack sprayer using simple proportion as suggested above, you will be applying the recommended concentration of 4 litres of atrazine in 200 litres of water applied evenly to a hectare of land area.

Simple proportion can be used to calculate the required quantity of herbicide for liquid or any other formulation such as granules or wettable powders

RECOMMENDED SPRAY VOLUME	Read the label to obtain the recommended amount of water in which the herbicide is mixed and applied per ha	200 litresper ha
RECOMMENDED HERBICIDE DOSE TAMK CAPACITY	Read the label to get the herbicide dose per ha Find the capacity of the tank or quantity of spray mixture if less than a full tank.	4 litres per ha (4000 ml) 15 litres
Calibrate amount of HERBICIDE to be added to knapsack sprayer by simple proportion	Tank capacity (litres of recommended spray volume (litres) x recommended dose (mls per ha) 15/200 x 4000	300 mls



How is a sprayer calibrated for spraying a band along the row?

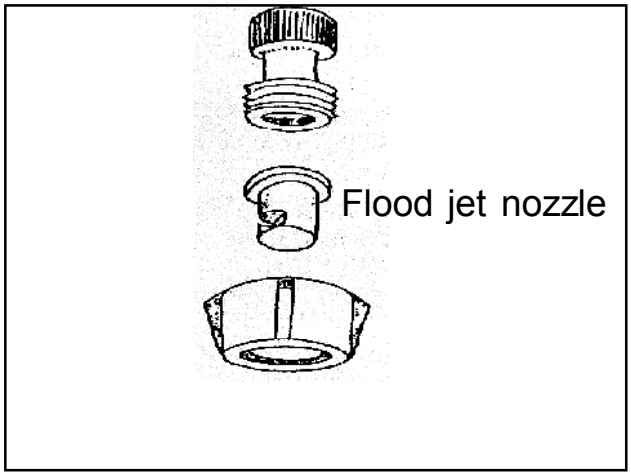
It is of greatest importance to kill weeds which emerge at the same time as the crop and grow in the row close to crop seedlings. This is because in the early stages of crop growth most competition will come from weeds close to the crop row. The farmer can save money by applying a band of herbicide along the crop row and then using a cultivator or plough to kill weeds in the inter-row spaces at three weeks after crop emergence.

If for example a 30 cm band is sprayed along each crop row only one third of the herbicide which would be used to spray a whole field is needed.

This does not change the way the sprayer is calibrated. Once the height of the nozzle has been set to spray a 30 cm band or swath the calibration is carried out using the steps described.

How to spray

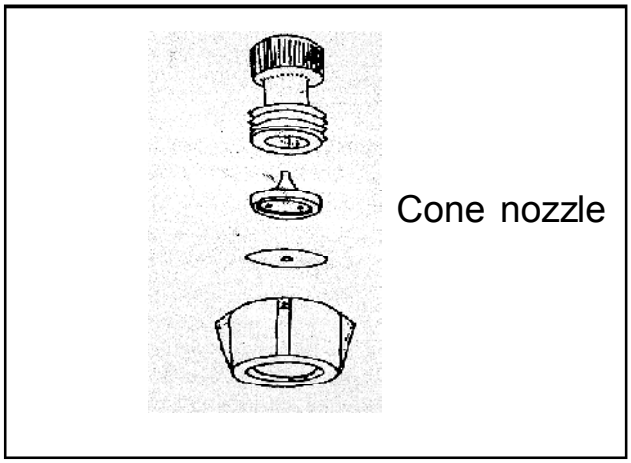
Always walk at the same speed used when calibrating the sprayer - Always ensure **an even walking speed**. Pump at an even rate while spraying. Hold nozzle at constant height above ground using a string and stone as shown in the diagram. If spraying over all the field first mark out the plot in swath widths with stakes to ensure there is a target to walk too, as shown in the diagram. This will ensure even application.

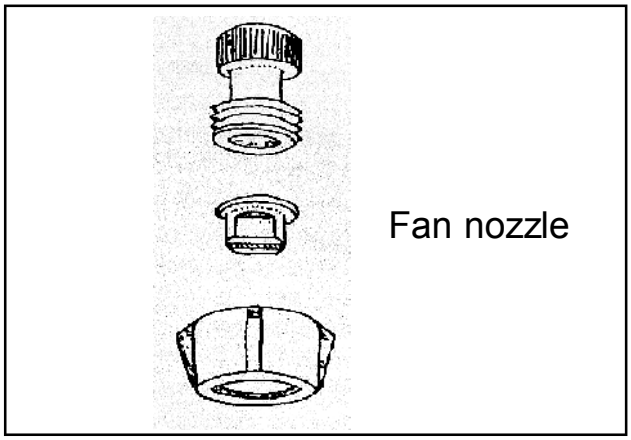


What happens if the nozzle is changed?

If a new nozzle is attached to the sprayer it is important to repeat the calibration steps given above to ensure the correct amount of herbicide is applied.

Different nozzles may apply different amounts of spray.





Filling the sprayer

Always use clean water. First fill the sprayer tank with water up to half final spray volume by pouring water through the filter provided. Then add the correct amount of herbicide concentrate through the filter

Add a small amount of water to the cup used to measure herbicide and add into the sprayer. Rinse the measuring cup twice more, each time adding the water to the sprayer. Finally add more water until the level is up to the 15 l mark on the sprayer tank

Precautions you should take

After spraying

- Dispose of unused spray mixture by spraying out onto unplanted headland, or a non-crop area in bush - avoid water courses.

- Add approximately 1 litre of water, rinse sprayer and spray out the waste onto unplanted headland or a non-crop area in bush - avoid water courses. **Repeat** this twice more to ensure the sprayer is clean. Spray out all contents of tank until empty and it is no longer under pressure. **Never** store with spray even over night

- Remove clothes used for spraying, **wash** them and discard washing water into the bush away from houses and livestock.

- Wash hands **immediately.**

Storage of herbicides and sprayer

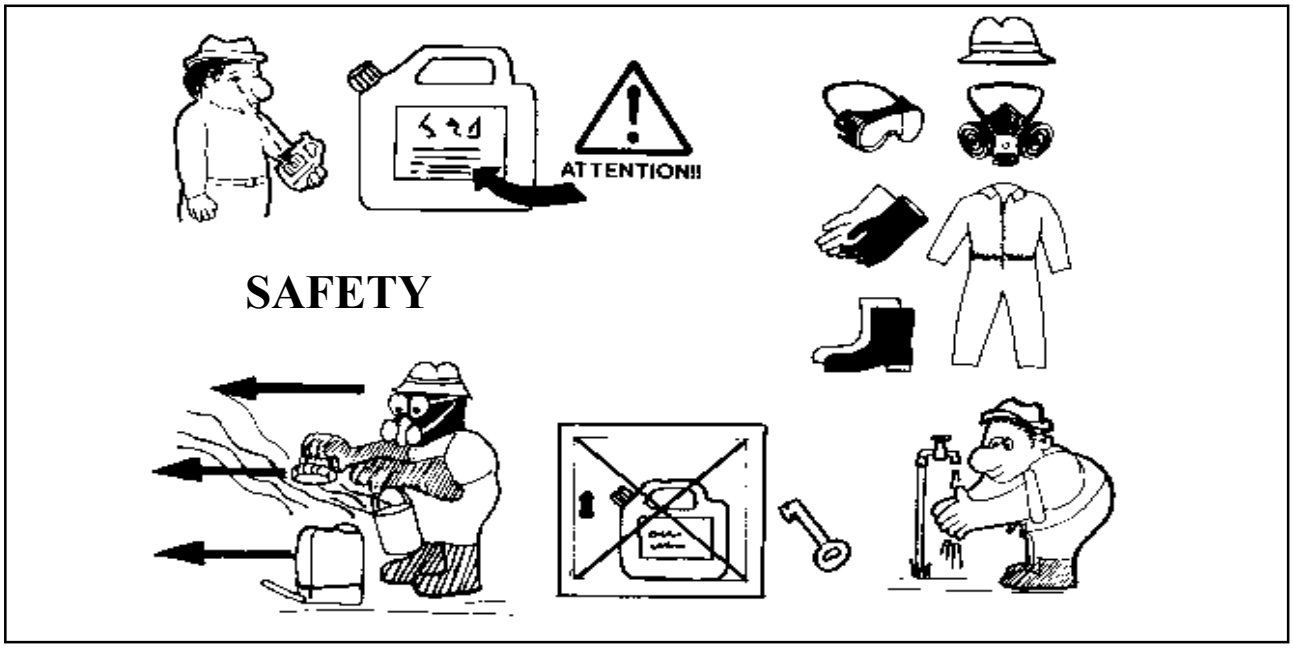
Store safely and securely away from food and people especially children.

What should be done if concentrated herbicide from the product container is spilled

Cover the spillage with soil to soak up the herbicide. Then bury the contaminated soil at least 0.5 m deep at edge of a field or in the bush away from paths, houses and water courses.

What should be done if a person becomes contaminated by concentrated herbicide or spray mixture

- Immediately wash down the affected area with plenty of water.
- Remove contaminated cloths and wash these – discard washing water carefully in safe area away from houses and not into a water course.
- If the person is then unwell (sickness, headache, dizziness, pains in body) see a doctor and take the concentrate bottle with you so the doctor can see the label.



GENERAL SAFETY PRECAUTIONS AND HANDLING OF PESTICIDES

1. **Make sure pesticides are packed in the original and fully labelled container.** Keep in this container

2. **Never transfer pesticides to other containers**, especially beverage bottles and food containers

3. **Read the label carefully**. Be sure the instructions for mixing, application and storage are fully understood. Follow instructions carefully

4. Store pesticides away from food, children, animals, seeds and fertilizer. Store in a separate locked ventilated area if possible,

5. **Avoid storing open partially used containers**. Try to estimate in advance the quantity needed and purchase only that is needed. Never use empty pesticide containers for drinking water or food. Rinse empty containers with water and burn away from houses and people

6. **Protective clothing should be worn when applying pesticides**. Clean long sleeved shirts, long trousers, rubber boots, hat and rubber gloves should be worn if possible. Wash these regularly and do not wear if they become heavily contaminated with pesticide.

7. **Avoid exposure to pesticides.** Never eat, drink, rub your eyes or touch your mouth when working with pesticides.

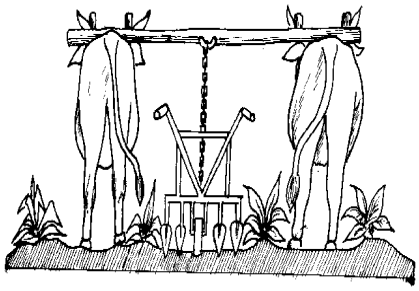
8. **Wash thoroughly after using pesticides**, especially before drinking and eating. Keep clothes used in spraying separate from other clothes and wash separately.

9. **Do not leave pesticides unattended** in the field.

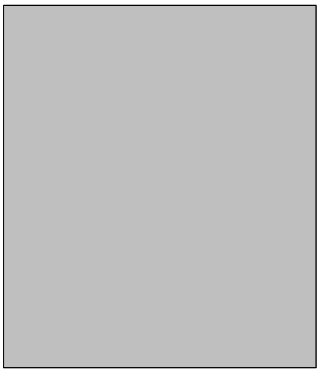
10. **Check equipment** using clean water only before spraying. Check for leaks, blocked nozzles, blocked filter or other problems.

11. **NEVER blow out clogged nozzles or blocked hoses with your mouth.**

WEED MANAGEMENT OPTIONS

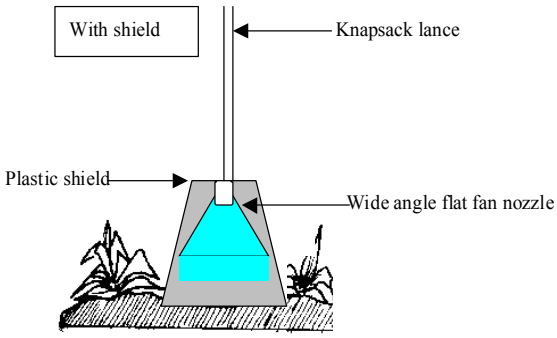


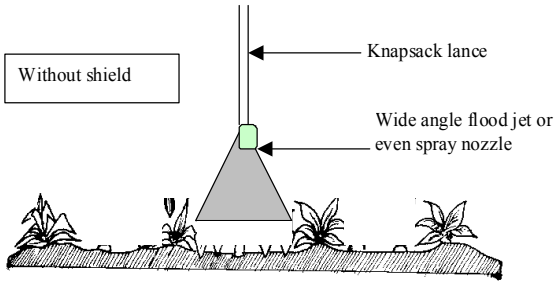
Animal drawn cultivator



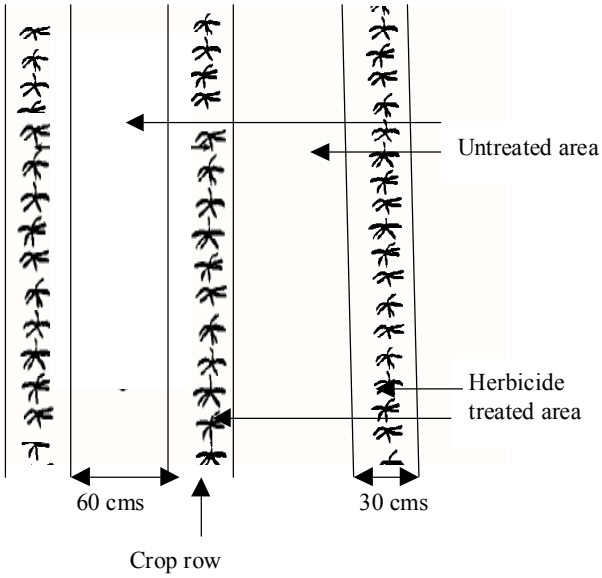
Herbicide spraying

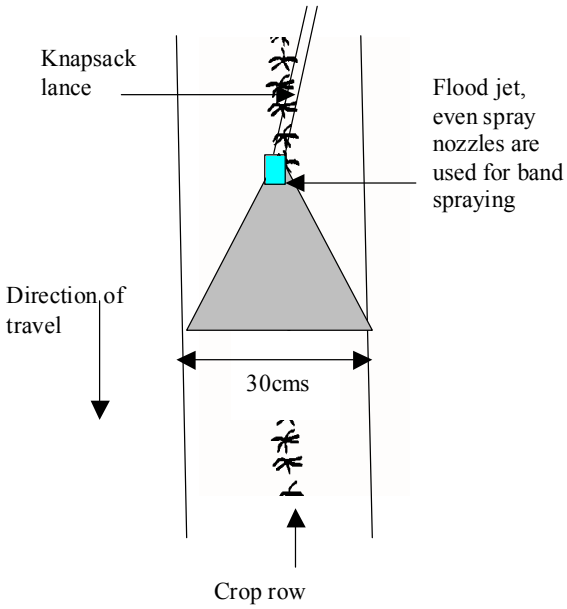
Hand weeding





Directed application using non-selective foliar applied herbicides such as glyphosate. Avoid contact between the crop and the applied herbicide





Band application of herbicides using a knapsack sprayer

Purpose of these Guidelines

These Guidelines have been developed to assist field workers and extension staff who help and advise farmers on the operation and maintenance of knapsack sprayers for applying herbicides.

Acknowledgements

These Guidelines have been prepared as part of a Crop Protection Programme project (R7473 and R7474), funded by the Government of Zimbabwe (GoZ) and the UK Department for International Development (DFID). The information in the Guidelines are the responsibility of the project team and do not necessarily represent the views of DFID or GoZ.

Contributions to this document have been made by

University of Zimbabwe: *AB Mashingaidze, Ostin Chivinge*
Natural Resources Institute: *Charlie Riches*
Silsoe Research Institute: *Jim Ellis-Jones (Editor)*

The second version was printed in January 2003
IDG/02/14
Silsoe Research Institute