



## TRansition paths to sUstainable legume-based systems in Europe

Effect of the farming system (organic or conventional) and rotation scheme with legumes (pea and faba bean) on biological nitrogen fixation efficiency, on soil  $\text{NO}_3\text{-N}$  concentration and head cabbage yield.

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### Introduction

To quantitatively assess the benefits of a cabbage crop from rotation with legumes, a field experiment was carried out at the experimental station of the Agricultural University of Athens, located in Copaida (Aliartos) in central Greece (38°23'51"N, 23°05'41"E, 95 m a.s.l.) during 2014-2017. The experiment was started with the evaluation of different pea and faba bean landraces and commercial varieties and continue with two year crop rotation experiments.

### Material and Methods

The experimental design was a split plot with four replicates, two main plots (conventional and organic farming system) and four sub-plots with three different rotation treatments for cabbage crop (C-C= Cabbage after Cabbage, F-C= Cabbage after Faba bean and P-C= Cabbage after Peas).

The tested pea genotypes were a commercial cultivar ('Onward') and three local landraces originating from the Aegean islands Amorgos ('AUAAMORG001'), Andros ('AUAANDRO001') and Schinoussa ('AUASCHIN001'). The tested faba bean genotypes were 'Aguadulche' (commercial cultivar) and three local landraces originating from Andros Island in the Aegean Sea (AUAANDROSfb001), Lefkada Island in the Ionian Sea (AUALEFKADAFb001), and Mani in southern Peloponnese (AUAMANIFb001) and cabbage was a commercial hybrid "Krautkaiser F1".

Biological nitrogen fixation was estimated using the natural <sup>15</sup>N abundance method. The <sup>15</sup>N content of the plant samples was determined in the Stable Isotope Facility of UC-Davis, CA, USA. The concentration of nitrates in the extracted soil solution was determined by applying the copperized cadmium reduction method (Griess-Ilosvay procedure).

### Results

#### Biological nitrogen fixation of pea landraces

Farming system	Genotype	Ndfa	Ndfa	Total-N	Total-N	BNF	BNF
		(%)	(%)	(%)	(%)	(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )
		2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Organic	'Onward'	80.88 cd	80.48 bc	2.72 b	2.28 c	69.41 b	61.40 c
	'AUASCHIN001'	85.24 ab	-	2.59 b	-	55.66 c	-
	'AUAANDRO001'	84.59 bc	84.10 b	2.66 b	3.06 ab	85.92 a	102.74 ab
	'AUAAMORG001'	88.95 a	-	2.68 b	-	66.95 bc	-
Conventional	'Onward'	88.73 a	88.81 a	3.35 a	3.36 a	101.85 a	125.25 a
	'AUASCHIN001'	81.27 cd	-	2.34 b	-	45.23 c	-
	'AUAANDRO001'	74.48 e	77.42 c	2.15 b	2.71 bc	52.20 c	71.43 bc
	'AUAAMORG001'	78.74 d	-	2.75 b	-	53.52 c	-
Statistical significance							
Farming system		***	*	ns	*	ns	*
Genotype		**	**	*	ns	***	*
Farming system × genotype		***	***	*	***	**	***

#### Biological nitrogen fixation of faba bean landraces

Farming system	Genotype	Ndfa	Ndfa	Total-N	Total-N	BNF	BNF
		(%)	(%)	(%)	(%)	(kg ha <sup>-1</sup> )	(kg ha <sup>-1</sup> )
		2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Organic	'Aguadulche'	79.28 b	76.73 b	3.23	3.18	107.01 c	123.48 b
	'AUAANDROSfb001'	91.01 a	-	2.77	-	151.73 b	-
	'AUALEFKADAFb001'	87.07 a	87.51 a	3.45	3.27	187.90 a	181.06 a
	'AUAMANIFb001'	86.86 a	-	2.96	-	146.08 b	-
Conventional	'Aguadulche'	89.64 a	90.08 a	2.96	3.10	160.47 b	181.00 a
	'AUAANDROSfb001'	90.29 a	-	3.19	-	158.10 b	-
	'AUALEFKADAFb001'	89.45 a	89.85 a	2.99	3.08	176.53 ab	193.90 a
	'AUAMANIFb001'	88.54 a	-	2.87	-	151.10 b	-
Statistical significance							
Farming system		*	***	ns	*	***	*
Genotype		**	***	ns	ns	*	*
Farming system × genotype		*	***	ns	***	**	***

'Onward' fixed symbiotically the highest amounts of atmospheric N<sub>2</sub> per cultivated area unit (BNF value) when cultivated in a conventional farming system 'AUAANDRO001' exhibited appreciably higher BNF efficiency in the organic farming system

'Aguadulche' fixed symbiotically the highest amounts of atmospheric N<sub>2</sub> per cultivated area unit (BNF value) when cultivated in a conventional farming system 'AUALEFKADAFb001' exhibited appreciably higher BNF efficiency in both farming systems

### Benefits of cabbage from rotation with legumes

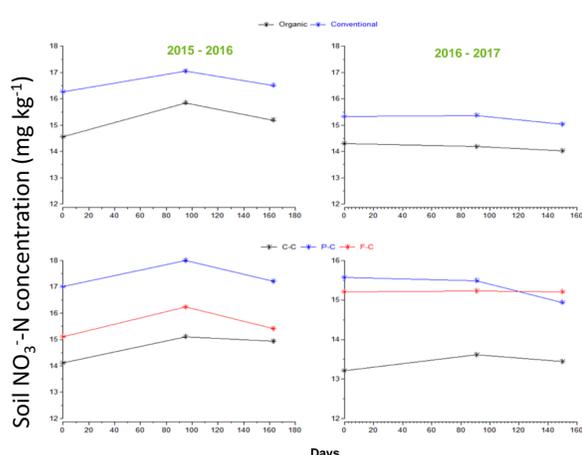


Figure 1. Effect of the farming system (organic or conventional) and the rotation scheme (F-C= Faba bean - Cabbage, P-C= Peas - Cabbage and C-C= Cabbage - Cabbage) on soil  $\text{NO}_3\text{-N}$  concentration at three different developmental stages of cabbage (BCE=Before Crop Establishment, EHF=Early Head Formation and FHS= Final Harvest Stage) during the 1<sup>st</sup> (2015 - 2016) and the 2<sup>nd</sup> (2016 - 2017) cultivation period.

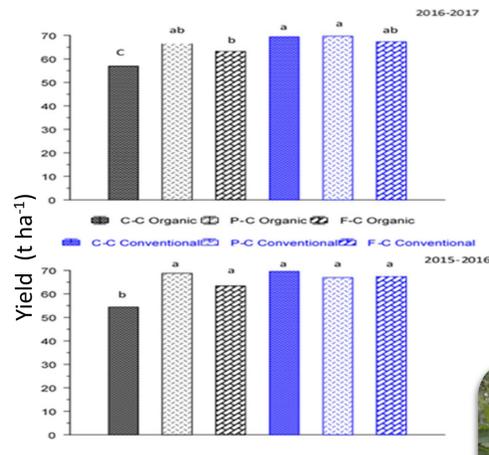


Figure 2. Effect of the farming system (organic vs conventional) and crop rotation scheme (C-C= Cabbage after Cabbage, F-C= Cabbage after Faba bean and P-C= Cabbage after Peas) on cabbage head yield (t ha<sup>-1</sup>) at the 1<sup>st</sup> (2015-2016) and the 2<sup>nd</sup> (2016-2017) cultivation period.



### Conclusions

The results showed that pea and faba bean:

- are legumes with a relatively high N<sub>2</sub>-fixation capacity (>74 - 75% of plant tissue N was biologically fixed from the atmosphere) and that peas were capable of fixing from 45 to 125 kg N ha<sup>-1</sup>, while faba beans fixed from 107 to 193 kg N ha<sup>-1</sup>, respectively, during the first and the second cropping year.
- as previous crops can increase nitrate concentrations in the soil before planting and in the early stages of the next crop compared to cabbage as previous crop in the organic farming system.
- enhanced yield of the following crop under organic farming systems due to legume ability to leave considerable amounts of soil N to the following crop.

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