Effect of plant dry mass on uprooting by intra-row weeders

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Introduction

The effectiveness of intra-row mechanical weed control depends on crop and weed growth stages, machine adjustments and soil conditions. We aim to develop a set of field assessments to quantify the performance of selective mechanical weeders such as weed harrows, torsion weeders and finger weeders. This measurement protocol should allow analysis of plant, soil, weather and machine effects and allow for better comparisons between sites and times. The method to quantify the percentage uprooted plants as related to plant dry mass presented in this paper is a component of this envisioned protocol.

Materials and Methods

Immediately after mechanical weeding, uprooted and non-uprooted plants were separately collected from 5-cm wide intra-row zones. The total length of the excavated zone per plot ranged from 2-10 m, depending on weed density. In the laboratory, collected plants were washed, separated per species, dried for 24 hours at 105°C and then weighed individually. Based on sorted lists of plant dry weight and uprooting status per species and implement, the relationships between plant dry weight and %uprooting were plotted, with each point representing 9-31 plants.

Data were gathered from field experiments with torsion weeders, finger weeders and a spring tine harrow on sandy and clay soil, at two subsequent treatment dates.

Results

The first mechanical weeding was generally more effective than a second pass 9-10 days later (Fig. 1). This was partially related to the increased median dry weight of all weeds (sand 9/16: 0.003 g; sand 19/6: 0.017 g; clay 24/5: 0.025 g; clay 2/6: 0.070 g). In most situations, the variation in plant dry mass within species was so large (variation coefficients ranging from 1.2 to 2.1) that uprooting effects at different sites and times can only be compared sensibly using plants of approximately the same size (Fig. 2).

When taking plant mass into account, torsion weeders were more effective than the weed harrow or finger weeders, except on clay soil (Fig. 3). On sandy soil, the first torsion weeding was more effective than the second with *Poa annua* (Fig. 3A, B), whereas points of *Solanum nigrum* and *Stellaria media* were approximately on the same curve (Fig. 3C, E).

Linear relationships between logit-transformed uprooting percentages and plant dry mass were fitted to individual plant data, using IRREML in Genstat 5. Maximum weed uprooting percentages (at zero plant weight) below 100% may indicate a less intense or an irregular disturbance of the intra-row topsoil. The plant mass at which a certain percentage is uprooted could be used to

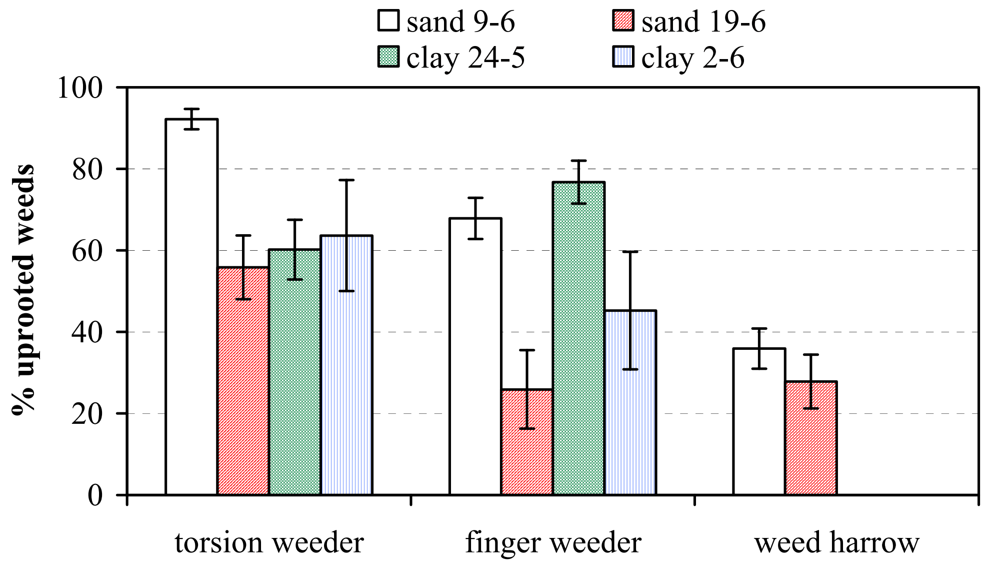

Figure 1. The uprooting effect of mechanical weeders on different soil types and treatment dates. Means of all species together with mean standard errors.

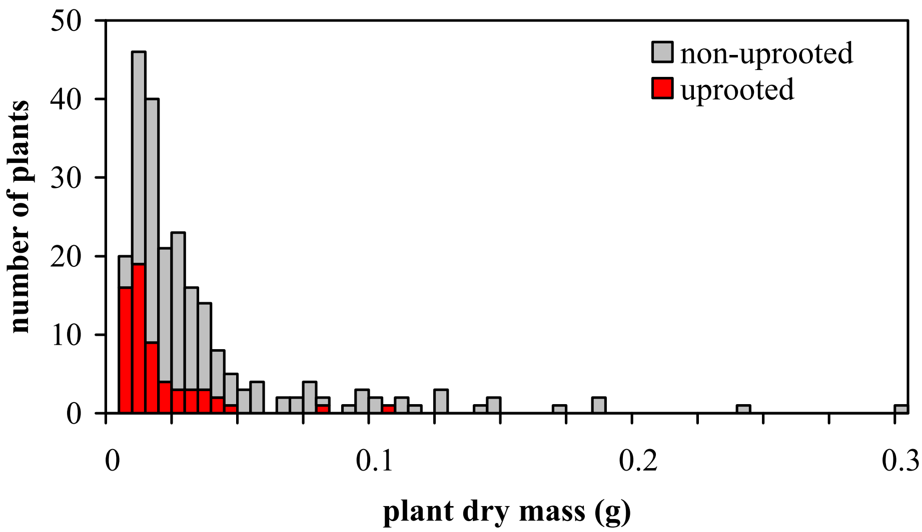

Figure 2. Example frequency distribution of *Solanum nigrum* plant dry mass collected directly after finger weeding and weed harrowing on sandy soil at 19/6. The corresponding relationship between plant dry mass and uprooting is depicted in Fig. 3D.

compare effects of site characteristics or implement adjustments. The slope of the curve may be related to the selective uprooting ability of the weeders.

Discussion

As the sensitivity of weeds to uprooting varied considerably within populations present in the field, it is sensible to take account of this variation when comparing mechanical weed control effectiveness between sites and times. If soil conditions and machine adjustments are adequately recorded as well, regression models that include individual plant dry mass may be used to analyse these effects.

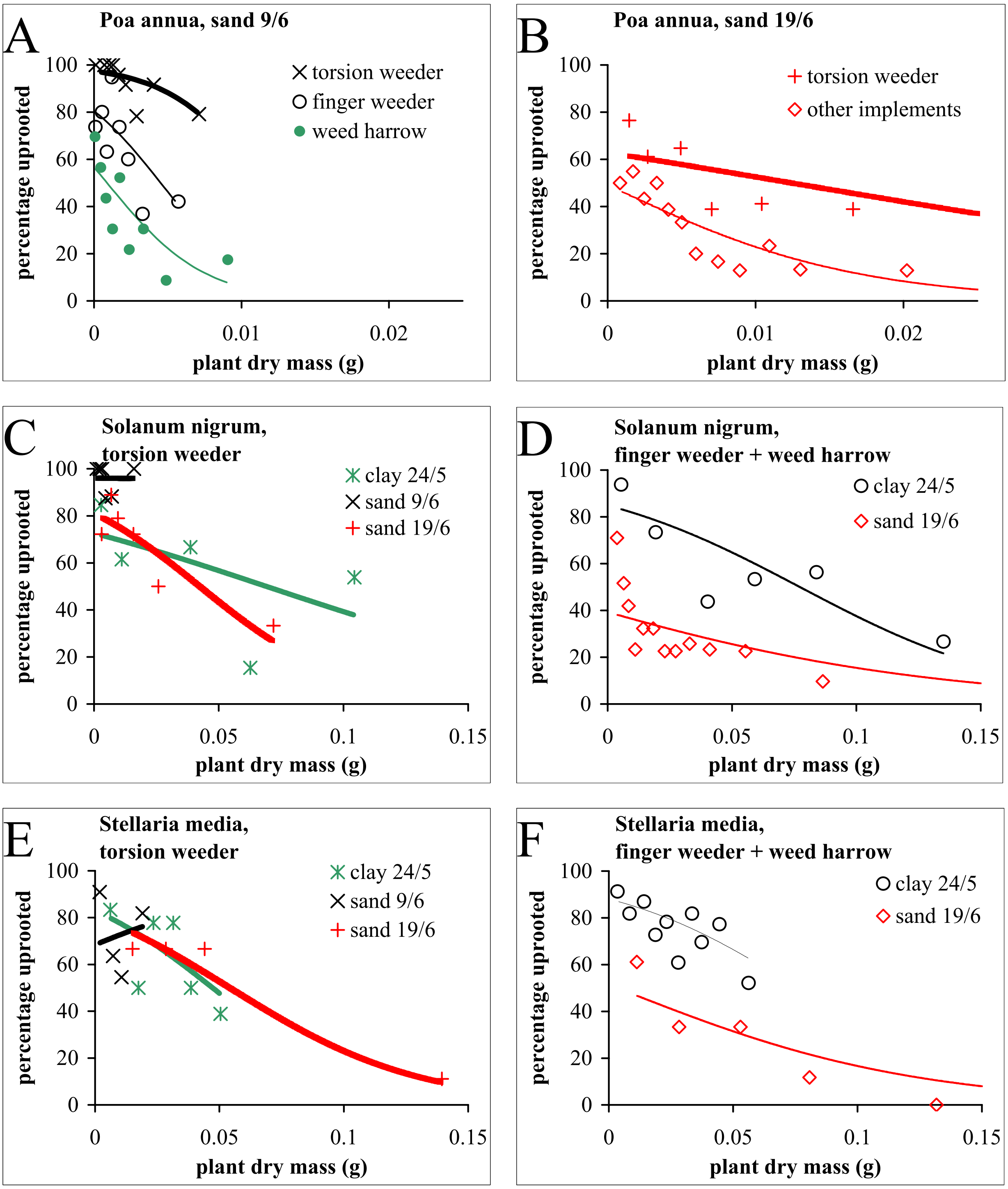

Figure 3. Relationships between plant dry mass and the percentage uprooted weeds per species.

This method appears suitable to assess uprooting if plants are not moved to or from the row. This precondition probably does not apply with finger weeders, so that weeds should also be counted before treatment at the same spot. Principally, this method could be applied to covering damage as well, by collecting plants in four categories (before excavation: visible uprooted, visible not uprooted; during excavation of loose soil: covered uprooted, covered not uprooted). Such measurements combined with a method to assess plant recovery from uprooting and covering damage and new weed emergence a few days after treatment could help explain the variability in mechanical weeding effectiveness.

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Shortcomings of current experimental methods

- Effect of time, year and location caused by:
  - Plant growth stage
  - Soil conditions
  - Implement use

  } Direct effect: { Uprooting / Covering

  - Weather and soil conditions after cultivation
- Problem: analysis of confounded effects
- Solution: separate factors by measurements:
  - Quantify both direct and final effect
  - Assess plant growth stage at cultivation
  - …

New method (1)

perform weeding treatment

collect
uprooted weeds

collect
non-uprooted weeds

wash, dry & weigh
uprooted weeds

wash, dry & weigh
non-uprooted weeds

database: individual uprooting status and dry mass

sort & group dry
mass per species

fit linear relation per
species (GLMM)

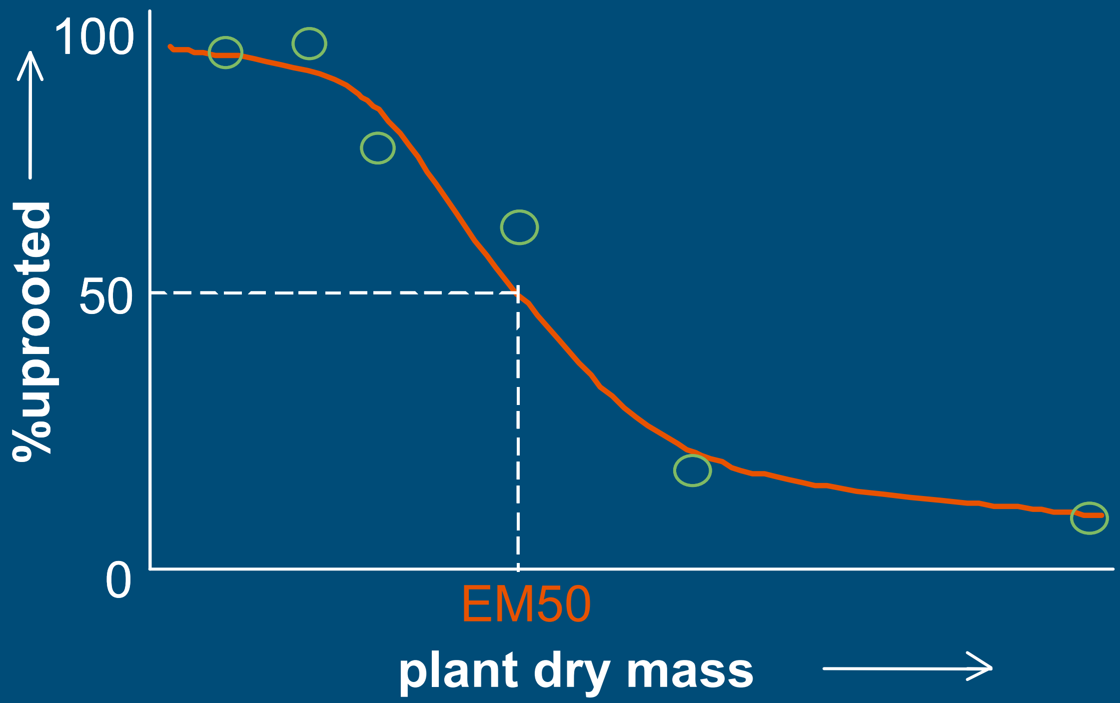
%uprooted per mass
class per species

EM50 + slope
per species

New method (2)

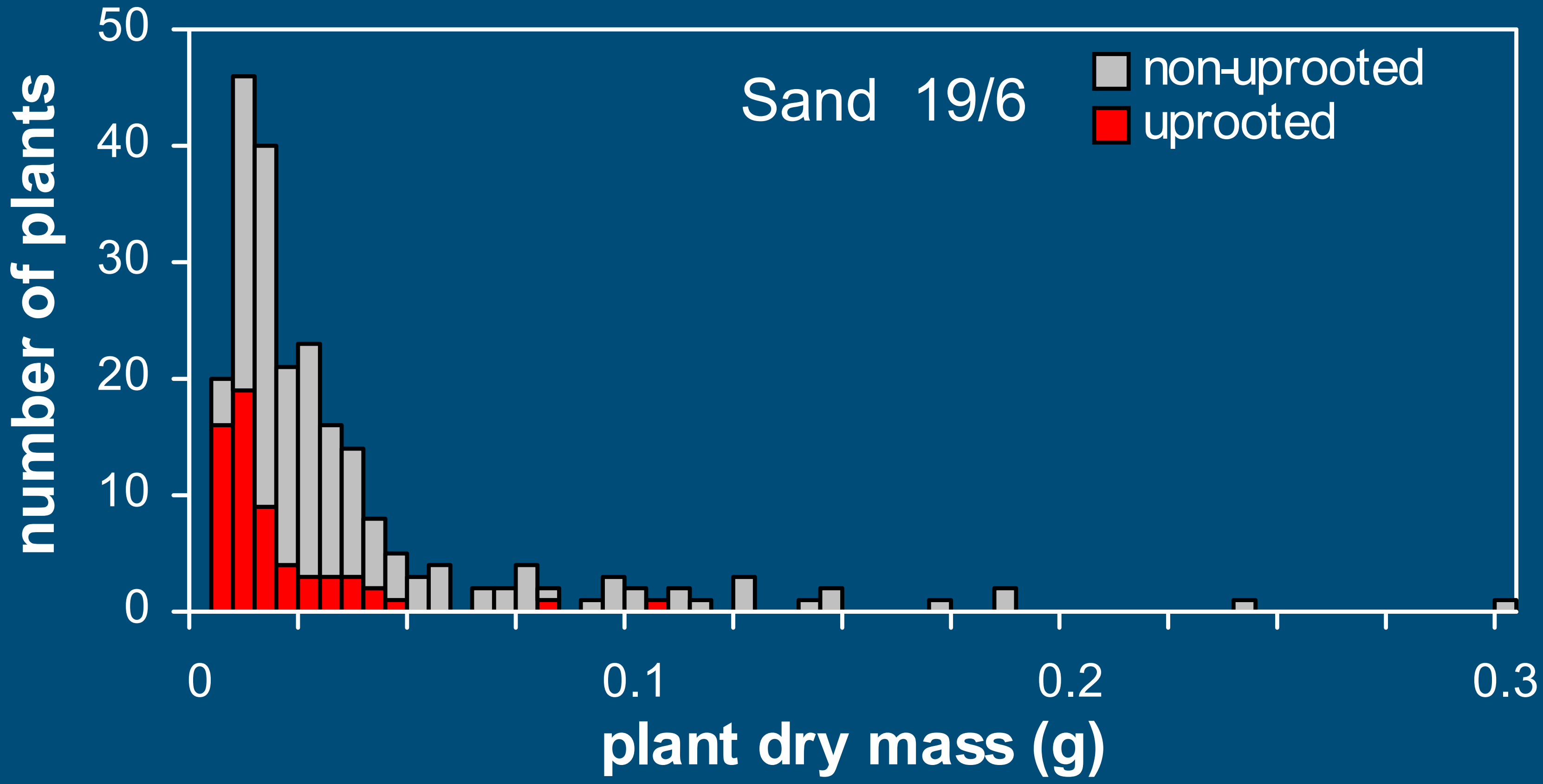
%uprooted per mass class per species

EM50 + slope per species



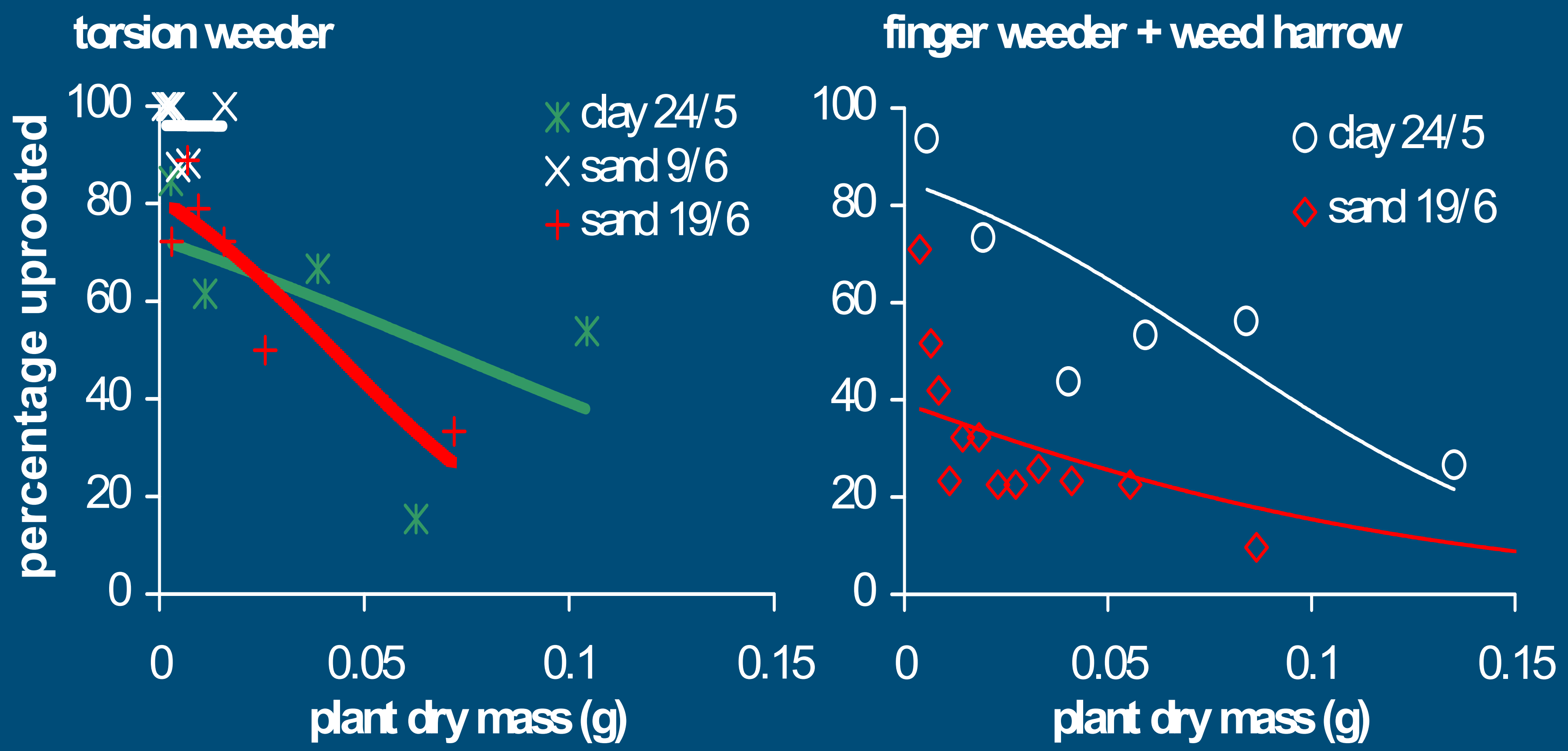
Results (1)

Solanum nigrum



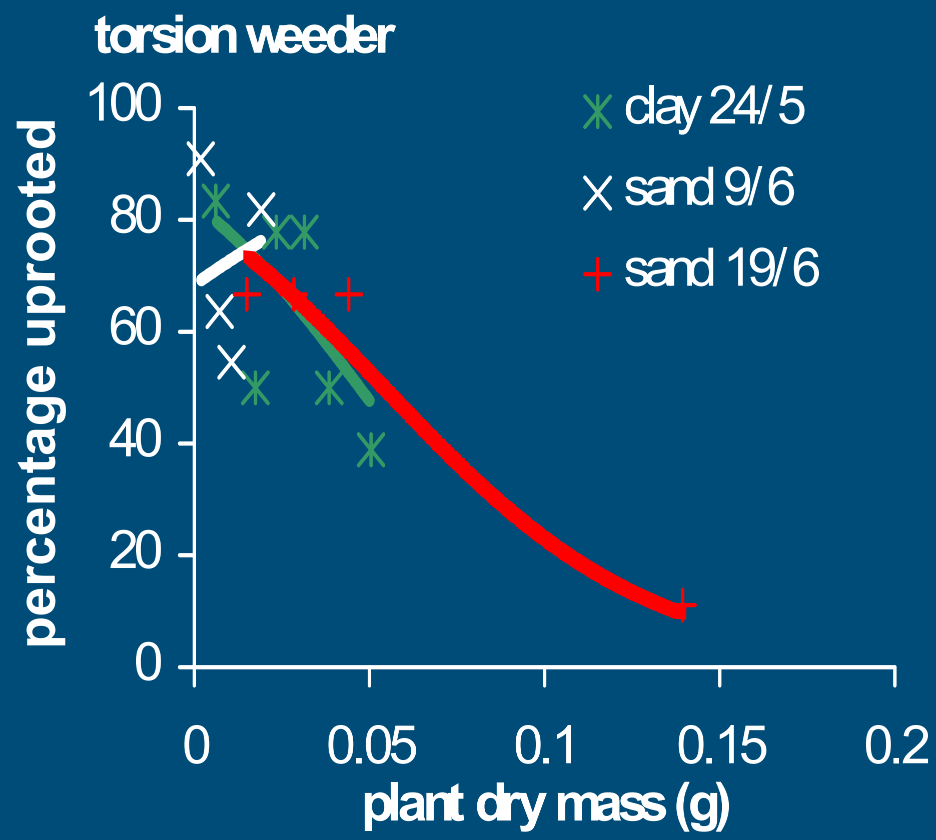
Results (2)

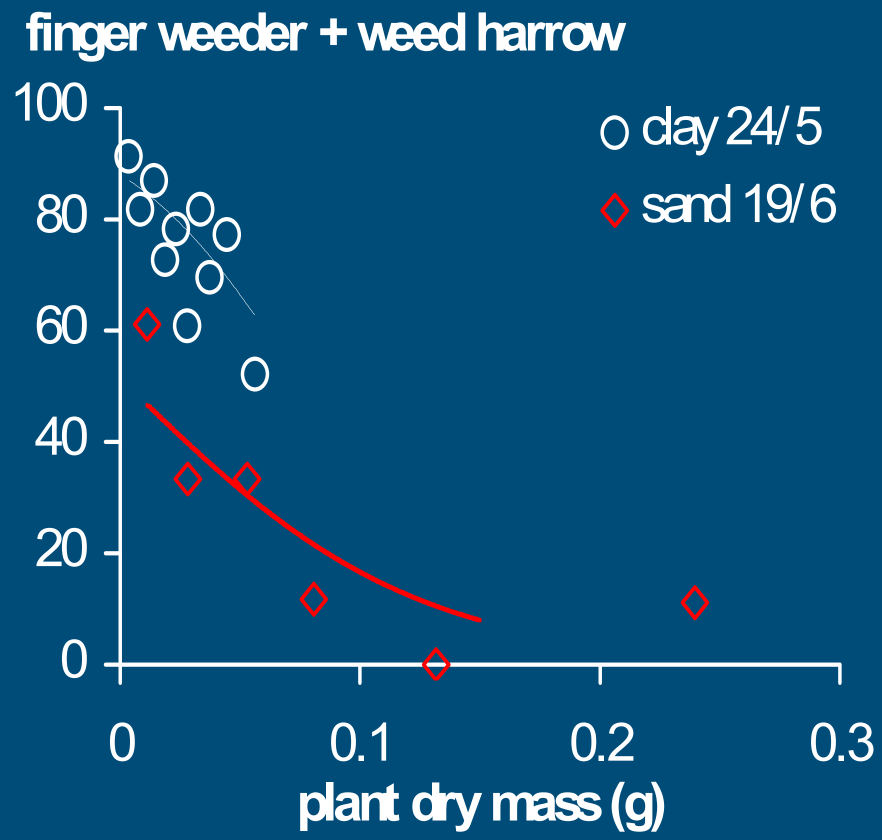
Solanum nigrum



Results (3)

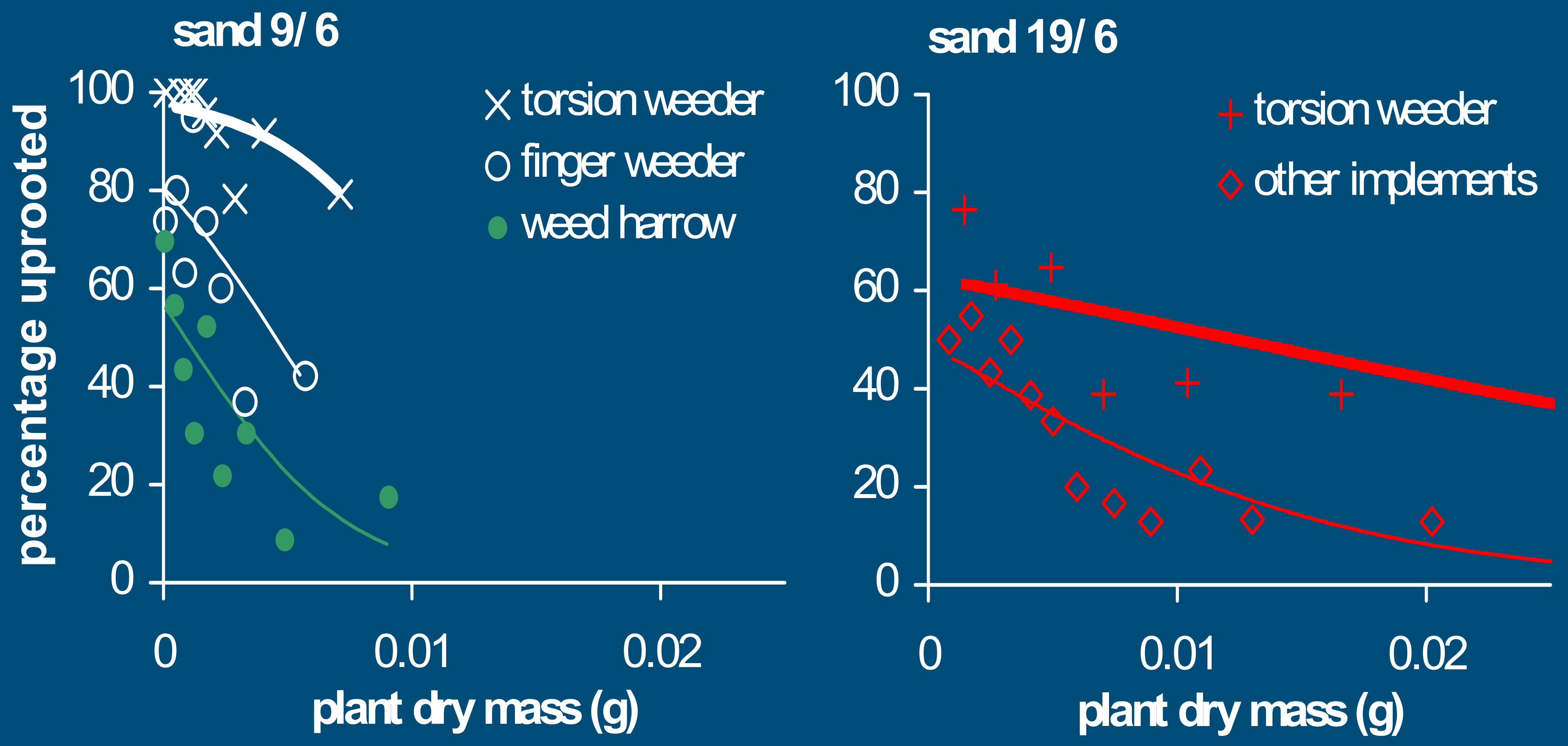
Stellaria media





Results (4)

Poa annua



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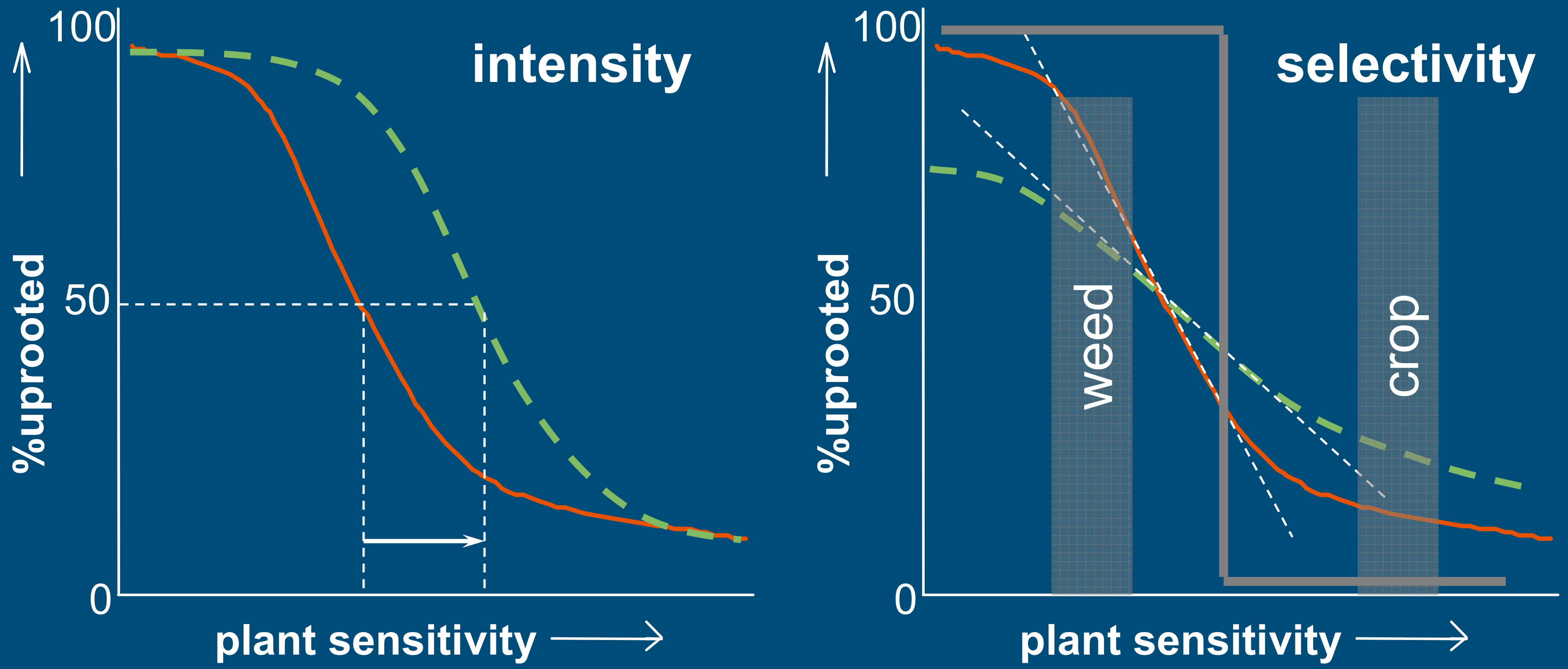
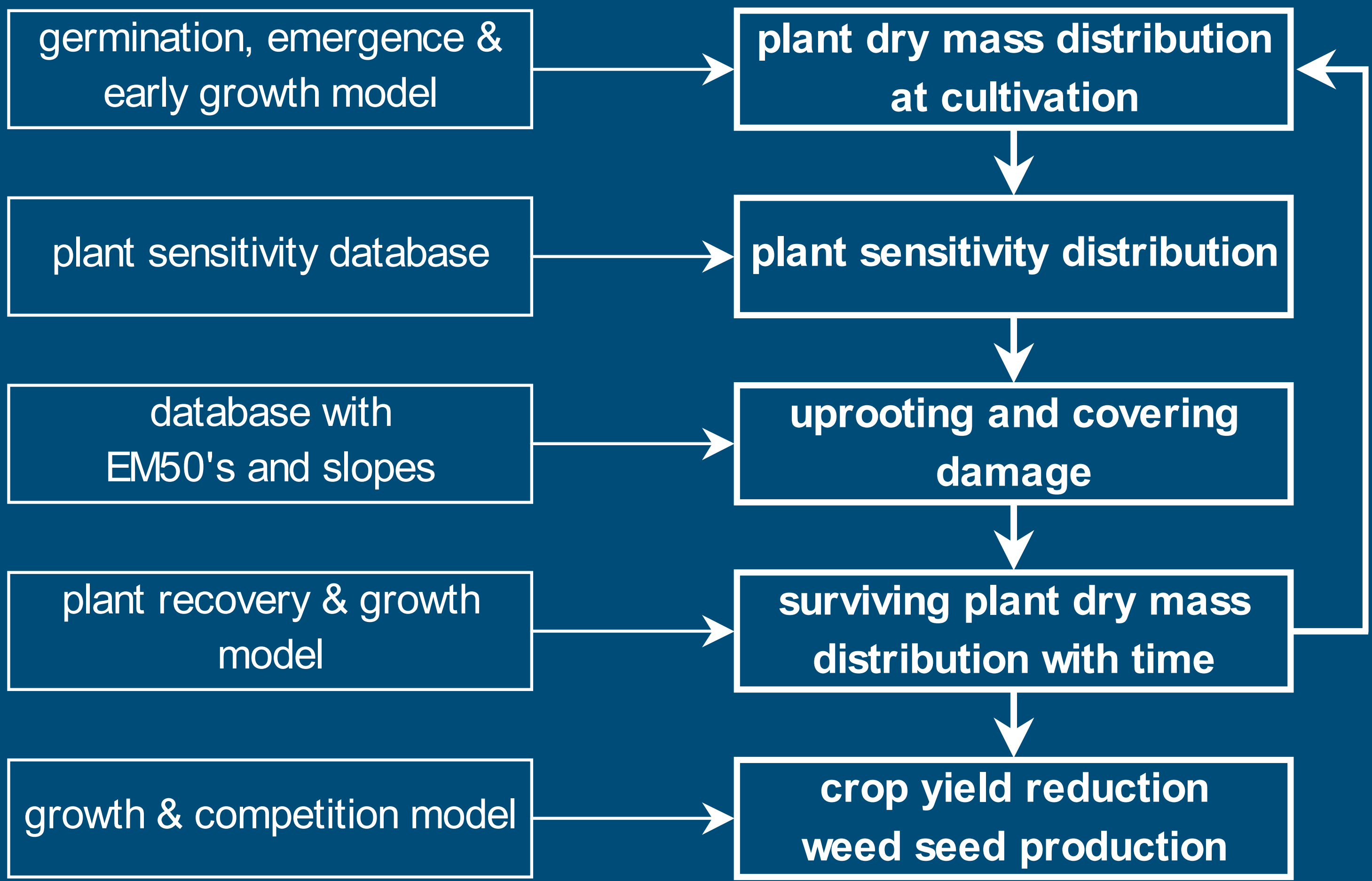
Quantitative analysis (1)



Quantitative analysis (2)



Next years' improvements

- Account for plant movement into or from the row:
  - Count weeds before cultivation
- Discriminate surviving from newly emerged weeds
  - Remove weeds before cultivation in a neighbouring row, count & weigh before the next cultivation
- Apply the method to covering damage as well
  - Collect & individually weigh weeds in 4 classes
- Assess recovery from mechanical damage
  - The same destructive assessments in a neighbouring row, counted at the previous cultivation
- Measure working depth and soil moisture content, describe topsoil conditions

Conclusions

- Different weed development stages explain a considerable part of uprooting variability between sites and times
- Assessment methods should take account of within-population variability
- The proposed method is a valuable component in the analysis and modelling of mechanical weeding effectiveness

Questions and discussion

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