Article

Strip cropping system for sustainable food and energy production

By Henrik Hauggaard-Nielsen, senior scientist, Risø National Laboratory for Sustainable Energy Biosystems Division, Technical University of Denmark

Strip cropping is a strategy for subdividing single fields into strips with different crops in order to gain the same positive effects known from crop rotations. No additional yield was found by using traditional market pricing, however.

Using traditional market pricing (produce weight) in the present study combining annuals and perennials, no additional yield was found.

In this article, the need for capitalizing additional ecosystem functions like N_2-fixation and soil carbon storage is discussed.

Organic farming and bioenergy

In the context of enhanced integrity of Organic Agriculture (OA) it is important to reduce the reliance on fossil fuels. However, a key question is whether it is possible to keep up food production, introduce production of biomass for bioenergy and on the same time maintain soil fertility.

Organic plant production is based on healthy rotations, but crops are typically sole cropped in large fields (except for pastures), with a tendency to increase individual field sizes (ref. 1). Thus, more emphasis on practices including rotational principles of dissimilar types of crops grown in sequential seasons might be needed to ensure food security and to address the problems of soil degradation coupled with increasingly variable climatic conditions (ref. 4). In the BioConcens project a strip cropping system was designed and tested to be used for biomass production for food and bioenergy, while at the same time safeguarding soil fertility.

Strip cropping

Strip intercropping is defined as the production of two or more crops within the same field in strips wide enough that each can be managed independently by existing machinery; yet narrow enough that the strip components can interact. It is practiced with success by e.g. several U.S. farmers. The motivation for a group of farmers in Iowa was greater net profit stability due to less soil erosion lowering general nutrient emissions, weed management aspects and less diseases and pests (ref. 2).

Strip cropping is like any other intercropping strategy based on the management of plant interactions to maximize growth and productivity caused by efficient use of plant growth resources such as light, water and nutrients (ref. 3). In the BioConcens project, an annual strip consisting of either winter rye + vetch or maize was grown beside a soil fertility building (SFB) strip of perennial grass-clover.

Field experimentation

Field experiments were conducted at KU Life, Denmark (Tåstrup, 55°40'N, 12°18'E) in 2007-2008 and 2008-2009.

Early September seedbed preparation for the annual crops were established by 6m rotavation machinery within an already established 1-y grass-clover sward giving a 6m annual crop x 6m perennial crop system. Winter rye + vetch and green rye (before maize) were sown medio September. Maize was sown early May after harvest of green rye (silaging) and rotavation. Winter rye + vetch were harvested early August and maize in medio October.

Winter rye – vetch yields

In both growing seasons the grass-clover strip revealed a comprehensive competitive strength towards winter rye + vetch grown in close proximity (0-25 cm) reducing the yield of the annual strip significantly (Fig.1).

Especially rye was limited in its growth, as compared to vetch, possibly indicating increasing competition towards soil N resources in the interface between the two strips – when taking into account vetch unique ability to fix atmospheric dinitrogen in symbiosis with root nodule bacteria. In contrast to rye+vetch grass-clover increased the dry matter production with about 10%.

Maize yields

Maize (Fig. 2) and winter rye + vetch (Fig. 1) are

Photo 1: Seed bed preparation (a; ©geography.cst.cmich.edu.jpg) and individual strip sowing pattern according to the actual landscape (b; © www.macalester.edu.jpg)

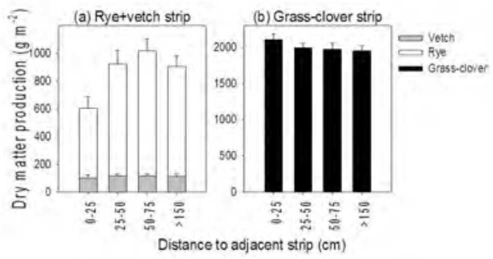

Figure 1. Total aboveground dry matter production during two subsequent growing seasons going from September to August, comparing annual winter rye + vetch (a) and perennial grass-clover (b) when grown with increasing distance to the adjacent strip. Values are the mean (n=8) ± SE

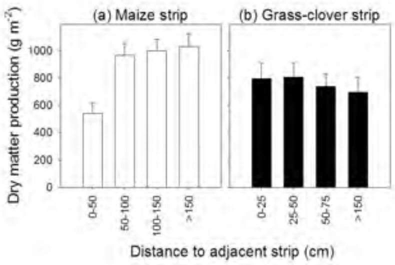

Figure 2. Total aboveground dry matter production during two subsequent growing seasons going from May to October, comparing annual maize (a) and perennial grass-clover (b) when grown with increasing distance to the adjacent strip. Values are the mean (n=8) ± SE

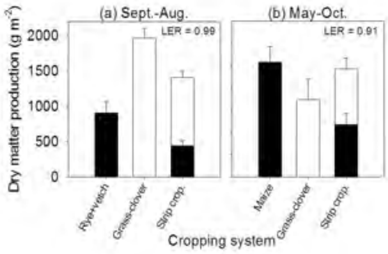

Figure 3. Total aboveground dry matter production during the two subsequent growing seasons comparing traditional cropping strategy of winter rye + vetch (a) and maize (b) as compared to strip cropping – evaluated by the use of LER (Land Equivalent Ratio) defined as the relative land area that is required to produce the yields achieved from strip cropping: LER values > 1 indicate an advantage in term of the use of environmental resources for plant growth. Values are the mean (n=8) ± SE

Read more
You can find more information about the DARCOF III research project BioConsens on the following webpages:

www.icrofs.org/Pages/Research/darcofIII_bioconcens.html

www.bioconcens.elr.dk

yielding approximately the same, but maize is only occupying the field area from May to October as compared to from September to August. Grass-clover yields illustrate these temporal differences, with 3-4 cuts included in the maize system as compared to 6 cuts in the rye + vetch system almost doubling the yield. However, before sowing maize green rye yielded between 100-200 g m-2 which in principal should be added to the maize system yields. Nevertheless the same annual crop effects were found in maize as compared to rye + vetch, with a yield decline of almost 50% when grown in close proximity (0-50 cm) to grass-clover. However, there was no added grass-clover yield when grown in close proximity to maize.

Strip cropping yield evaluation

When including negative and/or positive yield effects in the interfaces between strips (Fig. 1; Fig. 2) more or less the same biomass was produced when dividing the field into strips (6x6m) as compared to growing the same area with 50% annual crop + 50% perennial crop. Especially, the interspecific competitive ability of grass-clover during the initial growth stages reduces the final annual yields significantly. So, why bother changing the well-known sole cropping practices? It is believed that the success of this strip cropping system requires inclusion of additional ecosystems functions and service not necessarily pictured using traditional agronomic market pricing based upon weight of produce.

Additional functions and service

Ecosystem functions like leguminous N2-fixation and the capacity of e.g. perennial grass-clover to act as carbon sinks should gain more attention when addressing climate change mitigation tools within the framework of OA principles and values. Furthermore, the value of subdividing fields into strips to avoid the build up of pathogens and pests, depletion of soil nutrients and to improve soil structure and fertility by e.g. alternating deep-rooted and shallow-rooted plants needs further research.

References

1: Levin G. (2007) ”Relationships between Danish organic farming and landscape composition. *Agriculture, Ecosystems and Environment* 120: 330-344.

2: Exner D.N. et al. (1999) ”Yields and returns from strip intercropping on six Iowa farms.” *American Journal of Alternative Agriculture* 14, 69-77.

3: Hauggaard-Nielsen H. et al (2009) ”Pea-barley intercropping for efficient symbiotic N_2-fixation,...” *Field Crops Research* 113, 64-71.

4: Østergård H. et al. (2009) ”Time for a shift in crop production...” *Journal of the Science of Food and Agriculture* 89, 1439-1445.

Photo 2: Winter rye + vetch (a) and maize (b) annual crops combined with perennial grass-clover in 6x6m strip cropping system (©hnie@risoe.dtu.dk)