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Regulatory Directive

Guidelines for Efficacy Assessment of Herbicides and Plant Growth Regulators

This document provides guidance on specific procedures for efficacy assessment of herbicides and plant growth regulators.

This Regulatory Directive replaces parts 3 and 4 of Memorandum to Registrant R-92-02 dated April 30, 1992.

Users of this document should also consult *Guidelines for Efficacy Assessment of Chemical Pesticides* (Dir93-07a) which provides general requirements for efficacy trials, guidance on reporting of efficacy data and, procedures for efficacy data evaluation.

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Publications Coordinator
Pest Management Regulatory Agency
Health Canada
2250 Riverside Drive
A.L. 6606D1
Ottawa, Ontario
K1A 0K9

Internet: pmra_publications@hc-sc.gc.ca
www.hc-sc.gc.ca
Facsimile: (613) 736-3798
Information Service:
1-800-267-6315 or (613) 736-3799

Table of Contents

3.0*	Herbicides	1
3.1	General Aspects	1
3.2	Specific Use Patterns of Herbicides	6

Appendix H-I

Herbicide Efficacy Trials Summary Table	19
---	----

Appendix H-II

Summary of Weed Control Ratings for Product X	20
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4.0	Plant Growth Regulators	21
4.1	Definition and Scope	21
4.2	Performance Assessment	21

* Consult Dir93-07a for sections 1 and 2.

3.0 Herbicides

3.1 General Aspects

Herbicides are chemicals designed to control plants. They are used to control undesirable plants in defined areas but also have the potential to cause injury to desirable plants. Therefore, tests should be conducted to determine the range of conditions within which the product is useful without producing detrimental effects to the crop or other desirable plant species in the target area. Since some herbicides have residual effects in the soil, data should also be produced to demonstrate that succeeding crops can be grown safely and re-cropping intervals can be clearly defined.

3.1.1 Weed control claims

Label claims on weed control are generally made on a species-by-species basis. Therefore, the degree of control of each weed species in a test should be reported on species-by-species basis. General reporting on broadleaved weed or grass control, with a list of weeds present, is not sufficient to support specific label claims, unless the results indicate a consistent complete kill of all weed species present.

In reporting weed control data and in making label claims, common names of weeds are to be used. The Expert Committee on Weeds (ECW) publication *Common and Botanical Names of Weeds in Canada* and the Agriculture Canada publication *Weeds of Canada* should be used as reference in developing correct terminology.

3.1.2 Application rates

Tests should include a series of application rates. The following points should be noted in deciding the rates of application: (a) for crop tolerance assessment, some trials should include at least one dosage that is twice the label recommended rate; tests at lower-than-label rates are of no value in crop tolerance evaluation; and (b) for weed control evaluation, use of rates proving to be efficacious, but lower than those recommended may be considered; use of test rates above those recommended are of no value in supporting efficacy claims.

3.1.3 Timing of application

Timely application of a herbicide is important for both efficacy and crop tolerance considerations. A set of standardized codes should be used to describe the various stages of crop development. The BBCH scale (Lancashire *et al.*, 1991, *A Uniform Decimal Code for Growth Stages of Crops and Weeds*, Ann. appl. Biol-119:561-601) has been gaining acceptance in many countries and has been accepted by the

ECW. It is suggested that this method be used for timing of herbicide applications, where possible or applicable.

The timing of application(s) must be clearly stated in the use claim directions and supported by adequate data. The following terminology may be used in describing the time of application to crops:

- (a) Preplant treatments (PP): The herbicide is applied before the crop is planted, either as a foliar application to control existing vegetation or as a soil application. In most cases, the herbicide is applied and incorporated into the soil before seeding or transplanting, referred to as preplant incorporated treatment (PPI). The supporting data and use claim directions must specify the intervals required between application and crop planting to avoid crop injury. Any climatic, soil or other factors that affect the length of that interval should be described in the test report, so that the label directions may be written to take these factors into consideration in order that possible crop injury may be avoided.
- (b) Preemergence treatments (PRE): The herbicide is applied after seeding but before emergence of the crop or the weed(s). It may require shallow incorporation above the crop seeds before emergence of the crop to bring the herbicide into contact with underlying moist soil; this is referred to as preemergence incorporated (PEI) treatment.
- (c) Postemergence treatments (POE): The herbicide is applied after emergence of the crop or weed. The timing of the application must be given in the supporting test data. This time should be indicated by stage of development of the crop and/or weed; use time interval (days after emergence) only when conclusively shown that this is more critical than the actual stage of development of the crop or weed.
- (d) Fall treatments: The herbicide is applied in the fall for weed control in the next crop season. The precise timing of application in terms of date or in days before freeze-up should be provided with supporting efficacy data obtained during the crop season.

Note:

In addition to the above, there are other terms which are used to describe specific timing of applications, e.g., “ground crack” refers to application after emergence of the weeds but just before emergence of the crop (e.g., potatoes).

3.1.4 Location, duration and number of trials

Efficacy trials should be carried out over the course of at least two years. Trials should be conducted in a variety of locations which span the environmental conditions and geographic regions in which the weed and crop are found or for which registration is sought. Efficacy data produced solely in one region may not be useful to support the registration for use in another region. For example, to support the registration of a product in eastern Canada, some trials must be conducted in eastern provinces even though the product is acceptable for use on the prairies with sufficient supporting data.

For crop tolerance evaluation, the required number of trials may vary, depending on the soil / geographic distribution of the crop / climatic diversity and crop cultivar response. For example, for a crop like wheat or alfalfa which is grown in all regions, a larger number of trials will be needed to cover variations in soil and climatic conditions. In general, a product containing a new active ingredient would require a minimum of 10 trials in each year for at least two years, to support the use on each crop. Additional trials may be required if there is evidence of phytotoxicity. The number of trials may be reduced for adding a new crop to a product label when the spectrum of activity of the herbicide is well defined and predictable.

The number of trials required to support weed control claims may also vary depending on the nature of the weeds and the consistency of the results. Generally, consistent results from 10 trials conducted over two to three years under representative conditions are required to support the label claim of any specific weed species. The number of trials could be reduced if the new weed is closely related to weed species for which there is well established efficacy (e.g., extending label claim from green foxtail to yellow foxtail).

3.1.5 Weed control assessment

Weed control from a herbicide treatment should be expressed as a comparison with an untreated control. In addition, a hand-weeded control or a recognized standard treatment is useful for assessment of yield or adverse effects due to the treatment alone.

Weed control measurement can take the form of visual observations by experienced personnel, actual weed counts per given area (stand) and/or measurement of weed height, vigor, or weight. When visual observations are used, they should be accompanied by some quantitative measurements, where applicable, to reduce the subjectivity of visual assessment. The degree of control should be reported as percent control. In cases where other rating systems are used, the report should clearly define the conversion factor (from the rating system used to percent control).

To justify a label claim for weed control, the degree of control should consistently reach a level which is considered commercially acceptable. Commercially acceptable levels

may vary slightly depending on the use pattern and the weed problem, and the availability of alternatives. However, the level of control should, in all cases, be expected to provide a meaningful benefit to the user of the product.

For the claim of “control”, the treatment usually must provide at least 80 percent reduction in weed stand and/or growth, when compared to untreated check plots. A lesser claim for “suppression” or “partial control” of certain weed species may be appropriate when the data indicate a minimum of 60 percent reduction in weed stand and/or growth.

“Top growth control” will be acceptable for perennial weeds where consistent 80 percent reduction of top growth has been demonstrated.

If certain conditions or rates allow only “suppression” or “partial control” of weed species where other conditions or rates allow “control” of the same species, these conditions or rates should be identified on the product label.

Note:

For environmental and economic reasons, the “threshold” concept warrants consideration. Researchers are encouraged to establish threshold levels of infestation for each crop/pest situation where the weed will not compete with the crop. When a threshold is well established, the degree of weed control at the threshold level could be considered acceptable for registration.

3.1.6 Crop tolerance assessment

Crop tolerance assessment can take the form of visual ratings by experienced personnel and by measurement of crop growth and/or yield. The results can be reported in terms of percent tolerance, or injury, as compared to untreated check or preferably to a handweeded control. In cases where other rating systems are used, the report should clearly define the conversion factor (from the rating system used to the percent basis).

- (a) Varietal sensitivity trials: Phytotoxicity to host crops can be assessed from general trials for efficacy evaluation. In addition, varietal trials may have to be conducted to obtain more complete information on the selectivity of a herbicide for a crop species. These trials should include a large number of cultivars at several locations with distinct environmental conditions. It is important in initial varietal tests to select cultivars of different types, e.g., Argentine and Polish types of rapeseed, 2-row and 6-row barley.

If one or more cultivars have been shown injured by the herbicide treatment, further trials should be set up to test all commercial cultivars which currently exist.

In the interim, label directions should restrict the use of the product to those cultivars that have been tested and have demonstrated tolerance to the treatment.

- (b) Succeeding crop trials: When there is any indication of persistence of a soil-active herbicide, trials should be conducted to determine the potential of damage to sensitive succeeding crops. Trials can be done using well marked plots of a former trial, in which residues of the herbicide remain, and plant a variety of crops that might be used in a typical rotation. Label directions must clearly indicate when specific crops can be grown safely in a rotation, under various soil and weather conditions.

Adverse climatic conditions occurring after herbicide treatment may hinder crop development to the point where reseeding may be necessary. In such an event, recommendations concerning replanting should specify the time interval that must elapse between the original herbicide treatment and the replanting, the conditions under which the original crop or an alternate one may be planted, and whether or not an additional herbicide treatment is required. Label recommendations concerning replanting should be supported by pertinent data.

3.1.7 The role of the Expert Committee on Weeds (ECW)

The ECW is a national working group of industry, university, private and public researchers operating as a subcommittee of the Canada Committee on Crop Production Services. ECW consists of an Eastern Canada Section and a Western Canada Section. Each section meets once a year to conduct weed research planning and appraisal. Each section publishes an annual research report consisting of abstracts of recent weed control investigations conducted in their respective areas. Based on research results submitted to ECW, each section makes “suggested treatments”, together with suggested further testings, which are published in the Report of the Research Appraisal and Planning Committee.

While Agriculture Canada is not bound by the ECW “accepted treatments”, the ECW appraisals serve well in providing meaningful guidance in efficacy evaluation. The Product Managers will rely on the peer review inherent in the “suggested treatment” of ECW, providing that the review is complete and has followed the agreed evaluation criteria. The use proposed for registration must be consistent with the “suggested treatment”.

All researchers, including those of the pesticide industry, are encouraged to submit their test results to the respective sections of ECW for inclusion in their appraisal.

It should be noted that it is the registrant’s responsibility to include the relevant parts of the ECW research reports in the registration submission with the source of the

information clearly indicated (page number, year and east or west section of the ECW report). To avoid confusion and double counting, it is important that results from one test either be submitted as the ECW report or as the researcher's own report, but not both. If the individual researcher's report can provide additional essential information, it may be submitted as an attachment to the ECW report and it should be clearly indicated as such.

3.2 Specific Use Patterns of Herbicides

In addition to the above general considerations, further guidance is provided for the following specific use patterns of herbicides.

3.2.1 Cereals

- (a) Scope: This section applies to both winter and spring cereals including the following crops:
wheat (types):
 - (1) spring wheat (*Triticum aestivum*) -- spring sown;
 - (2) winter wheat (*T. aestivum*) -- fall sown;
 - (3) durum wheat (*T. durum*) -- spring sown;barley -- spring or fall sown;
oats -- spring sown;
rye -- spring or fall sown;
triticale -- spring or fall sown
- (b) Crop tolerance: Crop tolerance assessment for spring and fall sown cereals should be conducted separately and label claims on these crops must be specific. Label claims on wheat, for example, should specify the particular type(s) of wheat as outlined above. If the general term "spring wheat" is used in the label direction, it is interpreted as a recommendation for use on both types 1 and 3, and crop tolerance data should be available on both. If data are available for only one type, the label should specify the type with sufficient support data or contraindicate the other, e.g., spring wheat (except durum).

Label amendments for additional types of wheat may only require "bridging" data, rather than the "normal" quantity. For example, if spring wheat is already on the label and there is no indication of a crop tolerance problem, and if the registrant wished to add durum or winter wheat, a few confirmatory trials for each, representing several locations, may be satisfactory.

- (c) Winter cereals: Winter cereals are sown in the fall. Herbicide treatments can be applied in the fall and/or the following spring. However, some herbicides may cause serious crop injuries when applied in the alternate season. Therefore, label

directions concerning time of application should be specific and all treatments should be supported by field studies conducted at the appropriate time.

- (d) Cereals underseeded with forage crops: Cereals may be grown as a companion crop to forage legumes. Weed control is often a problem in this situation because of crop phytotoxicity. Therefore, crop tolerance should be assessed carefully to ensure that the herbicide treatment does not cause unacceptable injury to either the cereal or the underseeded forage crops. The trial plots should be sited, if possible, where the stands of both undersown species and weeds to be controlled are each uniform in development and density.

3.2.2 Rapeseed/canola and mustard

- (a) Scope: This section applies to all types of rapeseeds and mustard including the following crops:
 - (1) Argentine rapeseed/canola (*Brassica napus*).
 - (2) Polish rapeseed/canola (*Brassica campestris*).
 - (3) Triazine tolerant rapeseed/canola (*Brassica napus*).
 - (4) Yellow (white) mustard (*Brassica alba*).
 - (5) Oriental and brown mustard (*Brassica juncea*).
- (b) Crop tolerance: To obtain information on the selectivity of a herbicide, crop tolerance should be assessed for all label claimed species. Within each species, trials should cover a range of varieties including the principal cultivars grown in the regions.

Crop tolerance assessment for canola and mustard types should be conducted separately and label claims on those crops must be specific. Crop tolerance label claims must be supported by yield data for each type. If the general term “rapeseed/canola” is used in the label direction, it is interpreted as a recommendation for use on all rapeseed/canola species (Types 1, 2 and 3) and crop tolerance data should be available on all of them. If data is available for only one or two types, the label should specify the type(s) with sufficient support data or exclude the others, e.g., rapeseed/canola (except triazine-tolerant).

- (c) Winter rapeseed/canola: Winter cultivars are sown in the fall. Herbicide treatments can be applied in the fall and/or the following spring. Some herbicides may cause serious crop injuries when applied in the alternate season. Therefore, label directions concerning time of application should be specific and all treatments should be supported by field studies conducted at the appropriate time.

3.2.3 Corn

- (a) Scope: This section applies to all types of corn including field corn, sweet corn, popcorn and corn grown for seed production.
- (b) Crop tolerance: Tolerance to a herbicide treatment may differ among these types of corn. Therefore, crop tolerance data should be produced to support the registration of each particular type. Some inbred lines of corn grown for seed production purposes have been shown to be particularly sensitive to certain herbicides. Particular attention should be paid to tolerance assessment trials involving the production of corn for hybrid seeds.

3.2.4 Beans

- (a) Scope: This section applies to all types of beans including soybeans, adzuki beans, faba beans, mung beans, lima beans, scarlet runner beans, dry common beans and snap common beans. For registration requirements, refer to the Regulatory Directive concerning *Classification of Beans on Labels and in Use Standards*.
- (b) Crop tolerance: These beans include a wide range of species and varieties. They may have a wide range of variable tolerance to herbicide treatment. Therefore, crop tolerance data generated on one type may not be appropriate in supporting the registration of other types. In addition to species-specific data, field trials should be conducted to assess varietal differences in their tolerance to the proposed herbicide treatment. A certain degree of extrapolation is generally possible between and within these types of beans; however, application for registrations will have to be evaluated individually.

3.2.5 Forage crops

- (a) Scope: Forage crops are very diverse and are divided into two broad categories: forage legumes and forage grasses. Weed management needs and crop tolerance among forage crops differ greatly depending not only on the species but also on the stage of establishment (seedling vs established), the cropping system selected for stand establishment, and end use of the crop, as outlined below:
 - (1) Forage legumes
 - Stand establishment: Forage legumes may be established with or without a companion crop such as wheat, barley, rapeseed or flax
 - Established forage legumes grown for hay/pasture
 - Established forage legumes grown for seed production
 - (2) Forage grasses
 - Stand establishment: Forage grasses may be seeded alone or underseeded to a major crop such as wheat, barley, rapeseed and flax
 - Established forage grasses grown for hay/pasture
 - Established forage grasses grown for seed production

- (3) Mixtures of grasses and legumes
- (4) Rangelands and native pastures
- (b) Considerations: Where forage crops are underseeded to a companion or nurse crop, crop tolerance must be recorded for forage seedlings as well as the nurse crop. Since the nurse crop intercepts some of the spray deposits, the underseeded forage crop may not receive the full dose, and hence crop tolerance may be over-estimated. On the other hand, competition from the nurse crop plus the herbicide treatment may result in more severe long-term damage to the forage seedlings. In conducting trials with nurse crops, competitive crops such as barley or wheat should be included in the trial rather than a poor competitor like flax.

For seedling legumes, the crop growth stage should be recorded as the number of trifoliate leaves present at time of herbicide application. Alfalfa, for example, is most tolerant to post-emergent type broadleaved weed herbicides when the seedlings are between 1-3 trifoliate stage.

For established forages, the purpose for which they are grown should be stated. Alfalfa, for example, is grown for hay, pasture, the dehydration industry or seed production. An alfalfa seed crop may be more vulnerable to post-emergent type broadleaved weed herbicides than would an established stand intended for hay or pasture, as applications close to bloom may have adverse effects on flower development and seed set.

Tolerance of established forage legumes differs widely depending upon the timing of application. Alfalfa, for example, shows tolerance to most residual herbicides only if applied in the dormant stage in late fall or early spring. The height of regrowth in the spring should be recorded for early spring applications.

A forage stand is considered established if it is at least 18 months old. The crop is not normally harvested in the year of establishment. The plant material obtained for dry matter yield determination should be hand-separated into forage and weeds, and reported separately. Reporting weed dry matter yield for individual weeds is preferable to lumping all the weeds together.

Trials intended for weed control in forage crops grown for seed production must include data on seed yield and some quality characteristics. For established forage crops, seed or forage dry matter yield should be monitored for at least 2 years. For seedling forage legumes/grasses, the “residual effects” of the treatment on yield in the subsequent year should also be recorded.

Rangelands and native pastures are divided into natural vegetation zones, grasslands and woodlands. The general intent of weed management should be to influence pasture condition ratings towards excellent. To do this, several of the more prominent species, classed primarily as decreasers or increasers, should be chosen as the “crop.” The range condition classification system should be used to identify the “crop” for native grasslands, including native grasslands with woody species, when forage species have not been seeded. When woodlands, and woodlands with associated native grasslands are to be seeded to forage species, the seeded forage species should be the crop. Side-by-side treatments in native grasslands with treated and untreated areas should be assessed for herbage production by clipping and visual estimates. Soil texture, slope, aspect and position on the slope will aid in interpretation of the data. In native pastures there should be no reduction in herbage production for desirable species (decreasers or increasers) and in general there should be no change to an improvement in range condition ratings. To allow species time to recover following treatment, range condition should be monitored for at least two years after the treatment year.

3.2.6 Vegetable crops

- (a) Scope: This section covers weed control in vegetable crops, including those from which fruits, leaves or roots are harvested. Various herbs are also included.
- (b) Considerations:
 - (1) Vegetable crops are grown in soils varying widely in mineral and organic matter content. These different soil types may have a significant influence on the performance of a herbicide product, especially for soil active chemicals. Efficacy tests should be conducted for each type of soil unless the label claims specify only one type.
 - (2) Vegetable crops are generally weak competitors. For season long weed control, split applications at different time intervals may be required to control subsequent germinating weeds. The duration of control, precise timing of application and the maximum application rate per annum should be clearly established and labelled in the use directions.
 - (3) There are a large number of vegetable crop species with only a small acreage involved. Within some species (e.g., potato), different cultivars have also shown considerable variation in their tolerance to certain herbicides. Weed control research on these crops is limited. Yet, because of the high value of these crops, the requirement for efficacy data, especially that on crop safety, cannot be compromised.
 - (4) Vegetable crops are generally graded according to strict quality criteria. Yield evaluation should be reported as total yield and marketable yield

based on the Canadian grading system. Similarly, certain crops are harvested in several episodes. Marketable yields should be reported in such cases, for each harvest in order to determine the effect of the herbicide on the size of the premium yield (i.e., the timing and marketable yield of the first fresh market harvest) compared to the overall season yield.

- (5) All symptoms of crop damage for a pesticide should be clearly noted and described. This is important for vegetables destined for the fresh market since the quality of both the consumed portion of the vegetable and the other plant parts will have a direct impact on the perception of crop quality by the consumer and the price and ultimate marketing of the crop (e.g., onion, leek, radish, carrot and beet leaves).

3.2.7 Orchard and vineyard crops

- (a) Scope: This section covers herbicide trials on fruit trees such as apple, apricot, sweet and sour cherry, nectarines, peach, pear, plum, and wine and table grapes.
- (b) Overview: Unless the product is intended for use in orchards or vineyards under production only, the trial should begin in the year of planting. Trials should last, preferably, for several years and usually at least two years before conclusions can be made. Follow-up applications or other treatments may be needed to control weeds not controlled by trial chemicals.

The objective of orchard or vineyard weed control trials is to develop a program that will prevent competition for nutrients and soil moisture during the period of the season when the crop requires maximum vigor for high yields and good fruit quality (size, sugar content, etc.). Depending on the crop, this may be only a portion of the growing season, and re-establishment of a vegetation cover is usually beneficial for hardening off of crops, preventing soil erosion, etc. However, some plant species are generally considered undesirable at any time on the orchard/vineyard floor.

The objectives, therefore are:

- (1) control of all competing vegetation under trees and vines during the time of tree/vine growth;
- (2) eradication of certain highly undesirable species; and
- (3) selective treatments that will allow establishment and maintenance of species relatively non-competitive with the crop, as “living mulch.”

- (c) Trial layout and evaluation: Herbicides are usually applied to a band under the trees/vines to create a weed-free zone as wide as the trees drip line. Total weed control until the end of tree growth (late June) is preferred. Weed escapes by species and vigor should be documented at the end of this period. Some weed growth in the herbicide strip during the rest of the summer can be tolerated, but should be documented in the fall.

Trials to determine crop tolerance to repeated applications of a weed control program should have plots covering most of the rooting area of at least two trees. Observation of crop tolerance should be made throughout the entire duration of the trial.

3.2.8 Berry crops

- (a) Scope: This section covers herbicide trials on berry crops such as highbush and lowbush blueberries, cane berries (raspberries and blackberries), cranberries, currants, gooseberries and strawberries.
- (b) Overview: Herbicides should be tested in the year of planting and/or on bearing plantings, depending on their intended use patterns and phytotoxicity concerns. Several applications may be useful in berry crops, including spring, fall, post-renovation (e.g., for strawberries).
- (c) Crop tolerance evaluation: Crop tolerance determination should be conducted where herbicides are applied to the entire rooting zone. Cultivar sensitivity to herbicides should be screened in several berry producing areas. Any observed effect of herbicide treatments on winter hardiness and winter survival should be documented in the year following applications. Any effect of herbicide applications on fruit bud initiation should also be documented, especially for products applied during the critical times of flower bud initiation.

3.2.9 Ornamentals

- (a) Scope: This section covers herbicide trials in woody and herbaceous ornamentals grown either in nursery fields, landscape plantings or containers.
- (b) Considerations: In applying herbicides to woody and herbaceous ornamentals, there are two points to consider. Firstly, there is a very high number of available ornamental species and cultivars within species. Each species and, in some cases, each cultivar may react differently in their tolerance to herbicide treatment. The wider the variety of plants treated, the more comprehensive the efficacy results will be.

Secondly, it is important to note the growing site of the plants. Stock may be grown either in the field, container, liner or transplant bed, seed bed or in a landscape setting.

In evaluating control in container grown stock, one should consider the influence of the soilless, organic growing media generally used. The growing media will vary widely between nurseries, hence, tests with soil-active herbicides should be conducted for a range of media. The large amounts of water applied to maintain plant development may affect herbicide efficacy. The age of the plant material and time interval between planting or potting and herbicide application should also be considered. Generally, the herbicide can be applied four weeks after potting of container stock. However, some herbicides may be tolerated after the first irrigation application has settled the growing media. The efficacy of a herbicide can be altered by the regular irrigation practices of a container operation.

Herbicide trials carried out on field grown ornamental stock should be considered separately from container stock, since the soil growing conditions, watering practices and cultural weed control options differ from those of container stock.

- (c) Trial and evaluation: Because of the perennial nature of the crop, herbicide trials should investigate the options of spring, fall and sequential applications.

Complete weed control throughout the growing season is a requirement for aesthetic purposes. Weed control for the growing season may require split or follow-up applications to control subsequent flushes of germinating weeds. The duration of weed control should be assessed for soil-active herbicides. All crop injury should be noted since even low levels may produce a non-marketable product.

3.2.10 Forest

- (a) Scope: This section applies to weed and brush control for the benefit of forest tree species growing in nurseries, cutovers, old fields and natural stands. Hardwoods and conifers can be included as crop species.
- (b) Sources of information: The Southern Weed Science Society publication, *Standard Methods for Forest Herbicide Research*, contains much useful information about experimental design, sampling methods, measurement of crop and target species, and application methods (Southern Weed Science Society, 309 West Clark Street, Champaign, IL, USA 61820). In addition, each year, the Silviculture Summarizer for the Expert Committee on Weeds, Eastern Canada Section, produces a checklist of parameters which should be recorded for forestry trials.

- (c) Location of trials: See sections 2.1.4 and 3.1.4. More emphasis should be placed on carrying out trials in the different forest regions where use is anticipated than simply in different provinces (see *Native Trees of Canada* for descriptions of the forest regions of Canada).
- (d) Timing: Treatment timing should be recorded not only in terms of calendar date, but also in terms of developmental stage of the target and crop plants. For r(1+0) conifers in the nursery, stages include: emergence, apical meristem emergence from cotyledonary whorl, needle elongation, bud set. For r(2+0) and older conifers in the nursery or outplanted, stages include: bud burst, flushing, shoot extension, needle elongation, needle hardening, bud set. For hardwoods and herbaceous species, stages include: leaf emergence or flushing, leaf expansion, full leaf, coloration, leaf drop.
- (e) Soil: For soil active herbicides, it is important to specify the humus thickness and uniformity (degree of mineral soil exposure). See also notes on soil in section 2.1.4.
- (f) Crop trees: The history of crop trees affects their tolerance. Age of crop trees is not a good term to use as it is frequently ambiguous. Stock type and size at outplanting, and dates of outplanting and treatment should be specified. For nursery trials, date of sowing and cultural conditions should be specified (e.g., sown in greenhouse and then transplanted).

Damage to crop trees may not be expressed in the year of treatment. Crop trees must be assessed for damage at least until the end of the growing season in the next year after treatment. This may not be required for all nursery trials, but proposed uses must be supported by proof that phytotoxicity does not occur or become evident in subsequent years.

In most cases, the benefit (improved survival and growth) can not be detected until at least two growing seasons after treatment. Researchers should be prepared to assess crop tree performance at one, two, three and five years post treatment.

Visual assessment by itself is not an adequate measure of crop tolerance. The principal measures of tolerance and benefit should be: survival, annual height increment, annual diameter increment and form (e.g., multiple leadering). For nursery trials, it is desirable to measure end of season root and shoot dry weights.

Appropriate sample size is dependant upon population and site variability. If population variance is known, a sample size can be chosen which will detect a chosen difference with a chosen degree of confidence. If variance is not known,

generally a minimum of 25 individuals per species from a minimum of three to five plots per treatment should be assessed. Factors which may dictate a larger sample size include: non-uniformity of site, possibility of significant non-herbicide-related mortality and possibility of browsing.

- (g) Target species: In forestry, many of the weeds are perennial and control for more than one season is necessary. Thus, control must be assessed for at least two growing seasons after treatment. For nursery trials, assessment should continue until control is lost. For sample size, see item under crop trees above.

For woody vegetation, percent control may not be very meaningful. Percent defoliation (reduction in live crown volume) is a better parameter, if the degree of resprouting or suckering is included as well. Where there is 100 percent defoliation, the percent of stem kill (individuals with dead basal bark) should be determined. Changes in the live height and number of living stems per unit area is a relatively simple and objective parameter to measure. It provides a useful evaluation of the effect of the treatment on the target species although it may not reflect changes in competitive pressure, or changes in crown height and volume per unit area.

Change in percent cover is the most common parameter measured. However, for many species (e.g., blue-joint and raspberry), there can be several fold differences in density (stems/unit area), all being 100 percent cover. On the other hand, stems per unit area alone may not give a good picture if the species distribution is patchy. In these cases, reporting both percent cover and density is recommended. In nursery trials, weed counts by species, or time required for hand weeding, give figures that other nurserymen can relate to better than percent control.

3.2.11 Non-crop lands

- (a) Scope: This section applies to weed and brush control in non-cropland areas including industrial sites, roadsides and rights-of-way, railway tracks, and areas under power lines.
- (b) Considerations: Control of weeds and brush in non-cropland areas involves a large number of plant species, soil types, climatic conditions, use situations and application techniques. It is impossible to apply a single general rule for efficacy evaluation under these various situations. Appropriate trial designs would have to be considered for each specific case of proposed use. Therefore, efficacy trials should be well planned to define clear trial objectives and criteria by which they are to be judged.

Trial plots should be sited on representative non-cropland areas. Efficacy data from cropland may not be applicable to non-crop situations.

- (c) Weed control: Vegetation control along roadsides and rights-of-way usually requires the use of selective broad spectrum herbicides that control brush and broadleaved weeds but leave the low growing grassy species for ground cover. Selectivity as well as the degree and duration of control of the target species should be assessed and reported.

In some areas, such as industrial sites and along railway ballasts, total vegetation control may be desirable. Efficacy trials should be aimed to test the effectiveness of the products including degree of control and duration of acceptable control.

Efficacy assessment should be made at appropriate time intervals, depending on the objective of the trial and properties of the herbicide as well as effects on the weeds. For example, time periods of 14, 28, 56 days after application are suggested for assessment of the knock-down effects of non-residual herbicides. With residual herbicides, observations can be made one, three, six, nine months after application and thereafter at regular intervals. Assessment for perennial weed control may be extended to 12-15 months.

- (d) Brush control: There are several methods of applying herbicides for the control of woody species. Label directions should clearly indicate the application methods, and recommendations of each application method should be supported by efficacy testing using the specified method.

For brush control trials, evaluation should be made for extended periods at time intervals of, for instance, zero, three, and 15 months after application but prior to fall desiccation. Observations should include: (1) stem count by species of living trees (including resprouting, extrapolated to a per unit area); (2) tree height by species; (3) current annual increment (C.A.I.) for conifers; and (4) percent defoliation for conifers, subsequent to treatments. Efficacy evaluations near the end of the second season after treatment (15 months for stem-foliar or 15 months or more for basal treatments) are usually the most important.

3.2.12 Turf grasses

- (a) Scope: This section covers testing herbicides for weed control in turf in various sites including lawns, parks, and golf courses.
- (b) Efficacy trials: The use of herbicides for control of weeds in turf should be considered a supplement to good management practices which include adequate fertilization and watering as well as proper mowing. However, since not all turf swards can be properly managed, efficacy trials should be conducted in turf

swards under various levels of management. The herbicide products should be assessed at enough locations to adequately represent the range of environmental conditions, soil types and management practices. Tolerance to the herbicides should be assessed over a range of turf plant species and cultivars. If the full range cannot be tested, at least the principal species should be included in the trials.

Trial programs should include testing in established turf and establishing turf. Trials should also be conducted to study the effect of treatments on the germination and survival of new seeded areas (e.g., overseeding into treated swards and/or seeding into bare soil previously treated with the herbicide).

Since trees and ornamentals are often grown in turf swards, the effects of the herbicide treatment on desirable plants should be studied. Proper label directions should be developed to prevent damage to the desirable vegetation.

For weed control in turf, herbicides are often used in mixtures. They are also used in mixtures with fertilizers. In these cases, tests should be conducted to assess the efficacy of these mixtures.

3.2.13 Crop and weed desiccation

- (a) Scope: Desiccants for a variety of purposes including:
- increasing harvest efficiency;
 - reducing crop and weed moisture content;
 - perennial weed control;
 - modifying the time of harvest by terminating growth and hastening maturity;
 - dry-down of foliage to increase canopy penetration by light or air.

In Canada, desiccants are used for vine killing in potatoes, foliage desiccation of seed crops such as alfalfa, clovers and dry beans, plant desiccation of rapeseed, mustard, sunflowers, lentils, peas and flax and perennial weed control in flax.

- (b) Efficacy testing: Efficacy data should be produced to demonstrate that the treatment will provide commercially acceptable levels of crop desiccation. The proper timing of application (crop stage) should be supported by sufficient information and clearly indicated. Where the treatment may have a potential to affect the yield and/or quality of the crop, data on such quantity and quality should also be produced. Seed germination data may be required if the treated crop is used for seed production and the treatment may affect germination and seedling vigor. This requirement also applies to vegetative reproduction units, e.g., potatoes.

Specific label claims in addition to desiccation, such as perennial weed control, must have efficacy data pertaining to such claims. In the case of perennial weed control, efficacy data in both the year of application and the succeeding crop year must be available.

3.2.14 Aquatic weed control

- (a) Scope: This section applies to herbicide treatments designed to control algae and aquatic macrophytes (mosses and vascular plants). Efficacy data concerning plant pest control in swimming pools, industrial cooling water systems, pulp and paper mill water systems, and on ship or boat bottoms, as well as other underwater surfaces, are described elsewhere.

Aquatic sites may involve standing water, moving water, and locations expected to contain water at a later time.

- (b) Efficacy testing: The aquatic environment is very complex and many factors may affect the performance of a product. Field testing should include a geographical distribution of plot sites that reflect the general climatic and water quality variations expected in the locations where the product is proposed for use. Where possible, test sites should include those which have various water hardness, pH, temperature, turbidity, alkalinity, and weed infestations. In reporting test results, the data should include a detailed description of the test site (including water quality), vegetation present, date of application and the stage of growth of the target plants, method of application, dosage of herbicide (expressed in units appropriate to the method and placement of the application such as weight per unit area, weight per unit volume, or the weight per unit flow volume), and the results of the treatment on the target weeds.
- (c) Effects on non-target plants: In testing herbicides for weed control in aquatic sites, particular consideration should be given to the following:
 - (1) If label claims intend that the product be used to treat water used for irrigation purposes, or to treat ditchbanks in irrigation systems, tests should be conducted to determine if phytotoxic effects of the herbicide occur on crops normally expected to be irrigated with the treated water. The tests should also determine any limitations on the type of irrigation and on timing of irrigation after the treatment.
 - (2) In aquatic sites, some plant species in the target area are considered desirable for fish and wildlife. Side effects on these desirable species should be assessed. Guidelines for non-target plant phytotoxicity testing and evaluation are now in preparation.

Herbicide Efficacy Trials Summary Table

Ref. No.	Yr/Locations/ Co-operator	Trt.	Rate ai/ha	Applic.		Soil Factors	Growth Stage Crop/Weed	Weed Control	Crop Injury	Crop Yields	Note
				PPI/Pre/	Post						
1	2	3				4	4	5	6	7	8

Footnotes

1. To assign a numerical number to each trial for easy reference in the submission data.
2. Allow quick review of regional representation and quality/quantity of data.
3. Treatments including check and commercial product comparisons if available.
4. Soil factors required if soil applied; growth stage if post emergent.
5. List each weed proposed on label under a separate column; indicate percentage control or ECW 0-9 rating used in the data (convert 0-9 rating to percentage if possible).
6. Indicate injury by percentage or 0-9 ECW rating used in the data (convert 0-9 rating to percentage if possible).
7. Yields compared to untreated check.
8. Any comments relevant to results (e.g., unusual conditions resulting in failure of the trial).

Summary of Weed Control Ratings for Product X

<u>Weed Species</u>	<u>Frequency Distribution</u>			<u>Average¹</u>
	<u>100-90%</u>	<u>89-80%</u>	<u>79-50%</u>	<u>%</u>
	<u>Rate 1 (kg a.i./ha)</u>			
A	8	2	1	91
B				
C				
D				
	<u>Rate 2 (kg a.i./ha)</u>			
A	9	2	0	96
B				
C				
D				

NOTE: Non-representative results should be excluded from the summary with explanations, e.g., "results from trial #91-003 were excluded in the summary because heavy rainfall immediately following application rendered the treatments ineffective."

4.0 Plant Growth Regulators

4.1 Definition and Scope

Plant growth regulators (PGRs) are those substances used for controlling or modifying plant growth processes without severe phytotoxicity. PGRs are not conventional pesticides. However, they are subject to regulation under the *PCP Act* when they are used to control “any injurious or troublesome organic function of a plant.”

Currently, PGR products are regulated under either the *PCP Act* or the *Fertilizers Act* depending on the nature of their label claims, as defined below:

- (a) Products to be regulated as supplements under the *Fertilizers Act*: Claims that a plant growth regulator functions to aid plant growth are interpreted as “supplement” under the *Fertilizers Act* and regulated as such. Such claims include, but are not limited to breaking dormancy, induction of early germination or sprouting, root development and vegetative growth promotion.
- (b) Products to be regulated under the *PCP Act*: Claims that a PGR functions to limit root development or the vegetative development of a plant are interpreted as pest control, and such products are subject to the *PCP Act*. Pest control product claims also include modification of physiological, morphological and reproductive processes of plants other than those within the meaning of “supplement.” Such claims include, but are not limited to, the inhibition of sprouts or germination, sucker control, color enhancement, fruit setting, defoliation and the control of pre-harvest drop of fruits.

Products containing only PGRs and which carry mixed claims are subject to registration under the *PCP Act* contingent upon acceptance of the supplement claims under the *Fertilizers Act*.

4.2 Performance Assessment

General rules for efficacy testing of chemical pesticide products also apply to PGRs. However, the unique characteristics of plant growth regulator functions should be recognized. Many of the plant response levels are extremely subtle. Varying concentrations or varying application of a product to a single plant species at different growth stages will cause a wide variety of responses. Many PGRs eliciting a response in one variety or cultivar of a species may not perform similarly or at all on another variety within the same species.

Due to the varied responses, sites, crops involved, use patterns, and application techniques, each product should be evaluated on a case-by-case basis and according to claims proposed on the specific product label for the specified crop or commodity.

The following examples are provided to illustrate general guidance for certain categories of PGR uses. They are not intended to serve as an exhaustive list nor to exclude other plant growth regulator uses.

4.2.1 Products decreasing tobacco sucker growth

Tobacco sucker control agents may be divided into two types: systemic and contact. The systemic regulators are applied as sprays to leaves, absorbed by the plant, translocated throughout the plant and accumulate at the meristematic areas of the auxiliary buds. The contact type chemicals are applied by directed application down to the stalk so that they contact the auxiliary buds.

Efficacy comparisons should be made between treated plants, hand-suckered plants, and topped-but-not-hand-suckered untreated plants with respect to: (a) number and fresh weight of suckers at harvest; (b) effects on leaf drop and yield; and (c) cured leaf quality including percent usable by tobacco companies, chemical and physical properties, and smoke taste test.

Since the tobacco companies are the tobacco leaf buyers, the cured tobacco must meet the company standards.

4.2.2 Products inhibiting potato tuber sprouting

Several types of PGRs can be used to maintain tuber dormancy, including: (a) product for pre-harvest applications; (b) dipping tubers in a solution of the product before storage; (c) dusting the tubers with the product before storage; or (d) applying the product as a volatile suspendible solid to the tubers while in storage.

The usual procedure is to randomly collect about 400 tubers for each variable to be tested. They are divided into four replicates of 100 each and treated accordingly with the appropriate method at several dosage levels. In the case of pre-harvest applications, variables such as time of application, water volume and pressure of spray, dosage, time to harvest, must be considered in addition to subsequent storage conditions.

Treated tubers or tubers from treated plants should be stored at various temperatures, subjected to various airflows and treated with air of different humidity levels to determine length of control.

Efficacy comparisons should be made between treated tubers and untreated tubers with respect to: (a) sprouting (sprout number or weight per tuber), tuber weight loss and rot loss, tuber appearance, suberin and wound periderm formation, heat generated in piled potatoes, quality (sugar content, mealiness, fry colour, flavour, chipping) both before

and after storage, usefulness of tubers as propagation stock, shelf life; and (b) yield and grades, if the plant growth regulator is applied pre-harvest.

4.2.3 Control of fruit maturation and ripening

PGRs can be used to achieve a number of specific objectives related to fruit maturation, ripening and harvest. These uses include: (a) advancing or delaying maturity in apples, cherries and peaches; (b) concentrating ripening in tomatoes, blueberries, and apples; and (c) enhancing abscission to facilitate mechanical harvesting.

Efficacy tests should be designed to measure the effects on maturation and ripening process relating to the objectives. For products decreasing pre-harvest fruit drop, for example, comparisons should be made between treated and untreated plants with respect to: (a) percent fruit drop or retention; (b) fruit quality (grade, size, shape, color, flavor and storage characteristics); (c) harvest date; (d) effects on plant growth, immature fruit, yield; and (e) observations on plant growth, flowering, fruitset, yield, and plant quality obtained during the growing season following the initial application (if the product is intended for yearly or more frequent use on perennial plants).

4.2.4 Products reducing plant growth

Some chemicals can be used to reduce internode elongation or retard the growth of the whole plant. Efficacy tests should be carried out to assess the effects on growth reduction and the resulting quality of the plants. Measurements and observations may include: (a) length of internode; (b) plant size and conformation; (c) effects on growth rate, flowering, fruit-set, yield, crop quality, and harvest efficiency; and (d) residual effects during the second growing season after initial application (on perennial plants).

4.2.5 Products reducing crop lodging

Field tests should be conducted under conditions conducive to lodging, such as heavy rainfall or irrigation, intensive cereal management and certain lodging-prone cultivars. Comparisons should be made between treated and untreated plants with respect to: (a) lodging index, taking into account the extent and angle of leaning or lodging; (b) plant height measurements; (c) stem internode measurement; and (d) harvest assessments, including yield (harvestable yield vs. recoverable yield), 1000 grain weight, hectolitre weight (kg/100 litres of grain or g/litre in small plot trials).

4.2.6 Products increasing branch angle in young non-bearing fruit trees

Efficacy comparisons should be made between treated plants and untreated plants with respect to: (a) branch angle (angle less than 90 degrees formed by the main trunk and the primary branches) prior to treatment, at the end of the growing season (during which treatments were applied), and at the end of the next growing season (during which no treatments were made); (b) effects on the appearance of vegetative growth (colour, size, shape); and (c) observations made in the growing season following treatment including effects on winter hardiness, time of leaf expansion in the spring, effects on appearance and growth of vegetative parts and branch angles.

4.2.7 Products controlling alternate bearing in apples

Comparisons should be made between treated plants and untreated plants with respect to: (a) data collected the year of treatment, including flowering intensity, fruit-set, yield, delay of maturity, fruit quality (size, shape, color, flavor), and incidence of physiological disorders; (b) data collected the year after treatment, including all factors listed above and emphasizing data on the number of blossoms and time of blossoming; and (c) data collected both in the treated year and the following year, including performance effects of cultural practices such as pruning and use of plant regulators for fruit thinning and decreasing pre-harvest fruit drop; effects of environmental conditions such as temperature, frost, and rainfall, and effects on vegetative growth and appearance.

4.2.8 Products altering sex expression in cucurbits

Comparisons should be made between treated and untreated plants with respect to: (a) sex of flowers at each node, number of flowers per plant, vegetative growth rates and appearance, plant stand, time of flowering and harvest, and duration of effectiveness; (b) effects of cultural practices and environmental conditions on product performance; (c) data in support of hybrid seed production, including number of seeds per fruit, seed yield, percent seed germination, seedling vigor, and seed storage life; and (d) data in support of increasing yields in once-over harvest programs, including fruit yield per unit area by grades, market value by grade, and fruit quality (shape, color, and flavor).

4.2.9 Products increasing flowering of ornamental plants

Efficacy comparisons should be made between treated plants and untreated plants with respect to: (a) number of flowers per plant; (b) flower quality (size, shape, color); (c) timing of full bloom after treatment; and (d) growth rate, and conformation of vegetative plant parts; and all factors listed in 4.2.3 (e).

4.2.10 Products thinning flowers and/or fruit

Comparisons should be made between treated plants and untreated plants with respect to: (a) percent flower drop and/or fruit drop per plants; (b) effects on remaining flowers and/or fruit, conformation of vegetative growth, and phytotoxicity; and (c) all factors listed in 4.2.3(e).