Session 5 overview: Legumes in cropping systems – advantages and perspectives

Chaired by Liga Lepse[1] and Erik Steen Jensen[2]

Abstract: Legume re-integration in cropping systems and crop rotations has increased during recent years. Intercropping is found as one solution to introduce legumes in cropping systems. It was found that a pea variety mixture can combine the beneficial traits of the single varieties with maintained pea grain yield relative to the highest-yielding variety. It was also found that the use of legumes in intercropping with strawberries, needs further research to determine moisture influence on crop performance. Crop rotation trials showed that the soil NO_3-N concentration was increased by pea or faba bean as preceding crop in comparison to cabbage.

Key words: intercropping, variety mixtures, fababean, pea, crop rotation, sustainability assessment

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During recent years legume reintegration in cropping systems and crop rotations have increased in comparison to several decades ago. This is caused by the fact that European agriculture needs to meet both environmental and food production challenges. Agronomic and environmental benefits of legume-based cropping systems (CS) have been evaluated from different perspectives – with studies of a broad range of legume species on the soil and environment in various cropping systems (monocrop, cover crop, intercrop, agroecological service crop, etc.) not only in Europe but across the world, including Australia (CA4).

Introduction of legumes in broader scale in CSs is strongly dependent on the interest and knowledge of stakeholders. The nitrogen (N) contributed by legumes is an important component of the N supplied to subsequent crops. However, most Australian grain-growers have little idea about the potential inputs of fixed N provided by their pulse crops, and few routinely monitor soil mineral N before applying N fertiliser to crops grown after a legume. Peoples (CA4) presented a study on the role of legumes in cereal-dominated cropping sequences gained from 16 dryland (rainfed) experiments conducted in eastern Australia between 1989–2016, and from on-farm measurements of the symbiotic performance of 50 commercial pulse crops undertaken since 2001. The data collated from these studies were examined to identify the main factors regulating inputs of fixed N, and to explore the possibility of developing simple predictive relationships which farmers' could use to benchmark (i) likely inputs of fixed N, (ii) the expected availability of soil mineral N after legumes, and (iii) the relative value of legume N to a following wheat crop.

The understanding and knowledge by stakeholders regarding legumes value for design of cropping systems was investigated

in the LEGATO project (C3). The aim of investigation was to evaluate the sustainability and feasibility of legume-based locally-adapted CS, in three European regions (Scania, Sweden; Paris Basin, France; Andalusia, Spain). First – innovative CSs were designed in three steps: (i) an initial diagnosis in each region, i.e., description of the most frequent CSs and their advantages and limits, and definition of local improvement targets; (ii) the design of innovative CSs including legumes in a workshop (iii) multicriteria assessment of the CS with the MASC© tool. Second – stakeholder meetings were organized in each region, to (i) present and discuss innovative CSs including legumes and their assessment results compared to the reference CS, (ii) discuss the feasibility of the innovative CSs with stakeholders, to see if some of them could be implemented in farmers' fields, and (iii) gather the preferences of stakeholders on ranking of performance criteria (weight sets) of MASC©, reflecting their point of view on sustainability. Weight sets were synthesized into four MASC© trees and each innovative CS was re-assessed according to those trees. The results showed that it was possible to identify feasible CSs with grain legumes for each region, that were assessed sustainable according to four MASC© trees (C3).

One of the promising arguments *pro* legumes is their ability to improve soil properties and fix nitrogen. Thus, their incorporation in existing cropping systems would be promising for sustainable cropping practices. Crop diversification in space and time is a key component in the design of resource-efficient cropping systems with reduced dependency on synthetic inputs. A well-known example of crop diversification is the practice of intercropping, i.e. growing two or more crops together in the same field. Intercropping grain legumes and cereals in low-input systems makes use of complementary acquisition of light, water and nutrients to enhance the crop's resource use efficiency and competitiveness against weeds. Within-species diversification in variety mixtures may also increase yield stability, via e.g. complementary tolerance to abiotic or biotic stress. As part of the LEGATO project, a study has investigated whether a mixture of pea (*Pisum sativum* L.) varieties with two types of leaf morphology can increase the legume crop's standing ability and competitiveness against weeds. The pea varieties `Dukat` (normal-leafed) and `Partner` (semi-leafless) were grown as single varieties and variety mixtures with and without a wheat intercrop in field experiments at four locations in Europe. The results showed that a variety mixture of pea can combine the beneficial traits of the single varieties with maintained legume grain yield relative to the highest-yielding variety. However, the benefits in terms of weed reduction and standing ability were not as strong in variety mixtures as in pea-wheat intercrops, which remained the most efficient mixtures (C1).

Intercropping is assumed also as a powerful tool to develop sustainable cropping systems in horticulture. In order to match sustainable and optimal land use in strawberry plantation and to increase biological diversity a trial was established at Pūre Horticultural Research Centre in Latvia, in the frame of the EUROLEGUME project (C2). Three species of legumes (faba bean, pea and alsike clover) were sown as intercrop components in the strawberry fields to evaluate strawberry – legume intercropping efficiency. Intercropping influence on the soil biological activity was determined by detecting soil respiration rate, activity of dehydrogenase and cellulase. Strawberry yield and quality was determined in order to evaluate legume influence on the strawberry productivity. As the years 2015 and 2016 were uncommonly dry during vegetation season, the lack of moisture in the soil negatively influenced plant performance and soil microbiological activity. In the intercropping variant with faba beans soil was significantly dryer than in other treatments. Beans and peas had no notable influence on disease spreading in strawberries, but clover intercropping promoted strawberry disease spreading. In 2015 there were nonsignificant differences in yield quality and quantity between treatments with legumes intercropping and control treatment with nitrogen application. In the second yielding year (2016) with extreme lack of precipitation and no irrigation, treatments with legumes intercropping showed significant decrease in strawberry yield. It was assumed that pea and faba bean intercropping in strawberry plantations could be promising both for strawberry production and soil improvement under irrigation possibilities, but further investigations are necessary to clarify the plant performance in intercropping systems under different moisture regimes (C2).

Grain legumes do not compete strongly for soil N, leaving more soil N to be used by intercropped or successive species. It was demonstrated also in the trials performed in Greece (Agricultural University of Athens) in the frame of the EUROLEGUME project. To quantitatively assess the benefits of cabbage from rotation with legumes, a field experiment was carried out during 2014-2017. In the trial cabbage was grown either after pea, or after faba bean, or after cabbage, by applying either conventional or organic farming practices. It was found that the soil NO_3-N concentration was higher in plots with pea or faba bean as preceding crop than in those with cabbage as preceding crop. Pea as preceding crop increased significantly the yield of cabbage compared with faba bean, while cabbage after cabbage resulted in the lowest yield when grown according to organic farming practices. However, in the conventional cropping system, the highest yield of cabbage was obtained when the preceding crop was also cabbage. The quantification of biological N_2 fixation by measuring the natural abundance of ^{15}N in the tested legume species and reference plants at anthesis revealed that faba beans were capable of fixing from 119 to 194 kg N ha^{-1} (1), while the total amounts of biologically-fixed N_2 (BNF) by peas ranged from 45 to 125 kg N ha^{-1} (2).

Simultaneously with the introduction of legumes in crop rotations or intercropping also reduced tillage or no-till techniques are used in sustainable farming approach. In order to clarify some aspects of using non-legume cover crops, weed suppression, yield formation and N accumulation of organic peas grown in organic system were tested. Pea plants were sown after reduced tillage and no-tillage system by the use of cross slot no-tillage seeder. Early sown niger (*Guizotia abyssinica*) and millet (*Panicum miliaceum*) led to high shoot biomass accumulation of the cover crop and low weed growth in reduced tillage as well as in no-tillage pea plants. What is more important, after specific cover crops like niger and millet the grain yield of organic pea plants were higher by the use of reduced tillage than in no-tillage system. The study clearly show the importance of non-legume cover cropping for weed management and improved crop growth in organic pea production (C5).

References

(1) Ntatsi G, Karkanis A, Yfantopoulos D *et al.* (2018a) Impact of variety and farming practices on growth, yield, weed flora and symbiotic nitrogen fixation in faba bean cultivated for fresh seed production. Acta Agr Scand B-S P, 68-7:619-630

(2) Ntatsi G, Karkanis A, Yfantopoulos D *et al.* (2018b) Evaluation of the field performance, nitrogen fixation efficiency and competitive ability of pea landraces grown under organic and conventional farming systems. Arch Agron Soil Sci (accepted)

Conference Session presentations:

(C1) Carlsson G, Bedoussac L, Cupina B, Djordjevic V, Gaudio N, Jensen ES, Jeuffroy M-H, Journet E-P, Justes E, Mikic A, Pelzer E, Zivanov D (2017) Does a mixture of pea varieties with different leaf morphology improve crop performance? Book of abstracts of international conference "Advances in grain legume breeding, cultivation and uses for a more competitive value chain" Novi Sad, 27-28 September 2017, pp. 120

(C2) Dane S, Lepse L, Laugale V, Sterne D (2017) Evaluation of strawberry - legume intercropping. Book of abstracts of international conference "Advances in grain legume breeding, cultivation and uses for a more competitive value chain" Novi Sad, 27-28 September 2017, pp. 113

(C3) Pelzer E, Bourlet C, Carlsson G, Jensen ES, Lopez-Bellido R, Jeuffroy MH (2017) Design, assessment and feasibility of legume-based cropping systems according to stakeholders in three regions of Europe. Book of abstracts of international conference "Advances in grain legume breeding, cultivation and uses for a more competitive value chain" Novi Sad, 27-28 September 2017, pp. 102

(C4) Peoples MB (2017) Inputs of fixed N and soil mineral N benefits derived from legume cropping. Book of abstracts of international conference "Advances in grain legume breeding, cultivation and uses for a more competitive value chain" Novi Sad, 27-28 September 2017, pp. 5

(C5) Schmidtke K, Mick T, Lewandowska S (2017) Effects of cover cropping and tillage system on weed infestation, yield formation and N accumulation of organic pea. Book of abstracts of international conference "Advances in grain legume breeding, cultivation and uses for a more competitive value chain" Novi Sad, 27-28 September 2017, pp. 115