Einleitende Referate
Keynote presentation

Technical demands and political restrictions for weed control

Unkrautbekämpfung im Spannungsfeld zwischen Anbauproblemen und politischen Rahmenbedingungen

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Summary

Crop production has become very efficient in developed countries. One factor that has contributed to this success is modern weed control tools. Cropping practices have changed considerably within the last century. Today, spring crops are grown on a much smaller scale in Europe than a hundred years ago. Oats and potatoes are minor crops whereas winter cereals and maize have become the most important crops of European agriculture. This fact combined with a high amount of manure from animal production had a much greater impact on biodiversity than herbicides. Efficient herbicides have been used against a number of weed species such as blackgrass or mayweed in cereals or barnyardgrass and lambsquarters in maize for almost forty years. None of these major weed problems, however, has disappeared. Weed species have physiologically adapted and have become resistant. The application of Council directive 91/414/EEC has resulted in a reduction of production tools for the farmer. With the implementation of regulation EC 1107/2009 it can be expected that the number of active ingredients available to the farmer will be even more decreased. Also, the development of new herbicides will become more difficult for agrochemical companies. Farmers will have less tools to control weeds and will face a drastic increase of resistance problems. In consequence, ploughing and other mechanical tools will become necessary resulting in higher production costs and more economic pressure on farmers.

Keywords: Biodiversity, changes in crop husbandry, landscape management, rare weeds, regulation on plant protection products, weed resistance

Zusammenfassung

Die Nahrungsmittelproduktion in modernen Industrieländern ist heute enorm effizient. Ein Faktor, der dazu maßgeblich beigetragen hat, ist die moderne Unkrautbekämpfung. Die Anbaumethoden haben sich allerdings während der letzten hundert Jahre drastisch geändert. Während vor hundert Jahren Sommerkulturen wie Hafer und Kartoffeln in einem viel größeren Ausmaß angebaut wurden, bestimmen heute Winterweizen, Wintergerste und Mais das Bild unserer Felder. Dieser Umstand und die erheblich gestiegene Menge an organischem Dünger durch eine erhöhte Tierproduktion verändern die Biodiversität auf landwirtschaftlich genutzten Feldern in einem weitaus größeren Ausmaß als z.B. die Anwendung von Herbiziden. Hoch wirksame Herbizide mit unterschiedlichen Wirkmechanismen werden seit nahezu vierzig Jahren gegen Unkräuter wie Ackerfuchsschwanz oder Kamille im Getreide und gegen Hühnerhirse oder Gänsefuß im Mais eingesetzt. Keines dieser Unkräuter ist aber vom Aussterben bedroht. Diese Unkräuter haben sich physiologisch angepasst und sind resistent gegen viele Herbizide geworden. Durch die gestiegenen Anforderungen an moderne Pflanzenschutzmittel wird für die chemische Industrie die Entwicklung neuer Herbizide immer aufwändiger und damit teurer. Die Anwendung der EU-Directive 91/414 hat zu einer deutlichen Reduktion der Produktionsmittel in der Landwirtschaft geführt. Es ist damit zu rechnen, dass die Umsetzung der neuen Richtlinie EC 1107/2009 eine weitere Reduktion von Pflanzenschutzmitteln nach sich zieht. Die Entwicklung neuer Produkte dürfte darüber hinaus schwieriger und teurer werden. Die wenigen verbleibenden Mittel werden häufiger eingesetzt und das Resistenzrisiko steigt. Unkrautresistenz stellt schon heute ein großes Problem für den Landwirt dar. Der Pflugeinsatz und andere mechanische Maßnahmen kommen wieder verstärkt zum Einsatz – mit allen Nachteilen für die Umwelt wie z.B. der Erosion. Die Nahrungsmittelproduktion könnte sich dadurch auch wieder verteuern.

Stichwörter: Biodiversität, Kulturpflanzenspektrum, Landschaftspflege, Pflanzenschutzgesetzgebung, seltene Unkräuter, Unkrautresistenz

1. Introduction

Crop production has become more efficient than ever. In developed countries, the income related costs for food are at the lowest level since World War II. In Germany, citizens spend 11 % of their expenditures for food today compared with 44 % in 1950 or more than 50 % in the year 1900 (HEMMERLING et al., 2011). Milk has become cheaper than mineral water or coke. A number of factors have contributed to this achievement: Farming equipment and technical tools, education, breeding of high yielding and stress tolerant crop varieties, plant protection tools, free trade and global competition. Science and engineering including chemical and mechanical weed control are improvement factors that are part of this success. They affect crop yields considerably. ZWERGER et al. (2004) have shown that yields without weed control can be reduced by 50 % and more in major crops. This fact and high labor costs are reasons why chemical weed control plays a major role in arable crops nowadays. On a global basis, farmers spent around 17 billion $ (US) annually for herbicides in 2010 (MarketsandMarkets, Dallas, Sept 26, 2011 and Wallstreet Online). Farming is a business with a high level of global competition. European farmers using conventional weed control tools have to compete with farmers in the US, Brazil and Argentina where GMO crops are grown on more than 100 million hectares (JAMES, 2009 and The Economist, Feb 23rd, 2011). Both technologies can be very efficient.

The standard in chemical weed control is very high and has become rather cheap compared with other production factors. Many excellent herbicides are out of patent and are produced by generic companies. Biotechnology is a rather new research area which allows capturing value via seed with new patent-protected technologies. This is why some agrochemical companies invest less in conventional plant protection tools nowadays and more in seed production. This approach could lead to less new and innovative herbicides (KRAEHMER et al., 2007).

2. The role of weeds in the landscape and biodiversity

The first two factors determining the spectrum of weeds arising in a field are the planted crop and its management. Crop husbandry has changed over the last hundred years. In consequence, weed spectra have changed also. The most frequent and landscape dominating weeds in European winter cereals today are *Apera spica-venti* and *Galium aparine*, followed by *Alopecurus myosuroides* and *Matricaria* species. *Chenopodium album* and *Echinochloa crus-galli* are dominating in maize, volunteer cereals and *Matricaria* species in oilseed rape.

(see e.g. the EWRS website http://www.ewrs.org/weedmapping/default.asp)

Tab. 1 Cropping areas in Germany between 1935 and 2010 (mio hectares).

Tab. 1 *Anbauumfang einzelner Kulturen in Deutschland zwischen 1935 and 2010 (Mio. Hektar).*

	1935[a]	1950[h]	1990[h]	2004[f]	2010[g]
Winter wheat	1,1	1,5	2,4	3,1	3,3
Winter barley	0,2	0,9	2,6	1,4	1,3
Spring barley	0,6	0,6	1,0	0,6	0,3
Oats	1,4	1,7	0,4	0,2	0,1
Rye	1,7	2,7	1,1	0,6	0,6
Potatoes	1,2	1,9	0,6[c]	0,3	0,3
Sugar beet	0,1	0,4	0,6[d]	0,4	0,4
Oilseed rape	0,02	0,1	0,7[e]	1,3	1,5
Maize	0,01	0,3	1,4[b]	1,2	1,8

a) Häfner and Thiede (1956); b) AGRA-EUROPE 1992 and Erntebericht des Bundeslandwirtschaftsministeriums 1992/93; c) Agrarmärkte Jahresheft 2006, Teilauszug Kartoffeln, Bayrische Landesanstalt für Landwirtschaft; d) Landwirtschaft in Deutschland.- i.m.a. e.V., Bonn 2005; e) Erzeugung und Verwendung von Raps in Deutschland, ufop 2008; f) Land- und Forstwirtschaft, Fischerei – Agrarstrukturerhebung 2005, Fachserie 3/Reihe 3.1.2.-Statistisches Bundesamt; g) Land- und Forstwirtschaft, Fischerei – Landwirtschaftliche Bodennutzung, Anbau auf dem Ackerland 2010, Fachserie 3 / Reihe 3.1.2.-Statistisches Bundesamt; h) Adapted to Hartmann (2011), including data for the former German Democratic Republic

The agricultural landscape looked completely different fifty years ago. Table 1 shows that spring crops played a much bigger role in the first half of the last century than thereafter. Winter crops cover around 70 % of all arable land today compared to around 50 % until the late fifties of the last century. The acreage for rye was two to three times larger than today. Until the late fifties, oats had an acreage at least ten times larger than in 2010. This had to do with the role of horses as a working tool. Wild oat control in oats was almost impossible. In consequence, it was the dominating grass weed in cereals and in the agricultural landscape as e.g. BACHTHALER (1966) proves. The situation was very comparable in other European countries as e.g. CHURCH et al. (1962) or PHILLIPSON (1974) demonstrated for the UK or as ANDREASEN and STREIBIG published recently for Denmark (2011).

Scientists have tried to classify weed communities according to their germination behaviour as e.g. winter annuals or summer annuals or by habitat (RADOSEVITCH et al., 2007). Plant community research uses key or "character" species to specify plant associations (MUELLER-DOMBOIS and ELLENBERG, 2002). In the end, characteristic weeds are associated with specific crops.

Maize did not play a role in Germany until the end of the last century. Today, it is the second most frequent crop in Germany after winter-wheat. The typical maize flora in northern Europe differs drastically from weed spectra in other crops. This is confirmed by ANDREASEN and STREIBIG (2011) who stress that *Setaria viridis* could establish in Denmark only due to continuous maize cultivation. Cornflower (*Centaurea cyanus*) and poppy (*Papaver rhoeas*) are weeds associated with winter crops such as winter cereals or oilseed rape. One usually does not find them in a maize field despite of looking attractive to those who like aesthetics in agriculture.

Biodiversity is an issue that drives legislation today. Many scientists claim that herbicides have reduced biodiversity and that they are the reason for the extinction of species. Fact is, that agriculture has used different, very efficient herbicides against weeds such as blackgrass or lambsquarters for almost forty years and these weeds are still everywhere. None became extinct. In Canada, the relative frequency of the four to five most frequent weed species of major crops has not changed for the last thirty years (LEESON et al., 2005) despite a complete change of weed control tools: Completely different herbicides and the introduction of herbicide tolerant crops. Many rare plants grow on soils with low nitrogen content (*Adonis*, *Legousia*, ..) where other potential competitors cannot survive. The high amounts of manure in animal production have led to a drastic increase of nitrogen in soils with the effect that these rare plants have more or less disappeared. Sieves in harvesters have changed seedbanks. Dominance and weed-weed competition as described by ALDRICH and KREMER (1997) seem to be often forgotten factors in biodiversity research from my point of view.

The introduction of ornamentals to Europe in the nineteenth century and today's global traffic have increased the number of invasive species on agricultural and non-agricultural land. *Ambrosia artemisiifolia* has become the most frequent weed in many crops in Eastern Europe (e.g. NOVÁK et al., 2009). Many invasive weed species on non-crop land such as *Impatiens grandiflora* or *Fallopia japonica* do not leave room for any other plant species. Environmentalists argue that bees are attracted by *Impatiens grandiflora* and garden owners regard Japanese knotweed as a nice ornamental. It is still possible to buy seeds or rhizomes of many invasive species via the internet while EU legislation tries to stop these invaders wherever possible. The key for future legislation is to clearly define environmental protection goals which consider both the needs of agriculture as well as biodiversity.

Weeds are plants interfering with the interests of farmers. Weed control is important and has clear yield effects without being a major part of agricultural production costs. Almost fifty percent of all global agrochemical turnovers have been herbicide expenditures for decades. This must have a reason. Convenience may be one motive. The major reason is, however, efficiency (e.g. GIANESSI and REIGNER, 2007). Not only do herbicides reduce yield losses due to weed competition and provide the foundation for protection of yield potential, they also help to prevent erosion caused by tillage, having a direct impact on the exploitation of human labour in third world countries used in their stead. Technical tools for weed control are at a very high state of the art. Every weed can be controlled today in any crop.

Weeds have been a burden in biblical times already and they are a nuisance for the farmer still today.

Herbicide reduction programs will not be possible without consequences. They will result in effects that are only recognized in long -programs. PALLUTT et al. (2010) came to the conclusion that the long term changes of reduction programs become visible at least three to five years later. Incomplete weed control e.g. will result in continuous seedbank changes.

Nature is inventive and overcomes human tools for prevention. Weed resistance to herbicides has become a serious issue globally (e.g. VALVERDE (2007) for Latin America, WALSH and POWLES (2007) for Australia, BECKIE (2007) for Canada, NORDMEYER and ZWERGER (2010) for Germany or BLAKE (2011) for the UK). Some species seem to be quite successful in escaping modern weed control tools and have even become resistant against several herbicides with different modes of action (e.g. TRANEL et al. (2010) or HAMOUZOVÁ et al. (2011)). The intensive use of glyphosate e.g. (LORENTZ et al., 2011) has unfortunately led to the selection of tolerant or resistant weed species which make the Roundup Ready technology no longer as efficient as it used to be. New technologies such as Liberty and Ignite in herbicide tolerant crops provide valuable tools for the management of resistant weeds.

3. Legislation

Concerns over drinking water contamination are one important driver of the plant protection legislation next to e.g. biodiversity and ecotoxicology motives. These concerns are understandable and activities against groundwater contamination became necessary after the overuse of some agrochemicals. Council directive 91/414/EEC reduced the number of available herbicides, however, for different reasons. The factsheet "EU action on pesticides " (2009) states that "of some 1000 active substances on the market in at least one Member State before 1993, 26 %, corresponding to about 250 substances, have passed the harmonized EU safety assessment. The majority of substances (67 %) have been eliminated". Many details of the implementation of regulation EC No 1107/2009 are not known yet. It has to be expected, however, that the registration of agrochemicals will become even more restrictive, time consuming and expensive.

4. Consequences

Restrictions based on environmental concerns and the intention to avoid risks will have an impact on food production. The barrier for new weed control tools has become high. Therefore, only a very small number of companies will continue to invest into the discovery and development of new weed control tools (KRAEHMER et al., 2007). Weed resistance problems have achieved a dramatic magnitude and may increase all over the world if no new herbicides with new modes of action will be available within the next decade. Costs for weed control due to resistance have already increased considerably for a number of crops within the last ten years. In soybeans, it is estimated that it now costs $35 per acre for herbicides above what growers would have spent when they could control weeds with Roundup (BRANDON, 2011). Alternative energy production with maize as a major contributing crop will change our landscape and will have a far greater impact on biodiversity and the environment than all existing cross compliance activities yet. Conventional farming as a low income business (the average agricultural income in Germany was 28 500 € in 2010 according to HEMMERLING et al., 2011) may become less attractive for the young generation in many industrialized countries. In consequence, landscape preservation would become a community task and would not be managed by farmers any more who have until today played a role in landscape management and as providers for sufficient food of our population at the same time.

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