

Efficacy evaluation of plant protection products
Evaluation biologique des produits phytosanitaires

PP 1/135 (4) Phytotoxicity assessment

Specific scope

This Standard provides detailed advice on assessment of the phytotoxicity of plant protection products to crops or plant products including propagating material and is intended for use in association with EPPO Standards of series PP 1 (*Efficacy evaluation of plant protection products*, especially of herbicides and plant growth regulators).

Specific approval and amendment

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1. Definition

Phytotoxicity is the capacity of a compound (such as a plant protection product) to cause temporary or long-lasting damage to plants.

2. Phytotoxicity assessment

The assessment of the phytotoxicity of a plant protection product to a crop plant or plant product is an essential element in its efficacy evaluation (see EPPO Standard PP 1/214 *Principles of acceptable efficacy*). The basic principles for assessing phytotoxicity are the same whether the compound tested is a herbicide, fungicide, insecticide or any other type of plant protection product. The difference lies not in the method of assessment, but in the experimental design. The EPPO Standards in set PP 1 on the efficacy evaluation of herbicides, include both efficacy and selectivity trials because of the greater risk to the crop from compounds which are designed to have activity on plants. The selectivity trials are primarily designed to assess possible phytotoxicity to the crop in the absence of weeds, and include the dose specified for the intended use and a greater dose (usually the double dose to allow for spray overlaps in practical conditions). Effects on yield as well as symptoms are generally assessed in this case. The corresponding EPPO Standards on fungicides, insecticides and plant growth regulators, on the other hand, include only a relatively simple Section (3.3) on phytotoxicity assessment, because, for these types of plant protection products,

phytotoxic effects will be less frequent. However, if any such effects are seen, they should be accurately assessed and recorded and, in addition, specific crop safety trials should be set up which are similar to those performed routinely for herbicides (selectivity trials).

Specific crop safety trials may also be routinely performed for fungicides and insecticides intended for direct treatment of soil or seeds, as it is generally difficult to distinguish between effects due to phytotoxicity and those caused by soil- or seed-borne pests, or other external factors which may mask any inherent adverse effects on germination/crop establishment.

Specific crop safety trials may also be performed for fungicides, insecticides and acaricides intended for use under protected conditions (see Section 7) if risk of phytotoxicity is suspected or if symptoms of phytotoxicity appear in the effectiveness trials.

The methods used for scoring phytotoxicity will also be applicable if plant protection products have 'positive' effects on a crop in selectivity trials. Choice of cultivar is important with respect to phytotoxicity assessment. It may be useful to set up special trials to compare phytotoxicity to several cultivars (for more details see Section 8 - Varietal sensitivity trials).

3. Symptoms of phytotoxicity

Phytotoxicity effects may be observed on the crop at emergence or during its growth or may be expressed at harvest. They may be temporary or lasting. The symptoms may

affect the whole plant or any part of the plant (roots, shoots, leaves, flowers or fruits) and should be accurately described (it may be useful to provide photographs or figures). In practice, in trials for efficacy evaluation of plant protection products, it is unlikely that the most striking symptoms described here will be observed very frequently, for products causing such phytotoxicity would be unlikely to reach the stage of field testing. Accordingly, the symptoms of phytotoxicity will often be inconspicuous, and the experimenter will be looking for only a slight expression of the symptoms outlined below.

3.1 Modifications in the development cycle

Under this heading any inhibition or delay in emergence or growth, and all phenological modifications, particularly delays in flowering, fruiting and ripening, etc., or non-appearance of certain organs (leaves, flowers, fruits, etc.) can be considered.

3.2 Thinning

Loss of whole plants, by failure to emerge or to grow after transplanting, or by disappearance of plants after emergence.

3.3 Modifications in colour (plant tissue not destroyed)

The whole plant or parts of it may be discoloured: chlorosis, whitening, change in intensity of colour (lighter or darker), browning, reddening. The discolouration may be localized (internal or external spots).

3.4 Necrosis

Necrosis is the local death of tissues or organs, generally appearing first as a discolouration. Necrotic spots on leaves may eventually disappear, leaving perforations.

3.5 Deformations

This term covers any morphological modification of the plant or part of it (including roots) making it deviate from the normal range of morphology observed. This includes curling, rolling, stunting or elongation, change in size or volume (the latter sometimes being rated in terms of vigour). Effects such as wilting may also be considered under this heading.

3.6 Effects on quantity and quality of the yield

Phytotoxic effects may be apparent on examination of the harvested produce, or by a quantitative or qualitative analysis of the yield: quantitative effects on yield and its components (e.g. thousand-grain weight); effects on the technical quality of the harvested material; effects on the grading of

the produce; effects on the viability and development of propagating material; effects on taste (taint, etc., further guidance is available in EPPO Standard PP 1/242 *Taint tests with plant protection products* and PP1/243 *Effects of plant protection products on transformation processes*).

4. Assessment of phytotoxicity

4.1 General classification

Certain criteria of phytotoxicity are absolute, e.g. frequencies (numbers of plants at a certain stage, or showing a visual symptom) or measurements (height, length, diameter, weight of sample plants or organs).

Other criteria of phytotoxicity result from visual estimates of the intensity, for example, of deformation or discolouration. In this case, the effect is often scored by reference to a scale preferably 0 to 100%.

Finally, the above effects may in practice also be assessed by visual comparison of a treated plot with an untreated or reference plot to give a percentage figure (e.g. for crop volume, cover, height, etc.).

4.2 Methods used to assess individual symptoms

Delay of emergence: in days or in relative percentage of emergence or crop growth in the untreated or reference plot.

Thinning: in number of plants per plot or per unit area or per unit length of row, after emergence is complete (by counting or estimation).

Delay or acceleration in reaching growth stages: in days to reach a certain growth stage (50% of plants), or percentage plants reaching a certain BBCH growth stage on a given day.

Inhibitions or stimulations: in numbers of individual organs, in height, shoot length, diameter, etc. (absolute or relative).

Modifications in colour, necrosis, deformation: number of plants (or parts of plants) affected per plot (or per unit area, etc.) or use of scale (e.g. none, slight, medium, strong), or in percentage surface area affected, or relative to an untreated plot.

Yield: the criteria for assessing quantity and quality of yield are generally crop-specific and can be found in specific EPPO Standards in set PP 1 (*Efficacy evaluation of plant protection products*) or in Section 9 below for propagating material or in Section 10 – Notes for individual crops.

5. Conditions for crop safety trials

5.1 Trials under field conditions

Cultural conditions (e.g. soil type, fertilization, tillage) should be uniform for all plots/rows of the trial and should conform to local agricultural/horticultural practice. The pre-

ceding crop and any plant protection product used on or after it should be recorded. Fields treated with plant protection products known to have phytotoxic effects on the intended test crop should be avoided. If other plant protection products (or any biocontrol agents) have to be used, they should be applied uniformly to all plots/rows, separately from the test product. Possible interference with these should be avoided. Trials should be as free as possible from the target pest to avoid any impact of pest presence in the crop.

5.2 Trials under protected conditions

Cultural conditions (e.g. soil type, sterilized growing medium, pot size, fertilization) should be uniform for all plots of the trial and should conform to local practice. Separate glasshouses or separate glasshouse compartments (with similar conditions) should be used for each treatment if products are applied by techniques likely to cause drift (e.g. products to be used as aerosols or fogs) or for products with significant plant to plant vapour activity. Fields treated with plant protection products known to have phytotoxic effects on the intended test crop should be avoided. If other plant protection products (or any biocontrol agents) have to be used, they should be applied uniformly to all plots/rows, separately from the test product. Possible interference with these should be avoided. Trials should be as free as possible from the target pest to avoid any impact of pest presence in the crop.

5.3 Test product, untreated and reference product

The product(s) under investigation should be the named formulated product(s) and should be applied as specified for the intended use. The trial should include an untreated plot and, if possible, a reference product. The reference product should be a product known to be satisfactory in practice

under the conditions of the area of intended use (plant health, agricultural, horticultural, forestry, environmental, as appropriate). In general, mode of action, time of application and method of application should be as close as possible to those of the test product.

Where adverse effects, however transitory, are seen in trials at N dose, the margin of selectivity on the target crop should be established using a higher dose. More details can be found in EPPO Standard PP 1/226 *Number of efficacy trials* and PP 1/225 *Minimum effective dose*.

5.4 Assessments

For herbicide and PGR trials, timing of phytotoxicity assessment should be as given in specific EPPO Standards of the series PP 1. For all other plant protection products assessments should be made at appropriate intervals according to the activity of the product. The symptoms which should be assessed are listed in point 10, but reference should also be made to the relevant specific Standard in EPPO series PP 1.

Results should be reported as detailed in EPPO Standard PP 1/181 *Conduct and reporting of efficacy evaluation trials, including good experimental practice* and, where appropriate, use of statistics should conform to EPPO Standard PP 1/152 *Design and analysis of efficacy evaluation trials*.

5.4.1 Herbicides

Observations from direct efficacy (effectiveness) trials provide useful supporting information but are no substitute for specific crop safety trials. Specific crop safety trials in the absence of weeds, with a commercial reference product, are required. Herbicides should be tested for phytotoxicity at both the single (N) and double (2N) dose (see Table 1) in the absence of weeds.

Table 1 The circumstances under which specific crop safety/selectivity trials and yield assessment are required

| Trials required | Herbicides | Insecticides, fungicides and others | | Seed treatment | PGRs |
|-----------------------------|------------|---|---|-------------------|---------------------|
| | | Field crops (all treatments except seed treatments) | Protected crops (all treatments except seed treatments) | | |
| Selectivity trials | Yes | No [*] | No [†] | Yes | No [‡] |
| Doses in selectivity trials | N + 2N | N + 2N [*] | N + a higher dose | N + a higher dose | N + 2N [‡] |
| Yield in selectivity trials | Yes | No [§] | No [§] | No | Yes [‡] |

^{*}Observations for phytotoxic effects should be made in the direct efficacy (effectiveness) trials. However, if any adverse phytotoxic effects occur at 1N, then the effects of 2N doses should be investigated and specific crop safety trials should be conducted.

[†]Observations for phytotoxic effects should be made in the direct efficacy (effectiveness) trials. However, if any adverse phytotoxic effects occur at 1N or if the risk of phytotoxicity is expected, then the effects of 2N doses should be investigated and specific crop safety trials should be conducted.

[‡]No specific selectivity trials are needed, N + 2N dose may be included in direct efficacy (effectiveness) trials.

[§]Data needed only for active substances or major uses where no information on effects on yield is available and/or a case for crop safety cannot be made.

Note: If specific PP 1 Standards for herbicides/PGRs exists, the yield data requirement in the specific standard overrules the yield requirements given in this table.

5.4.2 Plant growth regulators

Doses higher than the intended dose (see Table 1) should be tested to determine the margin of crop safety.

5.4.3 Insecticides and fungicides

For insecticides and fungicides (and other products such as acaricides or molluscicides), observations for phytotoxic effects should be made in the direct efficacy (effectiveness) trials. If any adverse phytotoxic effects occur in any of the effectiveness or dedicated crop safety trials at N dose, then the effects of higher doses (see Table 1) should be investigated and specific crop safety trials should be conducted.

However, for seed treatments, specific crop safety trials are required in the absence of pests (see Table 1 and Section 6).

In addition, for active substances or major uses where no information on effects on yield is available and/or where a case for crop safety cannot be made, some assessment of effects on yield (or components of yield) should be made, preferably over 2 years, to demonstrate there are no unacceptable adverse effects. While these assessments should preferably be made via specific crop safety trials in the absence of pests, this is not essential provided that yield can be measured in the effectiveness trials at low pest levels with similarly performing reference products. When sufficient knowledge of safety of the active substance and formulation is gained on several crops, adequate crop safety information for additional crops (including major crops) may be gained from visual observations made in the direct efficacy trials without the need for yield assessment. For example, where crop safety has previously been demonstrated for several crops, and no significant visual damage has been observed in effectiveness trials across a broad range of conditions on new crops, then further evidence of crop safety (including yield assessments) would usually not be required.

6. Special phytotoxicity trials for seed treatments

Although normal field trials for efficacy evaluation of plant protection products will provide information on the phytotoxicity of products applied as seed treatments, specially established trials (under protected conditions or in the field) can provide more accurate information on the most particular risk of phytotoxicity due to such products, i.e. reduced emergence. The recommendations below were designed for cereals, but can easily be adapted for other crops if needed.

6.1 Preparation of seeds

The seeds should be certified and of known viability (germination rate). It may be also useful to test the levels of seed infection by pathogens that may affect crop establishment. Batches of seeds will be allotted to treatments as follows:

- (1) test product, at the normal dose and preferably also at least at 1 higher dose, for example 1.5 N. Where adverse effects, however transitory, are seen in trials at N dose, the margin of selectivity on the target crop should be established using a higher dose.
- (2) when available, a reference product known to have little or no effect on emergence of the species concerned (at the normal and preferably also at least at 1 higher dose, for example 1.5 N);
- (3) untreated control.

If several active substances are combined in the seed treatment (fungicide, insecticide, bird repellent), the compounds not under test should be included with all treatments.

6.2 Seed treatments

Non-pelleted seeds are treated in a conventional apparatus of which the interior surface is usually coated with the test or reference product before use to ensure a state of equilibrium. Pelleted seeds are provided by the supplier, who should also provide untreated pelleted seeds for the control.

Timing between seed treatment and phytotoxicity trials

Phytotoxicity can occur after long term storage (several months). Germination should be tested soon after treatment, but also after appropriate intervals of storage depending on the likely storage period of seed (e.g. 12 months for cereals). Usually at least 3 common cultivars of each crop should be tested in germination studies. The interval between seed treatment and planting should be recorded.

6.3 Trials under protected conditions

Such trials are particularly suitable for testing a series of doses of plant protection products. The seeds should be planted in a sterilized non-absorbent substrate (e.g. quartz sand).

Lay-out: for each treatment, at least 4 trays, preferably 6 (e.g. 30 × 30 × 8 cm), each planted with 100 seeds.

The trays are held in an unheated glasshouse until assessment. Temperature should be recorded.

1st assessment: when emergence is about 50% in the control, note any advance or delay in germination in the other treatments.

2nd assessment: at full emergence in the control, count emerged seedlings in all treatments. It may also be useful to quantify any relevant changes in seedlings compared to the control.

6.4 Special field trials

Depending on the results of trials under protected conditions, it may be useful to assess seedling phytotoxicity in special field trials.

The land used should be kept practically free from weeds, and, if possible, receive no herbicide treatment. Precautions should be taken to avoid any risk of losses from slugs, white grubs (chafer larvae), wireworms, birds, etc. Any treatment should be applied equally to each plot.

Lay-out: for each treatment, a known number or weight of seeds are sown in at least 4 replicate plots. The treatments are laid out in a randomized complete-block design.

Assessment: at full emergence in the control, emerged seedlings should be counted in all treatments. An earlier assessment may be useful to note any advance or delay in emergence. Observations may be continued on the plants through to harvest. It may be useful to assess yield.

7. Special phytotoxicity trials for protected crops¹

In protected crops, plant protection products can be applied throughout the year, including periods when the crop is most sensitive to these treatments, and can give (unacceptable) phytotoxic effects. If the risk of phytotoxicity is expected, or if symptoms of phytotoxicity appear in effectiveness trials, separate phytotoxicity trials may be conducted to establish the margin of selectivity. Such phytotoxicity trials should be conducted in the absence of pests or disease, in the most sensitive period within the intended use (e.g. young crop, low light conditions) and should include the dose specified for the intended use and a higher dose. Depending on the crop and target pest(s), when phytotoxicity is observed, an assessment of yield may be required.

8. Varietal sensitivity trials

Normal field trials for efficacy evaluation of plant protection products will provide information on the phytotoxicity of plant protection products applied on 1 variety at a time. In order to obtain a better knowledge of the selectivity of a plant protection product, varietal sensitivity trials may be carried out. Where the margin of safety is low, varietal sensitivity trials should be conducted. These trials can be set up at an early stage of development of the plant protection product by conducting preliminary variety sensitivity tests or later, when phytotoxicity is suspected (or assessed). They can also be set up as a baseline of sensitivity to the plant protection product to monitor sensitivity of new varieties for a product already marketed.

Such trials should be set up with a number of cultivars (including common varieties and those known to be sensitive), with a limited number of replicates, in at least 2 locations with distinct environmental conditions (except for

crops under permanent protected conditions). Varieties should be chosen to be representative for the geographic region where a product is intended to be used. Care should be taken to grow all the cultivars/varieties under good agricultural practice. Trials should be as free as possible from the target pest(s) to avoid any impact of pest(s) presence in the crop.

8.1 Design and lay-out of trials

Field trials should be carried out with a plot size of the same order as for typical replicated trials, or smaller if the crop is homogeneous and the treatments are applied carefully to avoid cross-contamination. Cultivars should be planted in parallel lines, with a sufficient number of rows per plot to avoid edge effects. The trial site should be on land that is homogenous and as free from the relevant pests (e.g. weeds for herbicides) as possible. Test treatments should be applied perpendicularly to the cultivar rows. The size of individual plots should relate to the availability of crop material and the method of application of the plant protection product (for example in the field: width of the sowing machine or distance between the rows of crops, width of the spray boom).

Trials can also be set up under protected conditions using, for example, 1 single pot per variety as the experimental unit (=1 plot).

8.2 Yield assessment of varietal sensitivity trials

If 1 or more cultivars show phytotoxicity, further trials may be set up in an appropriate design to assess the yield loss due to the plant protection product on the sensitive cultivar (s) by comparison with tolerant cultivars and untreated controls.

Such trials can be done either for varieties claimed on the product label only or on a larger range of varieties. These test results may lend support to either positive and/or negative lists of varieties.

9. Propagating material

Propagation material taken from selectivity trials (of both normal and higher dose) should be assessed for any phytotoxic effects by comparison with the reference product and untreated control. In Table 2, the circumstances under which data on plant parts for propagation are required are outlined.

Effects on the viability, germination capacity and development of seeds should be assured by standard seed testing methods (ISTA). According to the results of these trials, it may be useful to do further trials under protected conditions or in the field, following the methods of Section 6 above. Effects on vegetative propagating material are assessed following the methods given in some of the specific crop Standards.

¹Definition of a protected crop: glasshouses/greenhouses and cultivations grown under cover (EFSA Workshop: PROTEA Emissions from Protected Crop Systems).

Table 2 The circumstances under which data on plant parts for propagation are required

| Parent plant part | Data needed | Herbicides | | PGRs Including dessicants | Insecticides, fungicides and others | Nematicides | Post harvest treatments |
|--------------------|---------------------------------------|---|---|---------------------------------|---|-------------|----------------------------|
| | | Pre-emergence of the crop | Post-emergence of the crop | | | | |
| Seed | Germination | No | Required for foliar applied treatments* | Yes | No† | No | Yes |
| Cutting Runners | Rooting/viability | No | No | Yes | No | No | No† |
| | Assessment of viability | No | Yes‡ | Yes | No | No | No† |
| Tubers | Sprouting | No, except highly active/persistent compounds where risk to following crops | For translocated herbicides where residues present in tuber | Yes | No† | Yes | Yes |
| Bulbs and corms | Viability and subsequent growth | No | Yes | Yes | No | Yes | Yes |

*Data needed when application is made at or after inflorescence initiation *e.g.* for cereals when the first node is detectable (BBCH GS 30) or where detectable residues occur in harvested seed.

†Data needed where the plant protection product has systemic activity, is applied close to harvest and some phytotoxic effects are seen on some crops.

‡Data needed only if adverse effects occur on some broad leaved crops (assessments of effects on runners should be made during crop safety/ effectiveness trials). Note that although herbicide may be pre emergence of the weed, the crop from which the runners will be taken will be receiving treatment.

Note: Where data are not indicated as required, the applicant should justify this with a case for the particular product/active substance in question. The case should include reference to residue information as well as biological activity of any metabolites present. This is of particular importance for crops grown specifically as seed crops.

10. Notes for individual crops

This section aims to draw attention to the phytotoxicity effects which most often arise with certain crops. It also lists various specific yield quality parameters that should be assessed.

It does not aim to be comprehensive, as it is not possible to provide information for all crops. Relevant assessment parameters should be chosen on a case by case basis, depending on the product tested, mode of action, application time, etc.

In certain cases, suggestions are made on the methods which may be used to assess individual symptoms (see Section 4.2). These are provided only as useful indications, and other scoring systems may serve just as well, according to local conditions. Scales may be useful and should be recorded.

Growth stages are given as in BBCH Growth Stage Keys (Meier, 2001).

10.1 Small-grain cereals (including rice)

Delay in emergence

Thinning:

- number of seedlings
- number of inflorescences (ears or panicles)

Delay:

- in reaching various growth stages

- in emergence of inflorescences (GS 58/59)
- in ripening of grain (GS 89)

Inhibition:

- reduction in number of tillers

Discolouration of leaves:

- paler or darker green
- white leaves

Necrosis of leaves

All kinds of deformations of the leaves, the stems or the inflorescences may be noted:

- curling or other deformations of the leaves
- alteration in habit
- length or deformations of the stem
- deformations of the inflorescences (e.g. double or forked ears, additional spikelets)
- failure of normal booting and inflorescence emergence

Effects on yield:

- total grain yield in kg ha⁻¹ adjusted to a fixed moisture content (specified national or international standard)
- grain weight per hL
- thousand-grain weight
- seed grading

10.2 Maize and sorghum

Delay in emergence

Thinning:

- number of plants (by counting or estimation)

Delay:

- in reaching various growth stages
- in tasselling (GS 59)
- in silking (GS 65)
- in ripening of grain (GS 87)

Inhibition:

- reduction in number of plants tasselling

Discolouration:

- percentage affected plants per category (none, slight, medium, strong)

Necrosis:

- percentage affected plants per category (none, slight, medium, strong)

Deformations (percentage affected plants per category - none, slight, medium, strong):

- root pruning (brace roots)
- stunting
- abnormal plants

Effects on yield:

- total fresh weight of cobs without husks
- total grain yield in kg ha^{-1} adjusted to a fixed moisture content (specified national or international standard)
- fresh and dry weight of forage

10.3 Green forage crops (grasses and/or legumes)**Delay in emergence****Thinning:**

- estimated cover

Delay in growth (to a stated growth stage)**Discolouration or necrosis:**

- these assessments will generally concern the crop cover as a whole

Effects on yield:

- fresh weight of yield in kg ha^{-1} , taken from the centre of the plots
- dry-matter content in samples from each plot
- content of weed and crop species
- protein content
- quality indices (*in vitro* digestibility, metabolizable energy, etc.)

10.4 Potato**Delay in emergence****Thinning:**

- number of plants, number of stems per plant

Delay:

- in reaching full canopy
- in flowering
- in tuber initiation
- in ripening of tubers
- in haulm drying (or acceleration)

Discolouration of leaf:

- chlorosis
- yellow veins

- yellow spots
- general dark or light green colour
- whitening

Necrosis:

- of leaf or whole plant

Deformation of leaf:

- curling
- malformation
- swollen veins
- dwarfed growth of leaves
- aerial tubers

Effects on yield:

- potato yield in kg ha^{-1}
- weight of each size class after grading (according to national standards); malformed tubers should be noted
- starch content (for potatoes for industrial use)

10.5 Brassica oil crops**Delay in emergence****Reduced germination vigour****Thinning:**

- number of plants

Delay:

- in reaching various growth stages
- in flowering
- in ripening (or irregular)

Acceleration:

- of petal fall
- of ripening

Reduction:

- in mean stem height
- in number of buds formed
- in number of inflorescences
- in number of fruits set

Increase:

- in number of twisted stems
- in number of burst pods
- in number of stems lodging

Discolouration of cotyledons and leaves. Chlorosis or lighter colour:

- of the whole leaf
- of spots
- of the veins
- of areas between veins

Discolouration (chlorosis) of pods**Necrosis of cotyledons and leaves:**

- marginal
- apical
- scattered points
- between veins

Necrosis of:

- root collar
- petals
- Pods

Deformations of cotyledons and leaves:

- curling
- twisting
- failure to unroll
- others

Effects on yield:

- seed yield in kg ha⁻¹
- oil content, %
- dry-matter content

10.6 Leafy vegetables and root vegetables

Delay in emergence

Thinning:

- number of plants

Delay:

- in growth (to a stated growth stage)
- in maturity

Discolouration of seedlings or of established plants:

- darker green
- yellow veins
- yellow areas between veins
- chlorosis
- white seedlings (lack of chloroplasts)

Necrosis of seedlings:

- hypocotyl
- tips of the leaves
- edges of the leaves
- areas between veins
- total burning of the leaves

Necrosis of established plants:

- roots
- tips of the leaves
- edges of the leaves
- areas between veins
- dying of the 'heart'
- total burning of the leaves

Deformations of seedlings (hypocotyl):

- twisting
- others

Deformations of seedlings (cotyledons):

- crinkling
- twisting
- smaller
- spoonlike
- sticking together
- others

Deformation of established plants (roots):

- constricted roots
- multiple roots
- smaller roots
- others

Deformation of established plants (leaves):

- crinkling
- twisting
- sticking together

trumpet-shaped

others

Effects on yield:

- yield (kg ha⁻¹) ready for market, taken from the net plots
- quality and grading (specified national or international standard)

10.7. Sugar and fodder beet

Yield and sugar content needed for a new active substance.

As for leafy vegetables and root vegetables (see Section 10.6), but for yield, the following may be recorded:

- root yield in t ha⁻¹
- sugar content, % (sugar beet only)
- leaf yield in t ha⁻¹ (fodder beet only)
- Amino-N, Na and K content (sugar beet only)
- dry-matter content (fodder beet only)

10.8 Fruit crops (also applicable, where relevant, to forest trees)

Delay:

- in reaching various growth stages
- in bud burst
- in flowering
- in change in colour of fruit
- in fruit ripening

Acceleration:

- of flower fall
- of fruit fall

Reduction:

- in number of flower buds
- in number of leaf buds

Increase:

- in number of fruits falling prematurely
- in number of ripe fruits falling

Discolouration of the whole leaf lamina:

- chlorosis
- whitening
- other abnormal coloration

Local leaf discolouration or abnormal coloration of:

- veins
- areas between veins
- edges of leaves
- tip of leaves

Discolouration of current year's shoots:

- discolouration or abnormal coloration
- number and appearance of lenticels

Necrosis of leaves on current year's shoots:

- edges
- along the veins
- the whole leaf lamina

Deformations of leaves or annual shoots:

- stunting, dwarfing, curling, etc.

deformation of the leaf lamina (wilt, swelling, curling, etc.)
 modification of venation (position and form of veins)
 sticking together of organs (petioles, peduncles, leaf lamina)

Effects on yield:

weight and number of fruit harvested
 fruit appearance (form, coloration)
 russetting (at harvest, russetting should be recorded on a sample of 100 fruits)

10.9 Grapevine

Delay:

in reaching various growth stages
 in bud burst (GS 07)
 in flowering (GS 68)
 in ripening (GS 89)

Reduction:

in number of flowers
 in number of fruits set

Discolouration, necrosis of leaves:

edge of leaf lamina
 veins
 internal part of lamina
 localized in spots

Discolouration, necrosis of young shoots and bunches

Discolouration, necrosis of woody shoots (showing internal discolouration)

Deformations of the whole plant:

dwarfing
 curling
 shortening of internodes
 wilt

Deformations of leaves:

dwarfing
 curling
 swelling
 umbrella-shaping
 deformation by stretching of the veins

Effects on yield (quantitative):

the grapes harvested in the various plots may be weighed but extrapolation of the data is valid only if the vineyard is homogeneous.

10.10 Ornamentals

Delay in emergence

Thinning:

number of plants

Delay:

in reaching various growth stages
 in flower bud development
 in flowering

Reduction:

in number of flowers

Discolouration of seedlings or of established plants including flowers

Necrosis of seedlings or of established plants including flowers

Deformation of established plants (whole plant, leaves and flowers):

dwarfing
 crinkling
 curling
 sticking together
 trumpet-shaped
 others

Effects on marketable quality:

number of plants or cut flowers ready for market, taken from the net plots
 quality and grading (specified national or international standard)

Reference

Meier U (2001) *Growth Stages of Mono- and Dicotyledonous Plants. BBCH-Monograph*. Blackwell Wissenschafts-Verlag, Berlin (DE). <http://www.bba.de/veroeff/bbch/bbcheng.pdf>. [accessed on 24 January 2007]