

6th EWRS workshop on Physical and Cultural Weed Control, Lillehammer 2004.

Report on a roundtable discussion on
Guidelines for physical weed control research

Participants: Johan Ascard, Tijmen Bakker, Piet Bleeker, Tim Chamen, Alicia Cirujeda, Daniel Cloutier, Fredrik Fogelberg, David Hansson, Nasser Hosseini, Dirk Kurstjens, Henrik Larsen, Maryse Leblanc, Kjell Mangerud, Geert-Jan Molema, Jan Netland, David Pullen, László Radics, Michele Raffaelli, Jesper Rasmussen, Theo Ruissen, Helge Sjursen, Becky Turner, Petri Vanhala, Jan Wevers (total 24 people).

Brainstorming

In the plenary part of the roundtable discussion, expectations and useful topics to be covered by a guideline paper were identified. The present paper (full list of topics included at the end) already includes several of the topics (to some extent) mentioned by the participants:

- Statistical methods and experimental design
- What (combination of) assessments should be done to
 - assess the initial situation in an experiment
 - describe soil and weather conditions before and after treatments
- How to perform treatments and avoid bias by differences in personal skill.

However, some topics have not been covered yet (or to a very minor extent):

- Include experiences on methods that have been tried out without success, to prevent “re-inventing the wheel”.
- Discuss what could go wrong in experiments and what should be considered.
- How to deal with the complex dynamic adaptation of the systems we study?
- What is scientifically acceptable? The current paper mainly suggests methods and discusses their advantages and weaknesses but does not always provide a standard.
- Discuss different approaches (ranging from on-farm trials to fundamental) and their appropriateness as related to objectives. There is a need to review the achievements, strengths and weaknesses and perspectives of various approaches, with suggestions how to proceed. Jesper and Dirk would like to write a paper on this issue.
- Where possible, adopt existing guidelines and protocols from EPPO (the European Plant Protection Organisation) and ISSS (the International Soil Science Society) on experimental design and how to perform assessments on weeding effectiveness, crop damage and soil properties. These guidelines provide standards on HOW to perform measurements. As a group on physical weeding, we should deal with the question WHICH measurements and classification scales to use. Contacting these organisations and FAO or ISTRO (International Soil Tillage Research Organisation) to further develop and harmonise guidelines was recommended.

After the break, three topics were prioritised to be discussed in small groups, identifying specific problems, possible solutions, and people’s plans to actually work on it.

Describing adjustments and quantifying weeding aggressiveness

Participants: Tijmen, David H, Kjell, Piet, Jesper, Maryse, Jan N, Dirk, Geert-Jan, Helge, ...

- Stating the objective or reason for choosing a certain adjustment (e.g. aim at 20% crop covering) and quantifying the achieved level of damage (shortly after cultivation) are of prime importance. As there is no consistent relation between tool adjustment parameters (e.g. working depth, speed, tine angle, tine spacing and tine arrangement) and the resulting crop damage and weed control, these are of secondary importance. Nevertheless, they

should be documented as well. With torsion weeders, it should be stated whether tine spacing refers to the working or uplifted tool position.

- Crop damage is a better reference for weeding intensity than weed control. The development stage should be accurately described and tolerance experiments like those of Daniel and Maryse are of great value. Quantifying crop damage in terms of plant loss and soil cover is not applicable with blind harrowing before crop emergence. In that case, the number of uprooted emerging plants could be an alternative parameter for direct damage.
- We should use more pictures. Pictures of damaged and non-damaged crop (both a small area from above and plot overview) and stating the associated visual damage class is very helpful and could help to develop reference scales for different crops and growth stages. Reference charts are used to classify soil residue cover in tillage studies.
- Digital image analysis could be a suitable tool to classify both crop cover and soil crumbling, as alternative to (subjective) visual classification. More studies are needed.
- As crops recover from soil covering (sometimes rather quickly, within 24 hours), the time of assessment is very important. Repeating observations at several times (e.g. using digital image analysis) could reveal valuable information on this matter (e.g. derive a suitable time from the decline of crop soil cover over time, avoiding potential irregularities). The length of the soil-covered period logically is related to growth reduction and may depend on soil and weather conditions (e.g. plant turgidity, soil surface slaking).
- Relating crop cover and density reduction to yield reduction is important (plasticity in growth). What would be the threshold covering level that induces growth reduction? What level of plant loss cannot be compensated? This probably depends on conditions and could be important to study in tolerance experiments.
- Measuring tine draft (directly by force transducers or indirectly by tine deflection) could be a way to quantify weeding aggressiveness independent of (species- and growth stage-related) plant tolerance. These forces could then be compared to plant anchorage forces. Similarly, soil level upheaval and plant height could be independent parameters of covering aggressiveness and plant tolerance. Soil upheaval and the true working depth can be easily measured using marked sticks placed before cultivation. Visual classification of the degree of soil crumbling and the intra-row soil cross section area actually disturbed by cultivation could also be valuable qualitative indicators of disturbance intensity.

Some items for further work:

- There is a need for standardisation. It was decided that one or two people come up with specific suggestions. Who wants to volunteer besides Dirk?
- What level of crop damage would be a useful and approximately optimal guideline for weeding aggressiveness? Maryse intends to vary the level of aggressiveness in future tolerance experiments. This is very welcome.
- How to improve visual assessments and devise a standard for assessment time? Kjell and Lars-Olav Brandsaeter plan to conduct harrowing experiments using digital image analysis. This could provide highly valuable information.

Describing soil conditions

Participants: Tim, Alicia, David P, Jan W, Michele, ...

To clearly identify the site, documenting the location (grid reference), texture (% clay, % silt, % sand or using the ISSS soil type classification), the organic matter content, the presence of stones and defining the depth of the topsoil to which these parameters apply is essential. Combining gravimetric moisture content and plasticity index (Atterberg limits) suitably describes the moisture status and characteristics of the soil. Photographs should supplement measures before and after treatments are applied, and these can be calibrated for scale if required. Soil bulk density, cone penetration resistance and shear strength were also

considered essential. Two out of three should be measured to describe soil strength (or hardness). Basic soil mechanical properties to study soil-tool and soil-wheel interactions are soil cohesion and angle of internal friction, which together describe the relationship between normal pressure and shear strength (Mohr diagram). To assess these parameters, a special apparatus is required, which is generally unavailable to weed scientists.

Supplementary characteristics could be: pH, fertility (mainly N content), slope, elevation, and rainfall patterns, evapotranspiration and soil water content during the cropping cycle. If soil conditions (particularly soil moisture) vary within the field as a consequence of the different treatments, moisture sampling on the different plots is recommended. Photographs (with scale indicator) are also very instructive (e.g. indicating the aggregate size, evenness, the presence of a crust, etc.).

Choosing approaches

Participants: Becky, Fredrik, Nasser, Daniel, Theo, Petri, ...

Which approach you will choose for a specific situation depends on

- what are your objectives
- what are your opportunities to cope with the problems
- who are the stakeholders
- who are involved

There are several approaches ranging from fundamental research to on-farm trials. A scientist needs results that can be generalized, while a farmer needs solutions to his own specific situation. For fundamental research, aiming at extended knowledge, intensive scientific studies (on e.g. system dynamics) in controlled experiments is a proper approach. On-farm trials (led by scientists, or even farmers doing their own experiments) are useful when working for farmer's problems, while on-station trials is an option in between these two extremes. Additionally, other dimensions can be mentioned, such as doing farmer surveys or participatory research. None of the approaches is alone a solution to all needs. Often a combination of "experimental (scientific) design" and on-farm experiments is needed. Becky agreed to make a list of pros and cons for different approaches.

When choosing approach:

1. One needs the objective
2. The objectives should be parameterised, so one can deal with them
3. Then, the approach (fundamental research, on-farm, participatory, ...) can be chosen.

Some other notes and comments:

- Science is also to develop a theory. One of the problems in research is that we tend to ask "What if?" (e.g. "What if we increase the speed or ..."), but we don't frequently enough stop to think "Why?". However, this is a fundamental question.
- Deciding the approach is often constrained by where you get your funding from
- We may be dealing with constrains (such as weeds >< pests; the treatments may have different effects on these – some positive, some negative)

Further steps

This report will be sent to Daniel for publication on the EWRS-PCWC website. The current full guideline paper is on the proceedings CD and will be published on the EWRS Education and Training website (www.ewrs.org/et) with a DOI (Digital Object Identifier).

The report of this roundtable discussion is sent to all participants and authors of the present paper, so that everyone can make additions and follow up on the discussion. These discussions can be transformed into text (e.g. by Petri and Dirk) which will be added on the website. Becky agreed to make a table reflecting the possibilities and limitations of various approaches. Alicia will try to work out a suggestion for assessing topsoil conditions

(aggregate size distribution) with mechanical weeding. Further contributions to improve the guideline paper are very welcome. They will be acknowledged by adding you as a fellow author of the supplementary paper (and later on the second version of the guidelines), which will also be published on the EWRS Education and Training website. Also entire chapters or papers on specific guideline-topics by one or several authors can be added. These papers will also be given a DOI (Digital Object Identifier), so they can be properly referenced and all contributors are acknowledged for their input.

Guidelines for physical weed control research: Present topics

General aspects

Experimental design

- Related to objectives: comparing qualitative treatments, quantitative series (e.g. intensities)
- Plot size and position, blocks layout and structure. Randomised blocks, latin square, split-plot
- Number of replications and sample size, within- and between-plot variation, how to deal with spatial heterogeneity?

Analysis

- Transformations, distributions, dealing with counts and proportions
- Analysis of variance, generalized linear models, regression
- Presentation of results

Describing the experiment

- Site and experimental conditions
- Machines and adjustments
- Weeds and crops

Checklist for research

Assessing crop damage and weed control

Visual evaluations

- Strengths and weaknesses as compared to counting
- Reference scales, comparative (to weed free or no treatment) or absolute value?
- Statistical aspects, how to maximize reliability and accuracy

Countings and biomass

- Number, size and place of quadrats and samples
- The number of plants to be counted per quadrat
- Assessment timing and frequency

Thermal weed control

Experimental set-up

- Dose response experiments or qualitative comparison?
- Natural weeds or test plants (e.g. *Sinapis alba*)?

How to perform the treatments

Describing the equipment and adjustments

Advantages and limitations of temperature measurements

Mechanical weeding – weed harrowing and intra-row cultivation

Influence factors, different research objectives and approaches

- Comparing implement selectivity: quantitative approach
- Comparing methods by single cultivations, how to optimise weeding intensity
- Fundamental issues: intensity-response curves, distinguishing between selectivity and intensity (aggressiveness), methods to assess intensity, real-time crop damage, recovery

Describing the intensity, equipment and adjustments

Assessing plant response

- Crop soil cover, efficacy on natural or artificial weeds
- Tolerance experiments