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Non-chemical weed management strategies in minor crops: A review

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ABSTRACT

In minor crops the low availability or absence of herbicides impose to adopt an integrated use of non-chemical weed control methods. Minor crops include mostly vegetables, fruits, but also seed crops, herbs and plants for medicinal use and spices. Minor crops account for an EU production value of more than € 60 billion per year, representing more than 20% of the value of EU's total agricultural production. Sustainable production of minor crops is vital for both human health and national economies as it contributes to agricultural productivity as well as a diverse and nutritional food supply, and food security. Weed control vary depending on technical and economical factors such as cultivation system (open air or greenhouse), date of sowing or transplanting, market (fresh market, conservation industry, transformation industry, seeds industry) and knowledge. In this context, weed control with non-chemical methods can differ a lot due to the different peculiarities of minor crops. A review on the integrated weed management in minor crops using non-chemical methods could be useful to help the research to provide effective and sustainable solutions, push policies to deliver funding in order to improve from farmers the communication and the adoption of integrated non-chemical weed management strategies.

Contents

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1. Introduction

A combined use of different weed control methods (agronomic, cultural, physical, mechanical and chemical) is required in an Integrated Weed Management System (IWMS) (Buhler, 2002). This strategy is important to decrease the use of herbicides in agricultural systems (Berti et al., 2001). The use of non-chemical weed tactics in minor crops are important due to scarce availability of chemical compounds (Melander and Bàrberi, 2004; Upadhyaya and Blackshaw, 2007). An IWMS is accomplished by two steps: 1) management of weed community and 2) weed control (Berti et al., 2001). Management of weed community includes actions in crop and weed community. Actions on crop are represented by variety choice, densities of crops, mode and date of sowing or transplanting, in-row and intra-row distances, irrigation method, fertilization, the use of cover crops, etc. These actions are important to improve crop competitiveness against weeds. Actions on weed community are required to maintain a balanced weed flora and to reduce soil seedbank (Graziani et al., 2012). The first goal is reached by the use of crop rotation, cover crops and intercropping, while the second goal by cutting or uprooting weeds before they spread their seeds (e.g. stale seedbed, mechanical control).

In the European Union, a minor crop is defined as crop that is cultivated on a cultivation area of <10,000 >600 ha, the production is lower than 200,000 tons per year and the daily dietary intake contribution is <7.5 >1.5 g/day (European Commission, 2011). Whilst many major crops, such as cereals and maize, benefit from the access to a high number of herbicides, a wide range of minor crops grown in Europe suffers by the lack of herbicides (Tei and Pannacci, 2008; Lamichhane et al., 2015). Minor crops include mostly vegetables (i.e. leafy vegetables except lettuce, cabbages except cauliflower, radish, turnip, garlic, asparagus etc.), fruits, but also seed crops, herbs and plants for medicinal use and spices. Minor crops account for an EU production value of more than € 60 billion per year, representing more than 20% of the value of EU's total agricultural production (European Commission, 2014). Minor crops have the following features: 1) a large number of species 2) low acreage of cultivation; 3) cultivated mainly by small farmers and different farm management; 4) diverse organization form (industrial, familiar, etc.) with a different level of technology, marketing and merchandise. Weed control vary depending on technical and economical factors such as cultivation system (open air or greenhouse), date of sowing or transplanting, market (fresh market, conservation industry, transformation industry, seeds industry) and knowledge (Tei and Pannacci, 2005). Sustainable production of minor crops is vital for both human health and national economies as it contributes to agricultural productivity as well as a diverse and nutritional food supply, and food security (Lamichhane et al., 2015). In this context, there is a need that policy makers, researchers and stakeholders are together committed to reduce the use of herbicides in agriculture and develop robust non-chemical IWM tools. This could be especially true for minor crops which may benefit from an increased availability of non-chemical weed management solutions. The main objective of this paper is to call for intensified research efforts in the field of non-chemical weed management in minor crops, offering a synthesis and some ideas on non-chemical weed management strategies that could be useful to help develop practical and sustainable solutions for European farmers.

2. Cultural weed control methods

2.1. Prevention

The main objective is to prevent weeds spreading and to avoid the introduction of new weed species. This aim can be accomplished by following these basic principles: use the seeds with high pureness rate; clean tractors and mechanical tools if they have worked in a field infested with perennial weed; filter the irrigation water; use an efficient hydraulic system to avoid water stagnation, spread of some perennial weeds (e.g. *Cirsium arvense* (L.) Scop., *Equisetum* spp.) and low crop growth rate; eliminate weeds that are difficult and onerous to be controlled, before their dissemination (Graziani et al., 2008a) (Table 1).

In highly infested fields, it is recommended to avoid cultivation of species with poor competitiveness such as carrot, onion, leek and garlic. It is also advisable to avoid cultivation of asparagus and medicinal plants in presence of perennial weeds (Lichtenhahn et al., 2005).

In the greenhouse, the preventive measures are based on sanitation and include the following actions: avoid to introduce weed propagules (seed, rhizomes, tubers, etc.) in the greenhouse by using sterile substrates; introduce only "clean" plant materials; control weeds outside of the greenhouse; screen vents and other openings to limit the introduction of windblown seed; use a physical barrier such as a weed block fabric to limit weed establishment on greenhouse floors; regularly hand pull any escaped weeds before their dissemination (Neal, 2015).

2.2. Crop rotation, cover crops, intercropping

Crop rotation has a wide range of influence toward weed community and greatly prevents the establishment of dominant weed species (Hosseini et al., 2014; Graziani et al., 2012).

In other words, crop rotation contributes to maintain a weed community without the presence of herbicide resistant species, with a balanced spectrum among the various biological weed groups and where there is not a similar (and so troublesome) species similar to crop. All these factors contribute to the development of less competitive and easy manageable weed communities (Bonciarelli et al., 2016; Eyre et al., 2011; Benoit et al., 2003) (Table 1). This goal can be achieved by:

- alternating crops with different vegetation: leafy vegetables (e.g. lettuce, spinach, cabbage), root vegetables (e.g. carrot, beetroot, chicory, etc.), tuber vegetables (e.g. potato), bulb vegetables (e.g. onion, garlic), fruit vegetables (e.g. nightshades and cucurbits) and seeds (many species);
- cultivating cereals whenever possible (winter cereals, maize and sorghum);