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PP 1/337 (1) Principles of effectiveness evaluation of plant protection products in a plant protection programme

Specific scope: This Standard describes the principles to be followed when evaluating effectiveness of plant protection products applied in a plant protection programme and is intended for use in association with EPPO Standards of the series PP 1 *Efficacy evaluation of plant protection products*. Situations where plant protection products are used in programme or combination with non-chemical approaches are outside the scope of this Standard.

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1 | INTRODUCTION

In practice, plant protection products (PPPs) are applied as components of plant protection programmes, especially for the control of challenging and 'season-long' target pests, that is, pests that are present continuously and cause damage almost all-year round. Depending on the challenge, a programme may require multiple applications of a particular product, which is approved with only a limited number of applications per season, or the integrated application of a range of products over the growing season which may also include low-risk plant protection products (see PP 1/296 *Principles of efficacy evaluation for low-risk plant protection products*). In these instances, efficacy trials may be required to evaluate the effectiveness of a PPP when it is a component of a programme, in addition to the already generated dataset where the PPP is applied alone. These trials can be useful to assess the practical value of a plant protection product and may help support its authorisation.

This Standard provides examples of trial designs and layouts to be used in randomized small-plot trials and non-randomized large-plot trials for evaluating the effectiveness of PPP in plant protection programmes. The use of a large-plot trial layout is recommended in some EPPO Standards. The examples described in this Standard represent the minimum recommended treatments necessary to answer the trial objectives. Additional treatments can be included in the trial design, if deemed valuable.

Trials for effectiveness evaluation of a PPP in a plant protection programme can generate additional effectiveness data to complement those trials carried out to evaluate the effectiveness of the PPP applied alone. These should be evaluated according to the relevant EPPO Standards (PP 1/226 *Number of efficacy trials*, PP1/152 *Design and analysis of efficacy evaluation trials*, and PP 1/181 *Conduct and reporting of efficacy evaluation trials, including good experimental practice*).

All trials should form part of a series carried out under a representative range of growing conditions in different regions with distinct environmental conditions and preferably in different years or growing seasons. The standard plant protection programme (used as reference) should be known to be satisfactory in practice and recommended for the intended use in the country in which the trial is performed.

As far as experimental conditions, application of treatments and mode of assessment, recording and measurements are concerned, relevant specific EPPO Standards should be followed.

2 | SMALL-PLOT TRIALS FOR EFFECTIVENESS EVALUATION OF PPPs WITHIN PLANT PROTECTION PROGRAMMES

2.1 | Effectiveness of the test product as a component of a plant protection programme

The aim of the trial is to verify whether the effectiveness of a test PPP (henceforth TP) within a plant protection programme is comparable to one or more reference

products (RPs) while maintaining the same or a similar level of effectiveness as a standard plant protection programme. This can be done by:

a) selecting (an) appropriate application window(s) for the TP over the growing season, for example, a phenological stage, such as flowering or harvesting period, periods of high or low risk of infection/infestation, one or more of several pest generations. One or more applications of the TP may be required to cover the entire application window. If the TP is applied for the first time with infection/infestation already present, then in addition to the assessments provided for by specific EPPO guidelines, an additional assessment on crop damage or infection or infestation level should be carried out - at most 36 h before the first application of the TP, as well as after the application(s) of the TP (at most 36 h before the subsequent application of the RP). In case more than one application of the TP is necessary, additional assessments before each single application of the TP may be of value. An example considering 2 applications of the TP within a plant protection programme of 6 applications (application codes ABCDEF) is provided below.

(a) Example of application of the TP during an application window within a plant protection programme

	Application code					
Treatment	**A**	**B**	**C**	**D**	**E**	**F**
a. Standard programme[a]	RP1	RP2	RP3	RP4	RP5	RP6
b. Programme with TP	RP1	RP2	TP	TP	RP5	RP6
c. Partially treated control	RP1	RP2			RP5	RP6
d. Untreated control						
Timing of the recommended assessments[b]		↑ Before appl. in C		↑ Before appl. in E		↑ After appl. in F

[a] RP1, RP2, RP3, RP4, RP5 and RP6 are not necessarily different products.
[b] Additional assessments can be performed if deemed valuable.

b) replacing application(s) of RPs with applications of the TP (i.e. alternating some of the applications with RPs). As in the case above, in addition to the assessments provided for by specific EPPO guidelines, an additional assessment on crop damage or infection or infestation level should be carried out at most 36 h before the first application of the TP, if infection or infestation is already present. Additional assessments before each single application of the TP may be of value. An example considering 2 applications of the TP in alternation with RPs within a plant protection programme of six applications (application codes ABCDEF) is provided in the next example.

(b) Example of applications of TP in alternation with RPs within a plant protection programme

	Application code					
Treatment	**A**	**B**	**C**	**D**	**E**	**F**
a. Standard programme[a]	RP1	RP2	RP3	RP4	RP5	RP6
b. Programme with TP	RP1	TP	RP3	TP	RP5	RP6
c. Partially treated control	RP1		RP3		RP5	RP6
d. Untreated control						
Timing of the recommended assessments[b]	↑ Before appl. in B	↑ Before appl. in C	↑ Before appl. in D	↑ Before appl. in E		↑ After appl. in F

[a] RP1, RP2, RP3, RP4, RP5 and RP6 are not necessarily different products.
[b] Additional assessments can be performed if deemed valuable.

2.2 | Benefit of the test product in a tank mixture within a plant protection programme

The aim of the evaluation is to verify whether the addition of the TP in tank mixture with one or more RPs within a plant protection programme can improve the level of effectiveness of the programme. Including the product in tank mix within a standard plant protection programme with RPs at full dose rates could provide a benefit for the control in different situations, such as pests being present continuously or almost all-year round, which are difficult to control even with a strong conventional plant protection programme, and where repeated applications of RPs and/or tank mixes of RPs with different modes of action are common practice. Including the TP in tank mix within a plant protection programme with RPs at reduced dose rates, could provide a benefit for RPs with multiple target pests and multiple dose recommendations (see also EPPO Standard PP 1/225 *Minimum effective dose*). Reduced dose rates may be recommended for: (i) the control of less significant target organisms. (ii) highly susceptible target organisms, (iii) situations of low incidence, or (iv) use with resistant cultivars.

If the TP is used in a tank mix for the first time with infection/infestation already present in the untreated control, in addition to the assessments provided for by specific EPPO guidelines, at least one additional assessment on crop damage or infection/infestation level should be carried out - at most 36 h before the first application of the TP and RP in tank mix, as well as after the last application of the TP and RP in tank mix (at most 36 h before the subsequent application of the RPs).

Examples for additions of the TP to tank mixtures with RPs, in the case of a plant protection programme consisting of 6 applications (application codes ABCDEF) of different products over the season, are provided as follows:

Example of the application of a TP in tank mixture with reference products (RPs) at full dose rates

	Application code					
Treatment	**A**	**B**	**C**	**D**	**E**	**F**
a. Standard programme[a]	RP1	RP2	RP3	RP4	RP5	RP6
b. TP tank mix programme	RP1	RP2 + TP	RP3 + TP	RP4 + TP	RP5	RP6
c. Partially treated control	RP1				RP5	RP6
d. Untreated control						
Timing of recommended assessments[b]	↑ Before appl. in B			↑ Before appl. in E		↑ After appl. in F

[a] RP1, RP2, RP3, RP4, RP5 and RP6 are not necessarily different products.
[b] Additional assessments shall be performed if deemed valuable.

Example of the application of a TP in tank mixture with reference products (RPs) at reduced dose rates

	Application code					
Treatment	**A**	**B**	**C**	**D**	**E**	**F**
a. Standard programme[a]	RP1	RP2 (full)	RP3 (full)	RP4 (full)	RP5	RP6
b. Standard programme (reduced rate)	RP1	RP2 (reduced)	RP3 (reduced)	RP4 (reduced)	RP5	RP6
b. TP tank mix programme	RP1	RP2 (reduced) + TP	RP3 (reduced) + TP	RP4 (reduced) + TP	RP5	RP6
c. Partially treated control	RP1				RP5	RP6
d. Untreated control						
Timing of recommended assessments[b]	↑ Before appl. in B			↑ Before appl. in E		↑ After appl. in F

[a] RP1, RP2, RP3, RP4, RP5 and RP6 are not necessarily different products.
[b] Additional assessments shall be performed if deemed valuable.

A partially treated control (i.e. the same programme as the 'programme with TP' but without applying the TP) must always be included to demonstrate the benefit of the TP. The inclusion of an untreated control is highly recommended in line with EPPO Standard PP 1/152 *Design and analysis of efficacy evaluation trials*.

3 | LARGE-PLOT TRIALS FOR EFFECTIVENESS EVALUATION OF PLANT PROTECTION PROGRAMMES

Due to the large-plot size, the number of treatments which can be compared may be limited. The large-plot trial layout should include at least the following treatments:

- **Standard plot**: a large plot treated with the same standard programme (one or more RPs) as the TP plot, but without the application(s) of the TP.
- **TP plot**: a large plot treated with a standard plant protection programme (one or more RPs) plus the TP either as a component or in tank mixture (see Sections 2.1 and 2.2) at the rate(s) and frequency, which are considered appropriate for an improvement of the control of the target pest.
- **Untreated control plot**: an untreated control plot can be included, if considered feasible (optional).

The inclusion of a large untreated plot is often not feasible for several reasons, e.g.: (i) the high value of the target crop, (ii) the risk of pest population build-up or inoculum increase in the study area, (iii) the risk of high yield losses, and (iv) low tolerance of growers to damage. If the inclusion of an untreated plot is not feasible, one option to obtain information on pest density and pressure at the chosen site is to select one or several smaller untreated plot(s). Another option allows for the inclusion of an untreated plot (small or large in size) that is left untreated until pest infestation or infection levels reach recognized threshold levels for the application of RPs. These options allow estimates to be made of pest pressure at the chosen site, but do not permit evaluation of effectiveness compared to the untreated control.

Examples are provided below:

Example of the application of a TP in addition to a standard programme consisting of 4 applications (application codes ABCF)

	Application code					
Treatment	**A**	**B**	**C**	**D**	**E**	**F**
a. Standard programme[a]	RP1	RP2	RP3			RP4
b. Programme with TP	RP1	RP2	RP3	TP	TP	RP4
c. Untreated control (if feasible)						
Timing of the recommended assessments[b]			↑ Before appl. in D		↑ Before appl. in F	↑ After appl. in F

[a] RP1, RP2, RP3 and RP4 are not necessarily different products.
[b] Additional assessments shall be performed if deemed valuable.

Example of the application of a TP in tank mixture with RPs within a standard programme consisting of 6 applications (application codes ABCDEF)

	Application code					
Treatment	**A**	**B**	**C**	**D**	**E**	**F**
a. Standard programme[a]	RP1	RP2	RP3	RP4	RP5	RP6
b. Programme with TP	RP1	RP2	RP3+TP	RP4+TP	RP5	RP6
c. Untreated control (if feasible)						
Timing of the recommended assessments[b]		↑ Before appl. in C		↑ Before appl. in E		↑ After appl. in F

[a] RP1, RP2, RP3, RP4, P5 and P6 are not necessarily different products. P3 and P4 may be tested at reduced dose rates or at full dose rate.
[b] Additional assessments shall be performed if deemed valuable.

Randomization is not applicable in the case of a large-plot trial layout. A representative number of experimental units (the area in which observations are made) should be randomly selected within each large plot (=treatment) at each assessment. This facilitates the gathering of information on pest distribution within each large plot, and identification of critical infestation or infection spots.

4 | RESULTS

The results should be reported in a systematic form and should include appropriate statistical analysis and evaluation. Original (raw) data should be available. If statistical analysis is not used, this should be justified. See EPPO Standard PP 1/152 *Design and analysis of efficacy evaluation trials*.