Seven ways to improve the selective ability of mechanical intra-row weeders

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Introduction

In most farming systems, particularly the selective weed control methods (that control weeds but spare the crop when applied to both) fulfil a crucial role. Although many alternative preventive (e.g. cultivation, competitive (inter)crops, green mulch, weed seed harvesting) and curative (e.g. mechanical, thermal, biological) methods are available, farmers still rely heavily on the selective action of herbicides. As the available number of selective compounds will decrease (Chapman, 2001), the reliability and cost-effectiveness of other methods should be improved to facilitate their adoption. Possibilities for successful non-chemical weed control particularly influence the adoption of organic farming practises. Here, a main problem is controlling intra-row weeds in early growth stages of slowly growing, weakly competitive crops that are sensitive to mechanical damage. Basically, this problem could be tackled by:

1. Decreasing the number of weeds requiring control in this sensitive period (e.g. by false seedbeds, delayed sowing, pre-emergence flaming, competitive (inter)crops),
2. Improving crop resistance against damaging relative to the weeds (e.g. by altered seedbed structure, row-applied nutrients, crop cultivar selection),
3. Improving the selective ability of mechanical weeding operations.

This paper focuses on the last option and presents seven possibilities that emerged from field and laboratory experiments.

Material and methods

Laboratory harrowing experiments with three species (*Lolium perenne* L., *Lepidium sativum* L. and *Chenopodium quinoa* Willd.) in early growth stages were performed on sandy soil to explore the mechanism by which plants are covered (Kurstjens & Perdok, 2000) and uprooted (Kurstjens et al., 2000). Mechanical damage and plant response (mortality and fresh weight reduction after six days) of individual plants was assessed at various working depths, working speeds and soil moisture contents (Kurstjens & Kropff, 2001).

From 1999 until 2001 field experiments in sugar beets, seeded onions and maize on sandy and clay soil have compared several tools for mechanical intra-row weed control (Bleeker et al., 2000; Kurstjens & Bleeker, 2000; Bleeker, 2002). Torsion weeders, finger weeders, ground-driven brush weeders and spring tine harrows were used at various crop growth stages and aggressiveness of adjustment. Intra-row weed control and crop damage was assessed at cultivation (percentage uprooted), before the next cultivation (weed counts) and at harvest (crop yield), occasionally supplemented by recording the time required for hand weeding.

Results and discussion

Although the experimental evidence is still limited and cannot be fully presented in this paper, several possibilities for improving the effectiveness of selective mechanical intra-row weeders could be inferred:

1. Improving the handling of machines by making them quickly and easily (preferably centrally) adjustable and by training farmers in using implement adjustments and in estimating the allowable crop damage directly after cultivation.
2. Maintaining an accurate and constant working depth is necessary to prevent uprooting of crop plants while maintaining the ability to control emerging weeds. Increasing laboratory harrowing depth from 10 to 30 mm increased seedling uprooting from 8 to 31%, whereas

uprooting of emerging plants increased from 39 to 65%. Thus, uneven soil surface and spatially variable seedbed conditions may locally cause high crop plants losses.

3. By precision steering of implements, spatial patterns of soil disturbance and soil flow around tines that cause spatially heterogeneous patterns of uprooting and soil-covering could be better exploited. In laboratory harrowing experiments, particularly plants near and on the tine paths were uprooted, whereas the selectivity between emerging plants and seedlings of the same species was highest in the zone between two tine paths. In addition, there were zones were much uprooting and little covering occurred and zones showing the opposite. With precise steering, this phenomenon could open the following possibility:
4. Exploiting the specific strengths of the crop and weaknesses of the weeds, regarding their resistance to being uprooted and/or soil-covered. Implement adjustments such as working depth, working speed and tool-crop row spacing allow the mode of action to be predominantly uprooting or covering. The covering selectivity between small firm plants and tall flaccid plants could be also changed by manipulating the covering mechanism (soil surface level upheaval and plant downward bending).
5. Preserving the intra-row soil in a workable condition and improve trafficability of wheel tracks, to increase the workable time. Even when using light tractors, the trafficability under moist soil conditions often appeared to be more critical for timely weed control than topsoil workability for the implement. In the laboratory, soil moisture content affected the selectivity of uprooting and covering damage. Ridge tillage and controlled traffic might contribute to improved timeliness and selectivity of mechanical weed control.
6. Developing mechanical weed control strategies for specific weather conditions. For instance, in dry sunny conditions: killing weeds mechanically by uprooting; in wet, cloudy conditions: smothering weed growth by soil-covering. Although effects of weather after cultivation have not been explicitly studied in our experiments, results confirm those of previous studies. In the laboratory, drier soil at harrowing (5% as compared to 16% w/w) increased mortality of uprooted plants after six days without irrigation from 36 to 91%. Compared to 12 dry days after harrowing, applying 6.4 mm of water directly after aggressively harrowing L. perenne (50% covered, 34% uprooted) increased total mortality from 35 to 43% and increased the fraction of plants remaining buried from 12 to 33% (unpublished laboratory results). In the field, the weed control effect in a wet period was sufficient to reduce hand weeding by 30-66%. Control of covered weeds was not markedly influenced by rain after cultivation. Further systematic research of plant recovery from mechanical damage is needed to confirm these occasional observations.
7. Decreasing the variability of sensitivity within the crop and weed populations. As predominantly the smallest plants within the population were damaged, the acceptable loss of small crop plants and the size of the largest weed plants limit the aggressiveness of cultivation and weeding effectiveness.

Some of the above options (1-3) require technical innovations before their importance can be evaluated. Others (4-7) require more research before purposive innovations can be initiated. If farmers could improve intra-row weed control using versatile, simple and cheap mechanical weeders, the effectiveness of selective herbicides could be preserved.

References

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