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Improving food and feed security in the Nordic and Baltic region by using appropriate crop rotations

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Abstract: Rotations in the Nordic and Baltic region are, as elsewhere in Europe, heavily biased towards cereals. Broadleaved crops in general, and grain legumes in particular, offer a range of environmental and agricultural benefits that are inadequately exploited in this region. This article reviews some of the options available to the region. Brassica oilseeds can be used as catch crops, cover crops and biofumigants, as well as for their oil and protein-rich meal. Fibre hemp is a good soil-cleaning crop with excellent bioenergy potential. Grain legumes produce food and animal feed locally while contributing positively to soil health, and are particularly under-exploited regionally, in spite of the availability of suitable germplasm. The prospects for using mainstream alternative crops in regional rotations are therefore very good and this use should lead to improved agricultural sustainability and economic viability.

Key words: cereals, broadleaved crops, legumes, disease cycles, nutrition

INTRODUCTION

It is well known that crop rotation is an important part of farm management. Among other benefits, appropriate alternation of crops and crop types allows the breakage of disease cycles, prevents the development of pesticide resistance in the main pests of each crop type, supports biodiversity at the micro and macro scale, and buffers farm incomes against international crashes in individual commodity prices. Declining profit margins, however, have led farmers in many countries to focus increasingly on a narrow range of crops that they can grow easily and well. Thus cereals dominate European agriculture and many non-cereal crops are imported, leading to a dependency on intercontinental flow of vegetable protein in particular, often at the cost of the environmental health of the producing country and exposing Europe to high risks of price fluctuations. Increased usage of alternative crops offers the potential to increase food and feed security while improving local farm incomes and sustainability. This paper reviews potential ways to enhance crop rotations in the Nordic-Baltic region.

OILSEEDS

In the region, Brassica oilseeds (*B. napus* L. and *B. rapa* L.) are the main oil crops, although linseed (*Linum usitatissimum* L.) and sunflower (*Helianthus annuus* L.) are also grown on a limited scale. Oilseeds are grown on 2–16% of the arable land

area of each country, with higher figures in the Baltic than in the Nordic countries (Table 1). This equates to one oilseed crop every 6–10 years in a Baltic field, or 14 – 16 years in a Nordic field (even longer in Norway). Brassica crops have many additional, underexploited benefits. For example, breakdown products of glucosinolates are biocidal to many groups of organisms, giving Brassica crops and their residues a role in biofumigation of soils (Kirkegaard et al., 2008; Mattner et al., 2008). The rapid growth of Brassica seedlings allows them to be used as winter cover crops or catch crops, trapping nutrients as they are released by the breakdown of the residues of the previous crop (Vos & van der Putten 2004, Macdonald et al. 2005).

In spite of the large areas devoted to oilseeds, imports into the region and into almost every country have increased steadily since 1992 (Figure 1). Norway's oilseed meal exports are based on imported whole oilseeds. Three quarters of this imported oilseed meal is soybean meal and about 15% is from oilseed rape (*B. napus*), and most of it is used for animal feed. Although Brassica oilseed meal is an excellent stockfeed, the net yield per hectare of protein feed supplement is far less than that achievable from a protein crop such as a grain legume.

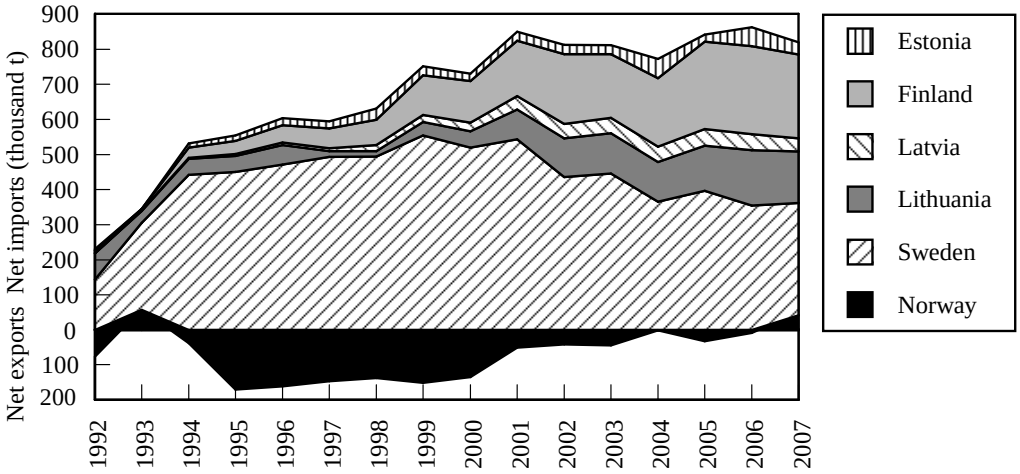

Figure 1. Exports and imports of oil cake (oil-free seed meal, mostly of Brassica crops) in the Nordic–Baltic region from 1992 to 2007. Data from FAO. Denmark's net import of oil cake in this period was 1.9 – 2.4 M t per year.

FIBRE CROPS

Both flax (*Linum usitatissimum* L.) and fibre hemp (*Cannabis sativa* L.) can be grown in the region. In addition to their use for high-value fibre, they have other uses. Flax seed (linseed) is a high-quality food and industrial oil and the oil-free cake contains lignans that have a variety of positive effects on human health, particularly of men (Thompson & Cunnane, 2003). Hemp has a relatively low fertilizer requirement combined with a high ability to suppress weeds (Bennett et al., 2006). High dry matter yields have been reported from many countries and where there is little lignification, yields of biogas and bioethanol per unit of stem mass are high (Zatta & Venturi, 2009).

Fibre hemp is thus an attractive option that can provide energy outputs with low inputs, combined with improved soil status for the following crop. Fibre crops are little used in the Nordic-Baltic region, with an average usage of much less than 1% of arable land (Table 1).

GRAIN LEGUMES

Legumes are a key part of the ecological intensification (Cassman 1999) of agriculture. They provide symbiotically fixed nitrogen, so not only are they free of the need for nitrogen fertilizer, they also contribute to the nitrogen nutrition of the following crop. A grass-free legume crop breaks soil-borne cereal disease cycles. Legume root exudates, and hydrogen released from root nodules during nitrogen fixation, enhance the growth of many beneficial soil organisms (Dean et al., 2006). Grain and forage legumes can be locally grown to provide stockfeed rich in protein, energy and bioactive compounds, without the need for long-distance shipment. Legumes add to the options available to the farmer, improving farm viability; they increase regional biodiversity and landscape diversity, and they support pollinating bee populations. The net release of nitrous oxide (N_2O, a powerful greenhouse gas) in two years of a legume-supported crop rotation was only 54% of that of a continuous cereal rotation in central North America (Dusenbury et al., 2008). In spite of these benefits and in the context of agricultural intensification, the cultivation of legume crops has gone through a long decline in Europe, leading to a dependence on protein imports (Stoddard et al., 2009). Recent increases in many agricultural commodity prices, including fertilizer and soybean meal, have rekindled grower and processor interest in both grain and pasture legumes. Grain legumes can be incorporated, with benefits to both profit and sustainability, into crop rotations from the Mediterranean to Denmark every 3-6 years (Nemecek et al., 2008). A new EU-funded project, “Legume Futures”, will extend this investigation into Northern and Eastern Europe and into a broader range of rotations.

Legumes represent a tiny proportion of the agricultural production of each Nordic-Baltic country (Table 1) and thus appear in the average field only once every several hundred years (Table 2). There are several reasons for this. Most farmers grow familiar crops, and if a grain legume is not familiar, it does not get grown. There are few species and within them, cultivars, that are tolerably well adapted to the region’s growing conditions of long days, short growing seasons, dry springs, and damp autumns. Available international cultivars need to be tested, breeding programmes in the region need to prioritize grain legumes, the advantages of grain legumes to the subsequent crops and to the soil and environment need to be confirmed in regional conditions, and the benefits need to be communicated to farmers.

Legumes and products made from them affect the health of the consumer. The cholesterol-reducing effects of legume storage proteins were first identified from soybean (*Glycine max* (L.) Merr.) (Sirtori et al., 1998) and have since been extended to white lupin (*Lupinus albus* L.), which has also shown benefits to atherosclerosis and blood lipid levels (Marchesi et al., 2008). Whole flour of blue lupin (*L. angustifolius* L.) has been shown to have blood pressure-lowering effects (Lee et al., 2009). The starch of grain legumes is generally slowly digestible, contributing to colon health, and they are rich in dietary fibre. Lupin grains are particularly rich in dietary fibre, as they

Table 1. Total cropped area in the Nordic and Baltic countries and its percentage usage for six main crop groups (average ± standard deviation) in 2003-2007, including Australia and Canada for comparison. Data from FAO.

	Denmark	Estonia	Finland	Latvia	Lithuania	Norway	Sweden	Australia	Canada
Total cropped area (M ha)	1.72	0.35	1.30	0.60	1.19	0.34	1.23	22.7	26.1
Percent cropped with:									
Cereals	86.5±1.3	78.5±2.1	89.2±0.9	78.5±1.3	78.4±0.8	93.9±0.2	85.0±1.3	85.1±0.9	62.8±2.4
Fibre crops	0.0	0.04±0.01	0.0	0.3±0.2	0.4±0.3	0.0	0.0	1.1±0.3	0.12±0.02
Grain legumes	1.1±0.6	1.3±0.1	0.3±0.05	0.36±0.14	2.9±0.6	0.0	1.9±0.5	6.9±0.4	8.2±0.8
Oilseed crops	7.5±1.7	16.0±2.7	6.4±1.2	11.0±3.7	10.4±2.6	2.0±0.1	6.9±1.3	6.7±0.5	28.2±1.8
Roots and tubers	2.3±0.1	4.1±0.9	2.2±0.02	7.9±1.7	6.1±1.8	4.1±0.1	2.4±0.1	0.16±0.01	0.6±0.04
Sugar beet	2.6±0.3	0.0	2.0±0.5	1.9±1.1	1.8±0.4	0.0	3.8±0.2	0.0	0.05±0.01

Table 2. Years between successive crops of the same type, assuming even distribution of crop types throughout each country(average ± standard deviation), using FAO data on cropped areas for 2003-2007, including Australia and Canada for comparison.

	Denmark	Estonia	Finland	Latvia	Lithuania	Norway	Sweden	Australia	Canada
Fibre crops		>500		>500	>500			99± 30	>500
Grain legumes	122± 70	74± 5.4	350± 69	313±124	36± 8.5		55± 17	14± 0.8	12± 1.2
Oilseed crops	14± 2.5	6± 1.0	16± 2.7	10± 5.0	10± 2.7	51± 2.8	15± 3.6	15± 1.2	3.6± 0.2
Roots and tubers	44± 2.3	26± 6.1	46± 0.4	13± 2.7	18± 5.2	24± 0.8	41± 1.4	>500	159±10
Sugar beet	38± 3.9		53± 16	478±973	58± 14		27± 1.4		>500
Total non-cereal crops	7.4± 0.7	4.7± 0.5	9.3± 0.7	4.7± 0.3	4.6± 0.2	16± 0.4	6.7± 0.6	6.9± 0.5	2.7± 0.2

store beta-galactan rather than oil or starch. lupin fibre and lupin protein, mostly from blue lupin, are being developed as functional food additives in Australia.

CONCLUSIONS

In the Nordic countries in particular, crop rotations are too heavily cereal-based, with up to 16 years between non-cereal crops on average (Table 2). In the Baltic countries, rotations are somewhat broader, with 4–5 years between non-cereal crops on average. Nevertheless, the situation needs to improve, with greater use of grain legumes in particular, and also other break crops, in order to maintain soil and environmental health, stabilize farm income streams, and buffer food and feed supplies against unpredictable external pressures such as the oil price peak in early 2008. In Australia, grain legumes are widely used, as are oilseeds, and this situation has developed strongly in the last 30 years from a predominantly wheat – sheep pasture rotation. In Canada, where the climate is more similar to that of the Nordic – Baltic region, oilseeds are very widely grown, and grain legumes also figure regularly in the rotations of most provinces. The agricultural systems of these countries show that it is possible to build a thriving and sustainable crop rotation using a wider range of crops, and thereby to gain the consequent environmental and economic benefits.

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