

# Field Crop Weed Management Recommendations

## Technoguide



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Department of Agriculture,  
Peradeniya, Sri Lanka.

CATALOGUED

RECOMMENDATIONS FOR WEED MANAGEMENT  
IN FIELD CROPS

43

TECHNOGUIDE

DEPARTMENT OF AGRICULTURE  
PERADENIYA, SRI LANKA

MINISTRY OF AGRICULTURE, FOOD AND COOPERATIVES

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT  
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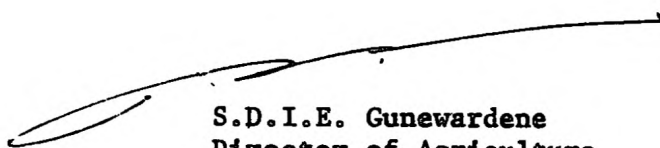
## FOREWORD

In most countries, weeds cause greater crop losses than all other pests combined. The weed population in farmers' fields suggest that the same situation exists in Sri Lanka. Weeds are frequently tolerated because their effect on crops is less obvious than it is with insects or diseases. Nevertheless, crop yields are severely reduced by competing weeds. Effective control of all weeds would likely boost crop production in Sri Lanka by 30-50 percent.

This is the first bulletin of its kind to be published on weed management in Sri Lanka. Its purpose is to introduce the principles of weed management to farmers, applicators, and suppliers, and to provide information on cultural and chemical weed control.

Registered herbicides are listed with rates of application for specific crops, based on research and practical field experience in Sri Lanka. A section is included on accurate and safe application of herbicides for maximum efficacy and safety to man and the environment.

It is envisaged that this bulletin will be updated periodically as new information on additional crops is developed or as new products prove to be efficacious and economical for farmer use.



S.D.I.E. Gunewardene  
Director of Agriculture  
Department of Agriculture

CATALOGUED

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Subsequently, a section was added by Dr. G.W. Selleck of the Diversified Agricultural Research Project (DARP) and inputs were made by Mr. Ross Lubigan on loan to DARP from the International Rice Research Institute, The Philippines. Further suggestions were made by officers in weed research and Mr. M.E.R. Pinto, Horticulturist. Contributions by Dr. S.B.D.G. Jayawardene, Head, Plant Genetic Resources Centre and the critical review by Dr. (Mrs.) N. de Alwis are gratefully acknowledged.

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## INTERIM RECOMMENDATIONS FOR WEED MANAGEMENT IN FIELD CROPS

This manual, intended primarily for use by field extension workers, covers interim recommendations for weed management in several field crops. The ultimate aim is to improve crop production by providing farmers with information on cultural control and both farmers and applicators on proper herbicide use.

### INTRODUCTION

Weeds are a major constraint on crop production in most countries, including Sri Lanka. They cause greater crop losses than all other pests and often reduce yields by 30-50 percent. Heavy weed stands can result in no yield.

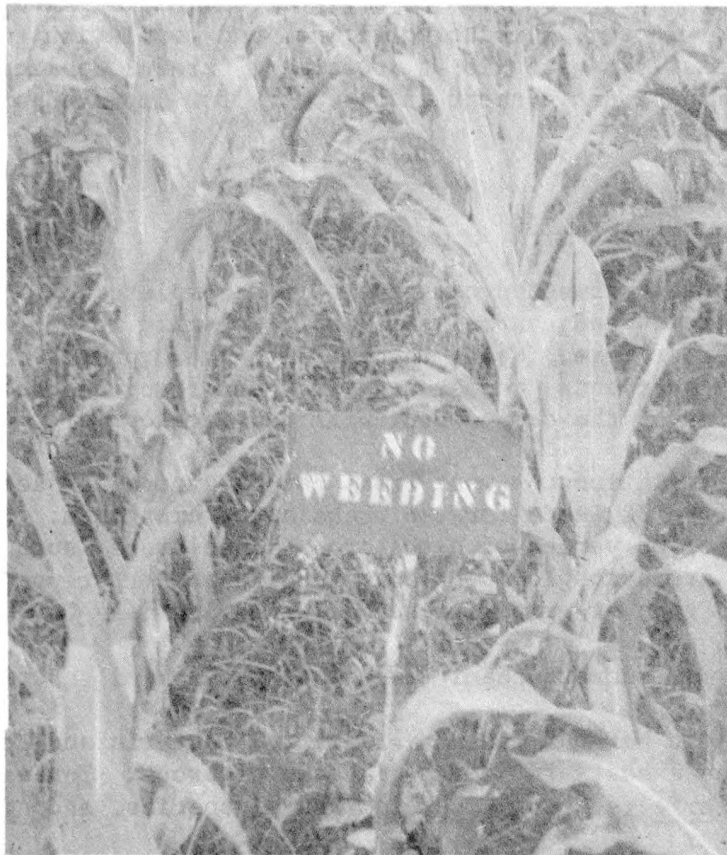
In any cropping situation, the most effective weed control program will involve a combination of cultural and chemical control methods. The goal of weed management is to integrate all feasible cultural control measures (tillage, water, fertilizer, seed management, plant spacing, biological) with application of herbicides to ensure maximum crop vigour and minimum competition from weeds. It also aims to shift the weed population to species which are easily manageable at low cost. Careful application of this weed management concept is necessary for improved crop production.

### CROP LOSSES DUE TO WEEDS

1. A crop left unweeded can result in a complete loss of harvest. Incomplete weed control can result in yield losses of 50 percent or more. Weeds compete with the crop for moisture, light, nutrients, and space. If these resources are fully utilized by the crop, weeds will not develop.
2. Major yield loss of most crops can be avoided by keeping them free of weeds for 6-8 weeks after emergence. However, this period varies with the crop. Some crops, such as cowpea, which are strong competitors, require a shorter weed-free period than others, like onion, which are less hardy.
3. Weeds may secrete chemicals which are harmful to crop growth.
4. Weeds can harbour insects, fungi and bacteria and act as alternate hosts for virus diseases of crops. For example, Crotolaria (sunhemp), Cassia (senna) species, and Ageratus



*A field of mungbean taken over by weeds.*



*Weed competition in a plot of maize.*

conyzoides (Hulantala or Pumpullu) are alternate hosts for viruses; members of the Convolvulaceae (morning glory) family harbour sweet potato weevil. These pests and diseases can cause crop losses not only where weeds are growing but in surrounding areas.

5. Weeds hinder cultural operations and increase the cost of land preparation and harvesting.
6. The presence of weeds or weed seeds in a crop harvest will reduce the quality and economic value of the crop.

#### CLASSIFICATION OF WEEDS

Weeds can be classified on the basis of their life span, morphological structure, and growth habit.

1. Life span - classifies weeds as annuals, biennials and perennials.
  - a) Annuals - produce flowers, set seed and die (complete a life cycle) in 12 months or less
  - b) Biennials - similar to annuals but complete a life cycle within 2 years
  - c) Perennials - grow from seed or vegetative parts such as roots, rhizomes, tubers, nutlets or stems and may live for 2 years or more.
2. Morphological structure - classifies weeds as grasses, sedges, rushes, ferns and broadleaves.
  - a) Grasses, sedges and rushes have linear leaves with parallel veins. However, sedges may be distinguished from grasses by the following characteristics:
    - triangular, solid stem
    - leaf sheath fused to form a tube around the stem
    - leaves attached on three sides of the stem (grasses have two leaves on opposite sides of the stem)Rushes have stiff, grass-like leaves with small, inconspicuous and chaffy flowers with flower parts in threes.
  - b) Broadleaf weeds - compared with grasses and sedges are easily identified by wider, net-veined leaves.
  - c) Ferns reproduce by spores which occur on undersides of leaflets. Leaves (fronds) arise directly from rootstocks

## PREVENTION METHODS

It is easier and more economical to prevent the introduction and establishment of weeds than to control them once they are established. Weed seeds are introduced through planting materials, organic manure, irrigation water, farm implements, mulching materials, and by man and animals. Weeds which are allowed to seed in fields, fallow, irrigation ditches or roadsides serve as a source of infestation year after year. To gradually reduce the weed population in cultivated fields and ultimately eradicate them requires an uninterrupted, integrated program with careful timing of operations.

The following precautions should be taken to prevent the introduction and establishment of weeds:

1. Plant only clean, weed free seed, if possible.
2. Prevent weeds from going to seed along banks of canals, waterways and irrigation ditches.
3. Prevent weeds from going to seed on fields between cropping seasons or on uncropped lands.
4. Clean implements of plant debris before moving them from one field to another.
5. Keep domestic animals off clean fields.
6. Make sure that clothing is free of weed seeds before entering a field.
7. Compost manure before using it as fertilizer.

## PRINCIPLES OF WEED CONTROL

1. All weeds can be killed by preventing top growth. Weeds survive by using energy from the sun to manufacture food in the leaves. If top growth is prevented entirely, weeds eventually starve. However, some perennials with underground rhizomes, such as Heen etora (Cynodon dactylon), or nutlets like purple nutsedge (Kalanduru) (Cyperus rotundus), can survive for long periods even with repeated killing or removal of top growth.
2. Weeds must be prevented from setting seeds. One plant will produce several hundred to several thousand seeds which will grow and compete with crops planted later. As some weeds can produce seeds even if the plant is destroyed at the blossom stage, plants must be killed or mowed before buds open.

3. Weeds can be spread by separation of nuts and fragmentation of stem pieces, rhizomes and tubers during cultural operations.
4. Continuous use of one method of weed control results in a shift of weed species to more resistant types.

#### CULTURAL CONTROL OF WEEDS

1. Where possible, till the soil lightly to promote weed germination, then destroy emerged weeds with thorough nursery or seed bed preparation, making sure that no living weeds are present at planting.
2. To provide maximum competition to weeds, use healthy, disease free seed and plant in moist soil for rapid emergence and growth. Use varieties having early vigour whenever possible.
3. Use recommended spacing for maximum crop competition against weeds.
4. To conserve fertilizer for use by crops rather than weeds, apply it by placement rather than by broadcasting.
5. Start weeding early in the season while weeds are still small. To kill most weeds they must be cut off well below the soil surface. Cutting at the soil surface permits rapid regrowth and continued competition with the crop. Weeds have the most damaging effect on crops within the first 60 days after crop emergence. Hence, crops should be kept weed free during this first 60-day period.
6. Weed early in the day (on a sunny day) so that cut weeds will wither and die. Weeding under moist soil conditions may not be effective because cut weeds can re-root. Cut weeds should be piled together or removed from the field to prevent re-rooting, or in transplanted rice, the pile can be covered with water to prevent regrowth.
7. Cultivation during the dry season results in desiccation of underground vegetative organs of perennial weeds. Tillage after each emergence will severely weaken these perennials and can result in complete control.
8. Intercropping utilizes crop resources more thoroughly than monocropping, thus increasing crop competition against weeds.
9. Crop rotations require different cultural practices and help to prevent development of a resistant weed flora.

10. Maintenance of a surface mulch will control weeds and conserve moisture. Well-dried crop residues and weeds can be used for mulch.
11. Burning helps to control a heavy infestation of weeds such as Illuk (Imperata cylindrica), as a prelude to later weed control measures.
12. In isolated patches of perennial weeds such as Illuk (I. cylindrica (cogon grass, tharupaipul) and Etorā (Panicum repens) (tharupaipul), it is advisable to dig out plants and remove rhizomes and stem pieces.
13. Large clumps of Ginitana (Panicum maximum) (guinea grass) or Chromolaena odorata (bonoset) can be dug out, allowed to dry and burnt.
14. To reduce weed seed fall during the next season, weeds can be grazed or slashed after the crop is harvested.

#### CHEMICAL WEED CONTROL

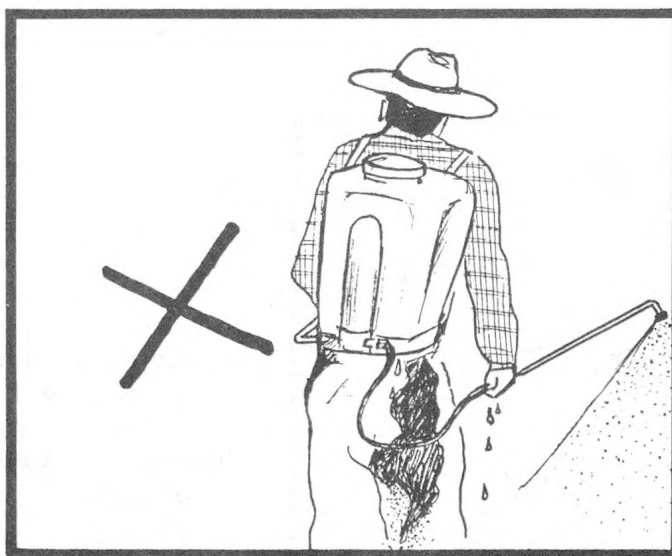
Chemical methods of weed control can be used alone or in conjunction with cultural methods.

#### Use herbicides safely

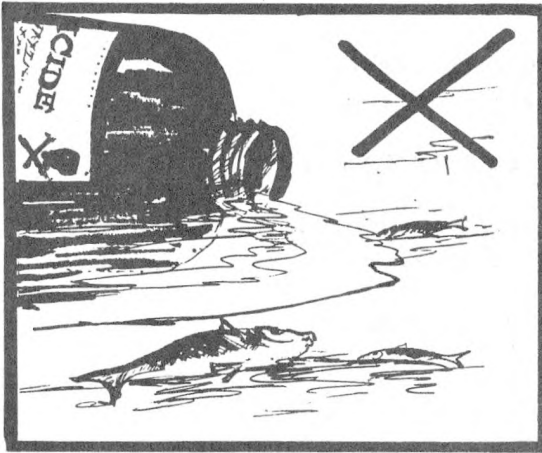
All pesticides are under Sri Lankan Pesticide Registration regulations to protect users and consumers. As with all pesticides, herbicide usage requires precautionary measures. Protection of human life and preservation of a clean environment should always be given highest priority. Herbicides may be poisonous to man and animals, but when properly used they are not harmful. The following guidelines should always be observed when using herbicides:

- Read labels carefully
- Follow instructions
- Store herbicides in closed, plainly labeled containers, out of the reach of children and animals. Lock up pesticides if possible.
- Dispose of empty containers and wastes by burying them in a safe place.
- Do not smoke while handling herbicides.

- Wear protective garments such as masks, boots and raincoats, if possible, while spraying.
- Do not allow herbicides to contact the skin.
- Wash thoroughly immediately after handling herbicides, particularly before eating or smoking.
- Avoid inhaling dusts, sprays or vapors.
- Do not apply in strong winds.
- In light breezes, spray in the direction the wind is blowing.
- To avoid accidental injury to susceptible plants, avoid drift of sprays and dusts.
- If possible, use separate equipment for applying hormone-type herbicides such as 2,4-D. Failing that, equipment should be carefully cleaned using several washings.
- Avoid contaminating water channels, especially when cleaning the sprayer.



Do not use leaky or defective equipment



Do not  
contaminate  
the  
environment

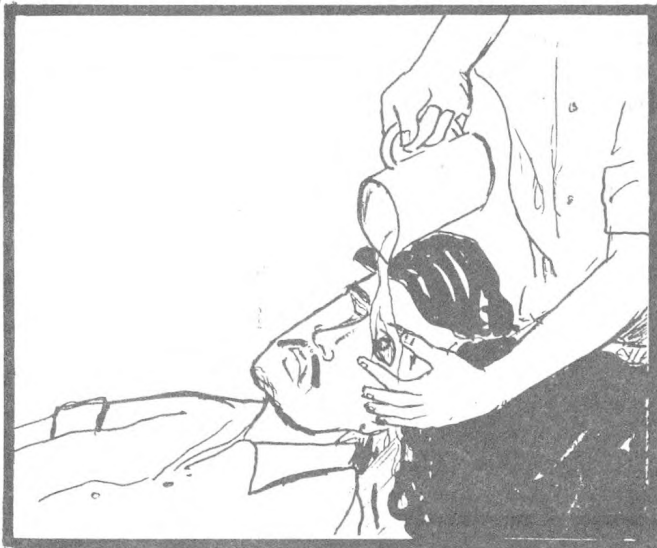
Do not  
spray  
into  
the  
wind



Cover as much of your  
body as possible when  
spraying. Do not allow  
herbicides to touch  
your skin.

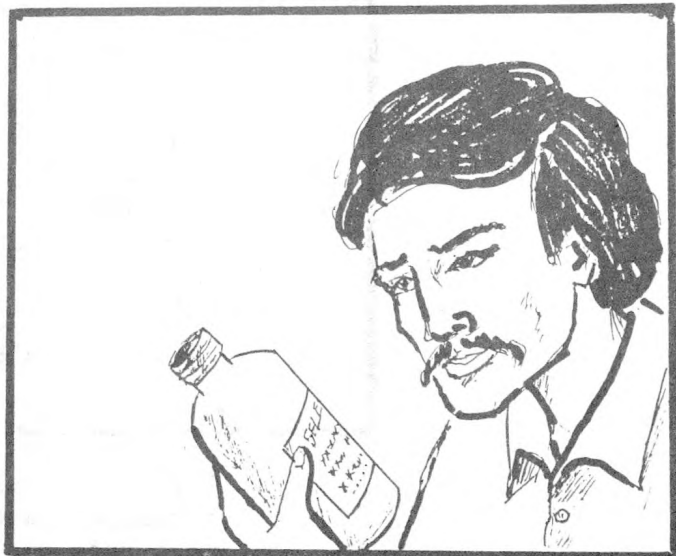


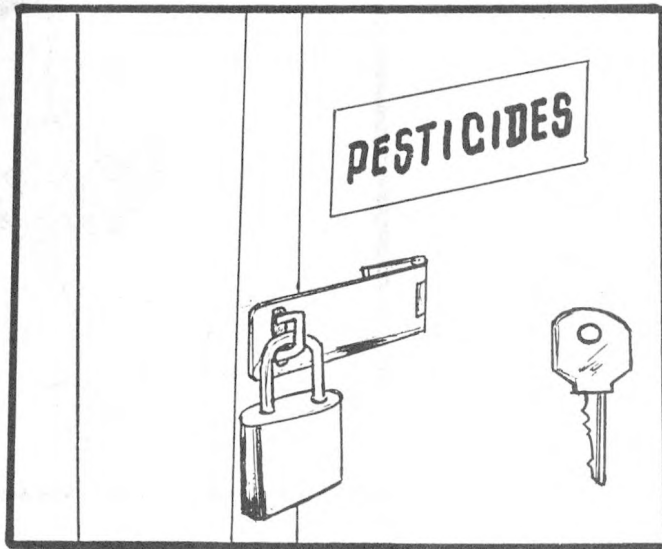
After spraying,  
remove contaminated  
clothing and wash  
your body thoroughly



Wash herbicide splashes  
from your eyes with  
clean water for at least  
10 minutes

Read labels carefully  
Follow instructions





Keep herbicides under lock and key. Isolate herbicides from human and animal food.

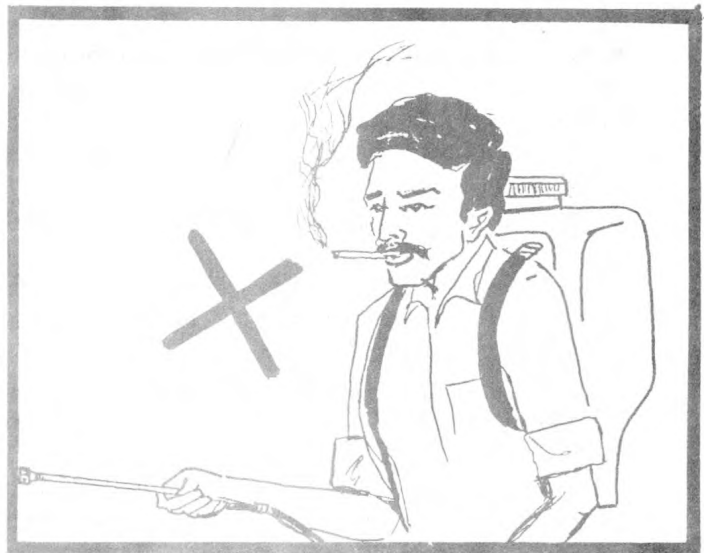


Bury empty herbicide containers and wastes in a safe place

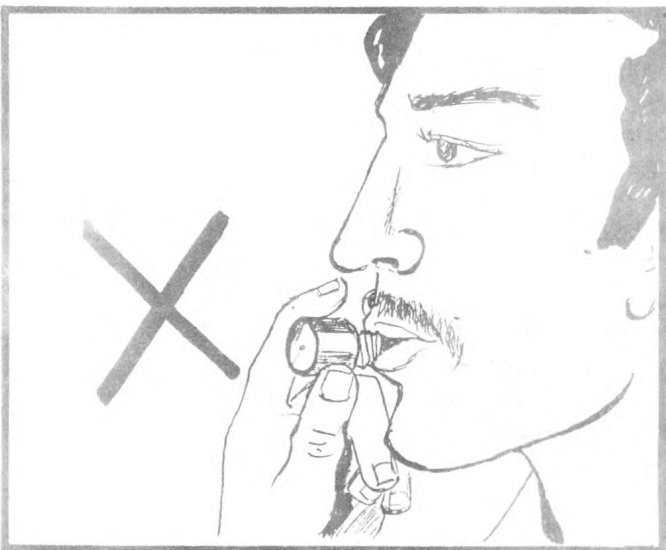


Use only original  
containers for storing  
or moving herbicides  
from place to place.

Do not smoke  
when handling  
herbicides



Do not use your  
mouth to blow out  
clogged nozzles -  
use a soft probe  
instead



## Basis for weed control recommendations

Crop recommendations are based on results of at least two seasons' trials. For wet-seeded rice, recommendations are based on results of co-ordinated trials conducted across the country. For other crops, including dry-seeded and transplanted rice, results were obtained from experiments at two or more research stations.

For convenience, crops are grouped into cereals, legumes and vegetables. Herbicides are also recommended for control of weeds in non-crop situations, either before planting or on fallow.

## Classification of herbicides

Herbicides may be classified by their use (how applied) and their effect on plants. The method of application depends on the formulation. Appendix I lists common formulations, their ingredients and functions. The killing process or "mode of action" usually disrupts some chemical process necessary for plant survival and growth. Their action may be selective, that is, effective on some plants and not on others (e.g. alachlor) or non-selective, with a similar effect on most plants (e.g. paraquat or glyphosate).

### 1. Selective vs non-selective herbicides

Selective herbicides kill susceptible weeds and leave the crop unharmed when applied at recommended rates and application times. Depending upon the mode of action, these herbicides are applied either pre-emergence (before weeds and/or the crop emerge) or post-emergence (after the crop and weeds emerge).

Non-selective herbicides kill both weeds and crops and are therefore used primarily to supplement or substitute for tillage operations during land preparation. They are applied to actively growing weeds in the vegetative stage before or after tillage.

### 2. Pre-emergence vs post-emergence herbicides

Post-emergence herbicides include contact killers or systemics and are applied to emerged foliage (see below).

Pre-emergence soil-applied herbicides (e.g. linuron) are applied before or after planting the crop and kill seedlings as they germinate. To be effective, they must be absorbed by seedling roots or shoots. These herbicides must be dissolved or suspended in the soil solution. The availability of soil-applied herbicides is influenced by soil texture and organic matter level, conditions that should be considered when determining herbicide rates.



*Department of Agriculture coordinated weed control trial in paddy.*



*Herbicide use for weed control in brinjal.*

Soils are a mixture of sand, silt and clay. Clay particles are negatively charged and have a large surface area. Hence, soils high in clay (heavy soils) absorb or tie up herbicides and generally require higher rates of application than coarse textured or light soils.

The absorptive capacity of soil is also increased by the presence of organic matter. Undecomposed plant and animal residues also influence herbicide performance, but well-decayed, fine organic matter particles (humus) are even more absorptive than clay. Consequently, herbicide rates must be increased on soils high in organic matter.

### 3. Soil sterilants

Soil sterilants are applied to bare soils and prevent emergence of all weeds. Methyl bromide and arsenic compounds belong to this group.

### 4. Contact killers

These herbicides are applied to plant foliage, killing susceptible plants upon contact, e.g. paraquat or propanil.

### 5. Systemic herbicides

When applied to plant foliage systemic herbicides are translocated to other parts of the plant, which also may be affected, e.g. 2,4-D, glyphosate.

Characteristics of recommended herbicides are listed in Appendix II.

## Herbicide application and sprayer calibration

Herbicides must be measured carefully and applied evenly to be effective and to avoid crop damage. Knowledge of sprayer delivery is necessary to calculate the amount of herbicide to be mixed with the required volume of water.

Sprayer delivery varies with the size of the nozzle opening, the rate of travel during spraying, and the spray pressure. Hence the sprayer must be calibrated before mixing or spraying begins. To calibrate the sprayer determine the amount of herbicide needed:

- a) Measure a 10 x 10 m area in the field.
- b) Put 10 liters (l) of water in the sprayer tank.
- c) Spray the measured area at a constant pressure, as evenly as possible, walking at a comfortable but steady pace.  
Remember to do the same when spraying your field.



Use proper measuring equipment

- d) Shut off the sprayer and measure the amount of water (l) left in the tank
- e) Calculate sprayer delivery as follows:

Sprayer delivery =  
 $10 \text{ minus the amount of water left in the tank} \times 100$

Example: If 7 l of water are left in the tank, the rate of delivery is:  
 $(10 - 7) \times 100 =$   
 $3 \times 100 = 300 \text{ l/ha}$

- f) To determine the number of tank loads needed to spray 1 ha, divide the sprayer delivery rate by its tank size in liters.

Example: If the sprayer's tank size is 10 liters, then, using the example in e):

$$\text{No. of tank loads/ha} = 300/10 = 30$$

- g) To determine the amount of herbicide (ml or g) needed per tank load of solution:

Multiply the recommended rate by 1000 (1000 ml/l) and divide by the number of tank loads/ha

Example: Butachlor is recommended at 1.6 l/ha in transplanted rice. Using the example in f), the amount of herbicide needed is:

$$1.6 \times 1000/30 \text{ (ml/tank load)} = 1600/30 = 53.3 \text{ ml/tank load}$$

#### Herbicide-sand mixtures

For sand mixture application of oxyfluorfen or butachlor in wet-seeded rice, dilute the herbicides with water as follows:

- a) 5 ml oxyfluorfen/25 ml water
- b) 16 ml butachlor/80 ml water

Mix the solution with fine dry sand, and apply uniformly over the measured area. To treat 100 m<sup>2</sup>, mix 600 gm of dry sand with either of the herbicide solutions.

#### Moisture requirements

For optimum efficacy on crops other than paddy, pre-emergence herbicides should be sprayed on soil with moisture at field capacity or greater. The best time to spray is one day after irrigation or a good rain.

Water should be from 0.5 to 1.0 cm deep when applying spray or sand mixtures of pre-emergence herbicides on transplanted and wet-seeded rice.

For maximum efficiency of post-emergence herbicides, weeds should be thoroughly wetted with the spray. Therefore, paddies should be drained before spraying, and herbicides should be applied during fair weather. Rain washes off the chemical, and reduces the killing effect. This applies also to non-selective herbicides in non-crop situations.

HERBICIDES FOR CEREAL CROPS

Crop	Common name TRADE NAME & FORMULATION	Rate of application	Time of application	Remarks
RICE Dry seeded Wet seeded Transplanted	Propanil SURCOPUR 36% EC REDSTAR WEEDEX 36%EC STAN-F-34 36% EC MORISON'S propanil 36%EC CEYPETCO 3.4 DPA 36% EC MACKHOOD'S 3.4 DPA 36% EC BAUR'S 3.4 DPA 36% EC HARCROSS 3.4 DPA 36% EC LANKEM 3.4 DPA 36% EC	2.5 - 3.5 kg/ha 6.9 - 9.7 l/ha (100 - 140 oz/ac) -do- -do- -do- -do- -do- -do-	2-3 leaf stage of grasses	- Drain the field completely before spraying - There should be no rain for 4 hrs after spraying - Do not apply carbamate or organophosphate pesticides either 7 days before or after spraying - Good for controlling annual grasses and some sedges - If possible, impound water 2-3 days after herbicide application
	Molinate + propanil ARROSOLO 66.2% EC (Molinate 33.1%, propanil 33.1%)	3.3 kg/ha 5.0 l/ha (72 oz/ac)	2-3 leaf stage of grasses	- Same as above but with additional residual activity against annual grasses
	Oxadiazon + propanil RONSTAR PL 31% EC (Oxadiazon 8%, propanil 23%)	1.1 kg/ha 3.7 l/ha (53 oz/ac)	2-3 leaf stage of grasses	- Same as above
	MCPA LANKEM-M50 40% WSC HEDONAL-M40 40% WSC HARCROSS MCPA 40,40% WSC AGROXONE 40% WSC REDSTAR WEEDEM400,40%WSC U-46M FLUID 4, 40% WSC BAUR'S MCPA 40, 40% WSC CEYPETCO MCPA 40% WSC MORICE 40, 40% WSC	0.8 - 1.2 kg/ha 2 - 3 l/ha 2 - 3 l/ha (29 - 43 oz/ac) -do- -do- -do- -do- -do-	3-4 weeks after emergence or transplanting	- Drain the field before spraying - There should be no rain for 8-12 hrs after spraying - Controls broadleaf weeds and sedges - Impound water for 2-3 days after spraying, if possible - Spray 3 weeks after emergence or transplanting

HERBICIDES FOR CEREAL CROPS - CONTINUED

Crop	Common name TRADE NAME & FORMULATION	Rate of application	Time of application	Remarks
RICE Dry seeded Wet seeded Transplanted	MCPA HEDONAL-M60, 60%WSC HARCROSS MCPA-60, 60%WSC REDSTAR WEDEM 600, 60%WSC U-46 M FLUID 6, 60%WSC BAUR'S MCPA 60, 60% WSC MORICE 60, 60% WSC	0.8 - 1.2 kg/ha 1.3 - 1.9 l/ha (19 - 27 oz/ac) -do- -do- -do- -do-	3-4 weeks after emergence or transplanting	- Same as above
RICE Wet seeded Transplanted	MCPA + 2,4-D BI-HEDONAL 70% SL (MCPA 60%, 2,4-D 10%)	0.8 kg/ha 1.2 l/ha (17 oz/ac)	3-4 weeks after emergence or transplanting	- Same as MCPA 40% WSC
	Oxyfluorfen GOAL-2E 24% EC	0.12 kg/ha 0.5 l/ha (7.0 oz/ac)	3-5 days after sowing or transplanting as sand mixture	- Dilute 5 times in water and mix with sand (60 kg/sand/ha) - Broadcast on moist soil or soil flooded with 1-2 cm of water - Field should be levelled - Controls weeds for 4-5 weeks - Good for annual weeds - May be slightly toxic to broadcast rice
	Butachlor MACHETE 60% EC	1.0 kg/ha 1.6 l/ha (23 oz/ac)	3-5 days after sowing or transplanting	- Use sand mixture as described above for broadcast rice - Use either sand mixture or liquid spray for transplanted rice - Field should be levelled - Controls weeds for 3-4 weeks - Controls mainly grasses - May be slightly toxic to broadcast rice
	Mefenacet RANCHO (FOE 1976) 70% WP	0.7 kg/ha 1.0 kg/ha 0.4 kg/ac	5 days after sowing or transplanting	- Drain the field before spraying - Good for controlling annual grasses, particularly, <u>Echinochloa</u> <u>crus galli</u> and some sedges

HERBICIDES FOR CEREAL CROPS - CONTINUED

Crop	Common name TRADE NAME & FORMULATION	Rate of application	Time of application	Remarks
RICE Wet seeded Transplanted	<u>Thiobencarb + propanil</u> <u>SATUNIL 60% EC</u> (Thiobencarb 40%, propanil 20%)	3 kg/ha 5 l/ha (72 oz/ac)	14 days after sowing or transplanting	<ul style="list-style-type: none"> <li>- Drain the field before spraying</li> <li>- There should be no rain for at least 4 hrs after spraying</li> <li>- Do not apply carbamate or organophosphate pesticides either 7 days before or after spraying</li> <li>- Good on annual grasses, sedges and broadleaf weeds</li> </ul>
	<u>2,4-D</u> <u>HEDONAL D 55% WSC</u>	0.77 kg/ha 1.4 l/ha (20 oz/ac)	4-6 weeks after sowing or transplanting	<ul style="list-style-type: none"> <li>- Drain the field before spraying sedges and broadleaf weeds</li> <li>- There should be no rain for 8-12 hrs after spraying</li> </ul>
	<u>Pretilachlor + Flinclorin</u> <u>SOFIT-300; 30% EC</u>	0.48 kg/ha 1.5 l/ha (22 oz/ac)	0-4 days after sowing or transplanting	<ul style="list-style-type: none"> <li>- Apply to wet soil</li> <li>- Controls weeds for 3-4 weeks</li> <li>- Good control of annual weeds</li> </ul>
RICE Transplanted only	<u>Piperophos + 2,4-D</u> <u>RILOF-H 50% EC</u> (Piperophos 33%, 2,4-D 17%)	0.62 kg/ha 1.25 l/ha (18 oz/ac)	5-10 days after transplanting	<ul style="list-style-type: none"> <li>- There should be 2-5 cm standing water at time of application</li> <li>- Controls weeds for 4-5 weeks</li> <li>- Good control of annual weeds</li> </ul>
RICE Dry seeded only	<u>Oxyfluorfen</u> <u>GOAL 2 E 24% EC</u>	0.12 kg/ha 0.5 l/ha (7 oz/ac)	Following first rains after seeding and before emergence of rice and weeds	<ul style="list-style-type: none"> <li>- Controls weeds for 4-5 weeks</li> <li>- Good control of annual weeds</li> <li>- Field should be levelled</li> <li>- Do not use on sandy soils</li> </ul>
	<u>Butachlor</u> <u>MACHETE 60% EC</u>	1.0 kg/ha 1.6 l/ha (23 oz/ac)	Same as above	<ul style="list-style-type: none"> <li>- Controls weeds for 4-5 weeks</li> <li>- Good control of annual weeds</li> <li>- Field should be levelled</li> </ul>

HERBICIDES FOR CEREAL CROPS - CONTINUED

Crop	Common name TRADE NAME & FORMULATION	Rate of application	Time of application	Remarks
MAIZE	Alachlor LASSO 45% EC BAUR'S ALACHLOR 45% EC RED STAR ALACHLOR 45% EC	1.4 - 2.4 kg/ha 3.0 - 5.0 l/ha (43 - 72 oz/ac) -do-	Pre-emergence	- Controls weeds for 3-4 weeks - Good on annual grasses and some broadleaf weeds
	Oxyfluorfen GOAL 24% EC	0.12 - 0.18 kg/ha 0.5 - 0.75 l/ha (7 - 11 oz/ac)	Pre-emergence	- Controls weeds for 3-4 weeks - Use lower rates on sandy soil - Good on annual grasses and broadleaf weeds
SORGHUM	Alachlor LASSO 45% EC BAUR'S ALACHLOR 45% EC REDSTAR ALACHLOR 45% EC	1.4 - 2.4 kg/ha 3.0 - 5.0 l/ha (43 - 72 oz/ac) -do-	Pre-emergence	- Control weeds for 3-4 weeks - Good on annual grasses and broadleaf weeds

HERBICIDES FOR LEGUMINOUS CROPS

Crop	Common name TRADE NAME & FORMULATION	Rate of application	Time of application	Remarks
SOYBEAN BLACKGRAM COWPEA MUNGBEAN	<u>Methabenzthiazuron</u> TRIBUNIL 70% WP	1.5 - 2.5 kg/ha 2.1 - 3.5 kg/ha (0.85-1.41 kg/ac)	Pre-emergence	- Controls weeds for 3-4 weeks - Good on annual grasses and broadleaf weeds - Use lower rates on sandy soils
	<u>Metribuzin</u> SENCOR 70% WP	0.5 - 0.75 kg/ha 0.7 - 1.0 kg/ha (0.28-0.40 kg/ac)	Pre-emergence	- Occasional temporary yellowing of crop leaves - Soybean: use lower rates on sandy soils - Blackgram, cowpea and mungbean: do not use on sandy soils - Controls weeds for 3-4 weeks - Good on annual grasses and broadleaf weeds
	<u>Alachlor</u> LASSO 45% EC BAUR'S ALACHLOR 480 g/l REDSTAR ALACHLOR 430 g/l	1.4 - 2.4 kg/ha 3.0 - 5.0 l/ha (43 - 72 oz/ac) -do-	Pre-emergence	- Crop may show initial leaf burn - Good on annual grasses and some broadleaf weeds - Use lower rate on sandy soils
GROUNDNUT	<u>Oxyfluorfen</u> GOAL 2E 24% EC	0.12 - 0.18 kg/ha 0.5 - 0.75 l/ha (7 - 11 oz/ac)	Pre-emergence	- Crop may show initial leaf burn - Do not apply on sandy soils - Controls weeds for 3-4 weeks - Good on annual grasses and broadleaf weeds
	<u>Alachlor</u> LASSO 45% EC BAUR'S ALACHLOR 45% EC REDSTAR ALACHLOR 45% EC	1.4 - 2.4 kg/ha 3.0 - 5.0 l/ha (43 - 72 oz/ac) -do-	Pre-emergence	- Controls weeds for 3-4 weeks - Good on annual grasses and some broadleaf weeds - Use lower rate on sandy soils

HERBICIDES FOR VEGETABLE CROPS

Crop	Common name TRADE NAME & FORMULATION	Rate of application	Time of application	Remarks
CHILLI Transplanted	Alachlor LASSO 45% EC BAUR'S ALACHLOR 45% EC REDSTAR ALACHLOR 45% EC	1.4 - 2.4 kg/ha 3.0 - 5.0 l/ha (43 - 72 oz/ac) -do-	Pre-emergence to weeds only Apply 1 week after planting on moist soil	- Controls weeds for 3-4 weeks - Good for controlling annual and some broadleaf weeds - Follow up with 1 or 2 hand weedings when weeds emerge - Use lower rate on sandy soil
B. ONION Transplanted	Alachlor LASSO 45% EC BAUR'S ALACHLOR 480 g/l REDSTAR ALACHLOR 430 g/l	1.4 - 2.4 kg/ha 3.0 - 5.0 l/ha (43 - 72 oz/ac) -do-	Pre-emergence (1-2 days after irrigation)	- Controls weeds for 3-4 weeks - Good on annual grasses and broadleaf weeds - Follow-up with 1 or 2 hand weedings when weeds emerge
	Oxyfluorfen GOAL 2E 24% EC	0.12 kg/ha 0.5 l/ha (7 oz/ac)	Pre-plant (1 day before transplanting)	- Same as above
	Methabenzthiazuron TRIBUNIL 70% WP	1.4 - 1.75 kg/ha 2.0 - 2.5 kg/ha (0.8-1.01 kg/ac)	Pre-emergence to weeds only (1-2 days after irrigation)	- Same as above
RED ONION	Alachlor LASSO 45% EC BAUR'S ALACHLOR 480 g/l REDSTAR ALACHLOR 430 g/l	1.4 - 2.4 kg/ha 3.0 - 5.0 l/ha (43 - 72 oz/ac) -do-	Pre-emergence to weeds only Apply 1-2 days after planting	- Controls weeds for 3-4 weeks - Good control of annual grasses and broadleaf weeds - Follow-up with 1-2 hand weedings when weeds emerge

HERBICIDES FOR VEGETABLE CROPS - CONTINUED

Crop	Common name TRADE NAME & FORMULATION	Rate of application	Time of application	Remarks
POTATO	<u>Methabenzthiazuron</u> TRIBUNIL 70% WP	1.5 - 1.75 kg/ha 2.2 - 2.50 kg/ha (0.89-1.01 kg/ac)	0-21 days after planting	- Same as above
	<u>Metribuzin</u> SENCOR 70% WP	0.5 - 0.7 kg/ha 0.7 - 1.0 kg/ha (0.28-0.40 kg/ac)	0-21 days after planting	- Controls weeds for 4-5 weeks - Good on most annual weeds - Do not apply on sandy soils or when potato plants are more than 5 cm tall
CARROT	<u>Metribuzin</u> SENCOR 70% WP	0.35 kg/ha 0.50 kg/ha (0.20 kg/ac)	Pre-emergence	- Controls weeds for 4-5 weeks - Controls most annual weeds

HERBICIDES FOR NON-CROP AREAS

Common name TRADE NAME & FORMULATION	Rate of application	Time of application	Remarks
<p>Paraquat GRAMOXONE 240 g/l HARQUAT 240 g/l BAUR'S PARAQUAT 240 g/l CEYPETCO PARAQUAT 240 g/l LANKEM PARAQUAT 240 g/l</p>	<p>0.4 - 0.6 kg/ha 2.0 - 3.0 l/ha (29 - 43 oz/ac) -do- -do- -do-</p>	<p>Pre-tillage or pre-plant</p>	<ul style="list-style-type: none"> <li>- Controls weeds in non-crop areas</li> <li>- Let weeds dry up after spraying and before starting land preparation</li> <li>- No soil residual effect</li> <li>- Poor control of rhizomatous weeds</li> <li>- There should be no rain for 4-6 hrs after spraying</li> </ul>
<p><u>Glyphosate</u> ROUNDUP 36% WSC HARCROSS COUNTER 36% EC REDSTAR GLYCEL 41% SL BAUR'S GLYPHOSATE 410g/l SPARL 120 g/l</p>	<p>0.72 - 1.44 kg/ha 2.0 - 4.0 l/ha (29 - 58 oz/ac) 2.0 - 4.0 l/ha 1.8 - 3.5 l/ha (26 - 51 oz/ac)</p>	<p>Pre-tillage or pre-plant</p>	<ul style="list-style-type: none"> <li>- Apply when weeds are actively growing and at least 12cm tall</li> <li>- Controls most weeds, including perennial grasses and sedges</li> <li>- Do not disturb sprayed weeds for 10-14 days</li> <li>- No soil residual effect</li> <li>- There should be no rain for 6-8 hrs after spraying</li> </ul>

## APPENDIX I

### COMPONENTS OF HERBICIDE FORMULATIONS

Active ingredients or technical materials must be formulated to be of value to consumers and effective in the field. The formulated product (also referred to as formulation) is made up of several components:

- Active ingredients (a.i.) - that portion of the toxicant formulation responsible for the herbicidal action
- Solvent or coupling agents - used when the solubility of the toxicant is not compatible with the diluent
- Carriers - in liquid formulations, the bulk of volume is made up of solvent(s) or diluent. Inert solid ingredients are used as carriers in dry formulations.
- Surface active agents - surface active agents which enhance wetting, sticking, and emulsifying and as such improve dispersion of the solution
- Special additives - includes stabilizers, wetters, defoamers, thickeners and softeners

A formulation may vary according to the solubility of its active ingredients and the manner in which it is to be applied. A herbicide may be available in two or more formulations.

### MODE OF ACTION

The mode of action of many herbicides is unknown or not well understood. However, the action of herbicides on plants are several:

- a) inhibition of protein synthesis, e.g. alachlor
- b) chemical reactions break down "ring systems", interfering with photosynthesis, e.g. paraquat
- c) hormonal action, causing abnormal growth, e.g. MCPA
- d) inhibition of amino acid biosynthesis and protein production, e.g. glyphosate

- e) inhibition of photosynthesis, e.g. metribuzin
- f) inhibition of the Hill reaction, e.g. diuron
- g) light-dependent membrane damage, electrolyte leakage, cytoplasm vesiculation and breakage of tonoplast and plasmalemma, e.g. oxadiazon

#### COMMON FORMULATION TYPES

1. Aqueous concentrate (AC), water soluble concentrate (WSC), soluble liquid (SL) is a solution of an active ingredient in a solvent miscible with water. Upon mixing with water a stable solution is formed.
2. Emulsifiable concentrate (EC) is a solution of an active ingredient in a solvent not miscible in water. An emulsifier disperses the concentrate in water to form an emulsion.
3. Water soluble powder (WSP), the active ingredient, readily dissolves in water to form a true solution. Surface active agents are sometimes added to improve solubility when the powder is dissolved in water. Anti-caking agents are added to prevent formation of lumps.
4. Water dispersable powder (WDP), also referred to as wettable powder (WP), forms a suspension when mixed with water in the presence of a dispersing agent. Agitation is required while spraying to assist dispersal and to prevent the powder from settling out.
5. Granules (G) are formed when the active ingredient is combined with an inert material. Granular herbicides are ready-to-use formulations which can be distributed evenly without drift.
6. Suspension concentrates (SC), also referred to as flowable (F), are formed when the active ingredient is milled with a solid carrier such as inert clay and mixed with a little water. Dilution with water is necessary for spraying.

## APPENDIX II

### HERBICIDE CHARACTERISTICS

1. 2,4-D (LD<sub>50</sub><sup>1</sup> - 375 mg/kg)

A selective, translocated phenoxy herbicide applied post-emergence, 2,4-D is effective on many weeds which are tolerant to MCPA. It is formulated as sodium, ammonium and amine salts and high and low volatile esters. Amine salts are less hazardous than ester formulations, causing less drift damage to susceptible crops.

2. Alachlor (LD<sub>50</sub> - 1200 mg/kg)

Alachlor is an acetanilide used as a selective pre-emergence herbicide in most crops other than rice. Absorbed primarily by seedling shoots, secondarily by roots and translocated throughout the plant, it controls weeds most effectively when applied on moist soil.

3. Benthiocarb (LD<sub>50</sub> - 1300 mg/kg)

This herbicide is a thiocarbamate used as a selective pre- and early post-emergence herbicide in rice. Absorbed through the leaves, stem and roots of plants, it kills mainly grasses and sedges.

4. Butachlor (LD<sub>50</sub> - 1200 mg/kg)

An acetanilide used as a selective pre-emergence herbicide in rice, butachlor, applied post-emergence, controls seedlings up to the 2-leaf stage. Applications to rice plants less than 12 days old may cause injury.

5. Glyphosate (LD<sub>50</sub> - 4320 mg/kg)

Glyphosate is a broad spectrum, post-emergence, translocated, systemic, isopropylamine salt of glyphosate. When applied to foliage, the herbicide moves throughout the entire plant, including the root system. Visible effects are a gradual wilting and yellowing of the plant, which may not appear for 1-2 weeks.

<sup>1</sup> LD<sub>50</sub> is the single dose that kills 50 percent of a test group of animals when taken orally. It is expressed as mg/kg of body weight of the test animal. Lower values represent higher toxicity.

6. MCPA (LD<sub>50</sub> - 700 mg/kg)

MCPA is a post-emergence, selective, translocated phenoxy herbicide used on rice. It is less toxic to rice than 2,4-D but crop injury can occur during seedling, early tillering and booting stages.

7. Mefanacet (LD<sub>50</sub> - 7500 mg/kg)

Mefanacet is a pre- and early post-emergence, selective acetamide in rice. Absorbed primarily via the root system, best weed control is attained when applied from pre-emergence to the 3-leaf stages of weeds.

8. Methabenzthiazuron (LD<sub>50</sub> - 1000 mg/kg)

This herbicide is a substituted urea used as a selective early post-emergence and pre-emergence herbicide. Soils should be moist at the time of application.

9. Metribuzin (LD<sub>50</sub> - 2200 mg/kg)

Metribuzin is a selective, pre-emergence triazine used in soybean, carrot and some legume crops, and pre- or early post-emergence in potato. Applied pre-emergence, weed control is best if the field is moistened by rain or a light irrigation shortly after treatment.

10. Oxadiazon (LD<sub>50</sub> - 3500 mg/kg)

This chemical is an oxadiazole with pre- and post-emergence activity. Applied pre-emergence, germinating seedlings absorb the chemical, but activity is greatly reduced when applied on dry soil. In post-emergence applications, absorption occurs through shoots and leaves which are killed rapidly in the presence of light.

11. Oxyfluorfen (LD<sub>50</sub> - 5000 mg/kg)

Oxyfluorfen is a selective diphenyl when applied pre-emergence, and a non-selective, contact herbicide when applied post-emergence. Insoluble in water, it is stable on wet or flooded soils. Activity is by contact with emerging seedlings when applied pre-emergence, or with emerged foliage on post-emergence applications.

12. Paraquat (LD<sub>50</sub> - 150 mg/kg)

A post-emergence non-selective herbicide with fast action, paraquat is rapidly absorbed through leaves and translocated to a degree through the xylem. It is rapidly inactivated by soil. Best results are obtained under conditions of low light

intensity and high humidity. The chemical may be fatal if swallowed. Prevent skin or eye contact by wearing rubber gloves and goggles or eye shields when handling. Avoid breathing spray mist, as paraquat can damage the lungs.

13. Piperophos (LD<sub>50</sub> - 3196 mg/kg)

This is a piperidine compound with pre- and early post-emergence activity primarily on annual grasses and sedges in rice. Absorbed by young plant roots, coleoptile and leaves, piperophos may injure young rice seedlings.

14. Propanil (LD<sub>50</sub> - 1384 mg/kg)

A selective contact anilide used post-emergence on rice, propanil has no residual effect. All rice cultivars are tolerant to this compound. Spray should thoroughly wet the weed. The killing action is characterized by chlorosis. Do not apply propanil with phenoxy herbicides.

15. Pretilochlor (LD<sub>250</sub> - 3196 mg/kg)

A chloroacetanilide with pre-emergence activity primarily on annual grasses and sedges, pretilochlor is absorbed through hypocotyls and coleoptiles. Mode of action is probably inhibition of protein and lipid synthesis. Selectivity on rice is accomplished by adding a softener to the formulation.

#### REFERENCES

1. Beste, C.E. 1983. Handbook of the Weed Society of America. Fifth ed. Champaign, Illinois, U.S.A. 515 pp.
2. Duke, S.O. et al. 1989. Weed Science 37 (2): 152-160.

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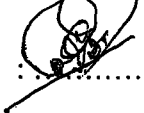
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