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ABSTRACT BOOK

INNOVATIVE CROPPING AND FARMING SYSTEMS FOR HIGH QUALITY FOOD PRODUCTION SYSTEMS

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sowings started earlier than in the preceding decades. This supports but also pressures for diversification of the monotonous crop sequencing patterns to better cope with the climate variability and extreme weather events that are projected to be even more frequent in the future. Farmers have intentions to diversify their crop rotations in the next 5-year period due to the experienced manifold drawbacks associated with cereal monocultures. In fact, the area under minor crops (faba bean, oilseed rape, pea, caraway) has already expanded, later maturing primary crops and cultivars have shifted northwards and novel crops (maize, winter rapeseed, lupin) have been taken into tentative testing by farmers. These all manifest an on-going adaptation to climate change and interest towards increasing diversity of currently monotonous systems. Though the changes are marginal so far when compared to the arable land dominated by cereal monocultures, the currently existing potential for diversification is significant and the future potential even substantial. However, Finnish field parcels are highly variable in their characteristics (size, shape, slope, distance to farm center and waterway, soil type, ownership) as well as productivity, and all these impact how land can be allocated to different crops and rotations, as does also farm size. By acknowledging the numerous field parcel characteristics and differences in their importance for farmer's decision making, we developed a dynamic land use optimization tool to facilitate land allocation processes, but also input and resource allocation, as a part of sustainable intensification of high-latitude agricultural systems. By this means we provided diversification pathways for current and future needs. We estimated realistic potential for today by acknowledging differences in field parcel characteristics, farm size, farm production line and region, and for the future by acknowledging climate warming. We also assessed how general diversity at farm and landscape scale is dependent on alternative pathways of increasing spatial and/or temporal heterogeneity in land use, and how all the envisaged changes in crop diversity impact resilience to climate variability.

Keywords: monoculture, crop rotation, field crops, diversity, field parcel, climate change, climate smart agriculture, sustainable intensification, northern Europe

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Clever Cover Cropping: Cover Crop Diversity and Yield Stability

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Abstract: Autumn cover crops are grown in between two cash crops to cover the soil, prevent leaching of nutrients and produce biomass that may be incorporated into the soil to enhance organic matter content. Weather conditions in autumn are variable and difficult to predict. They may be unfavorable for some but not necessarily all species. Hence, growing mixtures may be advantageous to reduce risk of cover crop failure. Here we determine yield and yield variability of cover crops under northern European growing conditions. Specifically, we tested the hypotheses that regardless of the prevailing weather conditions 1) mixtures of cover crops have, on average, higher biomass yield than pure stands, and 2) variability of biomass yield within cover crop mixtures is less than the variability within pure stands.

Field experiments were conducted at four different locations, in the South, mid and the North of the Netherlands (Neer, Wageningen and Scheemda, respectively) and in the North of Germany (Grundhof). Ten species mixtures, as well as the pure stands of the ten species that were included in these mixtures, were sown at all sites in August 2017. Species used belong to six plant families including crucifers, grasses and legumes. Harvests were made in November 2017. At each site three or more replications were installed. Variability in biomass was calculated across and within sites for both mixtures and pure stands.

Large differences in above ground biomass between sites were found, reflecting the wide variation in growth factors between sites. Across all sites, mixtures of cover crops had a higher average biomass yield (4.5 ton/ha) than the pure stands (3.7 ton/ha; P=0.027). Following from the huge differences between sites, no significant difference in overall yield variability between sites was found between mixtures and pure stands (P=0.15). However, analysis per site resulted in significant differences in above ground biomass between mixtures and pure stands in Wageningen (P=0.048), Scheemda (P=0.044) and Grundhof (P=0.043) and a marginally significant difference in Neer (P=0.054). At all sites, yield of the mixtures exceeded the yield of the pure stands. In addition, yield variability between treatments was at all sites significantly smaller for mixtures than for single species stands ($0.012<P<0.035$). Our results clearly demonstrate that growing cover crop mixtures is beneficial, as they produce a higher and more stable amount of biomass than pure stands.

Keywords: yield variability, cover crops, mixtures, pure stands, biomass.

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Taking Soybean Cultivation Further North: Agronomic Performance of Cultivars and the Effect of Irrigation

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Abstract: It is challenging to meet the global demand for protein to feed an increasing world population, while reducing negative environmental impacts of current production systems. Soybean is a grain legume providing large amounts and high quality protein for food and feed, and ecosystem services contributing potentially to more sustainable cropping systems in Europe. The cultivation of soybean is currently dominating in Southern and Eastern Europe and little is known about the potential in higher latitudes with relatively cool growing conditions in Europe. Therefore, we established a soybean cropping system experiment from 2014 to 2018 in Müncheberg, in north-eastern Germany, with the following objectives: (i) identifying soybean cultivars for high latitudes with a continental and relatively dry climate and sandy soils, (ii) compare the productivity of soybean as a novel grain legume with narrow-leafed lupin as an established crop under this climate, (iii) evaluate the effect of irrigation and cultivar on grain yield and nitrogen fixation, and (iv) assess the nitrogen dynamics after the harvest and the pre-crop benefits of soybean on a cereal grown in the following year. In the precrop year, three soybean cultivars, one narrow-leafed lupin cultivar followed by a turnip rape cover crop, and one buckwheat cultivar were tested with and without irrigation. In the following year, the effect of those precrops on oats was evaluated.

The soybean cultivars sultana and Merlin yielded 2.7 t ha^{-1} on average over three years under rainfed conditions. Grain yields of the cultivar Protibus were significantly lower with 1.7 t ha^{-1}. Average grain yields of the narrow-leafed lupin cultivar Probor were 2.0 t ha^{-1}. Irrigation increased grain yields by 41% and 36% for soybean and narrow-leafed lupin on average. Soybean fixed 58 kg N ha^{-1} above ground with an N_{dfa} of 67% on average, with no differences between cultivars and a positive effect of irrigation. After the soybean harvest, there was a significantly larger risk of nitrate leaching during winter compared to narrow-leafed lupin with a cover crop and buckwheat without a cover crop. Finally, the grain yield of the subsequent oat was significantly lower after soybean compared to narrow-leafed lupin with a cover crop and similar to buckwheat.

Overall, we demonstrated a large potential for soybean as a novel grain legume crop for higher latitudes with relatively cool growing conditions and sandy soils in Europe. We also showed a risk of nitrogen losses after the soybean harvest calling for strategies to reduce this risk e.g. through undersown cover crops or early sown winter cereals. Soybean could potentially become a new economic competitive grain legume crop that will support diversification of current cropping systems.

Keywords: Field experimentation, grain legumes, leaching, productivity, protein, pulses