Intercropping can support ecological intensification in organic agriculture

S.J. Himanen1, M. Saarnia1, H. Lehtinen1, H. Mäkinen2 & R. Savikko1

*1Natural Resources Institute Finland (Luke), Lönnrotinkatu 5, FI-50100 Mikkeli, Finland (sari.himanen@luke.fi), 2Lappeenranta University of Technology, Saimaankatu 11, FI-15140 Lahti, Finland*

**Implications**

Intercropping (IC) combines the temporal and spatial dimensions of crop diversification and offers a variety of ways to shape agroecosystem ecology and productivity. It has been most used with forage legumes for biological nitrogen fixation, but it might deliver also other, less known benefits such as buffering from weeds, pests and abiotic stresses, support for beneficial biota and greater yielding per acreage. Productivity gains are imperative for developing organic agriculture. We found that legumes added as intercrops had a positive impact on both a cereal and an oilseed co-crop yield under low fertilization, indicating that IC can support ecological intensification. Both additive and replacement IC designs resulted in overyielding. IC works well in line with the key principles of organic farming: utilizing and sustaining beneficial ecological interactions and biodiversity. It may support climate change adaptation as well (Himanen et al. 2016). In addition, it should be experimented more as a method to reduce reliance on external inputs and develop more sustainable conventional agriculture. Technological development and improved understanding on the mechanisms potentiating overyielding can help designing optimal IC using differential row, strip or mixed IC set-ups.

**Background and objectives**

Ecological intensification has been raised as one strategy for agriculture to operate more sustainably while aiming to meet the growing demand for food and feed. It entails, as stated by Bommarco et al. (2013), “replacement of anthropogenic inputs and/or enhancement of crop productivity by including regulating and supporting ecosystem services management in agricultural practices”. IC, growing two or more crops together in space and time, has been suggested as one central method to support ecological intensification (e.g. Bedoussac et al. 2015).

The use of IC can aim for an increase in main crop yield or for gaining a higher total yield. In the former case, associative crops with low sowing density and an additive IC design can be used to facilitate improved yielding of the main crop. In the latter case, replacement IC designs are often used. The lower competition between the intercrops and complementary use of growth resources can result in higher and more stable total yield per acreage.

The objective of our research was to determine whether the addition of legume intercrops with ecologically important crop traits (biological nitrogen fixation and nectar provision) in additive and replacement designs supports ecological intensification, i.e. leads to higher yielding per acreage under low fertilization. Two crop systems were studied in field experiments established in organic field plots in Karila, Mikkeli, Finland): 1) *Brassica rapa* ssp. *oleifera* (spring turnip rape) - *Vicia faba* L. (fava bean) – *Vicia sativa* L. (common vetch) mixed IC, and 2) *Hordeum vulgare* L. (barley) - *Vicia faba* L. mixed IC and row IC.

**Key results and discussion**

Turnip rape-common vetch-fava bean additive IC design yielded circa 15 % higher turnip rape seed yield than the turnip rape sole crop. In barley-fava bean IC with replacement design (50 % sowing density for both barley and fava bean used compared to the sole crop plots), barley gave 89 % and 77 % of the yield of sole crop plots in mixed IC and row IC, respectively. Fava bean yielded 45 % and 37 % of the sole crop fava bean plot yield in mixed IC and row IC, respectively. Land equivalent ratio exceeded 1 (indicating overyielding per acreage) both in mixed IC and row IC of barley and fava bean.

The results showed that adding of a legume intercrop resulted in ecological intensification, i.e. overyielding per acreage under low fertilization, both when using an additive IC design (for turnip rape) and a replacement IC design (for barley and fava bean). Our results are in line with earlier research reporting that cereal-grain legume IC benefits the cereal component yield (Bedoussac et al. 2015). There is little earlier research on IC of oilseeds and legumes in northern organic agriculture. Reduced competitive pressure for barley in replacement IC benefitted its yielding, whereas fava bean yield was suppressed by barley. Turnip rape benefitted from the presence of the legume intercrops in additive IC design, while it is difficult to state why. The flowering legumes may have impacted its root environment and nutrient availability, pests and their natural enemies, or the abundance of pollinators. Analyses on nutrient dynamics, insect abundance, and allocation of biomass in sole cropping versus IC might help reveal the underlying mechanisms.

**How work was carried out?**

Experiment 1 (2015): 6 kg ha-1 of spring turnip rape (‘Cordelia’), 10 kg ha-1 of common vetch (‘Ebena’) and 120 kg ha-1 of Fava bean (‘Kontu’) were sown in the mixed IC treatment and 6 kg ha-1 of spring turnip rape (‘Cordelia’) in sole cropped treatment in four 34 m2 replicate plots. Three replications in time (three sowing times in 2015) were conducted. Fertilization with 60 kg N ha-1 (NPK 4-1-2, organic fertilizer Arvo, Novarbo Oy, Finland) was added prior to sowing in both treatments. Seed yield of turnip rape at full maturity was measured from 0.25 m2 areas per plot. Experiment 2 (2016): 167 kg ha-1 of sole cropped barley (‘Wolmari’) and 167 kg ha-1 of sole cropped fava bean (‘Kontu’), 83.3 kg ha-1 of both crops in row IC and 83.3 kg ha-1 of both crops in mixed IC were sown in four 30 m2 replicate plots. Fertilization with 40 kg N ha-1 (NPK 4-1-2, organic fertilizer Arvo, Novarbo Oy, Finland) was added prior to sowing in all treatments. Seed yields were measured separately for barley and fava bean from 0.25 m2 areas per plot. Soil type in both experiments was fine sand. Land equivalent ratio (LER) was calculated as: (barley seed yield in IC plot/barley seed yield in sole crop plot)+(fava bean seed yield in IC plot/fava bean seed yield in sole crop plot).

**References**

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