HERBICIDE AND PESTICIDE MANAGEMENT MANUAL

ENVIRONMENTAL MANAGEMENT PLAN (EMP) CLEAN
DEVELOPMENT MECHANISM (CDM)

NARIVA SWAMP RESTORATION PROJECT

Government of Trinidad and Tobago

EMA

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TABLE OF CONTENTS

1. INTRODUCTION

2. HERBICIDE AND PESTICIDE MANAGEMENT MANUAL

   2.1 Pesticide Poisoning

   2.1.2 Pesticide Management

   2.1.3 Damage to Health

   2.1.4 Various Recommendations

   2.2 HERBICIDES

       2.2.1 Herbicides Applied to Soil
       2.2.2 Herbicides Applied to Leaves
       2.2.3 Annual Plants
       2.2.4 Perennial Plants
       2.2.5 Advice on Use of Glyphosate and Sulfosphates
       2.2.6 Herbicides and their Interaction with Plants or Absorption and Movement
       2.2.7 Detoxification

3. PRODUCT MANAGEMENT

   3.1 Selectivity and Susceptibility

       3.1.1 Means of Contact

       3.1.2 Precaution Measures

4. STAFF SAFETY EQUIPMENT

   4.1 Treatment of Containers

       4.1.1 Storage

       4.1.2 Procedure in Case of Spills

       4.1.3 Disposal of Containers

   4.2 During Application

       4.2.1 After Application

       4.2.2 Recommendation for Application of Containers
4.3 TOXICOLOGY

4.3.1 Diagram for Phytosanitary Product

4.4 Toxicology Concepts

4.4.1 Eco-toxicological Profile

4.4.2 Phytosanitary Application

4.5 Distribution and Volume of Application

4.5.1 Evaluation of Application Quality

4.5.2 The Drift

4.5.3 Placement of Drops
1. INTRODUCCIÓN

Regardless of the level of toxicity that they may present, phytosanitary products should be used with care, taking certain basic precautions.

Although the choice of the phytosanitary product depends on adversity, performance, and cost, the risk associated with its use should also be important at the time of selection. The risk is associated with toxicity and level of exposure. When evaluating toxicity, the following should be considered:

Hazards associated with the type of formulation: for example, dust can be easily inhaled and dissolvable concentrates can be absorbed by the skin.

Concentration of the formula: concentrates are more toxic than diluted versions of the same product.

What is the toxicological class?

Is it a restricted-use product?

What are the acute effects?

Each product has its respective safety sheets. These contain details about (immediate) acute toxicity upon exposure to the phytosanitary product, as well as information on skin, eye, and respiratory irritation. They also have information on personal safety equipment and health problems related to chronic exposure.
2. PESTICIDE AND HERBICIDE MANAGEMENT MANUAL

2.1 Pesticide poisoning

*Definition*

Pesticides are chemical substances used to control, prevent, or destroy pests that affect crops. Most of these substances are man-made and thus are called synthetic pesticides. The production of these substances emerged around the time of World War II, when industrialized countries began manufacturing commercial pesticides for the purpose of increasing agricultural production.

One of the first and most common pesticides was DDT, used to combat pests in agriculture and mosquitoes that transmit malaria. There are currently large numbers of pesticide brands in the world.

2.1.2 Pesticide Management

For years, the sale of pesticides has been promoted without proper information on their risks to health, to the environment, and to agriculture.

In Costa Rica, for example, for many years serious problems have been reported in humans as well as animals. What is regrettable is that little information has been provided to users on preventing the health problems that may be caused if the products are not handled properly. Although these products emerged as a great solution to combat diseases, currently there are still many diseases that are transmitted by insects, such as dengue, leishmaniasis, known as *papalomoyo*, and other diseases that have not been eradicated despite the efforts of health authorities.

One of the problems is insects’ resistance to this type of substances, and they are often misused.

2.1.3 Damage to health

Many pesticides cause poisoning, often fatal to humans. Because there are different classes, some produce long-term effects and may cause serious illnesses and even cancer. One example of a product that causes major health problems is *Paraquat*, known as *Gramoxone*, a highly toxic pesticide that can cause serious and often fatal poisoning, and a person can become poisoned just by breathing it or through skin contact. Ingestion is fatal. *Paraquat* can cause serious damage to the lungs, kidneys, brain, and liver, and one of the most serious problems is that it can be released and penetrate plants and water, and also contaminate soil.

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There are two types of toxicity: **acute** and **chronic**. Acute toxicity is when the effect is immediate. For example, a person is applying the pesticide for the first time and becomes ill—this is an immediate effect. Chronic toxicity refers to a worker who has been repeatedly exposed to pesticides for some time. He may have significant symptoms or malaise caused by chronic poisoning.

2.1.4 Various Recommendations

Before purchasing a pesticide, everyone should know what type of pest or crop it is meant for. What are the risks of applying this pesticide, what amounts should be applied, what are the established rules for handling it? Persons should also read the information on the product label, including precautions or warnings. If they have doubts about interpreting the information, they should consult with experts in this matter. This will help avoid serious problems due to misuse.

It is also important to pay attention to the symbols sometimes presented on labels. They look rather like a skull, indicating that the product is dangerous.

2.2 Herbicides

Whenever possible, it is better to avoid using herbicides. These are chemical products that contaminate and their application carries some risk to other plants, animals, and people. However, they are effective for very hard-to-kill perennial weeds.

In a practical manner, herbicides may be classified as:

Herbicides that are applied to the soil.

Herbicides that are applied to leaves: may be contact or systemic.

Among the above types, there may be total or selective herbicides.

**A total herbicide** is one that kills all types of plants.

**A selective herbicide** is one that mainly kills a certain type of plant. For example, herbicides for wide-leaf weeds and herbicides for narrow-leaf weeks (grasses). However, a total herbicide may sometimes become a selective one, thus lowering the dose, or a selective herbicide may become a total one, increasing the dose.
2.2.1 Herbicides Applied to Soil

These are not used much in gardening. In fruit production or in olives, they are used to keep the base of the trees free of weeds.

It is applied to the soil and creates a toxic film that, when crossed by germinating weeds, causes them to die. If this type of herbicide falls on existing weeds, nothing happens to them; it is only for weeds that are germinating. Several active materials are: Simacina, Diuron, Fluroxipir.

These herbicides are spread in early autumn (September/October in the Northern Hemisphere) and also in spring, before spontaneous vegetation begins to germinate. They do not evaporate with heat and their effect on the soil lasts weeks or several months, so application can be repeated about a month and a half later.

Remember that these herbicides have no effect on existing weeds, for which there is another type of herbicide. Despite their broad spectrum, they do not work on several weeks, especially perennial ones (e.g., grass, morning glory, etc.). In May, when these tolerant weeds are at their maximum growth, treat them with Glyphosate.

2.2.2 Herbicides Applied to Leaves

These include:

**Contact:** These herbicides reach leaves and green stalks where they fall. They do not reach the roots. Examples, Paraquat (for grasses) or Diquat (for broad-leaf weeds).

**Systemic:** These are applied to leaves and are absorbed, and the sap carries them to the roots so that the entire weed becomes poisoned. Examples: Glyphosate or Sulphonate. These have an effect on perennial weeds.

After seeing the types of herbicides, this is their practical application.
2.2.3 ANNUAL WEEDS

Annuals are born from seeds. They germinate, live a few months, release the seeds, and die. There are winter and summer varieties. For example, poppies (*Papaver* spp.), wild oats (*Avena* spp.), shave grass, hedge mustard, etc. 80% of weeds are annuals.

Eliminate annual weeds preferably with a hoe or with a grass trimmer. If you use herbicides, you may use:

a) Those that burn the weeds when the product falls on them.

b) Those that are applied to soil, to bare earth, and form a toxic film that causes germinating weeds to die when they touch it. Two applications of these herbicides per year (spring and early autumn) may be sufficient to keep the soil free of weeds that grow from seeds (annuals). Perennial weeds that sprout again from rhizomes, stolons, or small bulbs are not affected because they do not grow from seeds.

2.2.4 PERENNIAL WEEDS

Perennial or vigorous weeds are much more problematic than annuals. If we pull them out with our hands or with a hoe, many pieces of underground roots, stolons, rhizomes, and bulbs remain; they are not eliminated and will sprout again. Examples: Bermuda grass (*Cynodon dactylon*), Johnson grass (*Sorghum halepense*), Nutgrass (*Cyperus rotundus*).

In reality, we have not killed the plant, even though the earth looks clean on the outside. It keeps living underground. If we use the grass trimmer, the same thing happens: the underground organs remain alive, causing the plant to sprout again that same year or the next year.

However, even if they sprout again, if we keep eliminating them each time they come up, using a hoe, our hands, or a grass trimmer, they will progressively weaken and almost, almost disappear, but only after we really insist through manual elimination or use of a grass trimmer. In orchards, we see how regular digging discourages them.

Due to the hardness of perennial weeds, herbicides are more useful here.
One of the most used is **GLYPHOSATE**. This is the name of the active material. It is marketed under several brand names, such as Roundup or Tomcato. It eliminates all sorts of weeds: grasses, wide leaf, annual, and perennial. It is applied to leaves and penetrates the plant, reaching the roots. This is its principal quality, making it able to kill perennials.

Thus, these systemic herbicides can be used to kill perennial weeds (although it too is not 100% effective).

Another total and systemic herbicide (penetrating to the roots) is **SULPHONATE**, marketed in Spain as Touchdown. It acts similar to Roundup.

The best product is Sulphonate (brand-name: TouchDown). It kills the same way as Glyphosate, penetrating to the roots, but it is not necessary to wait for the morning glory to bloom, with the advantage of early applications that avoid seeds for the next years.

When the morning glory is in active growth or in bloom, sprinkle the dose from the container, wait three weeks, and if they are dead you can till the soil. In three or four years, there will be almost no morning glory.

If necessary, you can apply it with a paintbrush, in a solution of 50% product and 50% water, and “paint” the morning glory, preferably when they are in bloom. It will penetrate and extend throughout the entire plant, including the roots.

If you do not use herbicides to control this weed, pull it out by hand and use preventive methods, especially mulch and anti-weed screens. Fewer and fewer will come up.

This is one of the most resistant to herbicides, although it can be killed with Glyphosate or Sulphonate which reaches the roots and dries the small bulbs. It multiplies mainly from a few bulbs, and the more it is tilled, the more plants we will have.

The best time to apply the herbicide is when the weed is in bloom, with a sort of spike in the form of a chicken foot with three “toes.” This is usually in July or August.

Do not till for 20 days, and if you see new spikes after treatment, repeat. You have to keep insisting to stop regrowth.

### 2.2.5 Advice on the Use of Glyphosate and Sulphonate

These herbicides are **TOTAL** (not selective), i.e., they do not distinguish between weeds and ornamental plants. Whatever they fall on, they damage it, whether it is a weed or any other garden plant. Therefore, THEY SHOULD NEVER BE DROPPED ON THE LEAVES OF ORNAMENTAL PLANTS because these plants could burn. Pinpoint the weeds only.
A Way to Pinpoint the Product

Cut off the upper part of a plastic milk bottle and put it at the end of the backpack nozzle like a funnel. This way you can apply the product at the base of bushes without the herbicide dripping onto them. There is also a bell-shaped special accessory for backpacks, used for pinpointing. It can be used in a household spray bottle. This way, only the plant in question can be sprayed. You can also carry a can with a small paintbrush and “paint” the plant in question, without having to spread as much product as you would in sprinkling everything.

Apply on a still day (without wind)

Do not apply herbicide if rain is expected the next day or the day after that; it would drag most of the product from the leaves and the product would be wasted if it falls to the ground.

Use the doses recommended on the container

Glyphosate has the problem of being systemic and to work it has it reach the roots. If you apply too much it has a contact effect and it does not reach the roots, which is why the plant blooms again.

![Glyphosate](image)

Clean the container properly after a treatment. If you use a sprayer only for herbicides, that is even better.

You have to keep insisting, giving several applications until you kill various weeds that are very resistant and tough. You will NOT kill them with only one application. For example, Bermuda grass (*Cynodon dactylon*), morning glory, nutsedge.

2.2.5.1 Herbicides and their interaction with plants. Absorption and movement within plants.

Because absorption is the herbicide’s movement from the outside to the inside, it may take place through:

Foliage: in this case the herbicide passes through the different layers of the epidermis by means of the passive diffusion mechanism (without expending
energy). Absorption also takes place through the stalks, but is less due to their relatively smaller surface.

Root system and other underground organs (coleoptiles and hypocotyls): the herbicide passes through the various layers of the rhizodermis, at first by means of passive diffusion (without expending energy), and in a second stage expending cellular energy.

Once inside, herbicides may act where they were absorbed (CONTACT), moving to other plant organs (SYSTEMIC), or both ways.

If they move, the following means may be used:

- Apoplastic system: through the xylem, motorized by the flow of transpiration.
- Symplast system: through the phloem, motorized by the flow of photosynthates.
- Apoplastic-symplastic system: uses both means simultaneously.

The speed of transfer within the plant differs among herbicides and among different plant species. In the latter case, the detoxification mechanisms that plants may have, play a role.

The herbicide’s effect will depend on this speed, because systemics must move to the site of action to produce toxicity in treated plants.

2.2.5.2 Detoxification

The molecular destination of the herbicide inside the plant is related to changes in its structure that reduce the herbicide’s phyto-toxicity (deactivation). However, in some cases these changes produce the opposite phenomenon, i.e., activation, as in the case of 2.4-DB to 2.4-D.

The ability of crops to modify this molecular structure determines their tolerance to it.

3. PRODUCT HANDLING

3.1 Selectivity and Susceptibility

A herbicide’s ability to control a plant species (weed), without affecting another species (crop) is the differential behavior called selectivity.

Selectivity depends on the correct use of the herbicide under environmentally appropriate conditions.

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2 Control de Herbicidas y Malezas, [www.infojardin.com](http://www.infojardin.com)
In addition, it is influenced by:

Factors unique to plant species, such as state of development, morphology, hereditary factors, physiological, biochemical, and biophysical mechanisms.

Herbicide properties: molecular configuration, concentration of active ingredient, formulation, mixtures with other herbicides, characteristics of the treatment itself (positional selectivity, directed applications, use of antidotes, distribution in a certain zone of soil profile).

Environmental characteristics

SUSCEPTIBILITY is the weed’s degree of response to the applied herbicide. It may vary from tolerance to total control. It may be influenced by:

- State of development at time of treatment.
- Concentration of herbicide absorbed by the plant.
- Morphological and physiological characteristics of the plant.
- Herbicide’s own toxicity.
- Environmental factors.

3.1.1 Means of contact. To understand the types of protection against the risks involved in handling and usage, it is necessary to know the means of contact with the organism.

Dermal: through contact with the skin from spills, drips, splashing, and misuse of the product. This is the most common.

Oral: through ingestion.

Inhalation: breathing through the nose and mouth volatile products or those with tiny drips.

3.1.2 Precautionary measures

Personal safety precautions include:

Read the product label.

Use protective clothing: several products must be used with more care than other. Observe the toxicological category, hazard symbols, drawings, or other additional safety information to know whether it is necessary to take greater precautions than usual.

Avoid skin contamination: if a product splashes the skin or eyes, wash them immediately. If clothing is contaminated, remove it and wash it with detergent and soap.
Use proper elements to measure and pour the product. When spraying the
diluted product, always do it in the direction of the wind and avoid contact with
dew.

Avoid touching sprayed leaves and respect the period of re-entry to the treated
crop.

Use proper application equipment, with the corresponding periodic
maintenance.

Do not clean clogged nozzles by blowing on them with the mouth. Do this with
water and proper implements.

Personal hygiene is of vital importance. Do not touch the face or skin with dirty
gloves. Do not eat, drink, or smoke while using phytosanitary products. Wash
the face and hands before eating, drinking, and/or smoking.

### 4. PERSONAL SAFETY EQUIPMENT

In addition to these general precautions, to reduce the risks of contamination
the use of work clothing (which should cover most of the body) and personal
safety equipment (such as gloves, masks, face guards, or glasses) is
recommended.

Personal safety equipment should include:

**Hand protection:** The use of chemical-resistant gloves and long-sleeved shirts
can significantly reduce exposure to pesticides during the operations of
preparing the mixture and applying it. Elements of decision making at the time
of selecting gloves should include: resistance to chemical substances
(disposable or reusable gloves with a useful life of 4 hours), thickness, texture,
comfort, length, and unlined (with leather, fabric, or other material; do not use
talc inside them).

**Eye protection:** Eye exposure is related to the type of formula. There are three
types of equipment: safety glasses (for less toxic products), goggles, and
faceguards (these should be accompanied by one of the other two types).

**Lung protection:** especially recommended for work in closed areas, through the
use of masks with cartridges appropriate for the type of product being used, and
properly maintained.

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3 Agroquímicos Fitosanitarios y Protección Vegetal. Costa Rica, Febrero de 2001
www.mejorcontrol.com.ar
Body protection: In addition to the abovementioned measures regarding clothing, the following should be mentioned: use of boots or safety shoes, hats, (when spraying high crops), chemical-resistant aprons and overalls. Their use decreases the level of exposure to agrochemicals.

ALWAYS READ LABELS AND SAFETY SHEETS—THESE PROVIDE THE CORRESPONDING SAFETY INSTRUCTIONS.

4.1. TREATMENT OF CONTAINERS

4.1.1 Storage

Phytosanitary product warehouses should only be used for this purpose. Phytosanitary products should always be stored under lock and key to avoid access by children and unauthorized persons.

In the case of rural warehouses, products should also be stored under lock and key, far from the reach of children, unauthorized persons, animals, fodder, seeds, and water sources.

Keep products stored in open, ventilated places, tightly closed and on platforms.

In all cases, check the label for individual storage instructions. For the large majority of products, extreme temperatures (under 0° and over 35°) and direct sunlight on the containers must be avoided.
4.1.2 Procedure in case of spills

Do not smoke.

Collect the product by first spreading absorbent material on it (sawdust, peat, chemical product binders) and place in closed containers for subsequent destruction.

Do not eat or drink without washing.

4.1.3. Disposal of containers

Containers and their covering must never be re-used for any purpose.

4.2 During application:

Triple washing of empty containers: fill the empty container with water and shake briskly. The water from this washing will be added to the sprayer tank to be used in the intended phytosanitary task. Repeat this operation at least two more times.

Always use water from pipes or faucets. Never place or submerge containers in irrigation ditches, watercourses, or lagoons for washing.

4.2.1 After application

Make the empty containers unusable by puncturing the bottoms with a sharp object.

4.2.2 Recommendations for the elimination of empty containers

<table>
<thead>
<tr>
<th>Type of container</th>
<th>During application—Triple washing—Making container unusable</th>
<th>After application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Elimination</td>
</tr>
<tr>
<td>Paper and Cardboard</td>
<td>No</td>
<td>Destruction by fire</td>
</tr>
<tr>
<td>Plastic</td>
<td>Yes</td>
<td>Destruction by fire</td>
</tr>
<tr>
<td>Glass</td>
<td>Yes</td>
<td>Mechanical breaking</td>
</tr>
<tr>
<td>Metal</td>
<td>Yes</td>
<td>Mechanical breaking or melting</td>
</tr>
</tbody>
</table>

Locate a site far from populations or workplaces.

Keep other persons, children, or animals away from the site.

Use proper clothing and breathing protection (mask).
Destroy small quantities of containers in burning flames.

Avoid inhaling smoke or vapor due to wind.

Do not perform this task alone. As a precaution, there should be at least two people at the site.

Do not burn aerosol containers because they may explode.

Carefully read product label.

### 4.3 TOXICOLOGY

**Toxicological classification of phytosanitary products**

<table>
<thead>
<tr>
<th>WHO classification according to risks</th>
<th>Hazard classification</th>
<th>Band color</th>
<th>Leyenda</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class Ia</strong> Extremely hazardous product</td>
<td>Very toxic</td>
<td>RED</td>
<td><strong>VERY TOXIC</strong></td>
</tr>
<tr>
<td><strong>Class Ib</strong> Very hazardous product</td>
<td>Toxic</td>
<td>RED</td>
<td><strong>TOXIC</strong></td>
</tr>
<tr>
<td><strong>Class II</strong> Moderately hazardous product</td>
<td>Harmful</td>
<td>YELLOW</td>
<td><strong>HARMFUL</strong></td>
</tr>
<tr>
<td><strong>Class III</strong> Non-hazardous product</td>
<td>Caution</td>
<td>BLUE</td>
<td><strong>CAUTION</strong></td>
</tr>
<tr>
<td><strong>Class IV</strong> Products that normally present no hazard</td>
<td>Caution</td>
<td>GREEN</td>
<td><strong>CAUTION</strong></td>
</tr>
</tbody>
</table>

**DL 50 reference values for liquid and solid formulas in terms of classification**

<table>
<thead>
<tr>
<th>OMS classification according to risks</th>
<th>Acute DL 50 liquid formula</th>
<th>Acute DL 50 solid formula</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oral</td>
<td>Dermal</td>
</tr>
<tr>
<td><strong>Clase Ia</strong> Extremely hazardous product</td>
<td>&lt; 20</td>
<td>&lt; 40</td>
</tr>
<tr>
<td><strong>Clase Ib</strong> Very hazardous product</td>
<td>20 – 200</td>
<td>40 – 400</td>
</tr>
<tr>
<td><strong>Clase II</strong> Moderately hazardous product</td>
<td>200 – 2000</td>
<td>400 – 4000</td>
</tr>
<tr>
<td><strong>Clase III</strong> Non-hazardous product</td>
<td>2000 – 2000</td>
<td>&gt; 4000</td>
</tr>
<tr>
<td><strong>Clase IV</strong> Products that normally present no hazard</td>
<td>&gt; 3000</td>
<td>&gt; 2000</td>
</tr>
</tbody>
</table>
4.3.1 Diagrams for phytosanitary products

The labels of phytosanitary containers have a series of symbols that complement the information on the labels themselves. They were prepared by Global Crop Federation Protection with FAO cooperation.

a. Storage

b. Handling and application

c. Recommendations for safety and hygiene

d. Warnings on environmental risks
4.4 Various information on toxicology terms:

**DL 50:** Average lethal dose, minimum dose of the product from which 50% of the animals studied die due to ingestion.

**CL 50:** Average lethal dose, minimum concentration of the product in the air from which 50% of the animals studied die due to inhalation.

**Toxicology:** Scientific study of poisonings.

**Risk:** Probability that an individual exposed to a substance will suffer harm.

**Hazardousness:** Potential of a substance to produce an adverse effect.

**Exposure:** Contact by an individual with a substance.

These effects may appear quickly, producing the death of a certain organism, or through subtle changes that manifest themselves months or years later, depending on the level of exposure.

### 4.4.1 Eco-toxicological Profile

Reference values for bees, birds, and aquatic organisms

**a. Toxicity in bees**

<table>
<thead>
<tr>
<th>Category</th>
<th>CL 50 Value (ug/bee)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly toxic</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Moderately toxic</td>
<td>1 – 10</td>
</tr>
<tr>
<td>Slightly toxic</td>
<td>10 – 100</td>
</tr>
<tr>
<td>Virtually non-toxic</td>
<td>&gt; 100</td>
</tr>
</tbody>
</table>

**b. Toxicity in birds**

<table>
<thead>
<tr>
<th>Category</th>
<th>CL 50 Value (mg/kg)</th>
<th>DL 50 Value (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely toxic</td>
<td>&lt; 10</td>
<td>&lt; 50</td>
</tr>
<tr>
<td>Toxicity Level</td>
<td>CL 50 Value (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td>Very toxic</td>
<td>10 – 50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>51 – 500</td>
<td></td>
</tr>
<tr>
<td>Moderately toxic</td>
<td>51 – 500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>501 – 1000</td>
<td></td>
</tr>
<tr>
<td>Slightly toxic</td>
<td>501 – 2000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1001 – 5000</td>
<td></td>
</tr>
<tr>
<td>Practically non-toxic</td>
<td>&gt; 2000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 5000</td>
<td></td>
</tr>
</tbody>
</table>

c. Toxicity in aquatic organisms

<table>
<thead>
<tr>
<th>Category</th>
<th>CL 50 Value (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely toxic</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Very toxic</td>
<td>0.1 – 1</td>
</tr>
<tr>
<td>Moderately toxic</td>
<td>1 – 10</td>
</tr>
<tr>
<td>Slightly toxic</td>
<td>10 – 100</td>
</tr>
<tr>
<td>Practically non-toxic</td>
<td>&gt; 100</td>
</tr>
</tbody>
</table>

4.4.2 Application of Phytosanitary Products

Spraying

Spraying produces drops that make contact with plants. According to Himel, only 25% of the amount applied reaches plants.

These drops may be large or small.

Large drops fall rapidly and are less exposed to evaporation and drift. A drawback is that they tend to bounce off or slide down the leaves.

Small drops improve coverage and penetration in the crop. Due to their lower weight and greater relative surface, they are more exposed to drift and evaporation.

The objective of the application is to achieve a drop size that makes it possible to reduce the amounts of spraying and obtain the greatest possible uniformity, avoiding drops that are too small or too large.

The size of drops is expressed in microns (one thousandth of a millimeter). The spraying profile of a nozzle consists of a large number of different-sized drops.

The Average Volumetric Diameter (AVD) expresses the size of drops that divide spraying into two equal volumes that contain larger or smaller drops at that size.
Drop formation

The formation process takes place when liquid at a certain pressure passes through the tablets (part of the nozzle that determines the amount of flow, the size and distribution of the drops).

The type of tablets to be selected depends on several factors:

- Type of product to use
- Product’s mode of action
- Moment of application
- Coverage sought
- Environmental conditions

The types of tablets include:

Empty Cone Type: used to achieve a good penetration in the crop canopy, regardless of the drift that may occur. These are basically meant for the application of insecticides and fungicides, although they can also be used in applications of post-emergent herbicides when the weed is covered by the crop.

Flat Fan: these are the most widely disseminated for herbicide application. They produce a flat spray with 100- to 500-micron drops in the form of an inverted fan.

Full Cone: produces a full spray cone with large-sized drops, and is advisable for the application of herbicides that need to be incorporated.

4.5 Distribution and Volume of Application

The volume of application determines for boom terrestrial equipment the recommended volume of application. It alone does not offer certainty in treatment if the size of the drop, the coverage achieved, and the uniformity of application are not taken into account. If a certain number of impacts (drops/cm²) with a size around 200 microns is achieved, the volume will be less important. The amount of impacts needed for the product to work differs depending on the product’s function, its effect, and the adversity considered. The following values may be generalized:
<table>
<thead>
<tr>
<th>Phytosanitary Product</th>
<th>Nº of drops/cm²</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemic herbicide</td>
<td>20 - 30</td>
<td>30%</td>
</tr>
<tr>
<td>Contact herbicide</td>
<td>30 - 40</td>
<td>30%</td>
</tr>
<tr>
<td>Systemic insecticide/fungicide</td>
<td>20 - 30</td>
<td>70%</td>
</tr>
<tr>
<td>Contact insecticide/fungicide</td>
<td>50 - 70</td>
<td>50%</td>
</tr>
</tbody>
</table>

CV refers to the Variability Coefficient, a measure of the uniformity of placement obtained by adjusting the nozzles in the boom (the more precise applications are, increasingly lower limits will be required).

### 4.5.1 Evaluation of application quality

Application quality refers to the amount of the active ingredient deposited on the target with a determined coverage and persistence of the product, in an absorbable manner, on the leaf surface.

The different methods of controlling application quality include the use of hydro-sensitive cards.

These make it possible to estimate:

- The distribution of the application, making it possible to determine whether the lap is correct, and to check whether the product reached the bottom of the furrow.

- Density of drops per surface unit, making it possible to evaluate the amount of impacts and thus see whether it adjusts to the recommendation for the phytosanitary product in question that is being applied.

- Size of drops: their average size makes it possible to infer what proportion of impacts are deposited on the target and how much is lost due to drift or spillage.

In the case of weed control, the cards should be located at the same level as the weeds to be controlled, and it is important to carry out an adequate number of repetitions to obtain a representative sample.

The evaluation is made by visual observation through the use of special magnifying glasses or comparison with a standard size chart.
<table>
<thead>
<tr>
<th>Diameter of drop (µ)</th>
<th>Drops/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>19099</td>
</tr>
<tr>
<td>20</td>
<td>2387</td>
</tr>
<tr>
<td>50</td>
<td>153</td>
</tr>
<tr>
<td>100</td>
<td>19</td>
</tr>
<tr>
<td>200</td>
<td>2.4</td>
</tr>
<tr>
<td>400</td>
<td>0.3</td>
</tr>
<tr>
<td>1000</td>
<td>0.02</td>
</tr>
</tbody>
</table>

4.5.2 The Drift

This is the part of the spraying that does not reach the treatment target, either because it falls outside the area to be treated (exoderiva) or it falls inside the area but not on the target (endoderiva).

The following affect it:

- Characteristics of spraying: through the size of drops.
- Spraying equipment and techniques.
- Atmospheric conditions: wind, humidity, and ambient temperature. The following may be established as critical limits: temperature no higher than 25º, relative humidity above 60%, and speed no higher than 10 km/h.

4.5.3 Placement of drops

Once the drops reach the leaf surface, they should placed and remain on the leaves. This depends on two aspects: size of drop and characteristics of the leaf contact surface.

As stated, large drops fall faster, bouncing and falling to the ground or sliding on the leaves and mixing with others until finally falling.

Small drops adhere better due to their lower weight, and by remaining suspended for a certain time they penetrate the canopy and impact not only the right side but also the wrong side of leaves, stalks, and other structures.

In terms of leaf surface, the following may be distinguished:

Morphological characteristics of the leaf: presence of waxes that produce runoff and coalescence of drops due to sliding, pilosities that avoid contact with the epidermis.
Effect of the placement of drops on different types of leaf surface: (1) pubescent - (2) waxy - (3) non-waxy (Source: Herbicide Mode of Action, Kansas State University - Cooperative Extension Service)

Because the vehicle of application is usually water, it produces effects of high surface tension, making drops take a spherical form and these tend to roll. Thus, the use of surfactants decreases tension so that the drop takes a flatter position, favoring adherence due to greater contact.

Angle of drop’s contact with the leaf surface in Quinoa (1) and Bermuda Grass (2), with and without the addition of 0.1% surfactant (Source: The leaf surface of major weeds, Sandoz Agro Ltd.)

Presence of dew (washing), water stress (increases the thickness of waxy layers), and dust (inactivation of active ingredient).

In treatments that seek a contact and penetration effect, smaller drops and more of them will be needed than in applications with systemic products.