AN EVALUATION OF PESTICIDE USE REDUCTION POLICIES IN SCANDINAVIA

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Key words: Sweden, Denmark, Scandinavia, Pesticides, Finland, European Union, Pesticide Reduction, Environment, Norway, Herbicides,

Introduction

Beginning in 1986, the governments of two Scandinavian countries, Sweden and Denmark, adopted policies mandating reductions of 50% or more in the total use of agricultural pesticides (Thonke, 1991). The Netherlands also adopted a mandatory reduction policy. Activist groups claim that these policies have worked and have urged European Union-wide policy support for similar programs (PAN Europe, 2003). In 2009, the EU Sustainable Use Directive will be published. Under consideration are proposals to reduce the volume of pesticides used by requiring countries to put National Action Plans in place. The goal of these plans will be to set up "quantitative targets" and "to reduce risks and impacts of pesticide use". Within the framework of these discussions, the pesticide industry association (ECPA) has criticized the proposals for quantitative reduction targets as non-workable and cited the Denmark program as a "failure."

The US has shown some interest in adopting mandatory reduction policies with bills proposed at the national and state levels. Some analysts have suggested that the European initiatives may be "handwriting on the wall" for future policy directions in the United States (Matteson, 1995).

The CropLife Foundation Study

Because of the continuing interest in mandatory pesticide use reduction policies in the EU and the United States, the CropLife Foundation (CLF) undertook a study of four countries. The focus included the Scandinavian countries of Norway and Finland where mandatory pesticide use reduction programs have not been adopted and Sweden and Denmark where programs have been implemented. All four countries share similar characteristics in that cereal crops are the most important in terms of pesticide use and herbicides used for weed control are the most important pesticide category. By including two countries without mandatory programs, the CLF Study determines whether formal government policies influence the amount of pesticides used.

The CropLife Foundation study began shortly after the completion date of the latest Danish reduction program which ran from 2004 through 2008. Comprehensive pesticide use data are available for all four countries and provide a continuous record back to the early 1980s for Sweden, Norway and Denmark while for Finland the pesticide use data record is continuous from 1953. This availability of data made it possible for CLF to analyze each phase of the programs.

CLF set out to answer three questions in the Study:

- What quantitative changes have occurred in pesticide use in Scandinavian countries since 1980?
- To what extent were the quantitative changes due to use reduction policies?
- What are the latest quantitative trends in pesticide use in Scandinavia?

Finland

The first herbicide products containing 2,4-D and MCPA were acquired in Finland from the UK in 1946. At first, the use of these products developed slowly, and at the end of the 1950s only about 12% of the cereal area was treated annually (Mukula & Ruuttunen, 1969). A three-year National Weed Campaign was launched in 1962 (Mukula, 1963) with the promotion of chemical control in cereal crops as the foremost objective. The Campaign proved successful and the field acreage sprayed with herbicides was increased to 44% of the total cereal acreage by 1965.

By 1985 about 85% of cereal area in Finland was sprayed with herbicides (Mukula & Rantanen, 1987). In the 1980s new low-rate herbicides (sulfonylureas) with a wider spectrum of activity were introduced for Finnish cereal areas (Salonen & Ervio,1988). Throughout the 1990s, sulfonylureas replaced the traditional phenoxy herbicides on about 50% of the treated area of Finnish spring cereal fields (Hyvonen *et al*, 2003).

Finland has practiced actions aimed at pesticide use and risk reduction since 1992, first in the Rural Environment Program, which was never officially approved. The Rural Environment Program set a specific target of halving pesticide use by the mid-1990s from an average amount sold (2000 tons) in 1987-1991 (i.e. to a level of 1000 tons of active ingredient per year which was achieved in 1995). In large part, the decline in the total sales of pesticides was due to the decrease in sales of phenoxy herbicides and a switch to the new lower-rate cereal herbicides, which are used in amounts vastly lower than the phenoxy products (Savela & Hynninen, 2004).

Statistics on the sales of pesticides have been collected in

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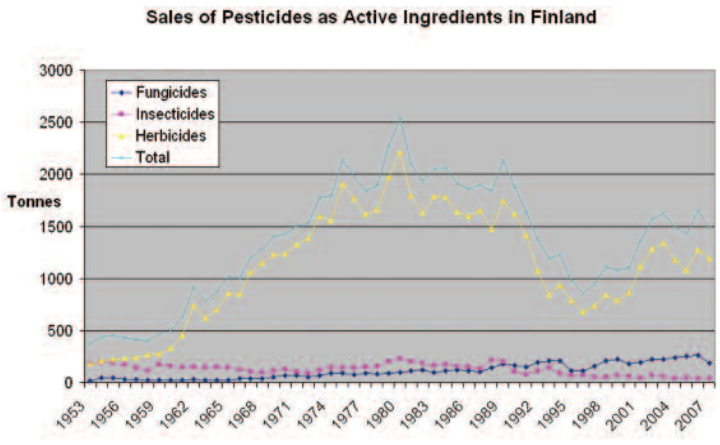
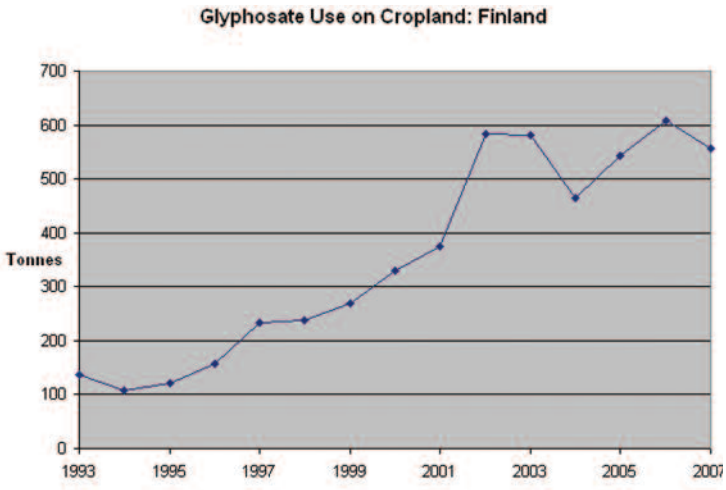
Figure 1:



Source: Savela and Hynninen (2004) updated from www.evira.fi

Finland since 1953 (Savela & Hynninen, 2004) (Figure 1). Since the 1950s, herbicides have accounted for more than 90% of the volume of pesticide use in Finland. The volume of herbicides increased in the 1950s-1970s peaking in 1980. With the adoption of the low-rate sulfonylureas, the volume of herbicides sold in Finland declined through the 1980s and 1990s. Following the reduction in use through 1996, the volume of pesticides increased in Finland due to higher herbicide sales, particularly of glyphosate, which tripled in usage volume from 1996 through 2006 (Figure 2). The growth in the use of glyphosate is due, in part, to changes in cultivation practices, especially the increased practice of no-tillage or minimum tillage (Lankoski *et al*, 2006).

Figure 2:



Source: Savela and Hynninen (2004) updated from www.evira.fi

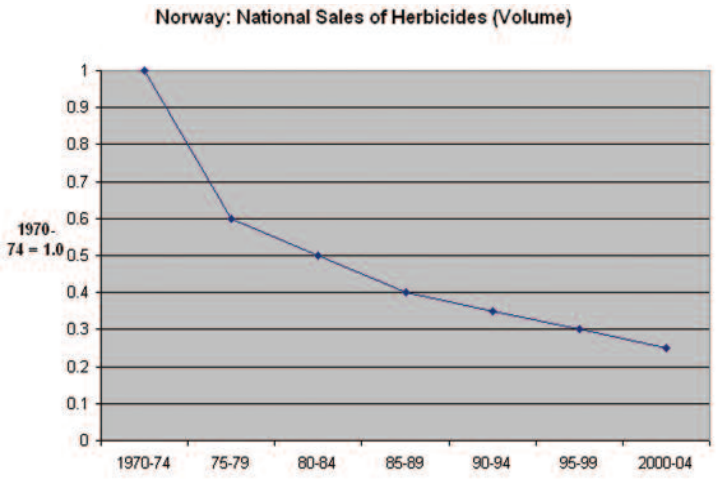
Norway

Research with herbicides in cereals in Norway began in the late 1940s. By 1970, chemical weed control was practiced on approximately 75-80% of the total cereal area in Norway. The resulting yield increase was estimated at 60,000 tons of grain annually (Jakobsons, 1970).

From 1970 to 2000, the annual sales of herbicides in Norway, in terms of volume of active ingredient, declined by 75% (Statistics Norway, 2008) (Figure 3). This substantial decrease in herbicide sales volume was largely due to a changeover from high dosage to low dosage products in cereal production. A 2005 survey of Norwegian farmers showed that more than 90% of the hectares of barley, oats and wheat were treated with herbicides (Bjorlo, 2006).

From 2003 to 2005, the total quantity of herbicides rose

Figure 3:

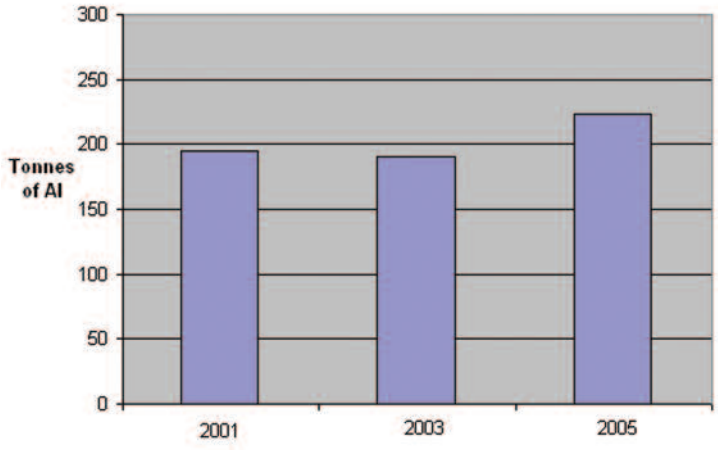


Source: Statistics Norway (2008)

by 17% (Figure 4), mainly due to an increase in the use of glyphosate, which increased in usage by 57% (Figure 5) (Statistics Norway, 2006); 120,000 more liters of Roundup (glyphosate) were used in 2005 than in 2003.

The increase in glyphosate usage is a consequence of the

Figure 4:

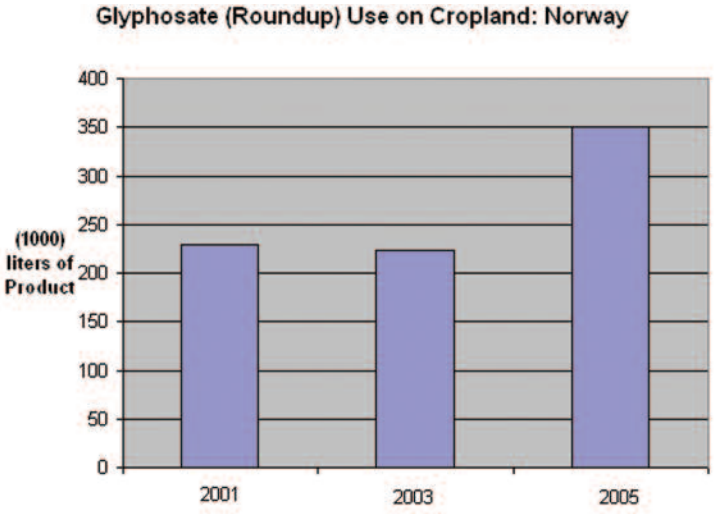


Source: Statistics Norway (2008)

greater adoption of low or no tillage practices to reduce soil erosion on land growing cereals (OECD, 2008). In order to fulfill the provisions of the North Sea Treaty of 1987 and reduce soil erosion and nutrient loss from agricultural land, farmers have since 1991 been paid to avoid autumn plowing (Fykse *et al*, 2004). In place of autumn plowing, glyphosate and other postemergence herbicides are used in early summer to control overwintering weeds (Torreson *et al*, 2006).

A national plan with a fixed target for percentage reduction of pesticide use volume does not exist in Norway.

Figure 5:



Source: Statistics Norway (2006)

However, the Norwegian Parliament decided in 1989 that the Government should produce a 5-year plan to reduce the use of pesticides in agriculture "as much as is justifiable" (Saethre *et al*, 1999). An Action Plan for 2004-2008 was adopted with the goal of making Norwegian agriculture less dependent on chemical pesticides (not yet released). The Plan explicitly states that the benefits to society of using pesticides be considered (Ministry of Agriculture, 2004). A working group has evaluated the 2004-2008 Plan and a new action plan is under development for 2010-2015.

Sweden

Sweden conducted 511 pesticide use trials in winter cereals from 1953-78, which determined that the yield increase following MCPA treatment was, on average, 202 kg/hectare. In an additional 741 trials in spring cereals during 1950-78, the yield increase was, on average, 217 kg per hectare (Svensson, 1982). By 1975, 75% of Sweden's cereal hectares were being sprayed with herbicides (Granstrom, 1976). In 2006, 90-93% of spring and winter wheat hectares were treated with herbicides in Sweden (Swedish Board of Agriculture, 2009).

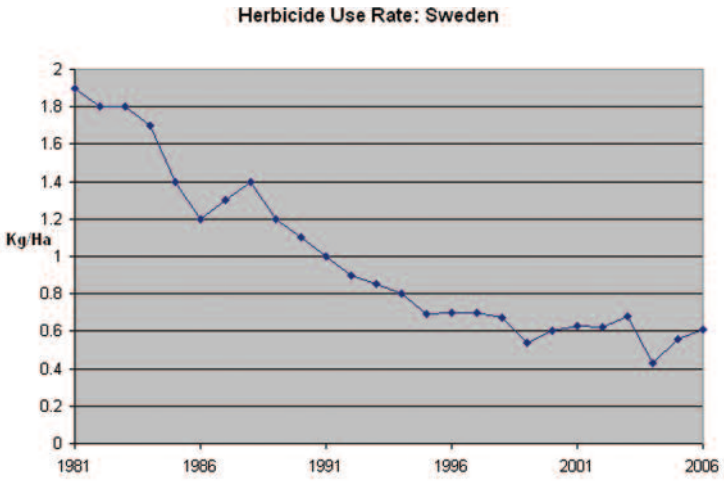
National risk reduction programs on pesticides have been in force since 1987 in Sweden. The first two five-year stages of the program included quantitative goals for reduced volumes of pesticide use: to reduce by half the quantity of active substances used over the period covered, 1986-1990 and 1991-1996 respectively. Accordingly, the two-fold halving added up in a goal of 75% reduction in 1996 compared to the average use during 1981-85. Pesticide volumes were reduced by 49% in the 1987-1990 time period and by 65% in the 1986-96 period (Swedish Board of Agriculture, 2009) (Figure 6). The average use between 1981 and 1985 was about 4500 tons of active ingredient. In 2005, the sold amount of active substances was about 1700 tons. Most of the reduction in pesticide use in Sweden reflects a decrease in herbicide use in cereals (Pettersson, 1994).

The quantity of herbicide active ingredients per hectare treated decreased from about 1.2 kg in 1981 to 0.4 kg in 2005 (Figure 7). The number of sold doses in 2007 was

Figure 6:

Source: Swedish Board of Agriculture (2009)

Figure 7:

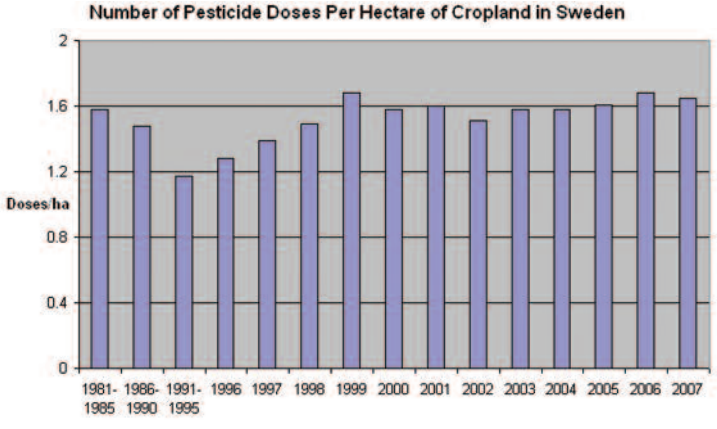


Source: Swedish Board of Agriculture (2009)

almost the same as it was in the base period 1981-85, 1.6 doses per hectare (Franzen, 2007) (Figure 8). The Swedes were not able to document a change in the treated area (Bellinder *et al*, 1994).

A report issued in the summer of 1990 by Sweden's National Board of Agriculture provided an analysis of how the 50% reduction goal was achieved (Weinberg, 1990). This

Figure 8:



Source: Franzen (2007)

report concluded that two-thirds of the goal's achievement could be attributed to the use of lower doses of traditional herbicides than originally recommended. One-third of the reduction was attributed to the use of new low-dose sulfonylurea herbicides used at g/ha (4 g/ha) rather than kg/ha (Bellinder *et al*, 1994). Products that were considered to be highly toxic and that were cancelled early in the mandate period included TCA which was widely used to control quackgrass (*Elytrigia repens*). Use of glyphosate was encouraged as a substitute control method. Rates of TCA for control of quackgrass ranged from 15 to 30 kg ai/ha and the shift to glyphosate, used at 1 to 2 kg ai/ha, caused a distinct decrease in the quantity of active ingredient used. The removal of inactive isomers from two cereal herbicides, mecoprop and dichlorprop, cut the use rates almost by half.

Research demonstrated that as a long-term effect of herbicide use, weed pressure had decreased in Swedish fields from about 700 plants/square meter in the 1950s to about 200 plants/square meter in the 1980s (Pettersson, 1997). Because of the lower weed pressure, research demonstrated that the best yields were achieved with the traditional herbicides at half the recommended dose. Farmers quickly adopted the lower dose concept since it was economically beneficial (Bernson & Ekstrom, 1991). However, it was stressed that herbicides needed to be used every year to keep the weed pressure low. Skipping herbicide applications would lead to gradual weed population increases which would eventually require applications of greater quantities of herbicides to bring the populations back to manageable levels.

In crops that were poor competitors with weeds or where herbicides were less effective, particularly postemergence, (e.g. spring-planted oilseed rape, legumes, sugarbeet, and row crops), Swedish farmers were seldom able to reduce herbicide use. In fields with higher weed densities, reduced herbicide rates were not recommended (Bellinder *et al*, 1994).

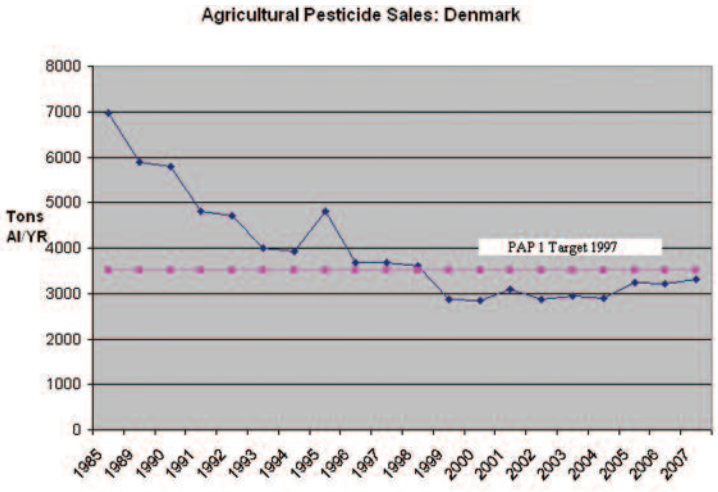
A recent rise in herbicide usage is mainly due to the growing use of glyphosate with the reduction in tillage and greater green cover over winter to help reduce nitrogen leaching and soil erosion (OECD, 2008)

Denmark

In 1986, the Danish Minister of Environment presented the government's first action plan to reduce the use of pesticides within a ten-year period. One of the primary goals of the action plan was a 50% reduction of total pesticide consumption by January 1, 1997. Pesticide consumption was to include: the quantities of active ingredients sold and spraying intensity expressed as treatment frequency index (Ministry of Environment, 2000). Farmers were expected to achieve an average spraying frequency of 1.34 applications per hectare in comparison to the average frequency of 1981-85 which was 2.67 applications. (The treatment frequency index expresses the average number of times per year agricultural land can be treated with the quantity of pesticides sold, assuming that they are used in the prescribed normal doses). The reduction was to be achieved partly through advisory activities and partly through intensified research on ways of reducing pesticide consumption.

In the autumn of 1997, the Danish Ministry of Environment presented a progress report on the action plan, which showed that the aim of halving pesticide consumption, measured by volume of active ingredients, had been achieved (Figure 9). One of the main factors accounting for the volume reduction was the use of new low-rate herbicides (OECD, 2008). Growers had switched from using phenoxy herbicides (1000-1500 g/ha) to sulfonylurea herbicides (4-8 g/ha) (Ministry of Environment, 2003). However, the aim of a 50% reduction in the treatment frequency index had not been achieved. The total index remained largely unchanged in relation to the reference period (Figure 10).

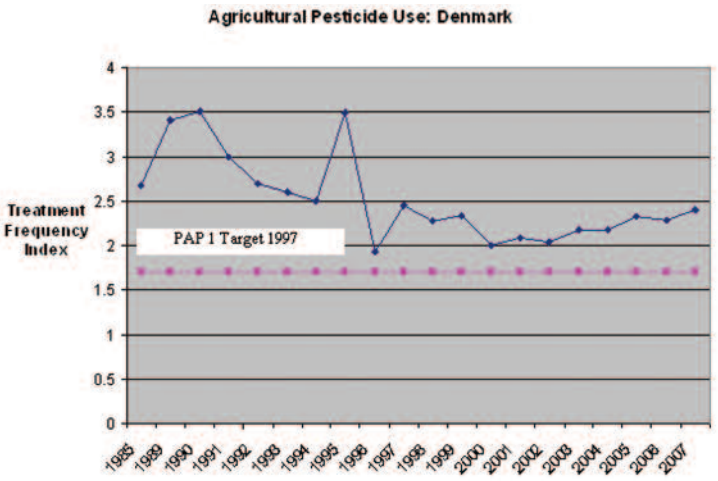
Figure 9:



Source: Ministry of Environment (1986 - 2008)

In 1997, the Minister of Environment and Energy appointed a committee to assess the overall consequences of phasing out the use of pesticides (the Bichel Committee). The Committee presented its report in March 1999. The Bichel Committee found that the use of pesticides in agriculture could be reduced from a treatment frequency index of 2.45 in 1997 to between 1.4 and 1.7 within a ten-year period without serious financial loss for farmers (Bichel Committee, 1999). The Committee concluded that the reduction could be achieved using existing knowledge such as use of damage thresholds, together with weed harrowing and other

Figure 10:

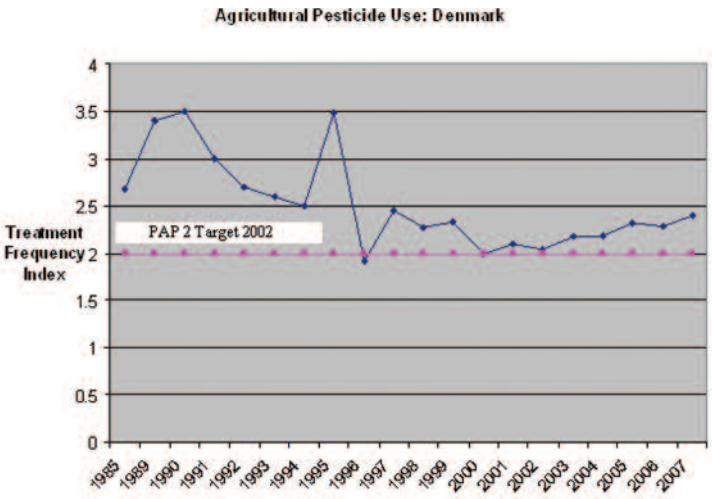


Source: Ministry of Environment (1986 - 2008)

mechanical weed control where these methods can compete with the chemical methods with respect to effect and economics. In 2000, the Danish government adopted Pesticide Action Plan 2 which set the goal for reduction of the treatment frequency index in stages. The target of 2.0 was set for 2002 with a plan to set a new target every three years. At the end of 2002, the treatment frequency index had been reduced to 2.04 (Ministry of Environment, 2008) (Figure 11).

The Pesticide Action Plan 2004-2009 was passed in 2003.

Figure 11:

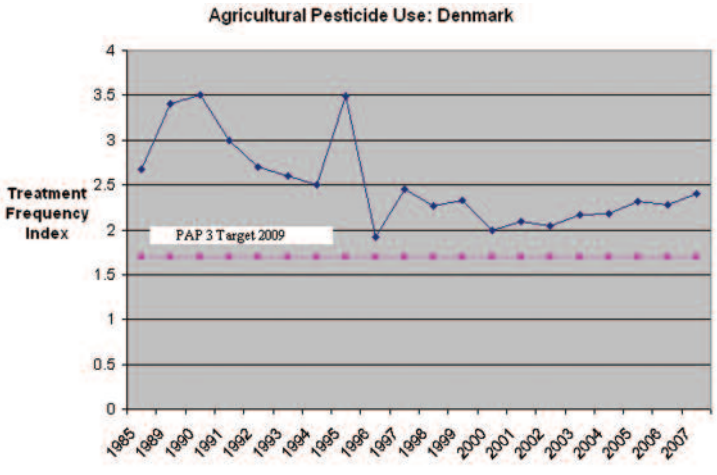


Source: Ministry of Environment (1986 - 2008)

The government aimed to reduce the treatment frequency index to 1.7 by 2009 (Ministry of Environment, 2007). The target was to be achieved through targeted communication and consultancy at the farm level so that existing knowledge would be disseminated to farmers. A recent evaluation of the 2004-2009 Plan showed that the frequency of treatment index was not reduced. In fact, the frequency of treatment increased significantly in the period, despite the objective of achieving a significant decrease (Ramboll Management, 2008) (Figure 12).

One recent trend in Denmark that has led to increased herbicide use is conversion to reduced or minimum tillage. It is estimated that 150-200,000 hectares are being tilled by a system without plowing (Sandal, 2006). Reduced tillage is not supported by environmental support schemes, and the increase in reduced tillage in Denmark seems to be driven by economic reasons (Orum *et al*, 2006). The driving forces behind this rapid development are mainly the decreasing grain prices and the fact that large farming units are being formed. (Large farms are often necessary to sustain a full-time farmer). This fact forces the farmer to seek opportunities for cutting down production costs and to find ways to farm larger areas with unchanged labor input (Sandal, 2006). As a result, farmers are relying more on herbicide spraying to replace more labor-intensive tillage for removing weeds from fields before planting. The use of glyphosate has accordingly significantly increased in Denmark in recent years (Ministry of Environment, 2008) (Figure 13).

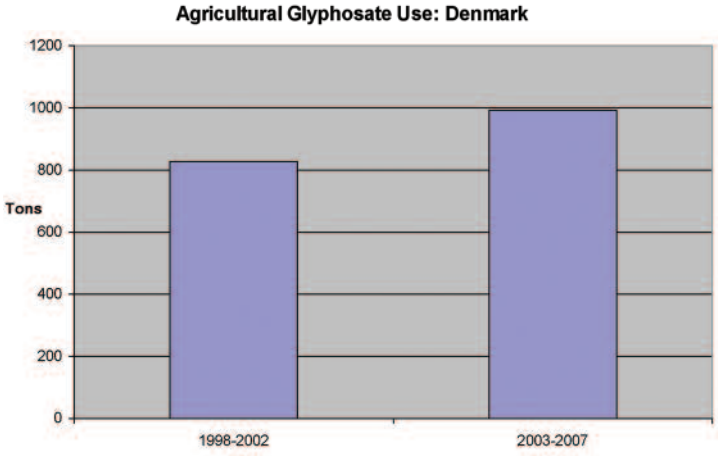
Figure 12:



Source: Ministry of Environment (1986 - 2008)

The Bichel Committee estimated that a total phaseout of pesticides in Denmark would reduce production of cereals by 70%, potatoes by 69% and sugarbeets by 63%. In addition the Committee concluded that a total phaseout of pesticides would make it very doubtful whether a commercial production of apples, pears, and cherries could be maintained to any significant extent. A comprehensive analysis of the potential for reducing pesticide use in horticulture and fruit growing was carried out as a follow-up to the recommendations of the Bichel Committee (The Kirsten Jensen Committee) (Jensen, 2003). The analysis showed that it would not be possible to set up specific reduction goals for horticulture and fruit growing because the crops are high value crops, for which failed pest and weed control may lead to substantial losses.

Figure 13:



Source: Ministry of Environment (1986 - 2008)

Conclusions

The CLF Study reveals that the main reasons for the reduction in the volume of pesticide use amounts in Scandinavian countries were research that showed the efficacy of lower doses of herbicides already on the market and the introduction and rapid farmer acceptance of low-rate herbicides in cereal crops. The reduction in herbicide use volume took place both in countries with formal policies (Sweden, Denmark) and countries with no formal use reduction policies (Finland,

Norway). Indeed, in the 1991-1995 time period, the pesticide volume reductions in countries without mandatory use reduction programs (Austria, Belgium, France, Germany, Italy, Spain, United Kingdom) averaged the same (-26%) as countries with use reduction policies (Denmark, Sweden, Netherlands) (Urech, 1996).

Reductions in pesticide use in Scandinavia should be considered more as an adaption to what is technically and economically possible rather than breaking any new regulatory and policy ground (Pettersson, 1994). It was largely coincidental that Denmark and Sweden introduced policies to reduce the volume of pesticides used at the same time that new low-rate herbicides were introduced. Farmers in Scandinavia are as dependent on herbicides today as they were before the policies were introduced with more than 90% of cereal acreage being treated.The number of applications per treated acre has not been reduced. Scandinavian countries have not even considered extending their policies to horticultural crops (fruit and vegetables) because of the practical impossibility of reducing pesticide use without a significant loss in yields.

The recent increase in herbicide usage volumes in Scandinavia demonstrates the benefits of herbicides in furthering the adoption of low-till crop growing with the goal of improving the environment.

References

Bellinder, R., G. Gummesson, and C. Karlsson. 1994. Percentage-Driven Government Mandates for Pesticide Reduction: The Swedish Model, *Weed Technology*, **8**, pp 350-9.

Bernson, V., & G. Ekstrom. 1991. Swedish Policy to Reduce Pesticide Use, *Pesticide Outlook*, **2**(**3**), pp 33-6.

Bichel Committee. 1999. Report from the Main Committee, Danish Environmental Protection Agency, http://www2.mst.dk/Udgiv/publications/1998/87-7909-445-7/html/default_eng.htm, accessed June 1st, 2009.

Bjorlo, B. 2006. Pesticide Use in Agriculture in 2005, Statistics Norway, http://www.ssb.no/emner/10/04/10/rapp_plantevern/rapp_200642/rapp_200642.pdf, accessed June 1st, 2009.

Franzen, M. 2007. Sweden: Programme to Reduce the Risks Connected with the Use of Pesticides, Swedish Board of Agriculture. http://www.jki.bund.de/cln_045/nn_1150582/EN/Home/ReductionofPlantProtection/Sweden.html, accessed June 1st, 2009.

Fykse, H., K. Semb Torresen, and E. Romstad. 2004. Production Systems and Plant Protection Requirements in Cereals: a Model Analysis of Long-term Effects, *Acta Agric. Scand*, **54**, pp 149-60.

Granstrom, B. 1976. Weeds, Weed Control and the Environment, in *Proceedings of the 17th Swedish Weed Conference,* Uppsala, Sweden.

Hyvonen, T., E. Ketoja, and J. Salonen. 2003. Changes in the abundance of weeds in spring cereal fields in Finland, *Weed Research*, **43**, pp 348-56.

Jakobsons, P. 1970. Norwegian Weed Control Experiments, in *Technical Papers of the FAO International Conference on Weed Control*, Davis, California, USA. Weed Science Society of America, pp 65-7.

Jensen K. 2003. Rapport fra udvalget til vurdering af konsekvenserne af en nedsat pesticidanvendelse i gartneri og frugtavl, Miljostyrelsen, Nr. 70. http://www2.mst.dk/udgiv/publikationer/ 2003/87-7972-761-1/html/default.htm, accessed June 1st, 2009.

Lankoski, J., M. Ollikainen, and P. Uusitalo. 2006. No-till technology: benefits to farmers and the environment? Theoretical analysis and application to Finnish agriculture, *European Review of Agricultural Economics*, **33**(**2**), pp 193-221

Matteson, P. 1995. The '50% Pesticide Cuts' in Europe: A Glimpse of Our Future? *American Entomologist*, **41**, pp 210-20.

Ministry of Agriculture. 2004. *Action plan on reducing risk connected to the use of pesticides (2004-2008)*, (Oslo, Norway).

Ministry of Environment. 2000. *Background Report for Pesticide Action Plan II*. (Copenhagen, Denmark)

Ministry of Environment. 2003. Status of the Minister for the Environment's Action Plan for Reducing the Consumption of Pesticides, 1997 updated 24/11/03 (Copenhagen, Denmark)

Ministry of Environment. 2007. Danemark: Pesticides Plan 2004 – 2009 for Reducing Pesticide Consumption and its Impact on the Environment. http://www.jki.bund.de/nn_1150582/EN/Home/ReductionofPlantProtection/Denmark.html, accessed June 1st, 2009.

Ministry of Environment. 1986-2008. *Bekaempelsesmiddelstatistik 2007*, Orientering fra Miljostyrelsen Nr. 4 (Denmark). http://www2. mst.dk/udgiv/publikationer/2008/978-87-7052-802-3/pdf/978-87-7052-803-0.pdf, accessed June 1st, 2009.

Mukula, J. 1963. National Weed Campaign of 1962, *Maatal ja Koetoim*, **17**, pp 192-200.

Mukula, J. & E. Ruuttunen. 1969. Chemical Weed Control in Finland in 1887-1965, *Annales Agriculturae Fenniae*, **8**, **Supplementum 1**, pp 12-43.

Mukula, J. & O. Rantanen. 1987. Climatic risk to the yield and quality of field crops in Finland, *Annales Agriculturae Fenniae*, **26**, pp 1-18.

OECD. 2008. *Environmental Performance of Agriculture in OECD Countries since 1990*. http://www.oecd.org/document/10/0,3343,en_2649_33793_40671178_1_1_1_1,00.html, accessed June 1st, 2009.

Orum, J.E., B.H. Jacobsen, and M. Andersen. 2006. Modelling farm economic and environmental effects from reduced tillage, in *Tillage Systems for the Benefit of Agriculture and the Environment*, NJF Seminar 378, Nordic Association of Agricultural Scientists, Nordic Agricultural Academy, Odense, Norway.

PAN Europe. 2003. *Pesticide Use Reduction is Working: An assessment of national reduction strategies in Denmark, Sweden, the Netherlands and Norway.* http://www.pan-europe.info/Resources/Reports/Pesticide_Use_Reduction_is_Working.pdf, accessed June 1st, 2009.

Pettersson, O. 1994. Reduced Pesticide Use in Scandinavian Agriculture, *Critical Reviews in Plant Sciences*, **13**(**1**), pp 43-55.

Pettersson, O. 1997.Pesticide Use in Swedish Agriculture: The Case of a 75% Reduction, in *Techniques for Reducing Pesticide Use*, John Wiley & Sons Ltd, West Sussex, England.

Ramboll Management. 2008. *Evaluering af malopfyldelse og virkemidler i Pesticidplan 2004-09*, Miljoprojekt Nr. 1247. http://www2.mst.dk/udgiv/publikationer/2008/978-87-7052-829-0/pdf/978-87-7052-830-6.pdf, accessed June 1st, 2009.

Saethre, M-G., H. Orpen, and T. Hofsvang. 1999. Action programmes for pesticide risk reduction and pesticide use in different crops in Norway, *Crop Protection*, **18**, pp 207-15.

Salonen, J., & L.R. Ervio. 1988. Efficacy of chemical weed control in spring cereals in Finland, *Weed Research*, **28**, pp 231-5.

Sandal, E. 2006. Why Danish farmers convert to reduced tillage systems, in *Tillage Systems for the Benefit of Agriculture and the Environment*, NJF Seminar 378, Nordic Association of Agricultural Scientists, Nordic Agricultural Academy, Odense, Norway.

Savela, M-L. & E-L. Hynninen. 2004. Slower Growth in Pesticide Sales, *Kemia-Kemi*, **31**(**6**), pp 57-9.

Statistics Norway. 2006. Pesticide Use in Agriculture in 2005 – Increased use of Herbicides, http://www.ssb.no/jordmil_en/main.html, accessed June 1st, 2009.

Statistics Norway. 2008. *Natural Resources and the Environment 2007* http://www.ssb.no/english/subjects/01/ sa_nrm/arkiv/nrm2007/, accessed June 1st, 2009.

Svensson, A. 1982.Methods of Weed Control in Cereals – Efficiency, Costs and Consequences, *Proceedings of the 23rd Swedish Weed Conference*, Uppsala, Sweden, pp 10-25.

Swedish Board of Agriculture. 2009. *Jordbruksstatistisk arsbok 2001-2008*, http://www.sjv.se/amnesomraden/statistik/ja.4.7502f61001ea08a0c7fff104195.html accessed June 1st, 2009.

Thonke, K.E. 1991. Political and Practical Approaches in Scandinavia to Reduce Herbicide Inputs, *Brighton Crop Protection Conference-Weeds*, pp 1183-90.

Torresen, K.S., J. Salonen, H. Fogelfors, S. Hakansson, and B. Melander. 2006. Weed Problems in various tillage systems in the Nordic countries, in *Tillage Systems for the Benefit of Agriculture and the Environment*, NJF Seminar 378, Nordic Association of Agricultural Scientists, Nordic Agricultural Academy, Odense, Norway.

Urech, P.A. 1996. "Is more legislation and regulation needed to control crop protection products in Europe?" *Brighton Crop Protection Conference-Pests & Diseases*, pp 549-57

Weinberg, A. 1990. Reducing agricultural pesticide use in Sweden, *Journal of Soil and Water Conservation*, Nov-Dec., pp 610-613.

Author Biographies

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