

Herbicide application techniques

Anil Dixit¹

National Institute of Biotic Stress Management, Barond, Raipur (Chhattisgarh) 493 225

Herbicides are chemicals that are used to kill or inhibit the growth of weeds. These chemicals at their recommended doses and time of application are not harmful to crops. The labour for weeding operation is increasingly becoming scarce and expensive. Manual weeding is less efficient, often not done on time and can not be practised under adverse soil and weather conditions. Herbicides, therefore, have come as a welcome alternatives for manual or mechanical weeding, which are far more efficient, less labour-intensive and often more cost-effective than other methods of control.

Key words: Application, Herbicide, Technique

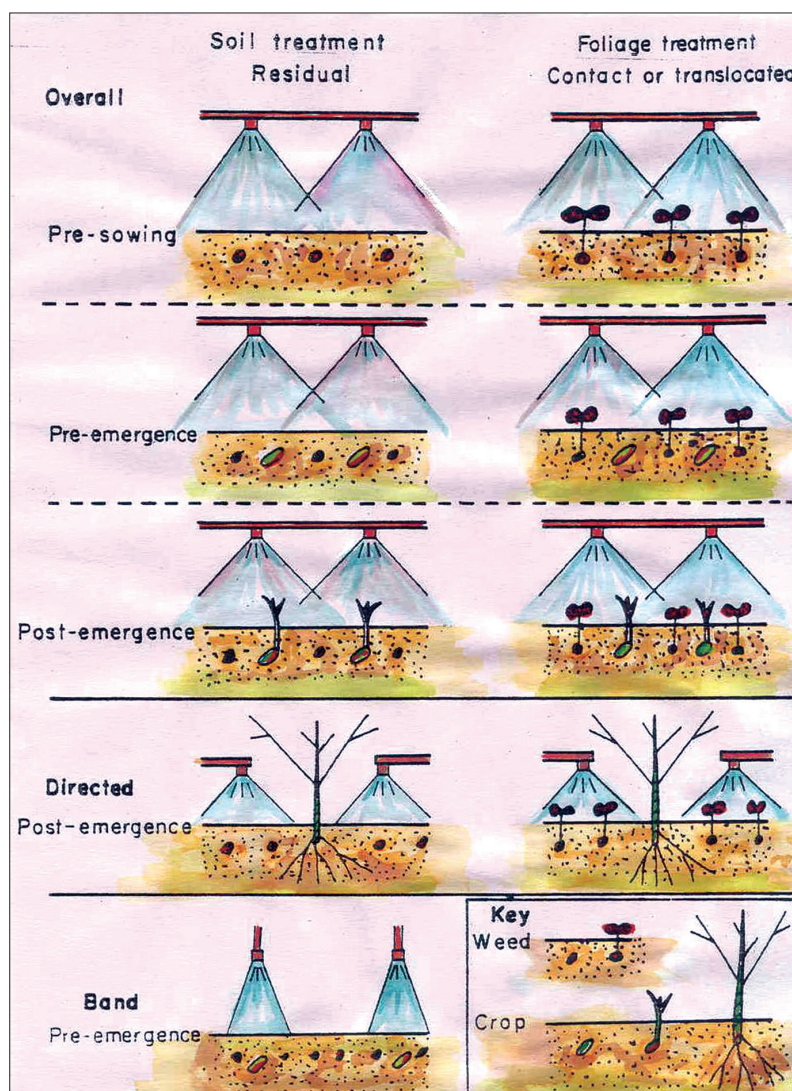
Although they look similar to other pesticides such as fungicides or insecticides. Herbicides are different, because they are used to eliminate undesirable plants (weeds) amongst desirable ones (crop). Thus the user has to exercise lot of caution while using herbicides. Proper technical know how is, therefore, a pre-requisite for successful adoption of chemical weed control technology. For instance, selection of a herbicide is dependent on crop where it is used. It is interesting that to control the same weed; one may have to use different herbicides in different crops. Any wrong selection would seriously damage the crop. This is not true with insecticides or fungicides. The other major difference is with regard to dose of application. With herbicides, if lower doses (than recommended) are used, it would result in poor weed control, whereas, higher dose may cause crop damage. Excessive application may also affect the succeeding crops grown in rotation.

HERBICIDE APPLICATION

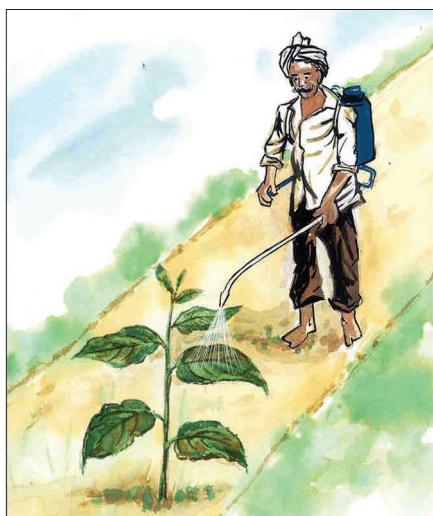
Methods

Blanket application is the application of herbicides over an entire area. In post-emergence applications this includes both crop and weeds and hence only highly selective herbicides are suitable for such applications.

Band application: Pre-emergence herbicides are applied in a restricted area over the crop row only. The weeds that emerge later in the remaining one-half to two-third



Source: Herbicide use in crops (with acknowledgements to *Weed Control Handbook*, Blackwell Scientific Publications, Oxford, United Kingdom)



Application of herbicide

area between the rows will have to be controlled by interculture operations. The band application is primarily a cost saving device as only one-half to two-third the total area is treated. This method is more suited in broad spaced crops (e.g. cotton) and in orchards and vineyards.

Directed application: Certain non-selective or partially selective herbicides can be used to control



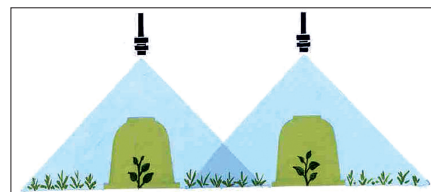
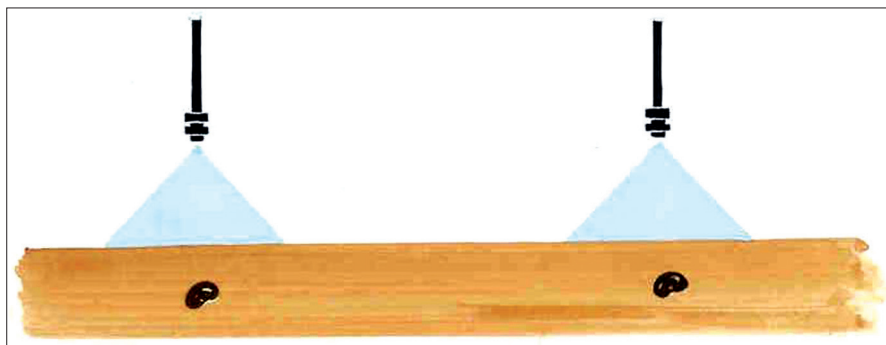
Contact herbicide-only treated leaf is killed

weeds in the inter-rows by directing the spray on weeds. This saves or minimizes the herbicide injury on crop plants. However, this will become practicable only when the crop plants are taller than weeds. This is often used in perennial crops and



Translocative herbicide - the whole plant is killed

vegetables or ornamentals by covering the crop plants with plastic or metallic covers. This is practicable only in high value plants or crops.



Spot application: It is the application of herbicides to small patches of weeds leaving the weed-free gaps unsprayed. This is mostly



broad-spaced crops with woody stem such as cotton, (*Gossypium hirsutum*), maize (*Zea mays*), or sugarcane (*Saccharum officinarum*).

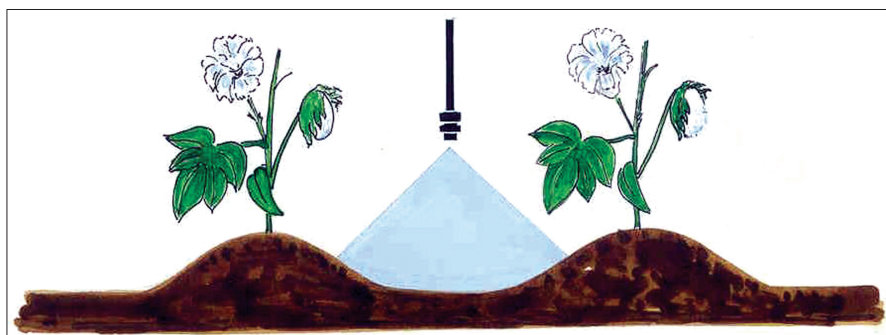
A spray hood is also used to reduce spray drift and the subsequent crop injury.

Protected spraying: Non-selective herbicides can be employed to control weeds in widely spaced



practised in treating patches of noxious perennial weeds with potential herbicides.

Lay-by application: It is the application of herbicides after the last cultivation in crops, for example after



ridging in sugarcane or cotton, after earthing-up in potato (*Solanum tuberosum*) etc. Usually soil-acting herbicides are used, which will prevent further emergence of weeds.

How herbicide is applied?

Broadcasting: It is done in granules and is limited to certain situations only. As sufficient water is required to dissolve the formulation, it is normally applied in standing water. Most widely practised for weed control in transplanted rice. The water is to be impounded for at least 2-3 days before draining it out. Although not very scientific, wettable powder and liquid formulations are also often broadcast after mixing with sand, soil or fertilizers. The concentrated liquid formulation may also be applied through sprinkler bottles in standing water as is done in transplanted rice crop.

Spraying: It is the most common method of herbicide application. The herbicides are dissolved in water and applied uniformly using a sprayer.

Rope-wick application: This technique is used in the application of non-selective herbicides particularly the translocative type (e.g. glyphosate). The idea is to prevent crop phytotoxicity caused by spray drift that occurs with conventional spray application. Here the herbicide is smeared on to the weeds by means of saturated 'wicks' attached to a tank. This technique can be successfully used for weed control in tall growing crops and in orchards. Smaller hand-held version of this applicator is also available for use in small farms. As the concentrated herbicide is wiped on to the weeds directly, considerable saving on herbicide requirement is

achieved. Very ideal for controlling perennial weeds such as *Cyperus* spp. in standing crop.

Selection of herbicides

Several herbicides are available in the market and the selection of a herbicide depends upon weed flora (broad leaved, sedges, grasses etc.) and time of application (before or after planting). Remember a single herbicide can not control all weeds. Two or more herbicides may be mixed together (tank-mix application) to achieve broad spectrum weed control. If they are not compatible they may be applied one after the other after a gap of a few days (*sequential application*). Expert advice, however, is to be sought before use in the field. Some formulations with mixture of herbicides are also available (*ready-mix*) for ready use by farmers (e.g. Butanil is the mixture of butachlor and propanil, Almix is the combination of chlorimuron-ethyl and metsulfuron- methyl).

Care may be taken while using herbicides in situations, where simultaneously more than one crop is grown (inter-or mixed cropping). Select a herbicide which is safe to all the crops grown. For example, choose atrazine for weed control in maize and pendimethalin for maize intercropped with legumes. Selection of a herbicide also depends on its availability in the market and the cost.

How to increase the herbicide performance?

The enumerated points may be considered for increasing the efficiency of herbicides and to reduce the cost of weed control:

- Apply herbicides at recommended

rate and time of application

- Apply pre-plant and pre-em. herbicides on a well prepared field free from clods and crop or weed residues.
- Use low dose in light soil and higher dose in heavy soils.
- Ensure optimum soil moisture at the application, especially with soil-acting herbicides.
- Lower herbicide dose integrated with hand weeding or hoeing is more effective and economical, than herbicide alone at higher dose.
- Take up spraying of herbicides on a calm, clear and sunny day for maximum benefit. Do not take up spraying, if the rain is expected in the next 4-6 hr.
- Untimely rain or heavy irrigation may accentuate crop injury.
- The performance of some of the herbicides can be enhanced substantially by adding adjuvants (e.g. surfactants like Teepol, Selwet, etc.) to the spray solution.
- Apply post-em. herbicides on the actively growing vegetation. Never apply when weeds are too small or when they are over grown.
- Follow herbicide rotation (different herbicides in different years) and use herbicide mixture to prevent weed flora shifts and development of herbicide resistant weeds.

Application of the herbicide

Uniform application of the herbicide is crucial for good weed control and for better crop growth. Often a very small quantity of the herbicide is required to be applied on a large area. Any deviation would result in serious consequences. While under-dosing would result in poor weed control, over-dosing may damage the crop. To apply the herbicide uniformly, one needs to calibrate the sprayer and calculate the herbicide requirement carefully. Herbicides are applied on area-basis (kg or l/ha) not by concentration basis (%) as is done in case of insecticides or fungicides. However, in controlling weeds in non-crop lands, aquatic ecosystem and in spot application, very often the herbicide

is applied on concentration basis.

Herbicide formulations

Almost herbicides are formulated as wettable powders (WP) or emulsifiable (EC) and aqueous concentrates which are diluted in water and applied with a sprayer. Granular formulations (G) are used directly mostly in submerged conditions. There is a growing practice amongst farmers to broadcast the mixture of other formulations of herbicides with sand, soil or urea, just before irrigation (as done with isoproturon in wheat) instead of spraying. Many small- and marginal-farmers in India do not own a sprayer, and it is natural for them to look for alternative methods to do away with spraying. However, it should be pointed out that mixing of other formulations of herbicides with sand, soil or urea to obtain 'granules' is neither very scientific nor safe as the farmers invariably make these mixtures by bare hands. It is also to be cautioned that it is difficult to obtain uniform distribution in the field with such application. Some ingenious farmers growing cumin (*cuminum cyminum*) in Gujarat resort to application of herbicide through irrigation water (herbigation)

Calibration of the sprayer

Calibration is nothing but finding out how much area could be sprayed with the sprayer you have. The area sprayed is also dependent on the type of nozzle, spray pressure and the speed of application. The most practical way to calibrate the sprayer is by actually using it in the field. Spraying can be done by moving the spray lance from side to side using a flat fan nozzle or walk forward holding the spray lance in one position using a flood jet nozzle. In both cases measure the swath width i.e., the width that is treated

- Mark an area having width equal to the swath width
- Keep the sprayer on a level ground and fill the water to a marked level
- Carry out spraying on the marked area at a normal speed
- Avoid skipping or overlapping

- Refill the sprayer to the original level marked earlier
- The quantity refilled is the quantity required to spray the marked area.
- Work out the volume rate/ha

Examples:

Marked area = 20 m²

Quantity of water used = 1 litre

Volume rate = $(1 \times 10,000)/20$
= 500 l/ha or 200 l/acre

With the same swath width and operating speed, the spraying could be undertaken to apply the herbicides in the field.

The basic principle in calibration of a boom sprayer (with more than one nozzle) or tractor-mounted sprayer is also similar, the only difference being the flow rate of all nozzles in a boom has to be taken into account.

Calculation of herbicide requirement

The product label and the literature supplied with the herbicide will provide details of herbicide name, active ingredient (a.i.), date of expiry, directions for use etc. It must be read before using the herbicide. It is particularly important to note the strength of the product (a.i.) as the same herbicide may be sold under different trade names with varying amounts of active ingredient. For instance, isoproturon is available at 50 and 75% formulations. For this reason only, the recommendations are normally made on kg a.i. basis. Even in liquid formulations the herbicide present is mentioned in g/l.

The amount of commercial formulation of the herbicide required can be calculated by the following formula:

$$\text{Commercial product (kg/ha)} = \frac{\text{Dose in kg a.i. / ha} \times 100}{\% \text{ a.i. in the product}}$$

Example 1

Isoproturon is available as 75% WP and 50% WP. If the recommended rate of application is 0.75 kg ai/ha then the amount of commercial product required is:-

$$\begin{aligned} 50\% \text{ WP product} &= \\ \frac{0.75 \times 100}{50} &= 1.50 \text{ kg/ha} \dots 1 \end{aligned}$$

$$\begin{aligned} 75\% \text{ WP product} &= \\ \frac{0.75 \times 100}{75} &= 1.00 \text{ kg/ha} \dots 2 \end{aligned}$$

Example 2

Paraquat is to be applied at 0.5 kg ai/ha. The herbicide is available as Gramoxone (commercial name of paraquat) which contains 25% paraquat

The quantity of gramoxone required is:

$$\frac{0.50 \times 100}{25} = 2.0 \text{ l/ha} \dots 3$$

Making stock solution

To apply herbicide uniformly in the entire required area, it is advisable to prepare stock solution of the herbicide.

Suppose:

Area to be treated = 1 ha (2.5 acres)

Sprayer capacity = 15 litre

Sprayer calibration = 450 litres/ha

then,

$$\frac{450}{15} = 30$$

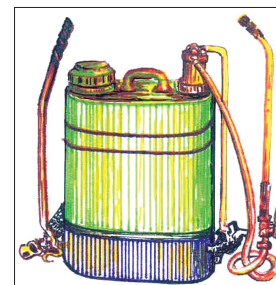
that is 30 refills are required to spray 1 ha area.

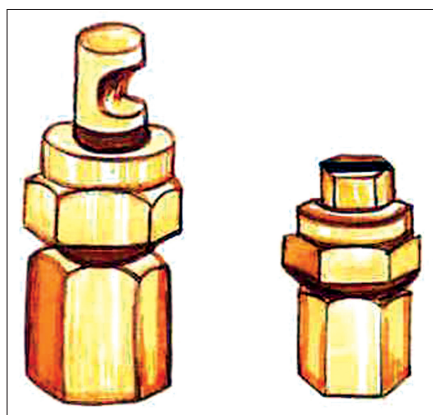
In such case, it is advisable to dissolve the required amount of herbicide as obtained in calculations 1, 2 or 3 in 30 measures (could be a glass tumbler, plastic mug or a container) of water which becomes the stock solution. Now add 1 measure of this stock solution to sprayer tank containing 15 litre water, stir it and spray as suggested earlier. Alternatively one can dissolve the entire quantity of herbicide in 450 litres of water contained in a big container and use this solution directly for spraying.

Herbicide sprayer

Herbicides except granular formulations, need to be dissolved in water and applied using a sprayer. The most ideal for spraying herbicide is the lever operated knapsack sprayer.

This involves continuous operation of the lever with one hand and directing the spray





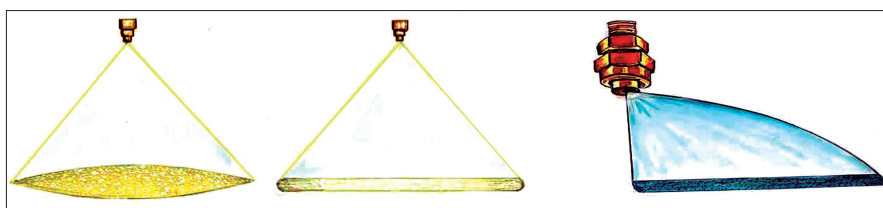
Flood jet nozzle (Left), Flat-fan nozzle (Right)

holding the spray lance with the other. The sprayer is available at different capacities and with plastic or metal body.

The important part of the sprayer is the nozzle. Flat fan nozzle or flood jet cut nozzle is recommended for application of herbicides. Cone nozzle (hollow/solid) and power sprayer should be avoided. Band

duration and enables better swath matching. Two sprayers may also be used to accommodate more number of nozzles. A number of nozzles are fitted on a boom in tractor-drawn sprayers for large-scale coverage of the area. The tapered pattern with tapered or uneven flat fan nozzle provides uniform application when overlapped with the same nozzle type thus making it ideal for herbicide application with multiple nozzle booms. Do not mix different nozzles on spray boom. Even spray nozzles are not to be used on multiple nozzle booms.

Correct height of boom is important for uniform herbicide application. More height means too much overlapping and too low height leaves area between two nozzles unsprayed. Both mean non-uniform distribution of the chemical resulting in either poor control of weeds or crop phytotoxicity or both.



Spray pattern with tapered flat fan, even flat fan and off-centre nozzles (Left to right)

application of herbicide requires a more uniform distribution from a single nozzle, so even spray nozzles are used. Off center nozzles are used for directed applications. For fan nozzles various nozzle tips are available to provide a range of spray angles and outputs.

Multi-nozzle (boom) sprayers

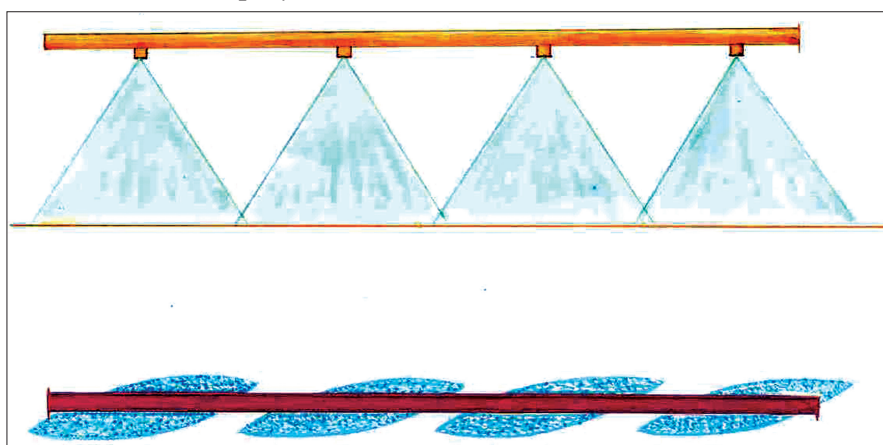
Use of such sprayer reduces

Suggestions for optimum spray of herbicides

- The spray tank should be at least one-third full with clean water before any concentrate is added and the contents well mixed while the concentrate is being put in slowly.
- Wettable powder formulations should be made up into a paste and then diluted before adding to

the spray tank.

- The spray tank should always be emptied completely before refilling to avoid altering the concentration of the spray.
- The spray should be made as required to avoid storing unused diluted spray. Should there be a short delay in application, stir or agitate the contents in the sprayer just before use to prevent settling down of the herbicide at the bottom.
- Wettable powder formulations are more prone to settling down than liquid formulations.
- Pressure should be built up before the control lever or tap is moved to the 'spray' position (eg tractor-mounted sprayers).
- Never operate the sprayer while standing still. In tractor-mounted sprayers open the nozzles only when tractor starts moving. Never apply herbicide, when the tractor is taking turns.
- Accurate swath matching is a must. Spraying along the rows can help in easy swath matching. With tractor-mounted sprayers adjust the height of spray boom for uniform application.
- Pumping should stop as soon as the tank is empty and a mark should be left in the field to indicate from where the spraying should recommence.
- It is worth dividing the area to be treated into convenient units for uniform spraying particularly for pre-em. application.
- Do not apply a herbicide, if a crop susceptible to that herbicide is growing down wind of the area to be treated. Volatile esters of herbicides should be avoided under such a situation. Early morning is often a good time to spray when the wind is gentle.
- It is advisable to use a separate sprayer for spraying hormone type herbicides (eg. 2,4-D). Small traces of herbicide, residues in the sprayer can cause phytotoxicity in susceptible crops.
- Avoid spraying foliage-active herbicide, if rains are expected in the next 2 hr or so. However, a light rain or irrigation is often beneficial for a soil-active



Multi-nozzle (boom) sprayer saves time and enables better swath matching

herbicide.

- Apply herbicide using a sprayer with 500-600 l/ha water.
- Flood jet or flat fan nozzle should only be used for spraying the herbicides.

After care of sprayers and nozzles

- Wash the sprayer thoroughly with water before and after each use.
- Any blocked nozzles should be changed or washed in clean water.
- Do not blow through blocked nozzles with the mouth or use hard objects (such as knives, wires, etc.) as they may alter spray output and droplet size.
- Nozzles should therefore be checked often and may require replacing once in a year or so.
- When sprayer is to be stored, it should be thoroughly cleaned by adding detergent to the water and rinsing several times to remove all traces of the detergent before storing. The tank should be drained and left with the lid off to allow air circulation.
- All bearings and hinges should be oiled or greased and wheeled machines should be put on blocks with the tyres out of sun.
- Hoses can be removed and stored hanging vertically to prevent rodent damage.

Safe handling of herbicides

It is important to read the label

before use and follow directions and precautions properly. The label tells what the herbicide is, lists the amount of active ingredient, and gives recommendations and precautions for use. Most herbicides are potentially dangerous particularly in concentrated form but they are not likely to cause injury, if used properly and if recommended precautions are observed. The dangers associated with mishandling and misapplication of herbicides may include possible injury to the operator and handler, poisoning livestock, damage to desirable plants, damage to equipments and poisoning fish and wild-life etc.

The following points may be taken note of in preventing the abuse of herbicides.

- Avoid prolonged contact with the skin, breathing vapours or dusts and splashing herbicide solution in to eyes or mouth.
- Wash off with soap water any herbicide spilled on the body.
- Do not smoke or eat while working with chemicals.
- Do not spray against the wind. Cover the face with a cloth while spraying.
- If unusual symptoms such as dizziness, nausea or skin rashes appear, seek medical attention at once.
- Dispose of empty containers immediately. Mutilate them to

avoid re-use and bury the remnants deep in an isolated area. Do not use them for domestic purposes.

- Avoid contaminating water supplies with herbicides.
- Store unused herbicides in original containers in a locked storage area away from food grains and children.

SUMMARY

Herbicides are the most effective and economical tool in weed management. They are applied as pre-plant soil incorporation, pre-emergence and post-emergence. Selection of a herbicide depends upon weed flora (broad leaved, sedges, grasses etc.) and time of application (before or after planting). Single herbicide can not control all weeds. Hence, tank-mix or sequential application of herbicides is needed for broad-spectrum weed control. Knapsack sprayer fitted with flat-fan nozzle or flood jet (cut nozzle) nozzle is recommended for application of herbicides. Proper calibration of sprayers, appropriate herbicide, dose and time of application, and proper precautions during and after spraying is required for safe and effective use of herbicides.

¹Principal Scientist, Division of Agronomy, Corresponding author.

Jai Kisan, Jai Vigyan

- A total of ₹ 788.33 crores have been sanctioned for opening six new agricultural colleges for eastern India under Central Agricultural University, Imphal, and a new Central Agricultural University in Meghalaya.
- For the establishment of two new agricultural research institutes in Asom and Jharkhand, a sum ₹ 100 crores is allocated.
- First academic session of the Rani Lakshmibai Central Agricultural University has been allocated for four new agricultural colleges in Datiya and Jhansi.
- An Memorandum of Understanding was signed for transforming the Rajendra Central Agricultural University, Pusa, Samstipur, Bihar. A proposal of ₹ 400 crores is submitted in EFC.
- Post-Graduate Institute of Horticulture is being established in Amritsar, Punjab.
- Foundation stone of the Indian Institute of Agricultural Biotechnology is laid at Ranchi for promoting agricultural biotechnology.