Pesticide Action Network Europe

Contribution on research needs for 2014-2020: Crop rotation – the forgotten practice in European Agriculture

PAN Europe position paper

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Whoever skilled agronomist you speak to will tell you that crop rotation[1] is one of the most important agricultural practices, existing for thousands of years, and often used in organic farming but with less and less use in conventional agriculture[2]. Though when trying to find out which scientific literature there exists about this topic, to prove its benefit, you realise that studies are scattered and have never been gathered in a same paper

Why? Few researchers are engaging in research projects, financed beyond three to five years terms, though it takes much longer to evaluate beneficial impacts of crop rotations; rotation may need to be 6 years or longer to achieve the desired crop protection effects, and to quantify such effects it would be necessary to monitor at least 2 successive rotations.

Generally, rotations are not a subject of interest as a business opportunity, as only few had a commercial interest. As a result this is a topic which should receive high priority for public research.

As the EU is currently negotiating the financial framework of the next EU budget, and discussing research priorities, this paper aims at giving an overview of some of the essential research needs on crop rotation

1.0 Long term experiments studying the effects of crop rotation:

Long-term field experiments are an indispensable aid to our knowledge of predominantly practical solutions for sustainable land use. A large proportion of current agronomic problems can be clarified exclusively using long-term experiments[3].

Some of the most famous field experiments on crop rotations include:

- Rothamsted's Classical experiments established in 1843 by Lawes and Gilles to study long-term changes in soil fertility and soil properties[4].

[1] Crop rotation is the practice of growing a series of dissimilar/different types of crops in the same area in sequential seasons.

[2] See for instance:
DG ENV report on crop rotation (http://ec.europa.eu/environment/agriculture/pdf/BIO_crop_rotations%20final%20report_rev%20executive%20summary_.pdf) and Brisson et all 'Why are wheat yields stagnating in Europe? A comprehensive' Field Crops Research Volume 119, Issue 1, 9 October 2010, Pages 201–212

[3] M. Körschens ,The importance of long-term field experiments for soil science and environmental research – a review, 2005

[4] http://www.rothamsted.ac.uk

- The Morrow plots established in 1876 by Morrow and Miles aiming at investigating whether productivity could be sustained and how various cropping-systems would affect yield and soil properties[5].

More recently examples of long term field experiments studying crop rotation include

- a 50 years field experiment in the Northern zone of Moldova showing that crop rotation is increasing significantly productivity of crops relatively to monoculture[6],
- a 40 years field experiment in Martonvasar in Hungary where comparing various crop sequences and fertilisation treatment proved, among others, that the yield of maize and wheat in a monoculture was always lower than in crop rotation[7];
- a 22 years field experiment in the Loess Plataus of China. Comparing 4 rotations, each of 3 to 4 years, involving different combinations of corn, wheat, bruncorn millet and peas, all showing increased yield and significantly better water use efficiency when applying crop rotation[8]; and finally
- a 22- and 25-yr period respectively research in loamy sandy soils in southwest France, showing positive change in the organic carbon content of soil in a long-term continuous non-irrigated maize crop rotation[9]

There thus already seems to be a high number of studies showing the many positive benefits of crop rotation[10], though, studies are scattered and have never been gathered. Furthermore, the continuous studying of crop rotation in combination with new analytical tools (meta-analysis, modelling, and simulation) will help in progressing towards a better understanding and design of crop rotations for improving agro-ecosystem health and thus disease suppressiveness[11].

Linked to this, it is important to mention an article recently published by Pulleman *et al.*[12] which provides an overview of current knowledge on the characterization and assessment of soil biodiversity. Examples of biological soil indicators and monitoring approaches are presented. Furthermore the value of databases for developing a better understanding of the relationship between soil management, soil functions and ecosystem services is discussed. The authors conclude that integration of monitoring approaches and data sets offers good opportunities for advancing ecological theory as well as application of such knowledge by land managers and other decision makers.

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[5] http://cropsci.illinois.edu/research/morrow

[6] Boincean B.P. (2012): The influence of predecessors, varieties, fertilizers and crop rotations on yields of winter wheat in the long-term field experiment (50 years long) in the Nortern steppe zone of Moldova. In Izvestia(News) of Moscow Agricultural Academy K.A.Timiriazev,Vol.3,2012,Moscow,Russia,p.115-127 (in Russian)

[7] Zoltan Berzsenyi, Bela Gyorffy, Dang Quoc Lap, Effect of crop rotation and fertilisation on maize and wheat yields and yield stability in a long-term experiment, European Journal of Agronomy 13 (2000) 225–244).

[8] Mingbin Huang, Mingan Shau, Lu Zhang, Yiasan Le, Water use efficiency and sustainability of long term crop rotation systems in the Loess Plataus of China, Soil and Tillage research 72 (2003) 95-104

[9] D. Plénet, E. Lubet and C. Juste Agronomie 13, 685-698 (1993) Évolution à long terme du statut carboné du sol en monoculture non irriguée du maïs (Zea mays L)

[10] for instance: Finkh, M., van Bruggen, A.H.C. and Tamm, L. (Eds.). APS Press.) Crop rotation. In: Plant Disease management in organic agriculture. (Chapter 4.2).

[11] Finkh, M., van Bruggen, A.H.C. and Tamm, L. (Eds.). APS Press.) Crop rotation. In: Plant Disease management in organic agriculture.

[12] Pullemand M, et all: Soil biodiversity, biological indicators and soil ecosystem services - a review of European approaches. Curre Opin Environm Sustain (2012) http://dx.doi.org/10.1016/j.cosust.2012.10.009

2.0 Research needs within Framework program Horizon 2020 on crop rotation
Taken into account the new research agenda for 2014-2020, PAN Europe has asked a number of scientists to highlight new research needs concerning crop rotations.

Professor **Carlo Leifert,** Newcastle University, states that "**Studies on crop rotation is essential as it help to study the potential for (a) reducing disease, pest and weed pressure (and thereby the need for pesticide use) and (b) mineral nutrient losses and use efficiency (and thereby the need for mineral fertiliser input) is enormous.** However, reluctance of both EU and national governments to fund truly long-tern research into the benefits of diversified rotations and possibly also lobbying of the agrochemical industry against research in this area currently prevents the development and implementation of improved crop rotations in Europe"

Franz Bigler, Senior Scientist at the Swiss research body, Agroscope, proposes a new literature review of the most relevant studies (possibly a kind of **meta-analysis**) on the effects of crop rotation on pest organisms incl. weeds, nematodes, insects and diseases, and recalls the need to investigate and to collate existing data on the economics of new models on how to organize crop rotation in a more economic way among groups of farmers as we know it since a few years in Switzerland. There are now economic data available in Switzerland showing the benefits when farmers share crop rotations on their land with other farmers.

Regarding long term experiments, Rasmussen *et al.*[13], identified back in 1998 that there is, both in a tropical and subtropical environment, a research need to establish an international network **ensuring systematic assessment** to determine the merits of long term experiments, including:

- Develop protocols for long term experiments management and data interpretation,
- Coordinate data collection and link sites, and
- Evaluate new experiments that have a documented record of management (including accidents and mistakes) and a properly managed soil and plant archive.

Mr **Paul E Rasmussen and Hero Gollany**, Research Soil Scientist, Ph.D., USDA-ARS-CPCRC who is the predecessor of Mr Rasmussen confirms that these requests are still all valid on a world scale.

Building on this, Professor **Katarina Hedlund**, Department of Biology, Lund University (Sweden) highlight the importance of **open access to data** that has been produced from resources such as EU research, and storage of data maintained for a long-term perspective, allowing a wider use of use data and information. Prof Hedlund, mentions the Integrated Administration and Control System (IACS) in Sweden as a good example, allowing researchers easy access to a lot of crucial data, among others containing information on which crop rotation farmers are applied, calling on the need to find more possibilities to use these data which exist in other EU member states, but which currently as a result of national restrictions, are unavailable.

Finally, **Celine Pelosi,** researcher at INRA Versailles in France goes even further calling on the **need to find common biological indicators** (to be included in the databases for all countries) to assess the effects of human management and, among others, of crop rotations on the environment. The sustainable management of soils requires soil monitoring, including

[13] Paul E. Rasmussen,* Keith W. T. Goulding, James R. Brown, Peter R. Grace, H. Henry Janzen, Martin Korschens, Sustainability and Global Change Long-Term Agroecosystem Experiments: Assessing Agricultural ,Science 282, 893 (1998);

biological indicators, to be able to relate land use and management to soil functioning and ecosystem services. The development and effective use of meaningful and widely applicable bio-indicators, however, continue to be challenging tasks.

3.0 The way forward for research on crop rotation in the EU:

PAN Europe encourages following work on crop rotation for the coming budget period:

- Keep on reserving EU funding to research into studies on crop rotation, both in short and longer term perspectives, for while some changes in practices show fast effects (eg. Stop ploughing on earthworms), others need more time to be visible/measurable (eg. Pesticide-stop because of the persistence in the soil and the lack of pesticides-eradicated natural predators),
- Launch a literature review on conclusions from already undertaken long term experiments,
- Launch a meta-study on the effects of crop rotation on pest organisms incl. weeds, nematodes, insects and diseases, and
- Reserve funding to study new models on how to organize crop rotation in a more economical way among groups of farmers to ensure practical uptake.

Furthermore PAN Europe calls for the need to increase general knowledge of crop rotation by:

- Collecting data on crop rotation and as part of that on the economics, and
- Spreading knowledge on crop rotation, by making sure the raw data from public bodies, like the Swedish ICSN, and publicly funded research on demonstration farms, like Valle Vacchia[14] , are made available to the public while also
- Investigating the need to develop EU-wide bio-indicators.

[14] http://www.venetoagricoltura.org/basic.php?ID=4050