Current European weed control methods and strategies against annual and perennial weeds in organic farming

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European research in physical and cultural weed control methods has largely been driven by an increasing concern about pesticide usage. Governmental actions have been taken in the Nordic countries and the Netherlands to introduce action plans to cut pesticide usage significantly. An increasing conversion to organic farming, favourably subsidised by some European governments, has followed this pesticide policy and further increased the need for knowledge on non-chemical weed control. This paper reviews some of the major results achieved with non-chemical methods and strategies especially adapted for row crops (e.g. maize, sugar beet, onion, leek, and carrot) and small grain cereals and pulses (e.g. barley, wheat, peas and lupin), and it also highlights some of the future directions.

Intra-row weeds in row crops, *i.e.* those growing between the crop plants in the rows, constitute a major challenge, and research has mainly aimed at replacing laborious hand weeding with mechanization. Investigations have focussed on optimising the usage of mechanical methods against intra-row weeds, such as harrowing, brush weeding, hoeing, torsion weeding and finger weeding. These methods have been successful in some row crops, such as potatoes, maize, oil seed rape and transplanted vegetables, but they generally work with low selectivity, as they do not distinguish between weed and crop plants. The need for thermal and cultural methods to act in combination with the mechanical ones became evident especially in slow emerging crops with low initial growth rates, where physical intra-row weed control is difficult to conduct. Pre-emergence flaming now plays an important role in creating better conditions for mechanical post-emergence control, and late cover cropping to suppress late emerging weeds might be a useful solution to end a weed control programme in crops with poor canopy closure. Although the need for hand weeding has been reduced markedly, partly thanks to the achievements in research, new research is now aimed at eliminating the need. Robotic weeding and GPS-technology are investigated for row crops with abundant spacing between individual plants, and band-steaming prior to sowing row crops, developing dense crop stands in the row, show promise of effective and prolonged control.

In small grain cereals and pulses, weed harrowing has high work rates but operates with low selectivity meaning that high weed control might be associated with severe crop damages. In contrast, inter-row hoeing does not impact on the crop plants directly and thus is less harmful to the crop, but work rates are low. Both methods provide the best results when they become part of a strategy that also involves cultural methods. Combinations with cultural methods such as fertiliser placement, variety choice, crop seed vigour and crop seed rate may improve the outcome by improving effectiveness, crop tolerance to mechanical impact and crop competitiveness against weeds escaping control. Mechanical control is widely used in organic cereals, but more propitious tactics have to be developed for conventional cereals.

All the methods mentioned above are mainly effective against annual weeds and seedlings of perennials. Some of the methods also have effects against shoots of perennials but the magnitudes of these effects are generally unclear and mostly of short duration. Effective and more prolonged control of e.g. *Elymus repens* and *Cirsium arvense* normally require a weed control programme with extensive tillage during crop free periods.

The European work on physical and cultural weed control is discussed and disseminated through the working group: *Physical and Cultural Weed Control* (www.ewrs.org/pwc) under the *European Weed Research Society*.