学 位 論 文 要 旨

Development of concepts for expanding the use of no-tillage farming in organic agriculture.
有機農業における不耕起農法の活用方法の開発

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Intensive tillage carries an elevated risk for soil erosion. However, conservation tillage is rarely used in organic farming due to potentially increased weed pressure. To develop organic systems, less dependent on tillage, this study evaluated the non-legume cover crops spring rye (*Secale cereale* L.), black oat (*Avena sativa* L.), sunflower (*Helianthus annuus* L.), white mustard (*Sinapis alba* L.), buckwheat (*Fagopyrum esculentum* Moench) and hemp (*Cannabis sativa* L.) for their ability to suppress weed growth, reduce soil nitrogen and produce large amounts of biomass with slow N mineralisation, without and with organic fertiliser (50 kg N ha^{-1}) before seeding. From these trials spring rye was chosen as cover crop before no-tillage, reduced and plough tillage cropping of legume cash crops. Winter and spring faba bean (*Vicia faba* L.), field pea (*Pisum sativum* L.) and spring narrow-leafed lupin (*Lupinus angustifolius* L.), monocropped and intercropped with winter wheat (*Triticum aestivum* L.) and spring oats (*Avena sativa* L.) were evaluated for dry matter production, grain yield and their ability to suppress weeds. An additional study determined if the transition to no-tillage could be carried out through no-tillage seeding of summer annual legume cover crops faba bean, normal leafed field pea, narrow-leafed lupin, grass pea (*Lathyrus sativus* L.), and common vetch (*Vicia sativa* L.) monocropped and intercropped with sunflower. Objectives were: (i) to examine six non-legumes for suitability for cover cropping preceding no-tillage legume cash crops through evaluation of biomass production, reduction of inorganic soil N resources and assessment of long term N immobilisation in plant compartments through simulations, (ii) to determine if incorporating fertiliser before seeding increases total biomass production and N accumulation, (iii) to assess the suitability of three legume species for no-tillage cash cropping by examination of their grain production, (iv) to determine the capacity of intercropped legume and cereal grains to improve weed suppression and grain yield, (v) to investigate if autumn

seeding enhances the weed competition of legumes, (vi) to determine if the transition to no-tillage can be alternatively realised through no-tillage seeding of legume cover crops or if tillage is indispensible.

The non-legume cover crop biomass production ranged from 0.95 to 7.73 Mg ha^{-1}, with fertiliser increasing it at locations with low N status. Sunflower consistently displayed large biomass and N accumulation at all locations but stored most shoot-N in leaf material, which can be easily mineralised making it less suited as cover crop before no-tillage spring grain legumes. Rye appears to be better suited; it produced slightly less biomass, but accumulated more N in the stem. Its simulated N mineralisation indicated prolonged immobilisation potentially improving weed suppression of subsequent legumes.

Winter field pea displayed no-tillage grain yields $\leq$ 3.39 Mg ha^{-1} - similar to the plough tillage system. For spring faba bean and field pea the reduced tillage yield amounted to 2.92 and 3.29 Mg ha^{-1}, respectively, similar to the plough tillage system, but did not exceed 2.15 Mg ha^{-1} in the no-tillage system. Narrow-leafed lupin consistently displayed no-tillage yields below 0.65 Mg ha^{-1}. Winter field pea appeared best suited for the transition period to an organic no-tillage system due to autumn seeding and its high competitive ability. Spring faba bean and field pea can be successfully grown in the reduced tillage system. Intercropping can increase grain yield and weed competition if soil nitrogen resources are sufficient.

The no-tillage cover crop shoot biomass, shoot N accumulation and N_2 fixation differed with year, location, tillage system and species due to varying weather, inorganic soil N resources and weed competition. Biomass production reached $\leq$ 1.65 and 2.19 Mg ha^{-1} (both intercropped field peas), and N_2 fixation $\leq$ 53.7 and 60.5 kg ha^{-1} (both common vetches) in the no-tillage and reduced tillage system, respectively. Without tillage consistently low sunflower performance prevented significant intercropping effects. Under central European conditions no-tillage legume cover cropping appears practicable if weed density is low at seeding. Interactions between year, location, tillage system and species demonstrate the difficulties in cover crop species selection for organic conservation tillage systems.

This study demonstrated two approaches for the transition to no-tillage in organic agriculture. Before no-tillage legume cash crops the immobilisation of inorganic soil N resources would be most successful with cereal grains with high C : N ratios potentially reducing infestations from emerging weeds in legume cash crops. No-tillage cash cropping of legumes with high weed suppressive abilities appears to be possible. Legume cover cropping could be carried out without tillage if weed density at seeding is low. This study´s results indicated that the complete transition to an organic no-tillage system is probably not practicable due to the different weed suppressive abilities of cash crops and increasing weed pressure after the omission of tillage. Nevertheless, certain cash and cover crops can be sown without tillage and the integration of short term no-tillage phases could make organic farming more sustainable.