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FABA BEAN: A POTENTIAL INTERCROP IN ORGANIC VEGETABLE PRODUCTION IN A EUROPEAN PERSPECTIVE?

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Abstract: Intercropping can provide ecological and yield benefits when selecting crops and management practices that balance the competition for resources. A field experiment was carried out under temperate conditions to study the effect of intercropping faba bean (*Vicia faba* L.) and pointed cabbage *(Brassica oleracea* var. *capitata* f. *conica)* on yield and plant nitrogen (N) uptake. Both crops were grown in mono cropping (MC) and intercropping systems (IC). The yield of pointed cabbage per meter row was 28% higher under IC compared to MC. The ratio between marketable yield and total yield of pointed cabbage was also higher in IC. However, faba bean yield per meter row was reduced by 15% under IC. There was an indication of higher total N accumulation under IC followed by cabbage-MC and faba bean-MC. Soil mineral N at harvest (0-2.5 m depth) was lower in cabbage-MC, followed by IC and faba bean-MC. The intercropping system had a positive land equivalent ratio (LER) of 1.06, which points to the potential of using faba bean as an intercrop in sustainable organic vegetable production systems with higher N use efficiency. Results will be discussed in the wider perspective of several European trials on intercropping from the SureVeg-project (Strip-cropping and recycling for biodiverse and resource-efficient intensive vegetable production) and point to new knowledge for farmers wanting to implement intercropping.

Introduction: Vegetable production systems are highly nutrient demanding and excess mineral nitrogen (N) in the soil can be lost by leaching, denitrification etc. Intercropping provides a tool to improve the N use efficiency (NUE) in organic vegetable production systems. Using legumes, especially faba bean in an intercropping system, requires less fertilizer N due to its ability to fix atmospheric N, which can also facilitate the companion crop.Only few studies have focussed on yield and NUE of systems of two intercropped vegetable crops. The main objective of this study is to investigate whether

intercropping can be used as a tool to improve the NUE in an organic vegetable production system of faba bean and pointed cabbage. This study is part of the SureVeg-project (CORE-organic COFUND) that aims to design IC systems in intensive organic vegetable production and smart technologies for its management, with the contribution of six other European partners (SureVeg, 2019).

Material and methods: A field experiment on intercropping faba bean (*Vicia faba* L.) and pointed cabbage *(Brassica oleracea* var. *capitata* f. *conica)* was carried out at AU Årslev Research Centre, Denmark, (10° 27'E, 55° 18'N) from April to August 2018 on a sandy loam soil under organic farming management. Both crops were grown in full mono cropping system (MC) and an intercropping system (IC), where the crops were grown in alternate rows (substitution design). The row distance was 0.5 m and spacing between plants were 0.1 m for faba bean and 0.35 m for pointed cabbage. The crops were aimed to be supplied with nationally recommended amounts of N fertilizer, which differed between the crops, including the potential N mineralization from the top soil layer, which was estimated based on an incubation study of spring potential mineralization (88 kg N ha^{-1}). The total amounts of fertilizer N and soil mineral N were 171, 100 and 107 kg N ha^{-1} in cabbage-MC, faba bean-MC and IC system, respectively.. The fertilizer was given by a combination of organic plant-based fertilizers s (grass-clover silage, composted garden and park waste and lupine seeds). The trial was irrigated. The experimental layout was a completely randomized block design with four replicates and plot sizes of 4.8 m x 10 m. The land equivalent ratio (LER) was used to compare the productivity of IC systems and calculated as LER = (pointed cabbage yield (IC) / pointed cabbage yield (MC)) + (faba bean yield (IC) / faba bean yield (MC)). LER indicates the relative area required to produce the same yield in IC as MC. A positive LER means that less area is required in IC to produce the same yield as in MC and vice versa. LER on N accumulation was calculated as described in Schröder and Köpke (2012).Soil mineral N (NH_4^+-N and NO_3-N)) to 2.5 m depth and plant N content were measured. The NUE was calculated as the total grain yield (kg) produced per unit of supplied N (kg N). Minirhizotrons were used for measuring root growth to 2.5m depth.

Results: Total head yield of cabbage and faba bean was higher under MC than IC (Figure 1). Comparing the yield per meter row, pointed cabbage yield was significantly higher under IC compared to MC, showing a yield advantage for cabbage when grown with faba bean. However, faba bean yield was lower under IC compared to MC (Figure 2). The ratio between marketable and total yield for both crops was not significantly different among the cropping systems. The calculated LER, was 1.06, indicating a slightly positive effect of IC on yields.

The total N accumulated in the above ground biomass of both crops was indicated to be higher in IC than in MC (P-value = 0.058) (Table 1). The LER calculated based on N accumulation was 1.12, which showed that IC promoted a higher N uptake. The cabbage-MC system was more efficient in taking up soil mineral N in 0-2.5 m depth, followed by IC and faba bean-MC systems. The NUE was higher under IC and cabbage-MC than faba bean-MC. The N content of crop residues did not differ among cabbage-MC and IC systems but was higher than in faba bean-MC (Table 1).

Table 1. The content of soil mineral N in spring and at harvest, plant N accumulation and nitrogen use efficiency (NUE) in pointed cabbage and faba bean mono and intercropping systems

Cropping system	Soil mineral N before sowing/ planting in 0-2.5 m depth (kg ha^{-1})	Soil mineral N at harvest in 0-2.5 m depth (kg ha^{-1})	Product N accumulation at harvest (kg ha^{-1})	N in crop residues (kg ha^{-1})	NUE (kg kg^{-1})
C-MC	148	43[b]	168	114[a]	181[a]
F-MC	148	105[a]	181	96[b]	54[b]

IC	148	64[b]	193	118[a]	202[a]
P value		***	ns	*	***

C-MC: cabbage mono cropping; F-MC: faba bean mono cropping; IC: intercropping. Values are means (n=4). Lower case letters indicate significant differences among cropping systems at P<0.05. (*) and P<0.001 (***). Ns = not significant.

Discussion: The grain yield of faba bean in this study was higher compared to 3.6 Mg ha^{-1} obtained under MC in a previous field trial in Denmark (Pristeri et al, 2006). However, yield calculated per total cropped area (Fig. 1) of both cabbage and faba bean under IC was lower due to the reduced plant density in the substitution design. Nevertheless, the yield of pointed cabbage per meter row was higher (28%) under IC than MC. This yield increase is further confirmed by a LER higher than one.

Despite of the reduction in total yield per area under IC, the benefit of intercropping with faba bean can be seen in the addition of the protein rich faba bean crop to the production; a crop that can be used for both human and livestock consumption.IC designs involving legumes like faba bean can improve the NUE of the cropping systems by reducing nutrient inputs, due to the biological fixation of atmospheric N. In our study, there was no significant difference among cabbage-MC and IC system in terms of NUE and N content of the plant residues. Compared to faba bean-MC, the IC system left less mineral N in the soil, which was due to the increased rooting intensity (data not shown) and the strong N demand of cabbage.

The positive LER and the indication of less risk of nitrate leaching under IC compared to faba bean-MC showed that IC systems of pointed cabbage and faba bean have promising perspectives for organic farming. Results will be discussed in the perspective of results from field trials in Finland, Latvia, Italy, Belgium and Netherlands on strip and intercropping of vegetables from the SureVeg-project (SureVeg, 2019).

References: Pristeri, A. et al. (2006): Yield performance of faba bean–wheat intercropping on spring and winter sowing in European organic farming system. In Proceedings of the European Joint Organic Congress: Organic Farming and European Rural Development, Odense (DK), 30–31 May 2006 (Eds C. B. Andreasen et al.), 294–295, DARCOF.

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SureVeg (2019) CORE organic COFUND, http://projects.au.dk/en/coreorganiccofund/core-organic-cofund-projects/sureveg/

Image:

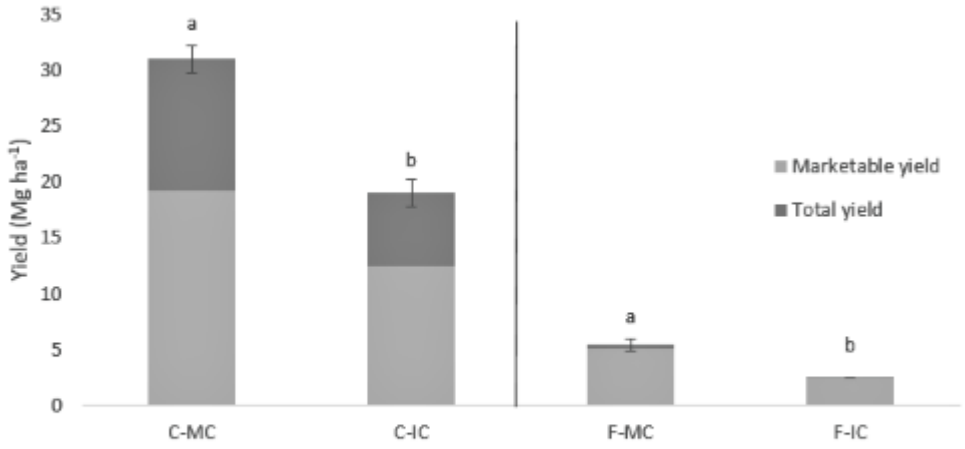

Figure 1: Total and marketable yield (Mg ha^{-1}) of pointed cabbage (C) and fababean (F) in mono (MC) and intercropping (IC) systems. Bars represent standard errors for total yield. For calculating marketable yield, cabbage heads and fababean beans are assessed.

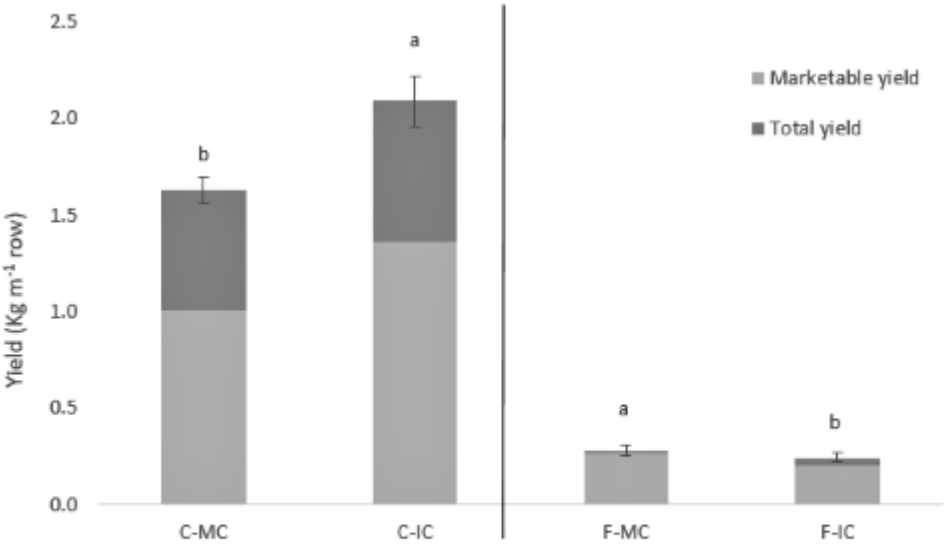

Figure 2: Total and marketable yield (kg m^{-1} row) of pointed cabbage (C) and fababean (F) in mono (MC) and intercropping (IC) systems. Bars represent standard errors for total yield. For calculating marketable yield, cabbage heads and fababean beans were assessed.

Disclosure of Interest: None Declared

Keywords: Land equivalent ratio, Nitrogen use efficiency, soil mineral nitrogen, Vicia faba L.