Guidelines for the conduct of chemical weed control trials in forage grasses grown for seed

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INTRODUCTION

Weeds are a serious problem in forage grass crops grown for seed. They cause reductions in both yield and quality. A major problem faced by grass seed producers is the limited number of herbicide treatments available to control weeds in their crops. Since impure seed can be a major means by which weeds are spread, the importance of weed control in forage grass seed crops is greater than in crops grown for non-seed purposes. There are several reasons for the limited number of herbicide treatments available to forage grass seed producers:

1. The grass seed crop species are generally limited in acreage. Hence, the market potential for herbicide treatments in forage grass seed crops is limited, making it uneconomical for chemical companies to develop use patterns for their products.
2. There is wide diversity in the tolerance of forage grass seed species to herbicides. Information on tolerance must be collected for each species.
3. In many cases herbicide tolerance in forage grass species depends on crop stage. Information is required for the tolerance of both seedling and established plants.
4. There is limited research being conducted on the tolerance of forage grass crops to herbicides. Changes in the structure of government research in the last 5 to 10 years have resulted in fewer researchers working on forage grass problems.

Because of limited resources it is very important to optimize the manner in which research on herbicide use patterns in forage grass seed crops is conducted. The data base on which herbicide use patterns in forage grass seed crops are registered are very limited relative to those in cereal and oilseed crops. Because of the limited number of trials each trial must be established carefully. They must be conducted in a manner which permits confidence in the data that is collected and they must be easily comparable with other trials used to make up the data base. Abnormalities in the conduct of a single trial can sometimes result in data which will either fail to reveal shortcomings with the use pattern or unnecessarily delay its registration. The guidelines presented here are an attempt to standardize procedures for the conduct of research on herbicide use patterns in forage grass crops. They are intended to serve as guidelines for all researchers who are conducting herbicide trials in forage grasses, but they are particularly aimed at those who are conducting this type of work for the first time.

BACKGROUND

The User Requested Minor Use Label Expansion program (URMULE) is administered by the Pest Management Regulatory Agency (PMRA) of Health Canada. The program is designed to permit the registration of herbicide treatments on minor use crops, i.e. crops which have such a small acreage or return per acre that private industry is unwilling to invest in because of inadequate returns. Forage grasses grown for seed fit the category of minor use crops.

The general procedure for obtaining a minor use herbicide registration in a forage grass grown for seed production is as follows:

1. A problem is identified by grass seed producers, extension agents and/or researchers.
2. A herbicide currently registered for use in a major crop is identified as having potential to solve this problem.
3. Prior to submission consent is obtained from the company producing the herbicide to support the request and to include the new use pattern on the label.
4. Existing information on the use pattern for this herbicide in forage grass seed producing stands is collected and a submission for minor use registration is made to PMRA by the end user of the treatment.
5. The information is evaluated by PMRA. The organization submitting the request for registration is then informed of the adequacy of the data submitted. If the data is insufficient then PMRA informs the submitter of the data that is still required.
6. Once data supporting the request is deemed adequate by PMRA, the use pattern is registered.

The research conducted in this regard must, therefore, have the objective of generating data to support the registration of specific herbicide treatments in forage grasses grown for seed production. The amount and type of data will vary with the registration being requested. However, the following can be considered as guidelines:

Amount of data:

1. Crop tolerance - Sufficient for confidence that tolerance is adequate for each forage grass species. Trials should be conducted over 2 to 3 years and over 3 to 4 locations (in areas where the herbicide treatment will be used) and there should be no serious crop tolerance problems.
2. Weed control (if required - should be conducted in trials separate from crop tolerance trials) - In seedling stands for control of annual weeds data from one forage grass species may be used for another forage grass species. Trials should be conducted over 2 to 3 years and over 3 to 4 locations (in areas where the herbicide treatment will be used) - ideally at least 10 trials with acceptable weed control. Efforts should be made to ensure that the target weed species are present in all trials where the treatment under study is evaluated.

Types of data collected:

I Crop Tolerance

During establishment (Seedling Stands)

1. Visual crop tolerance ratings at 4-7 (to evaluate any initial burn) and 28-35 days after application and in fall.
2. Companion crop yield if established in this manner.

3. Seed yield harvests in year following establishment.
4. Seed quality - seed weight and germination.
5. Percent ground cover.

Established Stands
1. Visual crop tolerance ratings at 4-7 (to evaluate any initial burn) and 28-35 days after application and at harvest.
2. Seed yields at maturity.
3. Seed quality - seed weight and germination.

II Weed Control

During establishment (Seedling Stands)
1. Visual crop tolerance and weed control ratings at 14 and 28-35 days after application and in fall.
2. Weed shoot or plant counts and shoot biomass (top growth).
3. Companion crop yield if established in this manner.
4. Visual crop tolerance and weed control ratings in June of year following establishment.
5. Seed yield harvests in year following establishment

Established Stands
1. Visual crop tolerance and weed control ratings at 14 and 28-35 days after application and at seed harvest.
2. Weed shoot or plant counts and shoot biomass (top growth).
3. Seed yields at maturity
4. Seed quality - seed weight and germination

GUIDELINES FOR PROCEDURES

Selection of Site

(Adapted from Deanna Koebernick)

There is probably no site that is perfect. However, the following guidelines may help when selecting a site.

Considerations for all sites:

_____ Is the site easily accessible? Can you access the site after significant rainfall? Are there any fences which may impede entry? Is there an access road?

_____ Are there any low spots on the selected area that may collect water with heavy rainfall? Is the area of uniform topography?

_____ Is there adequate room for the cooperator to drive around the trial with his/her sprayer? Check the sprayer width before flagging trial.

_____ When flagging the trial, leave a border of approximately 10 m around the entire trial to prevent drift from the cooperators pesticide application.

_____ Place tall stakes in the corners of the trial for increased visibility to the cooperator.

Considerations for sites for trials during forage grass establishment

If the stand has been established by a cooperator

_____ If the objective of the trial is to obtain weed control efficacy data, is there a uniform population of target weeds? Moderate, uniform weed densities are preferred to heavy, patchy densities.

_____ If the objective of the trial is to obtain weed control efficacy data and if the weed population is not uniform, can the replicates be blocked to accommodate variations in populations? (See section on statistics).

_____ Are there significant populations of weeds which are not controlled by products in the protocol which may interfere with the experiment? If the purpose of the trial is to evaluate crop tolerance, is there a maintenance herbicide application that will control these weeds without injuring the crop?

_____ Is the crop uniform? Avoid double seeded areas or areas where the drill was not functioning properly.

_____ What pesticides were applied the previous 2 years? Will herbicide residue be a concern?

If the stand is to be established by the researcher

_____ If the objective of the trial is to obtain_weed control efficacy data, does the seed bank in the soil contain target weeds seeds? Will target weed seeds need to be seeded?

_____ If the objective of the trial is to obtain tolerance data, is the site relatively free of weeds?

_____ Is there the chance that significant populations of weed will germinate which are not controlled by products in the protocol? If the purpose of the trial is to evaluate crop tolerance or to evaluate the benefits of controlling a target species, is there a maintenance herbicide application that will control these weeds without injuring the crop?

_____ What pesticides were applied the previous 2 years? Will herbicide residue be a concern?

Considerations for sites for trials in established stands of forage grass

_____ If the objective of the trial is to obtain weed control efficacy data, is there a uniform population of target weeds? Moderate, uniform weed densities are preferred to heavy, patchy densities.

_____ If the objective of the trial is to obtain tolerance data, is the site relatively free of weeds?

_____ If the weed population is not uniform, can the replicates be blocked to accommodate variations in populations? (See section on statistics).

_____ Are there significant populations of weeds which are not controlled by products in the protocol which may interfere with the experiment? Is there a maintenance herbicide application that will control these weeds?

_____ Does the crop appear to have been fertilized appropriately? Are there strips in the field where the applicator was not functioning properly? Ask the cooperator about his/her fertilization practices

_____ Is the crop uniform?
Avoid double seeded areas or areas where the drill was not functioning properly.

Avoid areas where windrows left from previous years harvest have smothered forage grass plants. If this is not possible arrange replicates to minimize effect of windrows - arrange replicates so that windrow cuts across all plots within replicate.

_____ Does the crop appear to be in a condition to produce a reasonable seed crop?

Creeping red fescue and other fine fescues

Stands that are producing their first major seed crop offer the best hope for a reasonably uniform seed crop. When established with a companion crop the first major creeping red fescue seed crop usually occurs in the third year in the life of the stand while when established without a companion crop first major creeping red fescue seed crop usually occurs in the second year in the life of the stand. The plants should be spaced approximately 30 cm (1 foot) apart or be in rows spaced 30 cm apart (when creeping red fescue plants become dense or fill in, grass rather than seed is produced). The plants should have a lush green appearance and not show signs of nutrient deficiencies.

Other grasses

As with the fescues plants should be in rows spaced 30 cm apart, have healthy appearance and show no signs of nutrient deficiencies.

Treatment selection

1. Use well thought out treatment lists with the latest information and suggestions from forage grass seed producers (suggestions of where problems occur) and herbicide companies.
2. In tolerance trials use the high recommended rate of the herbicide and 2x this high recommended rate.
3. Specify formulation of herbicide and surfactant (if required) and specify grass and weed stages at time of application. All cooperators should attempt to apply herbicide treatment at the same crop and/or weed stage.
4. Specify water volume.
5. Keep in close contact with project leader and herbicide company representatives.

Design of trial

(From"Manual for Field Trials in Plant Protection." Ciba Giegy Ltd. 1992)

I. Reasons for using experimental designs:

When an experiment is conducted the results from it are due to the effect of the treatments plus a the effect of a number of other factors which can either be controlled or not controlled. To separate these effects various "models", which depend on layout, are used. When a model for a trial laid down using a randomized complete block design is used (the most frequently used design for herbicide trials) the effects would be separated as follows:

Result measured = general mean value (determined by crop, location, cultural methods, etc.)
+ effect of treatments applied
+ effect of block
+ residual error term.

Thus, experimental designs serve the purpose of singling out the effects of the treatments.

II. Plot size:
The plots must be large enough so spray drift is not a major problem and an adequate sample for seed or weed yield can be obtained. In most trials conducted on weed control in forage grasses, handheld or bicycle type sprayers are used to apply the herbicide treatments. A plot size of 2 x 10 m or 2 x 15 m is generally adequate.

III. Number of replicates:
A minimum of 4 replicates is generally considered necessary to draw valid conclusions from a trial. Forage grass seed yields are generally more variable than cereal crop yields. If differences that are sought are small, increasing the number of replicates to 6 can sometimes be helpful.

IV. Layout:
The choice of layout is mostly governed by the infestation or natural gradients at the chosen location. The more the gradients are considered in the layout, the better the final interpretation of the results. Examples of common layouts are as follows:

Common types of experimental design:

1. Completely Randomized
   - 6 treatments, 4 replicates
   - no blocking

4	6	5	3	2	3
1	4	5	2	4	5
5	2	3	1	6	2
4	1	5	6	3	1

2. Randomized Complete Block
   - 6 treatments, 4 replicates
   - grouped - 4 groups of 6

6	1	2	5	6	1
4	5	3	6	1	2
3	4	5	1	6	2
1	3	6	4	2	5

3. Latin Square
   - 4 treatments
   - each treatment occurs once in each row and column

3	1	2	4
1	4	3	2
4	2	1	3
2	3	4	1

4. Split plot
   - 6 herbicide treatments, applied under weedy (W) and weedfree (WF) conditions
   - 4 replicates

Rep 1	4 W -------- 4 WF	6 W -------- 6 WF	5 WF --------- 5 W	3 W --------- 3 WF	2 WF --------- 2 W	1 WK -------- 1 W
Rep 2	1 W -------- 1 WF	3 WF -------- 3 W	5 W -------- 5 WF	2 WF -------- 2 W	4 WF -------- 4 W	6 WF -------- 6 W
Rep 3	5 WF -------- 5 W	4 W -------- 4 WF	3 WF -------- 3 W	1 W -------- 1 WF	6 WF -------- 6 W	2 W -------- 2 WF
Rep 4	4 WF -------- 4 W	1 WF -------- 1 W	5 W -------- 5 WF	6 WF -------- 6 W	2 W -------- 2 WF	3 WF -------- 3 W

The importance of proper layout is illustrated in the following example. A Randomized Complete Block Layout with 6 treatments and 4 replicates is shown. There are a total of 24 plots and these are divided into 4 groups (blocks) with each treatment present in each block. The blocks are properly laid out on the left. The gradient (which could be a gradient in weed population, vigour of crop or some other factor) runs from top to bottom. The 4 blocks are set up to remove this variation. The layout on the left is improper since the gradient runs from right to left and the blocks run across the gradient.

Proper Layout

6	1	2	5	4	[illegible]
4	5	3	6	1	2
3	4	5	1	6	2
1	3	6	4	2	5

Improper Layout

6	1	2	5	4	[illegible]
4	5	3	6	1	2
3	4	5	1	6	2
1	3	6	4	2	5

Site Description and Herbicide Application Information

Before trial information can be submitted to the Expert Committee on Weeds, Research Report specified information is required describing the site, application procedures, etc. The information requested for each trial is indicated in the following "Record of Operations" sheets. Note: For those using the Pesticide Research Manager program, information can be entered directly into this program. The information can be directly imported into the Expert Committee on Weeds EDI program using the Pesticide Research Manager Export program.

RECORD OF OPERATIONS

<u>TITLE:</u>

<u>EXPERIMENT NO.:</u>

<u>YEAR:</u>

<u>SITE DESCRIPTION:</u>

EXPERIMENT LOCATION:____

SOIL TEXTURE:______________________ % ORGANIC MATTER:___________________
% SAND:_______ % SILT:_____ % CLAY:_______ SOIL pH:________________________

PREVIOUS CROP:____

<u>EXPERIMENTAL DESIGN:</u>

EXPERIMENTAL DESIGN:____
NO. OF REPLICATES:________ PLOT SIZE:_________(M) PLOT AREA:________(SQ M)

<u>TILLAGE OPERATIONS:</u>

	OPERATION 1	OPERATION 2	OPERATION 3
DATE:	____________	____________	____________
IMPLEMENTS	____________	____________	____________
	____________	____________	____________
DEPTH OF TILLAGE (CM):	____________	____________	____________
OTHER INFORMATION:			

<u>PLANTING INFORMATION:</u>

CROP:_______________________VARIETY:______________________
DATE SEEDED:_____________________ DEPTH:______(CM) RATE________(KG/HA)
ROW SPACING_____________(CM)
PLANTING METHOD:____

<u>FERTILIZER INFORMATION:</u>

BROADCAST:DATE:__________ RATE:_______(KG/HA) TYPE:______-_______-________

WITH SEED:DATE:____________RATE:_______(KG/HA) TYPE:______-_______-________

<u>SEED TREATMENT:</u>
INSECTICIDE:____
FUNGICIDE:____

EMERGENCE DATA:

CROP:____________________DATE:____________________
CROP:____________________DATE:____________________
WEED:____________________DATE:____________________
WEED:____________________DATE:____________________
WEED:____________________DATE:____________________
WEED:____________________DATE:____________________
WEED:____________________DATE:____________________

SPRAYING INFORMATION:

TIME 1

SPRAY VOLUME:__________(L/HA) PRESSURE:__________(KPA)
TEMPERATURE:__________(C) HUMIDITY:__________(%)
APPLICATION METHOD:____________________
DATE OF SPRAYING:__________TIME:__________
RAINFALL: WEEK BEFORE:______1 WEEK AFTER:______ 2 WEEK AFTER:______
FIRST SIGN. RAINFALL:DATE__________ AMT:__________(CM)
GROWTH STAGE AND HEIGHT: CROP:______________(Use BBCH scale if possible)
CROP:____________________
WEED:____________________
WEED:____________________
WEED:____________________
WEED:____________________
WEED:____________________

TIME 2

SPRAY VOLUME:__________(L/HA) PRESSURE:__________(KPA)
TEMPERATURE:__________(C) HUMIDITY:__________(%)
APPLICATION METHOD:____________________
DATE OF SPRAYING:__________TIME:__________
RAINFALL: WEEK BEFORE:______1 WEEK AFTER:______ 2 WEEK AFTER:______
FIRST SIGN. RAINFALL:DATE__________ AMT:__________(CM)
GROWTH STAGE AND HEIGHT: CROP:______________(Use BBCH scale if possible)
CROP:____________________
WEED:____________________
WEED:____________________
WEED:____________________
WEED:____________________
WEED:____________________

TIME 3

SPRAY VOLUME:__________(L/HA) PRESSURE:__________(KPA)
TEMPERATURE:__________(C) HUMIDITY:__________(%)
APPLICATION METHOD:____________________
DATE OF SPRAYING:__________TIME:__________
RAINFALL: WEEK BEFORE:______1 WEEK AFTER:______ 2 WEEK AFTER:______
FIRST SIGN. RAINFALL:DATE__________ AMT:__________(CM)
GROWTH STAGE AND HEIGHT: CROP:______________(Use BBCH scale if possible)
CROP:____________________
WEED:____________________
WEED:____________________

WEED:______________________________
WEED:______________________________
WEED:______________________________

INCORPORATION INFORMATION:
DATE_________ IMPLEMENT___________________ DEPTH________(CM)

HARVEST INFORMATION:
DATE:____
METHOD OF HARVEST:_______________________________
SAMPLE SIZE:____________________________________
NUMBER OF SAMPLES:________________________

IRRIGATION:

Date	Amount (mm)
________	________
________	________
________	________
________	________
________	________

WEATHER INFORMATION (from closest weather station)
WEATHER STATION:_______________________________________

	Temperature (Mean monthly -°C)	Precipitation (Total monthly - mm)
April	________	________
May	________	________
June	________	________
July	________	________
August	________	________
September	________	________
October	________	________

OTHER INFORMATION:

variability is to ensure an adequately large sample has been taken from the plot. In cereal crops a 10 to 25 m^2 sample size is recommended. Because of the difficulty in handling forage grass seed yield samples a minimum sample size of 5 m^2 is recommended. The more uniform and heavy a seed production stand the smaller the sample size required. The samples should be obtained at the appropriate time:

(Adapted from H. Najda, K. Lopetinsky, M. Bjorge and B. Witbeck Harvesting Grass Seed. *http://www.gov.ab.ca/agdex/100/27000501.html.*)

Bentgrass	Late July or early August. Seed separates from seed head when rubbed in the palm of the hand. Does not shatter easily.
Bluegrass	July or early August. Heads will be yellow or brown and seed firm. Seed head moisture content 45-50%. Does not shatter easily.
Bromegrass	Late July or early August. Heads will be brown and upper stems turning brown. Scythed moisture content 50-55%. Can be combined when seed moisture content is about 14%,about 10 days after swathing. Meadow brome is about a week earlier than smooth brome and shatters more easily. 10-20% dockage can be expected
Canarygrass	Mid-late July. About ½ of the seeds will be brown or grey. Seed head moisture content 50-55%. Swathing reduces shattering.
Fescue	Creeping red fescue. Late July - Early August. Seed head moisture content 35-40%. Seed shatters easily if harvest is delayed. Meadow and Tall fescue. Early August. Heads will be brown with a slight tinge of green (5-15% of seeds immature). Seed head moisture content 45-50%
Foxtail	Meadow foxtail. Seed ripens over time in early July. Seed head moisture content 55-60%
Orchard Grass	Mid-July to early August. Heads will look light brown, some will be greenish, stem turning yellow to brown. Seed head moisture content 35-40%.
Ryegrass	Italian ryegrass. Crop will be on greenish side with a seed moisture content of 45%. Swath and combine from swath when dried to about 35% seed moisture. Shatters very easily. Perennial ryegrass. 1-2 florets will come off the head when pulled between fingers. Crop will be greenish with seed head moisture of 50-55%. Shatters easily when mature.
Timothy	Early to mid-August. Heads will be grey with brownish tinge and are gold

coloured at the base. Seed head moisture content 40-50%. Swath when 50-60% of head is ripe. Easily dehulled. Seed shattering, dehulled seed and maturity can vary.

Wheatgrass Crested Late July to early August. Heads will be brown, stems a bit green. Seed head moisture content 35-40%. Shatters very easily, especially Fairway and Parkway.
Intermediate, Pubescent. Late August. Seed head moisture content 50-55% for intermediate, 60-65% for pubescent. Shatters easily. Matures about 3 weeks later than smooth bromegrass.
Northern, Slender, Streambank Mid-July. Seed head moisture content 40-45%. Shatters easily. Tall Late August-September. Heads brown and stems a bit green. Seed head moisture content 50-55%. Shatters easily.
Western Mid-August. Heads will be brown and stems a bit green. Shatters easily.

Wildrye Altai, Russian Mid-late July. Straw will be just turning golden yellow. Seed head moisture content 40-45%. Shatters very easily. Altai does not shatter as readily as Russian.

* Moisture content for entire seed heads established by research at Agriculture Canada, Beaverlodge. You can use a commercial moisture tester or a home oven set at 180° F (82° C). Use a scale to determine before-and-after drying weights. Allow about 4 hours for drying to reach a stable weight when using the home oven method.

Note: If samples are cut by hand or plot binder and put in cloth bags, they should be hung to cure for several weeks.

SEED QUALITY

If seed weight and germination are determined two lots of 100 seeds should be selected at random for each plot. Germination should be conducted according to accepted procedures.

Reporting results

The results of all trials should be submitted to the Expert Committee on Weeds Research Report. The data are entered directly by means of the Expert Committee on Weeds EDI program or through the Pesticide Research Manager program as previously described. A sample of a report is attached (Appendix B). Please note that all units are metric and all herbicides are given their technical names.

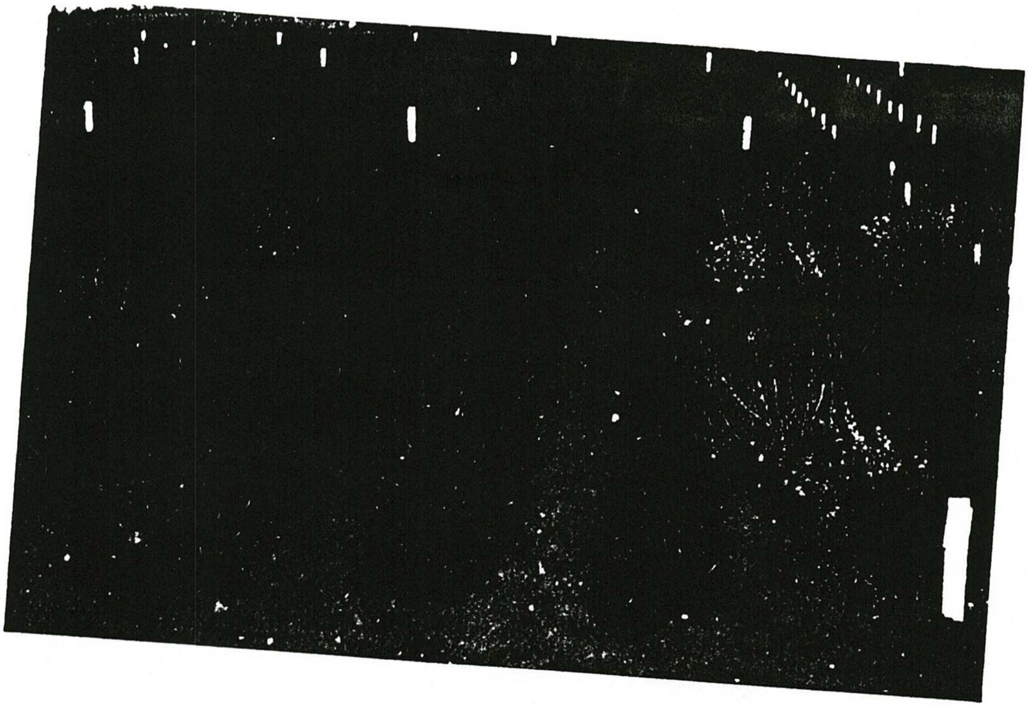


Figure 1

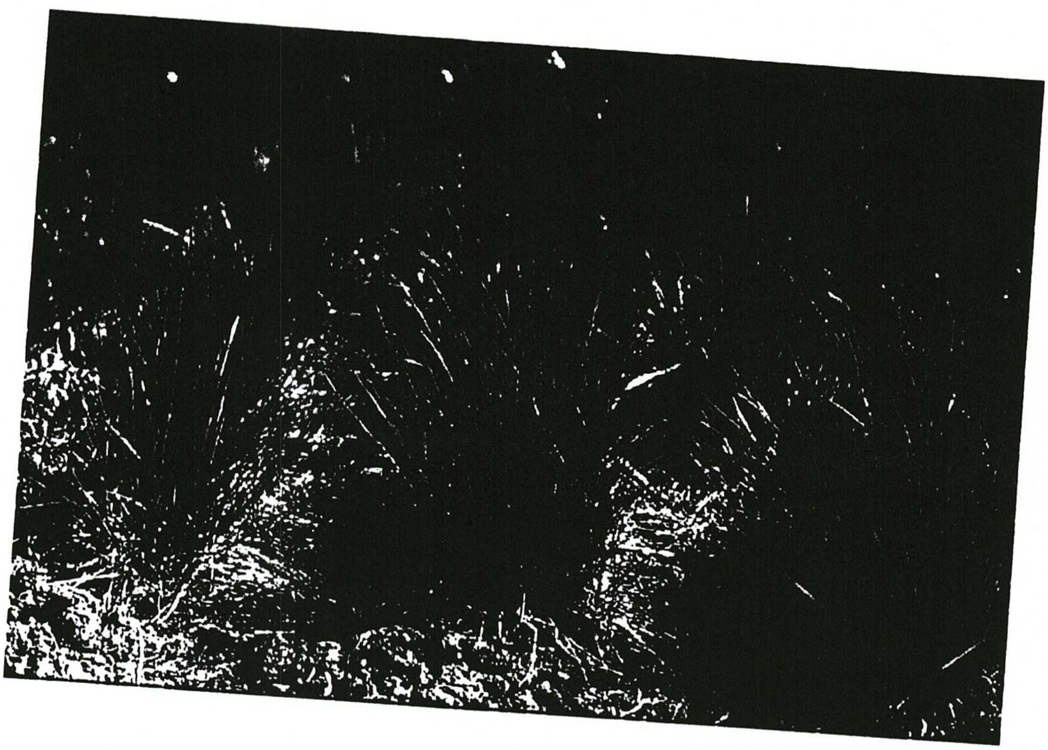


Figure 2

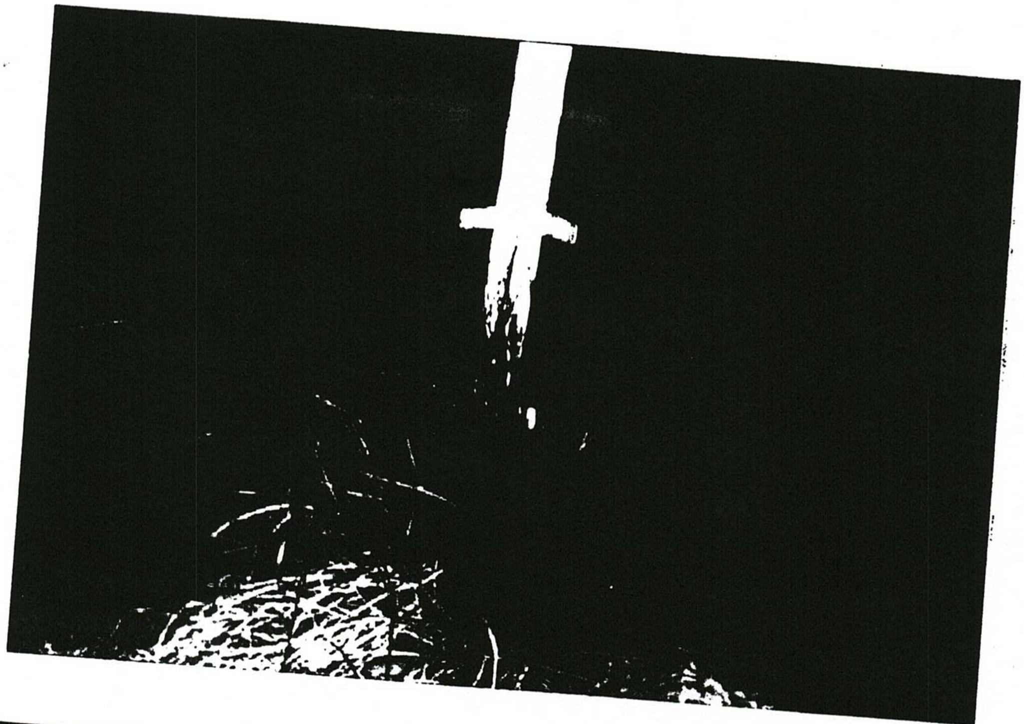


Figure 3

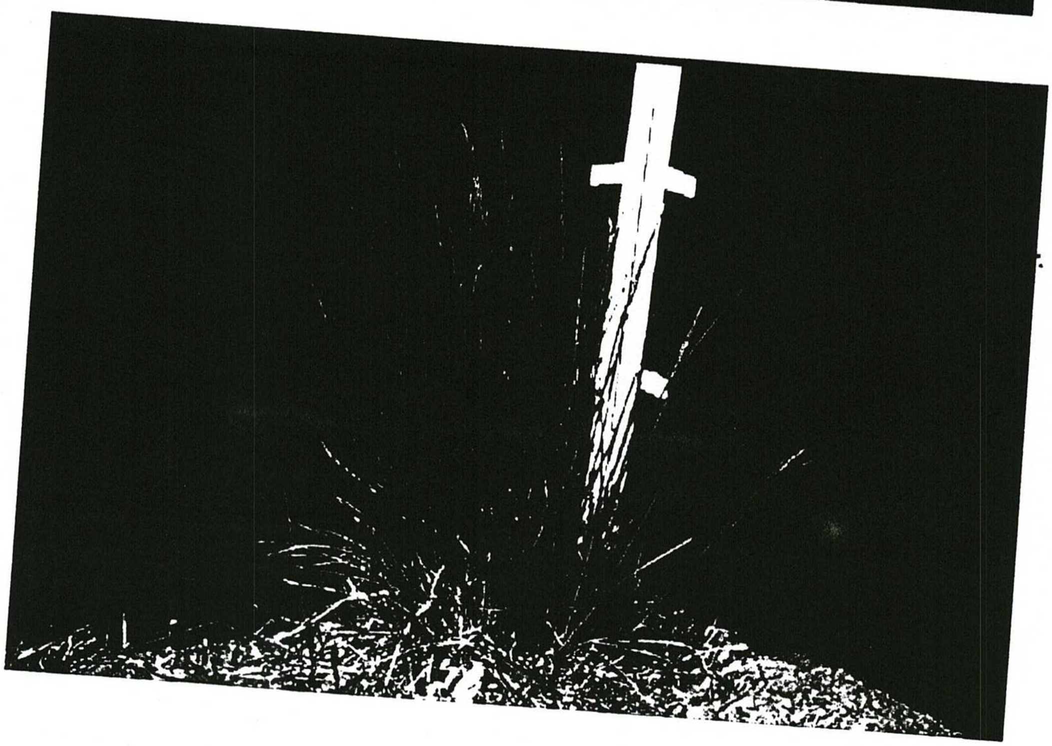


Figure 4

Seeding suggestions:

1. Use pedigreed seed and check the seed certificate for weed seed content.
2. Use a variety that is grown in the area or, depending on suggestion from project leader, grow the same variety at all locations.
3. Use seeding rates and spacings recommended for area that grass is grown in.
4. Conduct germination test and adjust seeding rate accordingly.
5. Use depth control bands on openers or some other device to ensure accurate and shallow seed placement.

Application of herbicides:

1. Use recommended water volume and spray when drift hazard is lowest. Use low pressure nozzles and other devices to reduce chances of drift.
2. Use accurate application eg. If applying by hand use a metronome.
3. Clean out sprayer between herbicides with water and ammonia.

Description of grass seed crop stages:

In newly established stands describing crop stage is relatively simple. Using keys such as BBCH (Appendix A) leaf number, tillering and other stages can be determined. In established stands describing crop stage is more difficult, particularly in the spring during the spraying season. In tolerance work at Beaverlodge three stages were noted in established grasses:

1. Before stem elongation - leaves are procumbent

   See Figure 1

2. After stem elongation - before flag leaf stage - plants take on an erect appearance - the seed head is near the bottom of the boot.

   See Figure 2 and 3

3. Shot blade or flag leaf stage to early heading - seed head

   See Figure 4

Data collection:

A. VISUAL RATINGS

Visual ratings are a fast and effective means of evaluating both crop tolerance and weed control. They are non-intrusive and permit researchers to conduct a larger number of trials than when other methods such as plant counts, etc. are used. However, they do have their shortcomings and researchers must be aware of these. First, for some variables, such as seed yields, visual injury ratings are inadequate. Experience has shown that significant forage grass seed yield reductions can occur despite no visual injury. Secondly, and probably the most important drawback, is that the method is to a large extent subjective. Statistical analysis of the results, and the interpretation of the results from the analysis, are difficult. Generally statistical analysis is not recommended for visual assessments. No two researchers will evaluate crop tolerance or weed control in exactly the same way. Often different systems of evaluation have been used (0-9 vs. 0-100% systems). As a consequence, results from different locations are difficult to compare.

As a means of reducing some of these problems, it is suggested that the 0-100% systems be used. This appears to be the system most widely used worldwide and is one favoured by most weed researchers in western Canada. Use of the same system in all trials will greatly help in summarizing and interpreting the results. The system is as follows:

DESCRIPTION OF THE VISUAL 0-100 RATING SCALE

Evaluation of Herbicidal Action

The assessment of the herbicide action of a product is based on the comparison of the treated plots with the untreated check plots. The aim is to assess as accurately as possible the decrease in biomass (i.e. number of plants, height, number of leaves, etc.) per weed species as compared to the check. The decrease in biomass is attributed to the action of the product. This reduction can be expressed by means of a linear scale.

Activity Range	Description of Control	Suggested Interval Size
91-100%	Very Good to Excellent	2%
81-90%	Good to Very Good	5%
80%*	Just Acceptable	
60-79%	Not Acceptable	5%
<60%	Poor	10%

*80% or greater is considered acceptable control.

Without an exact count there are limits to the accuracy of assessment even for the practised eye. It has therefore been found useful to aim for a differentiation of approximately 2% exactitude in the very good to excellent action range, but below that to estimate to not more than 5% or 10% accuracy.

Assessment is Best Done as Follows:

- First inspect all check plots and observe which weeds are uniformly and frequently present. To have a clear view of the weed pressures at each site one should characterize the weed infestation in the check plots.

- Decide which of the regularly present weed species correspond to the objective of the trial.

- Assess the effect (biomass reduction) of each individual species of weeds to be monitored when compared to check and record as a percentage number. Continually compare treated plots with untreated control.

- Do not rate minor infestations or non-uniformly distributed weeds when making a systematic analysis. Make note of any additional observed effects (e.g. suppression of weeds rather than total kill, potential for regrowth, discolouration, patchy control, etc.)

- Provide an estimate of the soil coverage by total weed infestation as a percentage.

- Determine the development stage (Zadoks scale) and density (number of plants per m^2) of the weed species to be monitored. This can be expressed as a percentage of the total weed infestation.

The evaluation is thus always based on a direct comparison between "treated" and "untreated" plots. If a particular weed is not uniformly present in the check plots and is similarly non-uniformly distributed in the treated plots, then it must not be evaluated. If, on the other hand, a weed is not present in the check plots but does appear in the treated plots, it must be classified as "not controlled" (i.e. 0% control).

The use of the 0-100% biomass reduction assessment is no more or no less subjective than using any other scale (i.e. 0-9 or 0-10), and the researcher's judgement still can be incorporated in the assessment. We must recognize this assessment as not representing an actual count since it does not. If actual counts are done then the ratings should be expressed as number of plants per m^2 which can then be converted as a percent of the total weed density or as a percent of the check.

Efficacy evaluations should be conducted at 14, 28-35 days after application and at harvest.

Evaluation of Plant Tolerance

The same basic principles apply. The evaluation should again be done with a comparison to the untreated checks. In most cases, however, the untreated checks suffer from the competition of the weeds and therefore one should include hand weeded check plots or ideally only conduct tolerance trials on naturally weed free land. Herbicides must not be used due to the possibility of confounding the results.

Phytotoxicity Range	Assessment of injury	Suggested Interval Size
0-9%	Very little injury	2%
10 - 20%*	Slight Discoloration and/or Stunting Just Acceptable	5%
21-30%	Not Acceptable	
>30%	Severe	10%

*20% or less is considered acceptable injury.

Initial damage of up to 20% will generally be outgrown and will disappear with time. The impact of these low levels of injury will not be reflected in yield losses. More severe injury, however, will almost always result in yield losses unless the suppression of a dense weed population can compensate for such damage. The observed damage should also be described (i.e. stunting, chlorosis, burning, malformation, retardation of flowering or of ripening, etc.). Yield determinations are a critical component of tolerance trials.

Tolerance evaluations should be conducted at 4-7 (for initial burn), 28-35 days after application and at flowering or ripening.

NOTE: Inclusion of decimal values is inappropriate. **USE WHOLE NUMBERS ONLY** to report.

B. WEED DENSITY AND WEED SHOOT DRY WEIGHT

The number and size of quadrats required will vary with the density and distribution of the weed species. The samples should be randomly selected from throughout the plot.

C. SEED YIELD

Seed yields from forage grasses are notoriously variable. One method to reduce this

Appendix A

BBCH Growth Stage Identification Key - Grasses

0 Germination, sprouting

BBCH code	Description
00	Dry seed (caryopsis)
01	Beginning of seed imbibition
02	-
03	Seed imbibition complete
04	-
05	Radicle(root) emerged from caryopsis
06	Elongation of radicle, formation of root hairs and/or lateral roots
07	Coleoptile emerged from caryopsis
08	-
09	Emergence; coleoptile breaks through soil surface

1 Leaf development (main shoot)

BBCH code	Description
10	First true leaf emerged from coleoptile
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
14	4 leaves unfolded
15	5 leaves unfolded
16	6 leaves unfolded
17	7 leaves unfolded
18	8 leaves unfolded
19	9 or more leaves unfolded

2 Formation of side shoots, tillering

BBCH code	Description
20	No tillers
21	First tiller visible
22	2 tillers visible
23	3 tillers visible
24	4 tillers visible
25	5 tillers visible
26	6 tillers visible
27	7 tillers visible
28	8 tillers visible
29	9 or more tillers visible

3 Stem elongation or rosette growth, shoot Development (main shoot)

BBCH code	Description
30	Beginning of stem elongation
31	1 node detectable
32	2 nodes detectable
33	3 nodes detectable
34	4 nodes detectable
35	5 nodes detectable
36	6 nodes detectable
37	7 nodes detectable
38	8 nodes detectable
39	9 or more nodes detectable

BBCH code	Description
4 Booting (main shoot)	
40	-
41	Flag leaf shoot extending
42	-
43	Flag leaf sheath just visibly swollen (mid boot)
44	-
45	Flag leaf sheath swollen (late boot)
46	-
47	Flag leaf sheath opening
48	-
49	First awns visible (in awned forms)

BBCH code	Description
5 Inflorescence emergence (main shoot)	
50	-
51	Beginning of heading
52	-
53	-
54	-
55	Half of inflorescence emerged (middle of heading)
56	-
57	-
58	-
59	Inflorescence fully emerged (End of heading)

BBCH code	Description
6 Flowering (main shoot)	
60	First flowers open
61	10% of flowers open or 10% of plants in bloom
62	-
63	30% of flowers open or 30% of plants in bloom
64	-
65	50% of flowers open or 50% of plants in bloom
66	-
67	Flowering finishing; majority of petals fallen or dry
68	-
69	End of flowering; fruit set visible

BBCH code	Description
7 Development of fruit	
70	First grains visible
71	Watery ripe
72	-
73	30% of grains reach final size
74	-
75	Milky ripe
76	-
77	70% of grains reach final size
78	-
79	Nearly all fruits have reached final size

BBCH code	Description
8 Ripening or maturity of seed	
80	Beginning of ripening or fruit colouration
81	-
82	-
83	-
84	Dough stage
85	-
86	-
87	-
88	-
89	Fully ripe; seeds full ripe colour beginning of fruit abscission

BBCH code	Description
9 Senescence, beginning of dormancy	
90	-
91	-
92	-
93	Leaves begin to change colour or fall
94	-
95	50% of leaves discoloured
96	-
97	End of leaf fall, plants or above ground parts dead or dormant
98	-
99	Harvested product

This leaflet will help you to understand and use the decimal growth stage key for cereals. The descriptions are now the recognised standard for agrochemical labels and fertiliser recommendations.

Plants should be sampled at random over the whole field. They should be dug, not pulled, to avoid breaking off leaves and tillers. At early stages count the leaves and tillers on the main shoot as shown in the diagrams and with reference to the complete key overleaf.

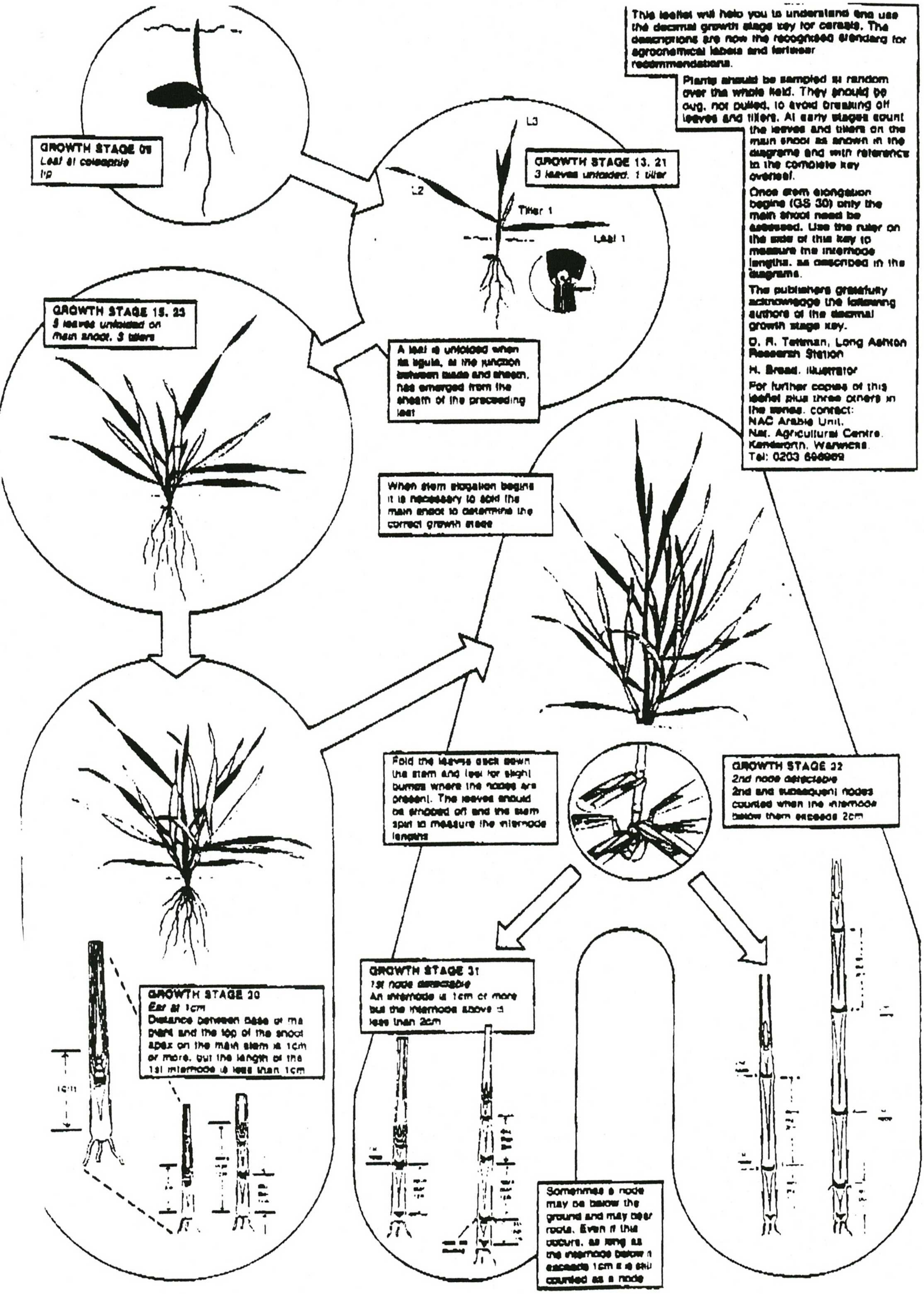
Once stem elongation begins (GS 30) only the main shoot need be assessed. Use the ruler on the side of this key to measure the internode lengths, as described in the diagrams.

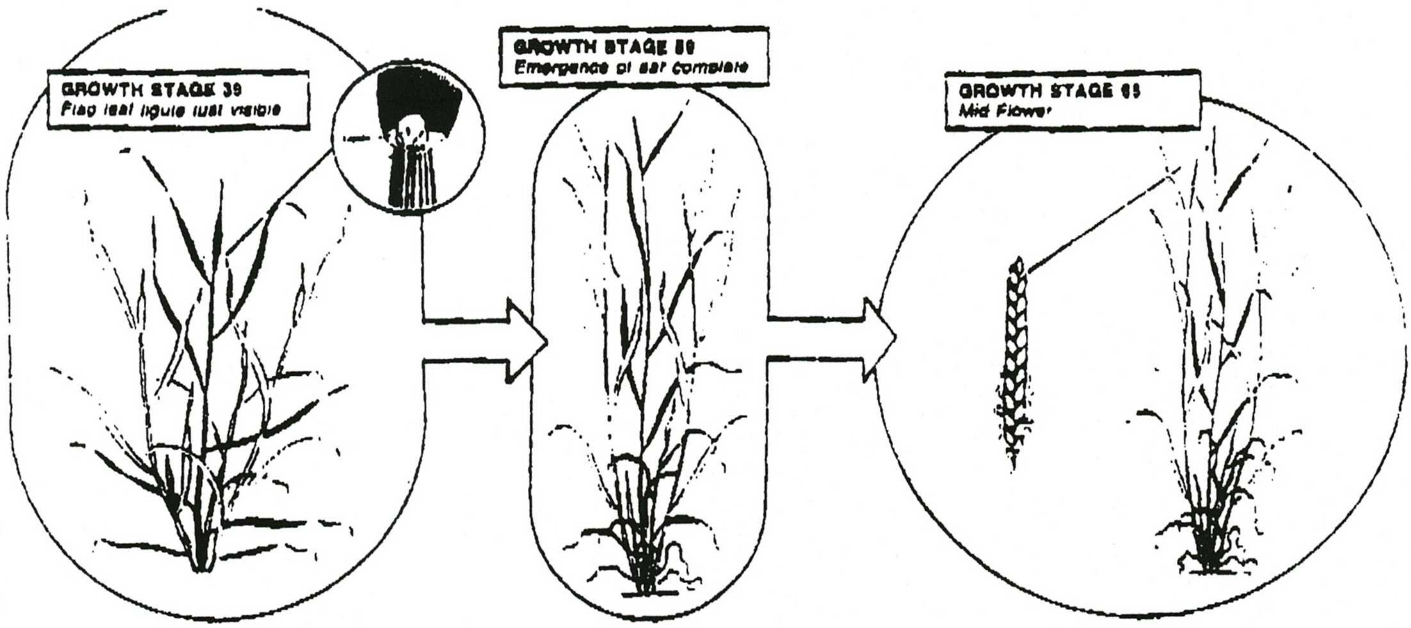
The publishers gratefully acknowledge the following authors of the decimal growth stage key.

D. R. Tottman, Long Ashton Research Station

H. Broad, Illustrator

For further copies of this leaflet plus three others in the series, contact:
NAC Arable Unit,
Nat. Agricultural Centre,
Kenilworth, Warwicks.
Tel: 0203 696969





Decimal Code for the Growth Stages of Cereals

2-digit code

Germination

- 00 Dry seed
- 03 Imbibition complete
- 05 Radicle emerged from caryopsis
- 07 Coleoptile emerged from caryopsis
- 09 Leaf at coleoptile tip

Seedling Growth

- 10 First leaf through coleoptile
- 11 First leaf unfolded
- 12 2 leaves unfolded
- 13 3 leaves unfolded
- 14 4 leaves unfolded
- 15 5 leaves unfolded
- 16 6 leaves unfolded
- 17 7 leaves unfolded
- 18 8 leaves unfolded
- 19 9 or more leaves unfolded

Tillering

- 20 Main shoot only
- 21 Main shoot and 1 tiller
- 22 Main shoot and 2 tillers
- 23 Main shoot and 3 tillers
- 24 Main shoot and 4 tillers
- 25 Main shoot and 5 tillers
- 26 Main shoot and 6 tillers
- 27 Main shoot and 7 tillers
- 28 Main shoot and 8 tillers
- 29 Main shoot and 9 or more tillers

Stem elongation

- 30 Ear at 1cm
- 31 1st node detectable
- 32 2nd node detectable
- 33 3rd node detectable
- 34 4th node detectable
- 35 5th node detectable
- 36 6th node detectable
- 37 Flag leaf just visible
- 39 Flag leaf ligule/collar just visible

Booting

- 41 Flag leaf sheath extending
- 43 Boots just visibly swollen
- 45 Boots swollen
- 47 Flag leaf sheath opening
- 49 First awns visible

Inflorescence

- 51 First spikelet of inflorescence just visible
- 53 ¼ of inflorescence emerged
- 55 ½ of inflorescence emerged
- 57 ¾ of inflorescence emerged
- 59 Inflorescence completed

Anthesis

- 60, 61 } Beginning of anthesis
- 64, 65 } Anthesis halfway
- 68, 69 } Anthesis complete

Milk development

- 71 Caryopsis watery ripe
- 73 Early milk
- 75 Medium milk
- 77 Late milk

Dough development

- 83 Early dough
- 85 Soft dough
- 87 Hard dough

Ripening

- 91 Caryopsis hard (difficult to divide by thumb-nail)
- 92 Caryopsis hard (can no longer be dented by thumb-nail)
- 93 Caryopsis loosening in daytime

Reference Tottman D.R., Broad H. (1987). *Decimal Code for the Growth Stages of Cereals. Annals of Applied Biology* 110: 683-687

Appendix B

CONTROL OF WEEDS IN FORAGE CROPS: GRASSES

TOLERANCE OF SEEDLING GRASSES TO FENOXAPROP AND CGA 184927/CGA 185072 - FORAGE AND SEED YIELDS ONE YEAR LATER. ECW/EDI-2.4
DARWENT A L, DRABBLE J C EXPERIMENT ID: SDGR93

CROP: OTHER CROP #1 PLANTED: 93/06/17, 8 KG/HA, 3 CM DEEP, 30 CM ROW WIDTH, STOCK TYPE: CERTIFIED. PLANTING METHOD: DOUBLE DISK DRILL. PREV CROPS: SUMMERFALLOW (92). FIELD EXPT. EXPT DESIGN: RANDOMIZED COMPLETE BLOCK. REPS: 4. PLOT SIZE: 4 X 9M. PLOT AREA: 36 SQ M. CROP ZONE: 27. EXPT LOCATION: BEAVERLODGE, AB. WEATHER STN: BEAVERLODGE CD, AB. ACTUAL PPT(MM): APR: 7, MAY: 42, JUN: 125, JUL: 73, AUG: 184.ACTUAL TEMP(C): APR: 5, MAY: 10, JUN: 14, JUL: 17, AUG: 16. FESCUE, CREEPING RED (BOREAL) EMERGED ON: 93/07/05. GRASS, MEADOW BROME (REGAR) EMERGED ON: 93/07/05. FESCUE, TALL (COURTNEY) EMERGED ON: 93/07/05. GRASS, TALL WHEAT EMERGED ON: 93/07/05.

SITE DESCRIPTION: SOIL TEXTURE: SILT LOAM. %OM: 6, %SAND: 22, %SILT: 28, %CLAY: 50, SOIL PH: 6.1. SOIL PARENT MATERIAL: LACRUSTRINE. SOIL DRAINAGE: WELL. SLOPE: 3%.
MATERIALS AND METHODS: CREEPING RED FESCUE, MEADOW BROMEGRASS, TALL FESCUE AND TALL WHEATGRASS WERE SEEDED AT 7.5, 9, 6.5 AND 8 KG/HA.

APPL INFO#	GROWTH ST INFO#	INCORP INFO#	MIX	MANAGEMENT	RATE KG/HA (AI)	% CONC	RED FESCUE BOREAL DRY WT G/SQ M	TALL FESCUE COURTN DRY WT G/SQ M	M BROM GRASS REGAR DRY WT G/SQ M	RED FESCUE BOREAL YIELD G/SQ M	TALL FESCUE COURTN YIELD G/SQ M	M BROM GRASS REGAR YIELD G/SQ M
1	1			FENOXAP-P-ETH/M	.092	9.2EC	99	195	223	30	5	14
1	1		T	FENOXAP-P-ETH/M	.092	9.2EC	115	194	255	42	10	31
			F	BROMOXYNIL	0.28	28EC						
			F	MCPA ESTER	0.28	28EC						
1	1		F	FENOXAP-P-ETH/M	0.092	5.6EC	126	159	265	35	5	18
			F	MCPA ESTER	0.42	25.6EC						
			T	THIFENSULFURON	0.015	75SU						
	1		F	FENOXAP-P-ETH/M	0.184	5.6EC	110	167	289	47	6	31
			F	MCPA ESTER	0.84	25.6EC						
			T	THIFENSULFURON	0.030	75SU						
	1		T	CGA-184927/185	.070	24EC	102	173	192	33	7	17
			T	SCORE	1							
	1		T	CGA-184927/185	.140	24EC	90	158	233	24	6	12
			T	SCORE	2							
	1		T	CGA-184927/185	.070	24EC	129	151	154	32	9	24

	MCPA AMINE	.56	50SN							
	T SCORE	1								
	T SCORE	1								
8 1 1	T CGA-184927/185	.070	24EC	120	159	244	48	10	28
	F BROMOXYNIL	.28	28EC						
	F MCPA ESTER	.28	28EC						
9 1 1	T CGA-184927/185	.070	24EC	76	139	187	27	6	26
	T 2,4-D AMINE	.56	50SN						
	T SCORE	1							
	T SCORE	1							
10 1 1	CHECK, WEEDED			117	154	190	31	4	15
				NSF	NSF	NSF	NSF		

SAMPLE SIZE (SQ.M)	2.4	2.4	2.4	2.4	2.4	2.4
NUMBER OF SAMPLES	1	1	1	1	1	1
DATE ASSESSED (YYMMDD)	940629	940629	940629	940726	940825	940825
LEAF RANGE						
HEIGHT (CM)						
GROWTH STAGE						
PLANT DENSITY (PL/SQ.M)						

2,4-D AMINE -RPC; BROMOXYNIL -RPC; CGA-184927/185072 -CGC; FENOXAPROP-P-ETHYL/MODIFIER -CAX; MCPA AMINE -RPC; MCPA ESTER -CAX (3:1); MCPA ESTER -CAX (4:1); MCPA ESTER -RPC (2:1); MCPA ESTER -RPC (8:1); SCORE -CGC; THIFENSULFURON (DPX M6316) -DUQ;

APPLICATION INFORMATION

APPL INFO#	SOL VOL L/HA	TOT SPR L/HA	PRES KPA	APPLICATION TIMING	APPLICATION METHOD	HT M	TEMP C	HUMID %	WIND KM/HR	DATE	TIME	RAINFALL (MM/WK) BEFORE	AFTER	SECOND	1ST SIG. RAIN DAYS	MM
1		100	210	POST-E	PUSH TYPE SPR		11	75	2	93/07/21	0900	10	8	3	18	24

GROWTH STAGE INFORMATION

GROWTH STAGE INFO#	PLANT (VARIETY)	BBCH MN	BBCH MX	ZADOKS MN	ZADOKS MX	LEAF MN	LEAF MX	LEAF MJ	HEIGHT (CM) MN	MX	MJ	GROWTH STAGE	DENS PL/M2
1	RED FESCUE (BOREAL)			12-	14	2	4	3					
	M BROMGRASS			12-	14	2	4	3					
	TALL FESCUE (COURTNE)			12-	14	2	4	3					
	T-WHT GRASS			12-	14	2	4	3					

INCORPORATION INFORMATION

INCORP INFO#	DATE	TYPE	DEP CM

NCLUSIONS: HAY AND SEED YIELDS FROM THE THREE GRASSES FROM PLOTS WHERE HERBICIDE TREATMENTS WERE APPLIED WERE SIMILAR TO OR EATER THAN THOSE FROM CHECK PLOTS. ICAR #: 39057001. SBD #: (AG CANADA ONLY) 38014217101. (AG CANADA RESEARCH STATION, AVERLODGE).