Self-sufficiency of fuels for tractive power in small-scale organic agriculture

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Implications

Small-scale organic agriculture, with integrated crop and animal production has the potential of producing significant amounts of food. Self-sufficiency of fuel for farm work has been investigated closer in this study, based on a set of prerequisites that were identified as important for future sustainability. An implication of the study is that low-tech solutions are more likely to be renewable in the production. Fuel production for farm work at the farm also facilitates nutrient recycling. Draught horse power turned out to be comparable with other biofuels, and in a system perspective even more efficient in some cases. For ensuring a sustained food production social solutions for cleaning and recycling human excreta must be developed. Low-input small-scale agriculture may in theory contribute to solving several environmental challenges. The real challenges are social: how to distribute food and how to have enough labour in agriculture to manage cropping systems that gives a diverse production.

Background and objectives

According to Rockström et al. (2009) modern agriculture currently contribute to crossing most of their identified "planetary boundaries". Reasons such as Peak Oil, Climate Change and Food Security has inspired for investigating self-sufficiency in agriculture in terms of fuel. Yet, a seemingly simple task, to use agricultural land to produce biofuels, turns out to be a complex set of tradeoffs as soon as more than one of the global challenges is addressed. Energy crop production for farm self-sufficiency of biofuel may be easy to obtain once there are no cravings that the production should be renewable. However, when including food production capacity, the importance of a sustainable crop sequence, nutrient recycling and biodiversity, the picture becomes more intricate.

This work is an attempt to address several of the global challenges when investigating what solutions for self-sufficiency of fuels is most viable. This lead to certain prerequisites of the study: as far as possible renewable biofuel production in all steps, low-input agriculture, small-scale agriculture that may have larger biodiversity than large scale (Belfrage et al., 2005), leguminous leys in the crop sequence for soil structure and nitrogen supply, animals required for ecosystem services and for producing food from leys and meadows and animals should not eat what humans can eat.

The aim of this study was to develop scenarios and assess and compare them regarding their impact on food production and NPK fluxes on farm level. From a cropping system based on these prerequisites and other practical limitations we ended up with three possible scenarios for biofuel: Draught horse power combined with cold-pressed rape seed oil in a tractor, ethanol from wheat produced in a conventional ethanol plant and farm-made ethanol from potato. Conventional diesel was used as a reference scenario.

Key results and discussion

Using wheat and potato for ethanol lowered the food production significantly, by 23% and 18% respectively compared to the reference scenario of conventional diesel. By changing the crop sequence to contain less ley and still having enough potato to cover the tractor demand of ethanol, the food production could be held up to 90% of the reference scenario, but such a sequence would be difficult to handle. By combining a draught horse and on-farm cold pressed rapeseed oil the least impact on food production was achieved; 94% of the reference scenario. We have 11.5 ha of farmland excluding the

pasture, meaning 58 persons should be supplied if all farmland globally was to be operated at similar yields (Johansson et al., 2013). This is managed when using draught horse power combined with rape-seed oil in a tractor, but not when using ethanol from wheat or potato for tractive power.

By producing the fuel on the farm a larger amount of nutrient recycling can be obtained. The draught horse-rape seed scenario had only a small deficit of P, but the K-deficit was significant in all scenarios except when potato was used for ethanol without altering the crop sequence to a large extent. The deficit of K is not a problem in soils formed of sedimentary clay in Sweden. However, for such systems to be viable in other regions some solution for K-recycling will be increasingly important. N is maintained in all scenarios due to the nitrogen fixing leys. P can be maintained at the fields if bones are recycled, however nutrients, especially K, is moved from meadow to field.

How work was carried out?

The work was carried out in collaboration with a research farm in Roslagen, south eastern Sweden (ca 59°52´ N, 17°40´ E). A model that calculates the amount of food available at a farm in terms of meat, milk egg and crops, converts it into energy units and calculates how many people can be supplied from the farm was developed in MS Excel. We have assumed an average energy requirement of 2,500 kcal/day and capita (Johansson et al., 2013).

A basic requirement was that the energy-crop should fit into a well-functioning crop sequence. The crop sequence developed at the farm functions well and is difficult to alter without making it less purposeful. Thus, when investigating how to be self-sufficient of fuels we had to carefully consider changes in the crop sequence. Which changes are possible without making the sequence unsuitable? What impact on the animal herds and food production capacity would the chosen biofuel system have? We also took into account what technologies that are reasonable at present. To have a measure on the difference between the crop sequences and altered production due to biofuels, we chose to focus on the macronutrients N,P and K.

References

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