

Efficacy evaluation of plant protection products
Evaluation biologique des produits phytosanitaires

PP 1/291 (1) Evaluation of the influence of tank mix adjuvants on the efficacy of plant protection products

Specific scope

For countries with national requirements for efficacy data to support claims on adjuvants marketed for use with plant protection products this Standard provides advice on how to generate the data. It may also be of use to manufacturers of adjuvants during development of their products and to manufacturers of plant protection products to support label claims. Differentiation is made between voluntary

recommendations and requirements of mandatory mixtures on label claims of plant protection products, as this latter case should be considered as a plant protection product use covered by the relevant EPPO Standards (PP 1).

Specific approval and amendment

First approved in 2016-09

1. Introduction

This Standard provides general guidance on the methods that may be used to evaluate the effectiveness or other pesticidal properties and the phytotoxicity of adjuvants in tank mixtures with a plant protection product. Adjuvants¹ are substances or preparations which consist of co-formulants,² or preparations containing one or more co-formulants, in the form in which they are supplied to the user and placed on the market to be mixed by the user with a plant protection product and which enhance its effectiveness or other pesticidal properties.

Efficacy evaluation should establish that there is an overall benefit from the use of the adjuvant in mixture with a plant protection product over the use of the same plant protection product used alone.

This evaluation should be performed according to the EPPO General Standards and the specific EPPO Standards from the series PP 1 on efficacy evaluation of plant protection products; these provide detailed instructions on trials for individual host–pest combinations.

The wording of this document specifies that one adjuvant is mixed with one plant protection product and with water to

form a tank mixture. However, other more complex mixtures with several formulations and/or adjuvants, or evaluations of mixtures with different plant protection products, can be assessed in a similar way. The term ‘active substance’ refers to the active substance contained in the plant protection product.

2. Initial examination of the properties of the adjuvant

Several situations can be envisaged in terms of combinations of an adjuvant with a plant protection product (mandatory or voluntary mixtures).

Mandatory mixtures:³

- Due to specific physicochemical properties (storage stability, etc.) of the formulation some active substances or plant protection products cannot be formulated with an essential co-formulant. In order to overcome these incompatibilities, applicants could support the use of a ‘twin pack’ or mandatory tank mix of their product in order to reach the level of efficacy needed. In that case, an efficacy dossier of the adjuvant should be part of the dossier to support the registration of the plant protection product in combination with a specific plant protection product at full rate. This dossier should be built up, from the start of its development, in the same way as a conventional registration dossier for a plant protection product.

¹As defined in EC Regulation 1107/2009 Article 2 (3d).

²‘Co-formulants’ are substances or preparations which are used or intended to be used in a plant protection product or adjuvant, but are neither active substances nor safeners or synergists (as defined in EC Regulation 1107/2009 Article 2 (3c)).

³As stated in the scope, mandatory mixtures are not covered by this Standard, however they are described here for clarity.

- For some plant protection products that are already registered against specific targets in specific crops, the addition of the adjuvant to the plant protection product at full rate can enable an extension of use to additional crops (e.g. cabbage with waxy leaves) or to improve efficacy against targets that are particularly difficult to reach (e.g. *Eriosoma lanigerum*, *Brevicoryne*, Coccidae).

Voluntary mixtures:

- Some adjuvants can be used to improve the efficacy of plant protection products; this may enable comparable efficacy at lower rates or durations of control by plant protection products. Such adjuvants are usually recommended as a voluntary tank mixture.
- Some adjuvants are not designed specifically to improve efficacy but are used to prevent spillover by reducing foam at loading, to improve the precision of application by reducing drift or to colour the area already treated.

It is therefore necessary for each adjuvant to have a clearly defined function, stating the plant protection product; the supported crops and target organisms; and the dose and composition of the spray mixture: adjuvant/plant protection product/water. Similar to plant protection products, adjuvants should be sufficiently effective for the proposed claim.

2.1 Determination of the function of the adjuvant

The function of the adjuvant should be clearly defined and substantiated by data (see the Appendix).

Functions may include:

- (1) Modification of the effect of the spray mix on the target:
 - improving retention, for example reducing the rebound of the droplets
 - improving the spread on the target surface
 - preserving/maintaining spray mix properties
 - maintaining the viability of microorganisms for biocontrol
 - improving wash-off resistance of the spray deposit to rain or irrigation
 - improving the speed of penetration or the rate of penetration into the target.
- (2) Modification of the physical properties of the spray mix:
 - improving the quality of the spray mix, for example antifoam agents, colouring agents, adhesive agents for treated seeds
 - improving the quality of application/sprayability, for example by reducing drift.

2.2 Determination of the possible plant protection products to be used with adjuvants

The plant protection products that can be used in a mixture with the adjuvant should be defined at product level or, depending on formulation type, by the chemical family or class of the active substance, lipophilic/hydrophilic properties of the active substance (see the Appendix) or the nature of the co-formulants in the plant protection products.

2.3 Determination of the possible intended crops

The intended crop should be defined as an individual crop or as a group of crops. The rules of extrapolation that are valid for other plant protection products should be applied to mixtures of adjuvants and plant protection products.

Determination of the possible intended crops should be based on the possible phytotoxicity of the mixtures and the presence of the target organisms on these crops.

Susceptible cultivars should be chosen for selectivity trials. The characteristics of the crop and test conditions which would improve its susceptibility should be considered when planning selectivity trials.

Evaluation of adjuvants which improve the efficacy by enhancing the contact of the active substance with the leaf surface should be performed on crops with waxy cuticles (e.g. cabbage, leek).

2.4 Determination of the possible target organisms

Evaluation of adjuvants which improve the efficacy by enhancing the contact of the active substance should be performed with target organisms which are difficult to reach: insects/mites with waxy cuticles, weeds with waxy cuticles, specific stages of the target organisms, etc.

2.5 Determination of the dose

Some adjuvants should be used at a fixed concentration of the spray volume (% or kg hL⁻¹ or L hL⁻¹) while others, like most plant protection products, should be used at a fixed rate (L or kg) per area (ha or leaf wall area). Full details on doses and volumes are given in EPPO Standard PP 1/239 *Dose expression for plant protection products*.

During preliminary studies on the function of the adjuvant care should be taken to define the appropriate dose or ratio by experiments in which the various concentrations/doses of the adjuvant and the plant protection product are included.

Depending on the function(s) of the adjuvant, any effect it has on the effect of the spray mix on the target can be considered in the same way as that of a change of formulation of the plant protection product.

- If modification of the effect on the target is claimed, discussion of the dose should also address the ratio of the adjuvant to the plant protection product.
- When only modification of the physical properties of the spray mix is claimed, the ratio of the adjuvant to the plant protection product is of lesser concern and the rate may mainly be related to the spray volume used or the area to be treated.

2.6 Determination of the uses to be tested in efficacy trials and other requirements

When a modification of the effect on the target of the tank mix to be used is claimed, efficacy trials performed on crops against a specific target are required. When only modification of the

physical properties of the spray mix is claimed, this should be demonstrated according to specific guidelines (if available); these are not covered by the present Standard except for phytotoxicity assessment (see Section 2.1 (1) and (2)).

2.6.1. Mandatory mixtures⁴

When use of the adjuvant is mandatory to reach sufficient effectiveness against specific targets, preliminary and minimum effective dose trials should compare the spray mix to the use of the plant protection product alone according to the methodology described in Section 3 'Efficacy trials'. After that, all the requirements of plant protection product regulation (concerning the efficacy, yield and quality, transformation processes, adverse effects on safety, succeeding crops, adjacent crops, propagating material, resistance, and tank cleaning procedure trials) needed to support the mandatory use of mixtures should be established with the claimed spray mix. In summary, a mandatory mixture should be addressed in a similar way to a 'use' on its own during the registration of a plant protection product.

2.6.2 Voluntary mixtures

When the use of the adjuvant is voluntary, for example a tank mixture for several products or broadening the target spectrum of a specific plant protection product, it is not possible or necessary to test the effectiveness against each individual target. Efficacy trials can be performed on representative combinations of crop/target/plant protection product for herbicides and crop/target combinations for other product types that can be tested to demonstrate the efficacy of the adjuvant/plant protection product mixture in a well-defined area of use. The number of trials should be decided on a case by case basis according to the crop/pest combinations claimed.

2.7 Adverse effects

2.7.1 Phytotoxicity

Specific assessment of the phytotoxicity of tank mixtures containing an adjuvant and a plant protection product should only be required in the case of applications directly onto the crop.

In any case, if efficacy is improved or sustained in the worst case condition, it should also be demonstrated that selectivity to the crop is maintained.

Selectivity testing is essential for adjuvants that improve penetration or stickiness of the spray mix. However, it can also be argued on the basis of the mode of action and physical and chemical studies that in some cases no impact on selectivity would be expected (e.g. colouring agents, anti-foam agents).

A germination test of the treated seeds could be requested in the case of sticking agent for seed coating.

For perennial crops, it may be useful to extend individual selectivity trials over 2 years or more, in order to detect cumulative phytotoxic effects.

More information on phytotoxicity assessment can be found in EPPO Standard PP 1/135 *Phytotoxicity assessment*.

2.7.2 Other effects

Other requirements of EC Regulation (2009) concerning plant protection products, such as yield, quality and effects on adjacent crops, should be addressed for some specific crop/target combinations and extrapolation could be claimed with justification.

Additional data are required for direct applications on plant parts which are consumed or on plants which are directly put on the market.

3. Efficacy trials

This section describes the requirements that have to be fulfilled when a modification of the effect of the spray mix on the target is claimed.

3.1 Experimental conditions

The evaluation should be performed according to the EPPO General Standards and specific EPPO Standards for evaluation of the efficacy of plant protection products (PP 1) which provide more detailed instructions on trials for individual host-pest combinations.

3.2 Applications of treatments

3.2.1 Test product(s)

When reference is made to a specific EPPO Standard, the test product(s) is understood as the mixture(s) of the plant protection product with the tank mix adjuvant(s) under investigation.

The named adjuvant should be applied as specified for the intended use (see EPPO Standard PP 1/181 *Conduct and reporting of efficacy evaluation trials, including good experimental practice*).

It may be useful to apply the adjuvant(s) under investigation alone in a limited number of trials, to assess the lack of intrinsic pesticidal activity or safety issues.

3.2.2 Reference product(s)

The plant protection product tested in a mixture should always be applied alone as a reference treatment. The plant protection product in the test mixture may also be applied in a mixture with another registered adjuvant if available. When the label claim of the adjuvant(s) under investigation includes extension of use (new target) or improvement of efficacy against targets that are specifically difficult to reach, an independent reference plant protection product known to be effective should be included if available.

3.2.3 Mode of application

Application should comply with good standard practice. The type of application, type of equipment and time and frequency of application should be according to the EPPO

⁴As stated in the scope, mandatory mixtures are not covered by this Standard; however, they are described here for clarity.

General Standards and specific EPPO Standards for efficacy evaluation of plant protection products (PP 1) which provide more detailed instructions on trials for individual host–pest combinations.

Dose and volume of the tested and reference treatments

The mixture of the adjuvant and plant protection product should normally be applied at the dosage specified for the intended use. Doses higher or lower than the intended dose may be tested to determine crop safety and the margin of effectiveness (see EPPO Standard PP 1/225 *Minimum effective dose*).

The following treatments should be included in field trials.

	Effectiveness	Selectivity
Untreated	Yes	Yes
Adjuvant alone	Some trials, need not include field trials	Yes some trials, n
Plant protection product alone	N and lower dose (e.g. 0.8N)	N 2 N for herbicides and PGRs
Plant protection product + adjuvant	N and lower dose (e.g. 0.8N) + n	N + n 2 N + 2 n for herbicides and PGRs

N, plant protection product at recommended dose; **n**, adjuvant at recommended dose; PGRs, Plant Growth Regulators.

In case of seed treatment or herbicides used in sensitive crops (e.g. flax) 1.5N + 1.5n can be used instead of 2N + 2n.

It should be specified whether the double dose is applied in two applications of the normal dose or in a single application of the double dose.

Full details on doses and volumes are given in EPPO Standard PP 1/239 *Dose expression for plant protection products*. In summary, 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. It may also be useful to record the dose in g of active substance per ha. In certain circumstances, the dose may be expressed as a concentration (e.g. % or g hL⁻¹), if possible combined with a volume (L ha⁻¹) appropriate to specific use. It may be useful to record information on water quality (e.g. pH, hardness) as some adjuvant functions are related to properties of the spray mix.

Deviations from the intended dosage should be noted.

3.3 Mode of assessment, recording and measurement

This evaluation should be performed according to the EPPO General Standards and specific EPPO Standards for the efficacy evaluation of plant protection products (PP 1) which provide more detailed instructions on trials for individual host–pest combinations.

4 Results

This evaluation should be performed according to the EPPO General Standards and specific EPPO Standards for the

efficacy evaluation of plant protection products (PP 1) which provide more detailed instructions on trials for individual host–pest combinations.

References

CEB Méthode Générale N°MG08 Principes généraux d'expérimentation des adjuvants – General principles for testing adjuvants. (C. Gauvrit, G. Vincent 2006). Ed. AFPP-CEB.
 CEB Documents Techniques N°DT 22 Recommandations concernant l'expérimentation d'un adjuvant en vue de préciser son domaine d'utilisation. (L. Thibault, 2014). Ed. AFPP-CEB.
 EC (2009) Regulation (EC) No 1107 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC. *Official Journal of the European Union* L 309/1-50.

Appendix – Preliminary testing methods for identifying the function of the adjuvant

Functions	Preliminary testing methods (not exhaustive)
1. Improving retention/adhesion	Measurement of retention/adhesion of the spray mix can be done in several ways: active substance content, co-formulant dosage or visually with the use of a colouring agent (e.g. fluorescein)
2. Improving the spread on the target surface	1. Assessment of target coverage by deposit 2. Measurement of contact angle
3. Preserving/maintaining the properties of the spray mix (to avoid degradation of the PPP)	Evolution of the physico-chemical properties of the spray mix over time (e.g. degradation of the active substance, salt precipitation with pH change, UV protection, pH correction, hardness of the water, etc.)
4. Wash-off resistance	1. Wash-off bank test 2. Residual efficacy assessment (on potatoes, in a vineyard) or other recognized method
5. Improving the speed or rate of penetration into the target	1. Electronic microscopy 2. Chemical dosage, (HPLC or GC for example, radiolabelled active substance [³ H, ¹⁴ C, ³² P (glyphosate), ³⁵ S(-Dim herbicides), etc.]
6. Improving the quality of the spray mix	Physico-chemical methods: CIPAC methods, e.g. MT 36, MT 47, MT 160, MT 161, MT 174, MT 184, MT 183, etc.
7. Improving the quality of application	1. Granulometry (droplet size distribution), velocimetry by laser and/or camera 2. Drift testing bank (wind tunnel) 3. ISO method no. 5682

PPP, plant protection product; HPLC, high-performance liquid chromatography; GC, gas chromatography; CIPAC, Collaborative International Pesticides Analytical Council.