EUROPEAN MANAGEMENT PRACTICES FOR SUSTAINABLE AGRICULTURE

Edinel ROBU[1], Vasile NECULĂIASA[2], Brînduşa ROBU[2], Matei MACOVEANU[2]

[1] Akkeron Farming Ltd., Bucharest, Romania
[2] Gheorghe Asachi Technical University of Iasi

Abstract

The impact on agriculture is arising from unintended adverse effects of herbicide use on plant life, and the resistance of plants to herbicides has become a global problem. The current approach is to limit the use of herbicides and pesticides in agriculture by integrated pollution prevention and control directive. Over the past two decades, tolerance to specific herbicides has been introduced intentionally, as a novel trait into a number of crop species to provide farmers with the additional means to control weeds without damaging their crops. In recent years, biotechnology has been used in the development of other herbicide tolerant crops. The practices for sustainable agriculture are essential, and it is recommended the promotion and maintenance of careful management practices for farmers. There are a number of beneficial management practices (BMPs) which agricultural producers can incorporate into their farming practices to decrease their impact on environment. These BMPs can be placed into four management sectors: soil and land management, livestock management, crop management, and nutrient management. This paper states the current European management practices used for achieving the sustainable agriculture concept and that can be applied in Romania too.

Keywords: sustainability, European agriculture, best management practices

Agricultural sectors can cause environmental contamination, and various pollutants are involved including organic compounds and heavy metals (HMs) such as cadmium (Cd), chromium (Cr), mercury (Hg), lead (Pb), copper (Cu), nickel (Ni) and zinc (Zn), which need to be studied closely, since they are generally toxic to animals and plants (McNeely and Scjerr, 2003; Popkin B., 1998; Robu and Macoveanu, 2005). The main risk is contamination of the water supply or food chain via crops. Impact on agriculture is also arising from unintended adverse effects of herbicide use on plant life. Plants become resistant to herbicides, and this resistance has become a global problem (Pretty J., 1991; Robu B. et.al, 2009; Robu T. At.al., 2008). Weeds can develop multiple herbicide resistance creating another problem for the agricultural industry. One approach to minimizing the emergence of resistant strains is to limit the exposure of the target species to the chemical agent, hence reducing selection pressure (Abruckle and Sever, 1998; Bane et.al., 1993; Pingali and Roger, 1995; Pretty at.al., 2000;Uphoff N., 2002). A great part of herbicides used in agriculture field have long lasting remanence, even over three years, and an important part of the active substances of the herbicides pollute the soil and subsequently the waters, sometimes with disastrous effect for the environment (Arbuckle T.E., Sever L.E., 1998; Bane G., Murray H., Dick R.P., *A*, 1993; N. Uphoff (ed), 2002). Also, some pollutants can be metabolized by culture plants which, in their turn, by consumption, can adversely affect the people's health. The measures of modern agriculture bring resistant species that occur with increasing densities after the removal of their competitors. In addition, they are able to enlarge their area and to invade sites, where they had not been able to compete before, or sites where they could not previously bear the environmental conditions together with the competition of the rich weed flora (NAF, 1994; NASS, 1992; Pimentel and Alo, 1998; Pretty J., et.al, 2001; WSSD, 2002). The use of herbicide-tolerant crops encourages the use of herbicides in the crop field without damage the crop. Herbicide tolerance does not increase crop yields, but it does increase the use of herbicides in agriculture and the pollution of agro-ecosystems and other ecosystems (DTI 2001; UNECE, 2003; Walters D.T., 2005).

There are three reasons to limit the use of pesticides to situations where significant benefits will result: they may harm human health, environment and may create problems in agriculture if used in excess. This is the reason that

European organism for agriculture established policies, strategies and best management practices that can converge to sustainable agriculture at European level (Downey R., 1999; California University, 1992; Norse et.al, 2001).

MATHERIAL AND METHOD

Many different terms have come to be used to imply sustainability in agricultural systems such as: eco-agriculture, permaculture, organic, ecological, low-input, biodynamic, environmentally-sensitive, community-based, wise-use, farm-fresh and extensive. There is continuing and intense debate about whether agricultural systems using some of these terms qualify as sustainable. Systems high in sustainability are making the best use of nature's goods and services whilst not damaging these assets, and the key principles are the followings (Crissman et.al, 1998):

1. *integrate natural processes* such as nutrient cycling, nitrogen fixation, soil regeneration and natural enemies of pests into food production processes;
2. *minimize the use of non-renewable inputs* that damage the environment or harm the health of farmers and consumers;
3. *make productive use of the knowledge and skills* of farmers, so improving their self-reliance and substituting human capital for costly inputs;
4. *make productive use of people's capacities to cooperate* to solve common agricultural and natural resource problems, such as for pest, watershed, irrigation, forest and credit management.

The idea of agricultural sustainability means that if a technology works to improve productivity for farmers, and does not harm the environment, then it is likely to be beneficial on sustainability grounds. Agricultural systems emphasizing these principles are also multi-functional within landscapes and economies. They jointly produce food and other goods for farm families and markets, but also contribute to a range of valued public goods, such as clean water, wildlife, carbon sequestration in soils, flood protection, groundwater recharge and landscape amenity value (Baumol and Oates, 1988; georgiou et.al, 1998; WSSD, 2002). Sustainability implies intensification of resources – making better use of existing resources (*e.g.* land, water, and biodiversity) and technologies. The intensification using natural, social and human capital assets, combined with the use of best available technologies and inputs (best genotypes and best ecological management) that minimize or eliminate harm to the environment, can be termed *sustainable intensification* (Altieri M., 1995; Hester and Harrison. 2005).

Agriculture can negatively affect the environment through overuse of natural resources as inputs or through their use as a sink for pollution. Such effects are called negative externalities because they are usually non-market effects and therefore their costs are not part of market prices. Negative externalities are one of the classic causes of market failure whereby the polluter does not pay the full costs of their actions, and therefore these costs are called external costs (Defra, 2005; NASS, 1993). Farmers have few generally incentives to prevent pesticides escaping to water bodies, the atmosphere and to nearby nature as they transfer the full cost of cleaning up the environmental consequences to society at large. In the same way, pesticide manufacturers do not pay the full cost of all their products, as they do not suffer from any adverse side effects that may occur. Partly as a result of lack of information, there is little agreement on the economic costs of externalities in agriculture. Some authors suggest that the current system of economic calculations grossly underestimates the current and future value of natural capital. Such valuation of ecosystem services remains controversial because of methodological and measurement problems and because of its role in influencing public opinions and policy decisions. The great success of industrialized agriculture in recent decades has masked significant negative externalities, many of which arise from pesticide overuse and misuse (Gulden and Entz, 2005).

RESULTS AND DISCUSSIONS

European management practices for sustainable agriculture

A key aspect of modern agriculture is how it uses land and other natural resources intensively to produce high yields of crops and other products. These processes depend on the use of fertilizers and agro-chemicals to control pests and diseases. Modern agricultural practices have, in the relatively recent past, prioritized food production above environmental concerns and, as a result, adverse impacts on biodiversity and water quality have been commonplace. These adverse effects are very specific to particular countries and regions. This is partly because of differences in management practices and partly because of natural environmental heterogeneity (Downey R., 1999; P2Pays, 1995).

It has been recognized that the effects on water quantity and quality, rates of soil erosion and biodiversity have been reaching levels where the costs of mitigation and remediation are sufficiently high to affect taxpayers' pockets (*e.g.* water bills can nowadays reflect the need to protect environmental resources). Concurrently, in many regions of the world, particularly in north-west of Europe, there are moves to reform *institutions* such as the Common Agricultural Policy (CAP) in a way that redresses the balance between agricultural yields and environmental goods and services. Thus, it has been accepted that any rebalancing of priorities would only be possible if land managers and owners were able to make a continuing living from the land. There is now a substantial move to encourage agriculture to use land and crop management practices that are more sustainable (*fig.1*). The use of appropriate agronomic practices is essential while growing herbicide tolerant varieties if this technology is to remain effective. It is recommended the promotion and maintenance of careful management practices for growers who use these crops to minimize the development of multiple resistances.

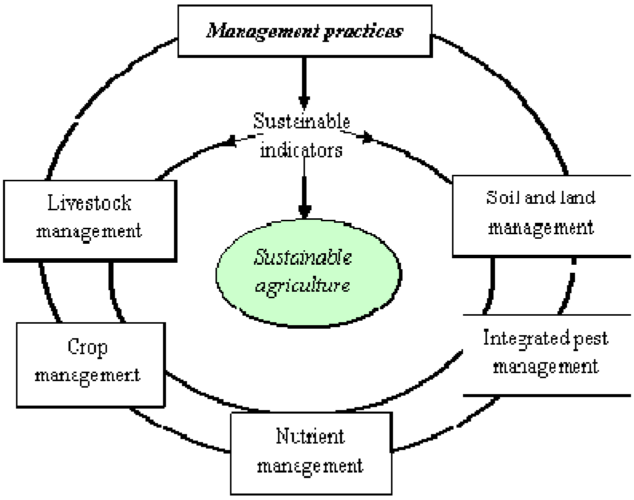

Figure1 **Management practices for sustainable agriculture**

There are a number of beneficial management practices (BMPs) which agricultural producers can incorporate into their farming practices to decrease their impact on greenhouse gas emissions. These BMPs can be placed into four management sectors: soil and land management, livestock management, crop management, and nutrient management (LeBaron and McFarland, 1990; Lee and Colt, 2005; Muir and Rattanamongkolgul, 2005).

Soil and land management

Reducing the number of tillage passes over a field decreases CO_2 emissions by both lowering total fuel consumption and sequestering, or storing, carbon in the soil. While zero tillage systems emit less carbon (C) through fuel and machinery use, they do exhibit greater herbicide use (table 1); however, the use of herbicides in agriculture constitutes a very small portion of total carbon emissions (less than 7 %/year).

Table 1

Comparison of carbon emissions (C/ha/yr) in conventional and zero tillage systems

	Conventional tillage (CT)	Zero tillage (ZT)	ZT as % of CT
Machinery	10.55	7.08	67.1
Fuel	22.56	14.57	64.6
N fertilizer	54.9	51.53	93.9
P fertilizer	7.7	7.34	95.3
Herbicide	4.52	5.87	129.8

The carbon content of restored wetland basins increases at a rate 2 times greater than if the wetland basin was left in the cropping system (Hester and Harrison, 2005). As well, the crop seeded in low-lying areas of the field often drowns out, building up azoth concentrations in the soil; therefore, the potential for N_2O emissions in these depression areas is high. Although seeding and harvesting around wetlands may be unfavorable to producers, including these areas in the cropping system is often a waste of seed and fertilizer (Gulden and Entz, 2005).

Livestock management

Higher quality feed needs less time in the rumen for digestion, leading to a decrease in methane emissions from cattle. The Westman Agricultural Diversification Organization (WADO) carried out a study and underlined that to decrease the risk of anaerobic decomposition of manure and lower CH_4 emissions, it is important to avoid stockpiling manure. The amount of bedding should also be kept to a minimum as the high C content of straw favors CH_4 production. Thus a best management practice could be avoiding excessive manure applications may also prevent the build-up of N in the soil (Janzen et.al, 2003).

Crop management

Establishing perennial forages is an important issue in agriculture sector. Perennial forages, such as alfalfa, require fewer tillage passes, extract N from deep in the soil and have the ability to sequester C deeper in the soil (due to the deep rooting habit of the crop). Growing the legume crops is an other appropriate practice that could be applied as best management practice in agriculture because the legume crops have the ability to "fix" their own N, thus requiring less N fertilizer during the season in which they are grown (Lee and Colt, 2005; Altieri M, 1995).

Nutrient management

Nitrogen source, rate, timing and placement should all be considered to match the availability of N to the requirements of the crop (use N fertilizer efficiently). Soil testing is a key part of this strategy as it informs the producer of N availability in the soil and N requirements for the subsequent crop. It is extremely important that residual N is not carried over through the winter, considering the potential for loss as N_2O during spring thaw (Janzen et.al, 2003).

Integrated pest management (IPM)

IPM is a decision-making process that can be used by growers to reduce pesticide use by evaluating the need for controls of pests on their fields and evaluating all available alternatives to controlling those pests. Globally, there is a need to agree on a definition of IPM, and communicate this definition to the stakeholders that work in the agriculture industry. Apparently, many growers are intimidated by IPM because, from their point of view, this could be an approach in which no pesticides are used, but IPM approaches do not eliminate the use of pesticides (LeBaron and McFarland, 1990; Riekman and Cavers, 2005).

Challenges in establishing Beneficial Management Practices (BMP)

The major challenge with establishing full BMPs is in the lack of quantitative data on the impact that these practices have on greenhouse gas production. In many cases, it is assumed that BMPs will decrease greenhouse gas emissions, based on current knowledge of the processes creating the gases. In the case of N_2O, research is currently being carried out on the landscape element of these emissions, but understanding the effect of landscape on emissions is complex. Nowadays, the orientation is to decrease greenhouse gas emissions, and for this it is important that precise data be collected to better understand the potential of these BMPs and their impact on mitigating greenhouse gas emissions.

Other management issues for sustainable agriculture

In order to make land management more sustainable, key issues of the international sustainability agenda need to be taken on board by any economic or social group trying to reach the goal of sustainability. These issues can be extracted from the United Nations document *Plan of Implementation of the World Summit on Sustainable Development, Johannesburg, 2002* and from related documents prepared under the auspices of the United Nations Economic Commission for Europe as follows:

- Patterns of consumption and production need to be examined throughout their complete life-cycle in order to determine the balance between economic and social advantage and environmental impacts. Such studies have to determine the capacity of the environment to produce a range of ecosystem services from any given parcel of land, to consider the function of soil in flood defense where the capacity of soil to absorb water can be a key mitigating factor.
- Stakeholders need to be aware of the options for managing land in different ways. In considering options, the risks and opportunities associated with each option need to be taken into account. Awareness of options, risks and opportunities will help them make an informed choice as to which option is the most sustainable given their particular set of social, economic and environmental circumstances.
- Stakeholders need to be engaged not only in the decision-making process but also in formulating information gathering and research activity designed to help them make informed choices (*i.e.* choices made with knowledge of the outcomes of decisions). The process of stakeholder engagement should make it possible to resolve conflicts over natural resources and devise sustainable management plans that should secure the livelihoods of future generations and the interests of the environment.
- Decisions on sustainable land-management may need to be made at geographical scales that are above the traditional decision-making unit of the field, farm or estate. In other words, land owners and managers may need to make decisions at the scale of the river catchments or the landscape. This would entail levels of co-operation between stakeholders of a very different kind to that which society is used to. One key to success would be the provision of information on options for land management at such scales.
- To make land management practices work, *indicators of sustainability* will need to be developed using multi-criteria techniques. For such indicators, or for key components of multi-criteria indicators, there would need to be thresholds of acceptability that were based on an understanding of ecological and environmental processes regulating biodiversity or setting the rates of biogeochemical or hydrological cycles. Thresholds would have to be set such that remedial action could be taken before any problems became serious enough to do harm or damage.

CONCLUSIONS

The agricultural sectors can cause environmental contamination by various pollutants involved in its processes such as organic compounds and heavy metals which need to be studied closely, since they are generally toxic to animals and plants. The main risk is contamination of water supply or food chain via crops. Impact on agriculture is also arising from unintended adverse effects of herbicide and pesticide use considering that they may harm human health, environment and may create problems in agriculture if used in excess. This is the reason that European organism for agriculture established policies, strategies and best management practices that can converge to sustainable agriculture at European level.

Adopting the key management issues is challenging for all concerned, it may well be that agriculture is a good area in which to test them and establish good working practices. This is because the agricultural sector has already dealt with environmental issues over a number of years. A system of regulation of pesticide use has evolved with a strong scientific base in the area of pest and disease control. In many senses this system of regulation has the effect of balancing, through a network of committees, the need for adequate supplies of good quality food against concerns for human health and environmental integrity. Good quality of impact and risk assessment has been the key to success in agriculture sector. But, landscape level management has yet to be tried. There are very few tools, easy to use to help make such systems work, and further policies should be stated in order to establish clearly the best practices for sustainable agriculture.

Acknowledgements

One of the authors would like to acknowledge the financial support from Romanian Ministry of Education and Research (Project ID 595, contract no. 132/2007).

BIBLIOGRAPHY

Altieri, M.A., 1995 - *Agroecology: The Science of Sustainable Agriculture*, Westview Press, Boulder.

Arbuckle, T.E., Sever, L.E., 1998 - Pesticide exposures and fetal death: a review of the scientific literature, *Crit. Rev. Oxicol.,* 28, 229-270.

Baldi, M., Mohammed-Brahim, B., 1998 - Delayed health effects of pesticides: review of current epidemiological knowledge, *Rev. Epidemiol. Sante Publique*, 46, 134-142.

Bane, G., Murray, H., Dick, R.P., 1993 - *A Sustainable Agriculture Resource Guide for Oregon and Washington,* EM 8531, Corvallis, Oregon State University Extension Service USA.

Baumol, W.J., Oates, W.E., 1988 - *The Theory of Environmental Policy*, Cambridge University Press, Cambridge, 1988.

Conway, G.R., Pretty, J., 1991 - *Unwelcome Harvest: Agriculture and Pollution*, Earthscan, London.

Crissman C.C., Antle, J.M., Capalbo (eds.), S.M., 1998 - *Economic, Environmental and Health Tradeoffs in Agriculture*, CIP, Lima and Kluwer, Boston.

Delgado, C., Rosegrant, M., Steinfield, H., Ehui, S., Courbois, C., 1999 - *Livestock to 2020: The Next Food Revolution,* International Food Policy Research Institute, Washington DC.

Georgiou, S., Langford, I.H., Bateman, I.J., Turner, R.K., 1998 - *Environment and Planning,* 30(4), 577–594.

Gulden, R.H., Entz, M.H., 2005 - Energy use and carbon production by manufactured inputs in crop production: A comparison of two Manitoba farms with contrasting tillage systems, *Natural Systems Agriculture*, University of Manitoba, Canada.

Hester, R.E., Harrison, R.M. (editors), 2005 - Issues in Environmental Science and Technology, *Sustainability in Agriculture*, The Royal Society of Chemistry, Cambridge, UK.

Janzen, H.H., Beauchemin, K.A., Bruinsma, Y., Campbell, C.A., Desjardins, R.L., Ellert, B.H., Smith, E.G., 2003 - The fate of nitrogen in agroecosystems: An illustration using Canadian estimates, *Nutrient Cycling in Agroecosystems*, **67**, 85-102.

LeBaron, H.M., McFarland J., 1990 - *Herbicide resistance in weeds and crops: an overview and prognosis*, ACS Symposium series - American Chemical Society, USA.

Lee, W.J., Colt J.S., 2005 - Agricultural pesticide use and risk of glioma in Nebraska*, Occup. Environ. Med.,* **62**, 786-792.

McNeely, J.A., Scherr, S.J., 2003 - *Ecoagriculture*, Island Press, Washington DC.

Muir, K., Rattanamongkolgul, S., 2004 - Breast cancer incidence and its possible spatial association with pesticide application in two counties of England. Public health 118: 513-520, UK.

Norse, D., Ji, L., Leshan, J., Zheng, Z., 2001 - *Environmental Costs of Rice Production in China*, Aileen Press, Bethesda.

Pimentel, D., Ali, M. S.,1998 - An economic and environmental assessment of herbicide-resistant and insect/pest-resistant crops. *Indian Journal of Applied Economics,* **7**, 241-252.

Pingali, P.L., Roger, P.A., 1995 - *Impact of Pesticides on Farmers' Health and the Rice Environment*, Kluwer, Dordrecht.

Popkin, B., 1998 - *Public Health Nutrition*, 1(1), 5–21.

Pretty, J., 1995 - *Regenerating Agriculture: Policies and Practice for Sustainability and Self-Reliance*, Earthscan, London and National Academy Press,Washington.

Pretty, J., 2002 - *Agri-Culture: Reconnecting People, Land and Nature,* Earthscan, London.

Pretty, J., 2003 - *Science,* 302, 1912–1915.

Pretty, J., Brett, C., Gee, D., Hine, R., Mason, C.F., Morison, J.I.L, Raven, H., Rayment, M., Van der Bijl, G., 2000 - *Agricultural Systems*, 65 (2), 113–136.

Pretty, J., Brett, C., Gee, D., Hine, R.E., Mason, C.F., Morison, J.I.L., Rayment, M., Van der Bijl, G., Dobbs T., 2001 - *Journal of Environment planning and Management*, 44(2), 263–283.

Pretty, J., Mason, C.F., D.B. Nedwell, D.B., Hine, R.E., 2003 - *Environmental Science and Technology,* 37(2), 201–208.

Pretty, J., Ward, H., 2001 - *World Development,* **29 (2)**, 209–227.

Riekman, M., Cavers, C., 2005 - *Best Management Practices to Combat Greenhouse Gas Production,* Manitoba Zero Tillage Research Association and Greenhouse Gas Mitigation Program, and Manitoba Agriculture, Food and Rural Initiatives, Carman, MB, Canada, On line at: http://www.umanitoba.ca/afs/agronomists_conf/proceedings/2005/riekman_best_management.pdf

Robu, B., Ioan, C.C., Robu, E., Macoveanu, M., 2009 - European frame for sustainable agriculture in Romania: Policies and Strategies, *Environmental Engineering and Management Journal*, 8(5), 1171-1179.

Robu, B., Macoveanu, M., 2005 - Integration of risk assessment into environmental impact assessment procedure – case study for steel processing, Proc. of the 9th Int. Conf. on Environmental Science and Technology Rhodes, Greece.

Robu, T., Robu, B., Robu, S.,2008 - Valorification of herbs in phytotherapy – an alternative of chemical treatments in agriculture, *Environmental Engineering and Management Journal*, 7(5), 579-588.

Röling, N.G., Ewagemakers, M.A. (eds), 1997 - *Facilitating Sustainable Agriculture*, Cambridge University Press, Cambridge.

Tegtmeier, E. M., Duffy, M.D., 2004 - *International journal of Agricultural Sustainability*, 2.

Uphoff, N. (ed), 2002 - *Agroecological Innovations*, Earthscan, London.

Uphoff, N., Dasgupta, P., Serageldin, I. (eds), 1998 - *Social Capital: A Multiperspective Approach*, World Bank, Washington DC.

Walters, D.T., 2005 - Fertilizer nitrogen source and management impacts on greenhouse gas emissions, North Central Extension Industry Soil Fertility Conference v21. Des Moines, IA, USA, On line at: http://soilfertility.unl.edu/Materials%20to%20include/Research%20Pubs/Walters_Fertilizer%20nitrogen%20source%20and%20management%20impacts%20on%20greenhouse%20gas%20emissions.pdf

*** * *, 1992 -** California University, *Beyond Pesticides -- Biological Approaches to Pest Management in California,* Division of Agriculture and Natural Resources, University of California, ANR Publications 510-642-2431.

*** * *, 1993 -** NASS, *Agriculture Chemical Usage-Vegetables, Summary,* United States Department of Agriculture, National Agriculture Statistics Service, USA.

*** * *, 1994 -** NAF, *A Better Road to Hoe: The Economic, Environmental, and Social Impact of Sustainable Agriculture,* Available from Northwest Area Foundation at 612-224-9635, USA.

*** * *, 1995 -** P2Pays, *Pollution Prevention in Agriculture: Pesticide use reduction - Report*, Pacific Northwest Pollution Prevention Research Centre, USA, On line at: http://www.p2pays.org/ref/03/02994.pdf.

*** * *, 1999 -** Downey R.K., Risk assessment of out crossing of transgenic brassica, with focus on *B. rapa* and *B. napus*, Proceedings of the 10th International Rapeseed Congress Canberra, Australia.

*** * *, 2001 -** DTI, *Towards More Sustainable Decisions*, Foresight Environmental Appraisal Task Force, Department of Trade and Industry, HMSO, London.

*** * *, 2002 -** WSSD, *Plan of Implementation of the World Summit on Sustainable Development*, *Johannesburg*, United Nations, New York (available at: *http:// www. johannesburgsummit. org/html/documents/summit_docs/131302_wssd_report_reissued.pdf*).

*** * *, 2003 -** UNECE, *Declaration by the Environment Ministers of the Region of the United Nations Economic Commission for Europe* (*UNECE*) *at the 5th Ministerial Conference, Kiev*, United Nations, Geneva (available at: *http://www. unece.org /env/ documents/2003/kievconference /ece.cep.94.rev.1.e.pdf*).

*** * *, 2005 -** Defra, *Securing the Future–the UK Government's Sustainable Development Strategy*, HMSO, London, 2005 (available at *http://www.sustainable-development.gov.uk/ publications/uk-strategy/uk-strategy- 2005.htm*).