

European and Mediterranean Plant Protection Organization  
Organisation Européenne et Méditerranéenne pour la Protection des Plantes

## Efficacy evaluation of plant protection products

### Dose expression for plant protection products

#### Specific scope

This standard defines how the dose of plant protection products is expressed and describes the parameters, specific to the site and type of application, which should be recorded so that the dose can be determined in a standard way whatever the crop or product, or the equipment used for treatment.

#### Introduction

The aim of this standard is to provide information on how crop and treatment should be described in the trial report so that dose can be expressed in a standard way for all plant protection products whatever the equipment used for application and the model chosen for registration by the different national authorities. For the simplest cases, a harmonized expression of dose is proposed.

The oldest and easiest expression of dose is concentration of the formulated product in the spray volume. However, a dose expressed in this way may give highly variable deposits of active substance, mainly due to crop structure, to application (spraying) technique and to the volume of water used. This is particularly true for high-growing crops of variable size (e.g. orchards). At the present time, great efforts are being made to obtain optimum efficacy from the applied product and to avoid unnecessary emission of products into the environment and residues in feed and food. To achieve this goal, scientific studies have started on the deposit of products on the targeted crop area, and are leading to the development of various models, which are already in use in some countries (Rüegg *et al.*, 2001). Trials carried out for the biological dossier in these countries also use these models. To allow better exchange of data between countries, to avoid unnecessary repetition of trials and to prevent residue problems between countries, dose expression should be harmonized in trial reports. This can be achieved if the reports contain all relevant information allowing calculation of the applied dose whatever the model chosen by the registration authority. The same consideration applies to residue trials.

#### Units

The units used should always be in the metric system. Generally the amount of commercial product will be given in kg or L, except in some cases, such as product

#### Specific approval and amendment

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used in very small amounts, where g or mL are acceptable. The amount of active substance will be given in g or in mg. Spray volume should be reported.

Concentration of microbial pest control agent (MPCA) in a microbial pest control product (MPCP) is measured in terms of g kg<sup>-1</sup> or g L<sup>-1</sup> of the MPCP and in cfu (colony forming units) or other appropriate potency units. The content of MPCA in Technical Grade MPCP should be provided in the same terms.

The description of the treatment will be given in relation to: a length in m; an area in m<sup>2</sup>, 100 m<sup>2</sup> or ha; a volume in L, 100 L or m<sup>3</sup>; a weight in kg, 100 kg or metric ton; an item (burrow...).

#### Types of treatments

##### *Soil treatments*

The product is applied on or in the soil by watering, injection, spraying or spreading in liquid or solid form. If the product is applied as a bait, the number of baits per kg of formulated product should be given to allow calculation of the number of baits per unit of soil area. The dose for a broadcast treatment should be given in kg or L per unit of soil area. The treatment is sometimes restricted to sowing of seedling rows, plant rows or to individual plants or to a fraction of the inter-rows. In all cases, the inter-row width should be given, as well as the width of the treated area. The dose for a row treatment should be given in kg or L per row m. For band application, the dose may also be expressed in kg or L per unit of treated area, and the band-width should be recorded. The dose for a plant treatment should be given in g or mL per plant number.

##### *Treatment of aerial parts of plants*

###### *Field crops*

These are considered to include agricultural crops, as well as many horticultural crops grown for the fresh market or vegetables grown for industry. In these crops, plant protection products are usually applied

from sprayers fitted with a horizontal boom, though other kinds of equipment are sometimes used (spray gun or air-assisted sprayer). The target is two-dimensional, and height of the crop is not the primary factor that determines the choice of application equipment. The dose is given in kg or L of formulated product per unit of area. For some crops (generally crops with substantially increasing leaf area e.g. tobacco and some horticultural crops), however, dose and application should be adapted to the growth stage and the leaf area of the crop.

#### *Commercial orchards, hops and vineyards*

In orchards, hop gardens and vineyards, the spray is directed at 3-dimensional targets. Many types of high-performance air-assisted sprayers have been developed for this group of crops and many teams are still working in different countries to improve the quality of application, helping the grower to apply a small dose with high efficacy and with low emission to the environment. In this work, different modes of dose expression have been adopted, based on "standard orchard", "leaf-wall area", "tree-row volume" or "tree-area density", and used on the labels of plant protection products. Greater technical knowledge is now expected from growers, who are being trained in the use of the new modes of dose expression. However, research work is continuing and there is still no general agreement on any one mode of dose expression (except to say that % concentration is no longer sufficient). Several methods are available in parallel, and any can be used provided that adequate information is given on the experimental plots, so that the data can be recalculated.

In EPPO Standards PP1 on Efficacy Evaluation of plant protection products, the standard text for such crops is "the dosage applied should normally be expressed in kg (or L) of formulated product per ha and volume of water per ha should also be recorded for sprays. In certain circumstances, the dose may be expressed as a concentration (%) combined with a volume (L ha<sup>-1</sup>) appropriate to specific use." This does not allow the actual height of the crop to be considered. To achieve this, it is possible to express the dose in kg or L per m<sup>3</sup> of Tree Row Volume, or in kg or L per ha of Leaf Wall Area, or in kg or L per ha and per m tree height, or in kg or L per 100 m of plant row. To interconvert between these systems, it is necessary to measure crop structure parameters as follows: cropping system (single or multiple rows), distance between rows and between plants in the row, maximum height of the plants, height and mid-width of the crown, BBCH growth stage. An estimation of leaf canopy density by means of pictographs, such as those adopted by PSD (2002) for apple orchards, could be useful. The actual applied spray volume (and not just the expected volume) should be recorded and given in the trial report, as well as information on the application equipment.

#### *Taller fruit trees*

Treatment of old or isolated tall trees is not easy to model. For this kind of orchard, the dose may still be given in kg or L per 100 L of spray volume. The trees should be measured as for commercial orchards, and the spray volume actually applied should be recorded.

#### *Small-fruit crops*

As for commercial orchards and vineyards, the target of the spray is 3-dimensional and the same dose expression can be used: in kg or L per ha of Leaf Wall Area, in kg or L per m<sup>3</sup> of Tree Row Volume, or in kg or L per ha.

#### *High-growing crops*

For crops like cucumber or tomato, in the field or under protection, spray is also directed at a 3-dimensional target and the dose can be expressed in kg or L per ha of Leaf Wall Area or kg per 100 L (%) of spray solution. At early growth stages, treatments may be directed at the soil and then the dose can be given only in kg or L per ha. Crop structure parameters should be measured.

#### *Treatment of seeds and propagating material*

##### *Seeds*

For seeds sold by specific number per unit, such as sugarbeet, maize and sunflower, dose should be given in g or kg or mL or L per unit. The unit should be specified. For seeds sold by weight, such as wheat, dose should be given in kg or L per 100 kg of seed. For seeds with a small thousand-seed weight that can vary significantly (e.g. leeks and crucifers), it is acceptable to express the dose in g or mL per number of seeds, even if the seeds are sold by weight. As the efficiency of seed treatment can vary greatly according to the equipment used and the characteristics of the seeds, the amount of active substance actually present on the seeds should be verified. This will allow definition of the target dose in relation to the efficacy results.

##### *Tubers, cuttings and bulbs*

For products applied by dusting or spraying, dose should be given in g or kg or mL or L per weight (or per number where relevant) of material to be treated. For products applied by dipping, dose should be given in kg or L per 100 L of water volume and the dipping time should be stated as well as the amount of material dipped in a given volume of mixture.

### *Treatment of harvested products*

Harvested products may be treated by dusting, dipping, watering, fogging, spraying or fumigation. For products applied by dusting, dose should be given in kg t<sup>-1</sup> or kg m<sup>-3</sup> of material to be treated. For products applied by dipping, dose should be given in kg or L per 100 L of water volume and the dipping time should be stated, as well as, the amount of material dipped in a given volume of mixture. For products applied by watering, dose should be given in kg or L per 100 L and the volume of water per weight of plant product should be stated. For products applied by spraying, dose should be given in kg or L per weight of plant product. For products applied by fumigation, see heading '*Treatments by fumigation, smoking and fogging*'.

### *Treatment of special crops*

Some crops such as Christmas trees, or nursery beds of young trees or ornamentals, can vary greatly in size, shape, crop structure and substrate and are generally treated "to run-off". Dose should then be given in kg or L per 100 L of spray volume. The spray volume should be reported.

### *Treatments in forestry*

Herbicides are applied as for other crops, but insecticides and fungicides are applied in forestry uses as aerial, foliar, band or spot treatments. Doses applied for all products can be expressed as kg or L per ha, and the volume of water used should be reported. The rate may be adjusted to account for the variable characteristics in tree habit, such as height.

Dose expression is also dependent on the proposed use. Treatments applied to cut wood (e.g. to control scolytid bark beetles) are expressed as a concentration (e.g. kg hL<sup>-1</sup>), indicating the volume of solution to be applied per m<sup>2</sup> of bark area (i.e. log length x mid circumference for single logs) or in amount of product per cubic metre. For dip treatments of plantlings (e.g. against weevils, *Hylobius abietis*) the amount of product in the dipping solution is expressed as a percentage. Wound paint treatments and repellents are usually applied directly to the plants. Wound paints usually refer to application of product over a specified area, whereas for repellents the dose is expressed as a concentration or in kg or L per plant or in kg or L per m<sup>2</sup> of plant (i.e. tree) surface.

### *Treatments with special application techniques*

#### *Treatment of growing media*

The dose for the treatment of growing media (e.g. soil, compost, cocopeat) should be given in kg or L per unit of volume of substrate (L, 100 L or m<sup>3</sup>). The density of the growing medium should be indicated.

#### *Treatment via nutrient solutions or by irrigation*

For products applied in a recycling nutritive solution (e.g. for forcing of chicory, growing tomatoes), dose should be given in kg or L per 100 L of nutrient solution. The number or weight of plants should be indicated, as appropriate. For a non-recycling nutrient solution, or for irrigation (drop or sprinkler systems), dose should be given in kg or L per number of treated plants or per unit of treated area. The volume of water applied per ha should be recorded.

#### *Treatments applied to plants or plant products moving on a transport chain*

Harvested products such as potatoes, carrots or cereals may be treated in this way. Dose should be given in kg or L per weight or per number of plant or plant product. The flow of the transport chain may be recorded.

#### *Treatment of inert surfaces*

Plant protection products are applied to surfaces such as walls, litters or wood boxes to control pests. Dose should be given in kg or L per unit of area to be treated.

#### *Insecticide or molluscicide baits*

Dose should be given in kg per unit of ground area. The number of baits should be recorded per unit of ground area.

#### *Pheromones*

The number of pheromone dispensers should be recorded per unit of ground area. In stored product protection, the dosage is expressed in number of traps or dispensers per m<sup>3</sup>.

#### *Game and rodent repellents*

Repellents are generally applied to the base of plants to protect them against debarking by game or rodents, or sometimes to the growing points. Dose should be expressed in kg or L per number of plants or per plant surface. For seed treatment, see the relevant section.

#### *Treatments by fumigation, smoking and fogging*

Fumigation is applied to control pests of mushroom beds, glasshouses or store rooms for harvested products. The following application methods may be distinguished: fumigation, i.e. treatment with a gas; smoking, i.e. treatment with airborne particulates or gases generated by thermal combustion (e.g. nicotine); fogging, i.e. very fine airborne aerosols. The dose is given as presented in Table 1.

### Treatments against vertebrates

Cartridges or tablets generating toxic gas can be used to control some burrowing mammals e.g. voles (*Arvicola* spp., *Microtus* spp.) or other field rodents. In this case, the dose is the number of cartridges or tablets per soil area or per m burrow length or per entrance hole or per baiting station. This kind of product can also be used for the treatment of stored seeds, and the dose is then the number of cartridges or tablets per metric ton of treated product.

Against synanthropic rodents (*Mus musculus*, *Rattus norvegicus*, *Rattus rattus*), rodenticides and rodenticidal preparations are used as ready-to-use or prepared baits, or as dusts. Various special systems are

used for the placing and timing of baits and dusts. See EPPO Standards PP 1/97 and PP 1/114.

### References

PSD (2002) *Efficacy Guideline 403 Provision of information on tree canopy size in efficacy and residue trials in apple orchards*. PSD, York (GB).

Rüegg J, Siegfried W, Raisigl U, Viret O, Steffek R, Reisenzein H & Persen U (2001) Registration of plant protection products in EPPO countries: current status and possible approaches to harmonization. *Bulletin OEPP/EPPO Bulletin* **31**, 143-152.

**Table 1** Expression of dose for products applied by fumigation, smoking or fogging

Particulates and aerosols applied to crops	g or mL or cartridges per m <sup>2</sup>
Gases (e.g. nicotine) applied to crops	g or mL or cartridges per m <sup>3</sup> or m <sup>2</sup>
Fogs and smokes applied as space treatments to empty structures	g or mL or cartridges per m <sup>3</sup>
Fogs and smokes applied to commodities	g or mL or cartridges per m <sup>3</sup>
Fumigants applied to commodities	kg or L or tablets or other specified units per m <sup>3</sup> or tonne duration and CTP (concentration-time product) should be specified
Soil fumigants	kg or L per ha depth of incorporation/injection and duration of sheeting should be specified where appropriate