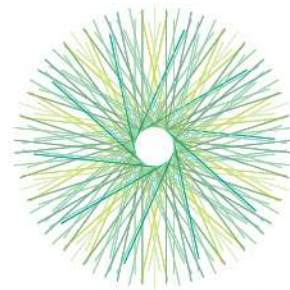


# EIP-AGRI Focus Group

## Non-chemical weed management in arable cropping systems



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AGRICULTURE & INNOVATION



# Mini-paper on Farmers' Perceptions and Decision Making

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## 1. Introduction

Examples of technological solutions for Non-Chemical Weed Management (NCWM) can be found in the literature (e.g. diversification of strategies, plant breeding, information technology applications) however, uptake of new technologies by farmers is still limited (Liebman et al., 2016 Wilson et al., 2009, 2008). In this mini-paper we aim at addressing what aspects affect farmer's perception and decision making towards NCWM.

The increasing use of herbicides in recent years led to the increase of farm profitability, the adoption of conservation agriculture techniques, and the increase of farm labour efficiency, resulting in a general improvement of farmer's lifestyle. On the other hand, heavy use of herbicide resulted in environmental degradation (Freemark and Boutin, 1995; Kolpin et al., 1998). General concern about health issues related to herbicide use, particularly raised after several inquiries on glyphosate, affects farmers as well as the general public.

While society is demanding new approaches towards weed management, no significant progress in herbicides technology has been achieved in recent years. Availability of herbicide is reduced by the lack of development of new herbicide compounds in the last 30 years. Nonetheless farmer's techno-optimism (i.e. the belief that new herbicide chemistry will be available in the future) is still a factor limiting the adoption of NCWM strategies. A certain degree of misinformation from the industry may occur in this regard.

In this mini-paper, we explore constraints related to economic aspects and policy issues, social constraints, lack of knowledge and lack of machinery, farmers' mindset and communication which may affect farmers' behavior towards NCWM.

## 2. Economic constraints, evaluation and labour

When introducing a new practice or innovation in the farming system (as in the case of NCWM strategies) farmers have to go through a complex decision-making process where personal attitudes, knowledge on the practice, on the farming system resources and the external world (market, regulation, land prices etc..) need to be taken into account. Moreover, external influence of the family, peers and neighbours, and society at large affect farmers' decision-making (Ajzen, 1991; Farmar-Bowers and Lane, 2009; van Dijk et al., 2016).

Farmers have a wealth of information about growing crops but generally lack information regarding NCWM practices. Lack of information is particularly strong concerning the efficacy of practices, especially in the long term, and the quantification of benefits provided by NCWM strategies, in terms of yield gain/losses, but also in terms of positive externalities and ecosystem services provided.

The farmer cannot see an alternative while their margins are tight or non-

existent. Alternatives to chemical weeding can be labour consuming and an expensive capital cost. Moreover, some of the alternatives involve inter-row cultivations which results in extra diesel consumption, compaction and may have a negative effect on soil and farm biodiversity.

In NCWM, economic costs can mainly be related to the cost of tillage and other practices like cover crops for which labour cost is high, the cost for acquiring new machinery and seeds, and the indirect costs related to less effective weed control and yield loss due to changes in crop rotation. Weather conditions are also a major constraint for the adoption of NCWM strategies such as delayed winter cereals drilling. Mechanical weed control takes more time than using herbicides and soil conditions and developmental status of the weeds must be right for mechanical methods to be successful. If the weather conditions are bad in the short period of possible weed control, that means a lot of stress and uncertainty for farmers. Plannable work runs are preferred by farmers to reduce stress and provide crop protection.

Farmers also have to analyse costs and benefits associated with NCWM practices and also take into account the related risks. The identification of trades-off in decision making is particularly complex. During the decision making process, specific trades-off are often not considered and benefits and losses are not well quantified and weighted (Zwickle et al., 2016). Research that clearly identifies farmer's risk perception and subsequent decision-making on weed management is needed. A simple analysis of NCWM tactics based on ecological weed management principles shows that they are less reliable than herbicides, also its complex integration of tactics is difficult to manage, knowledge intensive and site-specific (Bastiaans et al., 2008). Moreover, farmers do not feel comfortable in changing an entire set of practices because of the uncertainty of benefits and trade-offs. In 2008 Bastiaans et al. highlighted that "quantitative estimates are also the only way to establish the true costs of ecological weed management practices". A comprehensive quantitative estimate of weed control trade-offs is very difficult to achieve and difficult to generalise. Cost-effectiveness of innovative technologies such as "precision agriculture" are not yet clear. This uncertainty may hinder the adoption of technologies such as robotics for weed control.

Farmers' economic considerations generally focus on the short term. Ecologically-based NCWM strategies are associated with higher costs in the short term but greater environmental benefits in the long term, (including overcoming herbicide resistance and health benefits). A long-term perspective is however not appealing, unless payments compensate for the short-term revenue reduction. Moreover, long-term benefits need to be clearly identified (Doohan et al., 2010) and communicated more clearly to engage farmers.

Analyses of the profitability of NCWM vs chemical weed management at both micro-economic (farm level) and macro-economic (regional, national and European levels), are needed to give useful information to steer future actions in this field.

### 1.1. Policy

Regulation in the EU may cause a decrease in herbicide active ingredients, which limits the possibility of herbicide use for farmers. Subsidies contingent on cross-compliance proved to be ineffective in changing farmer's attitudes towards herbicide use, since farmer's compliance generally last as long as the political arrangement. Public policy should put in place long-term programs to maintain

payments for farmers. This implies the acceptance by society of sharing the cost of environmentally sound practices. A possible example of this mechanism could be the premium payment to organic farmers.

An option envisaged by public authorities might be to introduce an herbicide use taxation, as promoted by the Danish Ministry of the Environment in 2012. Such an option could force farmers to reduce herbicide use but could also promote the use of cheaper herbicides, which could lead to herbicide resistance and have negative effects on the environment. A measure of this kind can frustrate farmers who see their autonomy for choice being reduced concerning an important input that has a direct effect on crop yield. At the same time this measure is ontologically ineffective since the problem of intense herbicide use is not tackled with a systemic view but using a rather reductive approach.

When CAP policy has offered financial returns for adopting environmental tasks, farmers have demonstrated a quick uptake to put these measures into action. However, at present CAP has no holistic approach to encourage farmers to reduce pesticide use (PAN Europe, 2017). For the adoption of NCWM it will probably require both "carrot and stick". Ideally CAP would provide incentives and the large retailers can play a significant role in shifting farmer's practices towards NCWM following consumer demand.

### 3. Social

#### 3.1. Fear of change

Chemical weed control is the tried and tested method and any change is perceived as a risk. The idea of making changes in weed management (e.g., not using herbicides) can trigger anxiety, fear of not achieving the task, and also whether enough income can be generated from the farm. This does not usually affect one single person, but the whole co-operating family, because in the field of agriculture, the workplace and family are strongly linked.

Farms are traditionally passed on from generation to generation. That's why the fear of failure weighs heavily on the responsible people. The fear of going bankrupt, losing the farm that has been successfully farmed for generations, and to be unable to hand it over to the next generation is very strong.

Often, there is a feeling of powerlessness to confront established structures. Thus, farmers often lack the courage to go towards new or unfamiliar ways for fear of being sidelined and because of the fear of failure.

#### 3.2. Intergenerational conflict

In Europe, agricultural operations are usually passed on within the family to the next generation. Parents and children or children-in-law often work together on the farm. This brings particular social friction due to the family dynamic. If the younger generation wants to introduce changes, this often has to be done against resistance. So, if the father has always used herbicides and had good experiences with them, the young generation will have a hard time experimenting with cropping systems without herbicide use.

#### 3.3. Social reputation

Farmers live in the countryside with contact to their neighbours. Farmers know each other and observe the field management of others very closely. It's obvious when a colleague grows weeds. Some landlords do not like to see their property with weeds. Perhaps even the loss of leased land threatens because landlords prefer to lease their land to another farmer, who ensures clean fields.

An optically pleasing impression creates social acceptance and is like a visiting card for the farmer.

On the other hand, pioneer farmers who adopt innovative practices can have a positive influence on the local farming community by providing successful examples of innovations in NCWM. These innovators can be a focal point for the dissemination of novel effective practices, peer to peer learning and foster knowledge exchange.

### 3.4. Public opinion

Whereas farmers feel a sense of disquiet about how consumers regard chemicals, they also feel there is no alternative unless they convert to organic and receive a price premium. Most conventional farmers are not prepared to do this because it would result in reduced yields. Moreover, for some farmers it does not sit well with them that they are only producing for the 'well heeled' and argue that organic yields would not feed the world. Whilst consumers do not want chemicals used in agriculture they also have a limit on how much they are prepared to pay for food.

## 4. Lack of knowledge concerning adoption of non-chemical weed control

### 4.1. Multi-stakeholder approach and transdisciplinary research

As pointed out by Jordan et al. (2016) weed management can be considered as a part of a complex problem which is the environmental, social, and economic sustainability of farming systems (Jordan et al., 2016). Many studies, especially in environmental sciences, highlight the need of adopting long-term multi-stakeholder engagement to tackle complex problems. Approaches such as adaptive co-management are advisable if a collective action for change is required (Armitage et al., 2009).

To effectively put in place a multi-stakeholder research approach it is crucial to be open to negotiations with stakeholders in order to meet stakeholder's expectations and objectives. Stakeholder engagement plans should be prioritised and a right amount of resources, especially in terms of time, should be allocated to stakeholder engagement in applied research projects. Among farmers there could be a diffuse sense of fatigue after a few engagement experiences in research projects. This is because farmers' expectations are not always met by research. Moreover, farmers are not adequately compensated for the time and resources they devote to research. Farmers take risks in opening their fields to trials without any compensation, sometimes assuming also related costs. Ad hoc measures in project calls should be put in place to guarantee a fair remuneration of farmers who participate in research projects and contribute to the testing and spread of innovations and the development of rural communities.

Farmers knowledge should be strongly valued and knowledge exchange from farmers to scientists should be promoted (Riemens et al., 2010; Wilson et al., 2009). On farm trials that test farmers' observations should be put in place (Zwickle et al., 2016), to promote farmers' knowledge instead of research-centred trials.

A multi-stakeholder platform requires to take into account the multidimensional nature of a problem (environmental, social and economic dimensions of sustainability), the effect at geographical and time scale of stakeholder's

decisions and the different and often contrasting interests and objectives of various stakeholders involved. In this regard, transdisciplinary research is crucial to bring together information and foster co-creation and sharing of knowledge in a holistic way (Jordan et al., 2016). Fundamental research needs to be integrated with applied research and social sciences to address complex problems, such as switching from chemical weed management to NCWM. Social sciences are a crucial discipline since, more often than not, barriers in the adoption of environmentally friendly practices regard issues such like social norms, networks structure and axis of power, and socio-economic factors that affect farmer's decision making.

It is important to acknowledge a certain degree of research inertia, especially referred to the different time scales at which different actors in the agricultural sector operate. Farmers and policy makers require quick answers, quick solutions with high level of certainty while results in research take a lot of time, are complex, usually context dependent and do not give definitive answers. More often than not, research outputs consist of more research questions to be addressed in further investigations. This is a strong gap between research and practice that could be filled by an intermediary figure (facilitators, or more specifically, extension service), able to translate into practice and for specific contexts research. Agriculture Knowledge and Innovation Systems (AKIS) should be implemented to fill the gap between research and practical application of innovations, particularly in NCWM.

#### **4.2. Farmers' discussion groups with facilitator**

Because herbicides have been so effective at combatting weeds, farmers have depended on them excluding the necessity to discover other methods. It would be necessary to disseminate information about alternatives to chemical weed control. Discussion groups which are overseen by a facilitator have proven to be a satisfactory method. If a farmer adopts a new practice and it works well for him, then other farmers will quickly follow suit, this will then be discussed within the group.

For the implementation of innovations and actions derived from multi-actor participatory approaches at the local level, the presence of a valid innovation broker (often a team of trained experts), is crucial. Innovation brokerage in NCWM has significant relevance as it constitutes a bridge between different stakeholders' outputs: scientific research, technological innovation by agritech companies, farmer's interests. Extension services can be seen as a fundamental structure to deliver the service of innovation brokerage and could have a high policy relevance. However, in most European countries, innovation brokerage (i.e. extension service), has been delegated by governments to the private sector (often the same companies which also sell seeds, fertilisers, pesticides and herbicides to farmers).

#### **4.3. Lack of knowledge transfer and practical demonstrations**

Lack of knowledge is a major obstacle to change, so the problems associated with chemical weed control as well as its alternatives must be effectively transmitted. Firstly, the problems of chemical control need to be highlighted followed by clear demonstrations of NCWM alternatives. It helps when there is a trust between the farmer and the administration.

Generally, farmers claim that contradicting information is provided to them by various actors that have an interest in weed management.

For successful weed control and for reducing management costs, farmer's co-operation at field level is key (Gonzalez-Andujar, 2018). Organisation of social events to foster relationship building among farmers can foster co-operation. Ervin et al. (2019) found that farmers relying on extension educators were more likely to collaborate with other farmers for co-operative management of herbicide resistant weeds (Ervin et al., 2019). Participatory budgeting (i.e. collective decision making on public budget allocation) could be a strategy to foster cooperation among farming communities (Schneider and Busse, 2019). However, examples of participatory budgeting in farming systems in the literature are lacking. Also decision support systems (DSS, based on farmer's knowledge and experience) and modelling can be used to give long-term information to farmers to help decision making on weed management.

Farmers learn well from their peers. It has been shown that farmers prefer a learning by doing style through farmer-to-farmer networks (Doohan et al., 2010; Groot and Maarleveld, 2000). Other methods to foster knowledge transfer are demonstration farms, the agricultural press and broadcasts. These methods are important to showcase management alternatives. Good examples of EU projects fostering knowledge transfer are Nefertiti and PLAID projects ([www.nefertiti-h2020.eu](http://www.nefertiti-h2020.eu); [www.plaid-h2020.eu](http://www.plaid-h2020.eu) ).

Agriculture Knowledge and Innovation Systems (AKIS) are a crucial tool to foster knowledge creation and exchange thanks to their multi-stakeholder and practice-oriented approach. It will be important to improve AKIS development to support farmers in the transition to NCWM in the next CAP.

#### 4.4. Engagement of young farmers (Schools, University)

In order to enable young farmers to carry out weed control without chemicals, key contents should be integrated into curricula at an early stage. Young people are often more flexible and open to new ideas. However, this requires sound knowledge about how to prevent weeds. Instead of focusing on the use of the sprayer, other options such as more diverse crop rotations, sowing data that favour plant growth compared to weeds, adapted variety selection, etc., should be addressed in training.

### 5. Availability of machines in the region

#### 5.1. Sharing of Machinery

Sharing machinery between farmers would lower the capital costs and making it possible to use a machine that otherwise could not be afforded. However, it is not practiced extensively in Europe. Some of the reasons concern transportation costs, cost of legal agreements, risk of damage to the machinery and risk of delays at planting or harvesting. Contracting and hiring of machines is a more popular approach.

If well-functioning machines could be rented out at low prices, it could help farmers start experimenting with mechanical NCWM measures. The EU could reflect on the implementation of ad-hoc funding instruments to promote machine sharing for NCWM. Grants aiding capital expenditure for NCWM equipment could be beneficial.

There is also need to foster integration of farmers' knowledge and experience in machines design. Due to high investment cost, machinery should be designed to be versatile and adaptable to different farming conditions (see [www.farmhack.org](http://www.farmhack.org) ). Improved machinery and new technologies such as robotics, should be designed to be accessible to all farmers.

## 6. Farmers mind-set

### 6.1. Motivation for change

In recent years, public perception of farming and its impact on the environment has changed. At present, the portrayal of farmers in different parts of Europe is complex. Farmers can be portrayed as abusers or protectors of the environment, blamed for environmental degradation or victimized in different media platforms. Farmers' public image is being damaged, creating tensions and conflicts between the farming community and public society. This is reflected in a deterioration of farmers' lifestyle and social recognition. It is questionable whether the confusing and sometimes unfair portrayal of farmers will have any positive effect in changing farmers' mindset towards herbicides, since with the price of grain as low as it is, they can't see economical alternatives.

Looking at the literature on farmers' perceptions and decision making and weed management, it emerges that the main factor pushing farmers to adopt diverse weed management strategies is herbicide resistance (Dentzman, 2018; Ervin et al., 2019; Sarangi and Jhala, 2018; Schroeder et al., 2018; Ulber and Rissel, 2018). It is worth noting that research on drivers of farmer's choices on (alternative to herbicide) weed management is relatively recent and reflects the general societal trend aimed at limiting the use of herbicides in agriculture due to their negative impact on health and environment.

Some farmers feel an unease about the growing public awareness of chemical residues in the food, detrimental effect of herbicides on soil microorganisms, insects and human health. An increasing number of farmers feel that the practice of pre harvest spraying is unnecessary and has induced consumer resistance. Herbicide drift is also an important concern for organic farmers since contamination of their crop could result in the loss of certification and market premiums.

Low financial margins predispose the farmer to adopt new techniques if the customer is prepared to pay a worthwhile premium. However, there are several factors that are keeping farmers dependent on chemical weed control.

Despite evidence that herbicides affect human health, soil and living organisms putting both terrestrial and marine ecosystems at risk (Carvalho, 2017), some farmers still feel there is no concrete evidence that herbicides are harmful.

Since it would not be possible to adopt alternative weed control without a premium price or financial incentive, the farmer only has two choices at present. That is to farm conventionally with chemical weed control or go organic. The organic alternative does not appeal to everyone because of the yield reduction and the level of weeds on some long term organic farms does not demonstrate an inspiring alternative.

Agroecology is gaining importance and popularity as an alternative way of farming. However, there is lack of a clear and common understanding of what agroecology is, especially between the scientific community, policy makers, farming organisations and farming industry. A solid framework for agroecology is provided by Agroecology Europe ([www.agroecology-europe.org](http://www.agroecology-europe.org)), but this framework is not widely adopted. The lack of clarity may slow down or complicate the process of transitioning towards the agroecology paradigm, leaving room for the possibility for some actors to promote their agenda or business by imposing their own interpretation of the term "agroecology" for their own benefit. While some stakeholders debate on agroecology, farmers appear to



be marginalised. On one hand there is a niche of farmers who embrace the agroecological paradigm, sustained by social movements and the public. On the other hand, the majority of farmers are not familiar with agroecology. Even if they have heard about it, they lack knowledge and appropriate guidance to adopt agroecological practices (extension services, knowledge transfer, innovation networks). Organic farming is for many “the” alternative because of the presence of a clear regulatory framework and a well-established, growing, market.

The farming community holds the belief that without glyphosate there would be considerable disruption and that NCWM would need to make major developments before it could be considered as a realistic alternative without a financial incentive.

## 6.2. Zero Tolerance of weeds

There is an opinion held amongst some conventional farmers that no weeds should be tolerated (Wilson et al., 2009, Wilson et al., 2008). They think that if any weeds are present they will seed and create an ever increasing problem (one years seeds is seven years weeds). It is also assumed that weeds reduce machinery output and increase crop moisture and disease risk.

Alternatively, for instance organic farmers recognize weeds benefits, though there is a need to keep control on weeds’ presence in the field. In other words, there can be an acceptable level of weeds. As also proved by scientific literature, weeds can provide several benefits (Adeux et al., 2019; Blaix et al., 2018).

Some of these benefits include:

- Improved soil structure due to the diverse rooting systems.
- Greater biodiversity, see 6.3 below
- The increased plant diversity helps reduce some diseases.
- A weed seed bank creates a ground cover when crops are removed. This could be looked on as a cheap way of establishing a cover crop without having to use expensive seed and with minimal labour.
- Weeds can give farmers information about their soil, so can act as soil indicators as well as protecting against erosion
- Weeds also provide food, shelter and habitats for insects and even birds and small mammals, thus having a positive impact on biodiversity.

A proportion of farmers (mainly organic) believe that a culture of zero tolerance to weeds has been inculcated by the chemical industries' vested interest.

## 6.3. Loss of Biodiversity

Weed presence in the field increases biodiversity. Diverse plants flower at different times, with some of these plants providing a rich source of pollen and nectar for insects. These insects may attract predatory insects and birds. Similarly, the birds will attract further predators. This will benefit the farmer in creating a balanced system that will prevent pests like aphids and slugs, for instance, reaching unbalanced proportions.

Herbicides can also directly kill insects. For example, in July 2018, it has been reported that glyphosate can kill non target pollinator bees, specifically *Apis mellifera* L. (the honey bee). Moreover, “exposing bees to glyphosate alters the bees gut community and increases susceptibility to infection by opportunist

pathogens' and 'bees fed with food containing traces of glyphosate had a higher proportion of larvae with delayed moulting and reduced weight' (Montaut, 2018).

#### **6.4. Lack of awareness of the effects of chemical herbicides**

Farmers have only recently become aware of the reduced population of insects that has been brought about, among others, by the intense use of pesticides and reduced farm biodiversity, including the lack of weeds (Hallmann et al., 2017; Sánchez-Bayo and Wyckhuys, 2019). The effect of herbicide use on water quality is also not sufficiently understood.

Very little information seems to be available to farmers about the negative effects that herbicides are having on biodiversity and the environment even though it has been well documented by research. Lack of awareness can be explained by the attitude that farmers may have towards risks and benefits. As Doohan et al. pointed out, there is an inverse relationship between risk and benefits. Beneficial practices are generally perceived as low-risk. This is the case for herbicide use, which provides great benefits to farmers, and because of this, farmers tend to neglect related risks such as herbicide resistant populations or health risks. The reverse is also true, in fact preventive strategies are considered not as beneficial (in the short term) as herbicides and are perceived to be high-risk strategies (Doohan et al., 2010; Wilson et al., 2009). This is coupled with lack of reliable information and misinformation on the real effect of herbicides on ecosystems and human health. These two factors exacerbate the gravity of lack of farmers' awareness on the effects of chemical herbicides. It must not be forgotten that farmers are the first subjects exposed to herbicides chemical compounds and to their potential detrimental effects.

#### **6.5. Proactivity**

If farmers are going to adopt non chemical weed control techniques it would need to be done on a proactive basis. Meaning that it can be made to work if multi non-chemical approaches are used from the beginning to prevent a weed seed bank from establishing. Prevention is easier than cure.

Organic farmers who wait until they have run into a serious weed crisis before taking an action like buying an inter row hoe, find they are always fighting a rear guard action after that. The farmers who foresee the problems and start with good rotations and the necessary equipment, generally manage to keep their weed density at an acceptable level (Riemens et al., 2010).

Crop rotation is an important factor to be successful in working without chemicals. In order to increase diversity of farming systems (for instance, by introducing diversified crop rotations) it is necessary that markets exist for additional crops. Together with policy and societal change, the change towards NCWM needs to be led also by market, otherwise it may not be sustainable: if farmers have no way to sell their products, they will not change their usual farming system.

## **7. Dissemination**

### **7.1. Infrastructure e.g. farming press and social media**

The points of view from the farmer's associations have great influence on agricultural policy and on farmers' practices. Trade journals published by farmers' associations are an essential source of information for farmers and constitute an important means to disseminate information regarding NCWM practices among

farmers.

Other methods could include the Mayor's office, rural fairs and shows. Information can also be disseminated through mobile phones and social media which has the advantage of being quick, flexible, accessible and user friendly. Modern communication platforms such as Facebook, YouTube, WhatsApp and Twitter can be useful to spread information among farmers' communities. They are an efficient means to spread information among farmers but also from farmers to advisors and vice versa. Especially the younger generation of farmers uses social media. Here information can be spread not only fast but also with long range. Therefore, it is important to use these media as a source of positive information to help changing farmer's attitude towards NCWM.

## 8. Conclusion

Because chemical weed control has been economical and effective in the past, it has been heavily relied upon at the expense of developing new methods of NCWM. However, the increasing use of herbicides, increasing knowledge of their harmful effects and weed resistance could shift the focus towards increasing understanding of the importance of NCWM strategies.

At present farmers are not convinced that suitable alternatives to herbicides exist that are as effective and that do not bring other problems for the soil and the environment.

Since farmers alone should not carry the extra costs and labour associated with NCWM, there will have to be incentives. Farmers in Europe have a good history of responding to incentives. While there are existing and effective NCWM strategies, more research and technological information is required. All available platforms, both traditional and IT, for disseminating new ideas will be needed.

Before NCWM will be widely adopted and embraced by farmers, it will be necessary for advancements to take place to improve the efficiency and availability of new technologies. Innovative techniques together with well-established NCWC tools need to be demonstrated to farmers to show that they can effectively and economically maintain weeds at an acceptable level. Whereas several developments have already taken place with NCWM techniques, more still has to be achieved before a transition from chemical herbicides to NCWM can take place in a smooth manner. Issues related to the "human side" of weed management still need to be effectively addressed.

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