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Effect of weed & crop variability on selectivity of mechanical weeders

Dirk Kurstjens Institute of Agricultural and Environmental Engineering (IMAG), P.O. Box 43, 6700 AA Wageningen, The Netherlands. d.a.g.kurstjens@imag.wag-ur.nl

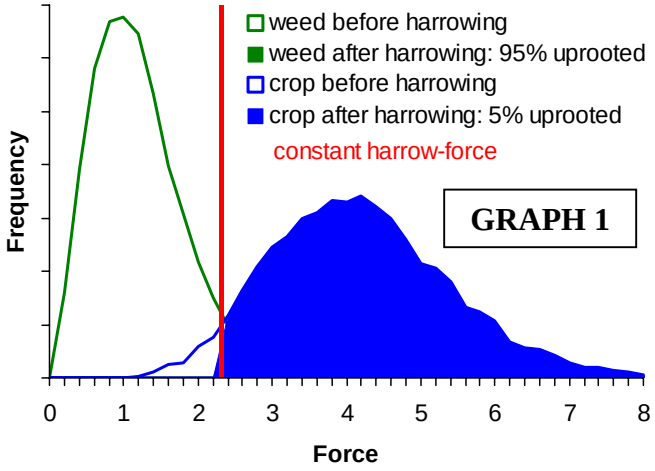
Introduction

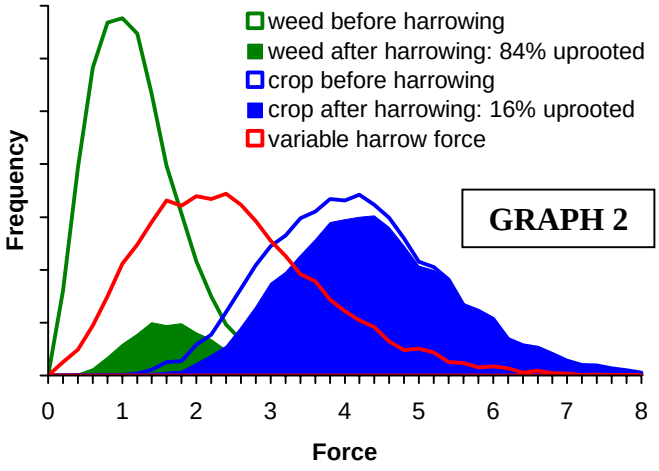
This paper discusses the role of variability between individual plants within the crop or weed population on the ability of mechanical weeders to uproot intra-row weeds with minimum crop loss. This selective ability is required to control weeds in small, weakly established crops. In addition, the role of variability of the implement action (e.g. weed harrow, torsion weeders or finger weeders) is discussed.

The variations we refer to occur within assessment plots of experiments. Variations between assessment plots (flora composition: species, stage, density; soil properties; implement effect & steering variations) are regarded as experimental error, which is dealt with by experimental set-up and statistical techniques. The variations within assessment plots (flora composition: species, stage; spatially heterogeneous implement action) are essentially process-related variations. How to deal with this type of variation?

Selective uprooting of intra-row weeds

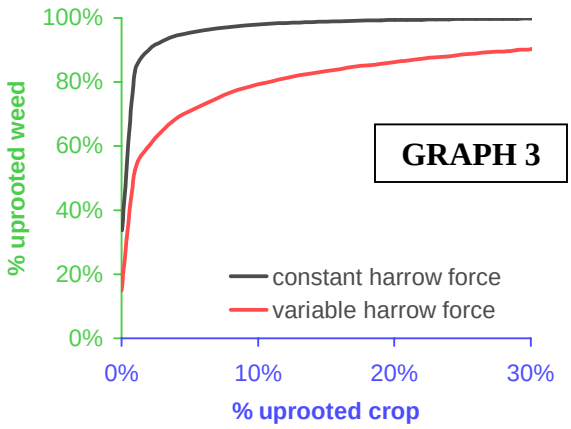
A simple case to start with is uprooting action of a weed harrow, torsion weeders or finger weeders. We assume that an individual plant is being uprooted if the force applied by the implement exceeds the anchorage force of that plant. As there is certain variability in anchorage strength, only the weakest plants are uprooted. As crop plants are generally better anchored than weeds, their uprooting probability is lower. If the force applied by the harrow were constant, the uprooting action would be very selective (graph 1). In case of a variable harrow force, less weeds and more crop plants will be uprooted (graph 2).





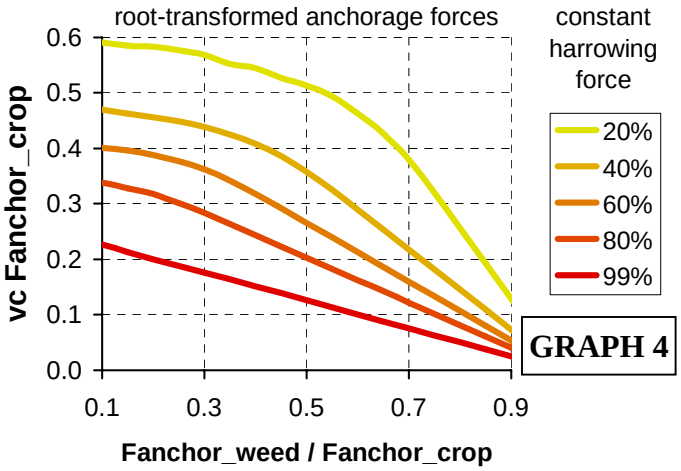
Thus, weeds that are most difficult to control are left to be controlled by a subsequent treatment. This phenomenon could cause a declined efficacy of later treatments. The fact that mainly the smallest crop plants are uprooted could imply a relatively low impact on yield (as compared to sowing density – yield relationships in sowing density experiments). If this were realistic, higher crop losses could be tolerated if the forces applied by the implement are less variable. Moreover, if implement-applied forces are less variable, the mean force could be higher (more aggressive adjustment), resulting in more weed control.

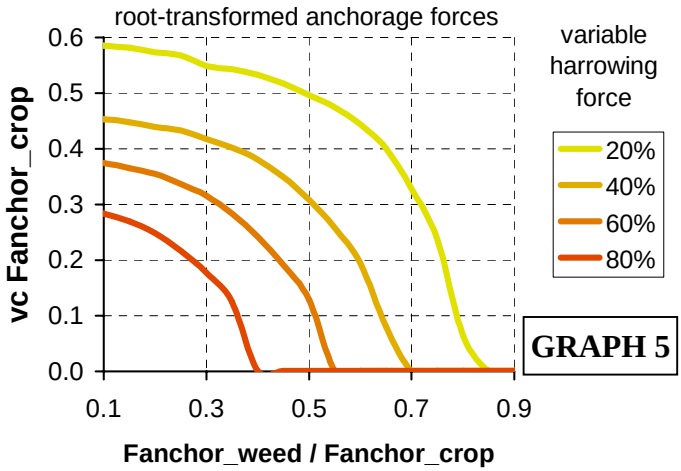
Graph 3 shows the simulated relationship between uprooting of the weed and crop population (from graphs 1 and 2), when the mean harrow-applied force is varied (with constant variation coefficient of the square root transformed harrow-applied forces).



Achievable selectivity

The effect of weed and crop variability (identical standard error of square root transformed anchorage forces) on the achievable percentage uprooted weeds at 5% crop loss is simulated assuming a constant harrow-applied force (graph 4) or a variable harrow-applied force (graph 5, variation coefficient of the square root transformed harrow-applied forces = 0.4, which is higher than 0.26 used in graphs 1-3).





Graphs 4 and 5 show that more weed control can be achieved if the variation between plants (vertical axis, vcFanchor_crop = standard error of the anchorage force / mean anchorage force of crop plants) is smaller. As the difference between weed and crop declines (moving to the right on the horizontal axis), lower variability between plants is required to achieve the same selectivity. If harrow-applied forces become more variable (graph 4 -> graph 5), the difference between crop and weed anchorage limits the achievable weed control. In case of the example in graphs 1-3 (vcFanchor_crop=0.15, Fanchor_weed / Fanchor_crop=0.5), the achievable degree of weed control declines from 95% to 60%.

Concluding remarks

The previous examples show that variability between individual plants within assessment plots can influence the result of mechanical weeding. The notion of within-plot variability may have implications for research methodology. There are many questions left to be discussed, such as:

- Is within-plot variation large enough to be relevant?
- What are practical ways to deal with within-plot variation?
- Would it be possible to use the within-weed or within-crop variation to assess the selectivity of intra-row weed control treatments?

If you have thoughts on this matter, please contact me.