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SERBIA FOR EXCELL, WORKSHOP, 2018

THE ESTABLISHMENT AND PRODUCTIVE AND QUALITY CHARACTERISTICS OF SAINFOIN (*Onobrychis viciifolia* Scop.) IN INTERCROPPING

Ph.D. thesis

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Sainfoin (*Onobrychis viciifolia* Scop.)

- Origin – south part of Central Asia and part of Middle East (Turkey, Iran)
- The largest area - Turkey (94 000 ha), East Europe, Italy, Spain, Kazakhstan, Iran



- Perennial forage legume (5-6 years)
- Considered as “honey“ plant

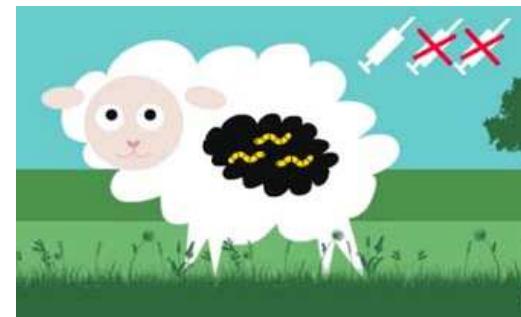




- French *saint foin* – healthy/holy hay



- Crude protein content ~ 19%
- Condensed tannins (increases protein absorption, decreases gastrointestinal nematodes)





Growing sainfoin

"Sainfoin is something of an agricultural paradox; from the point of view of animal nutrition it seems to be the most desirable of all forage legume plants; from an agronomic point of view it is an undesirable plant because it doesn't grow very well", Dr. J.E. Sheehy, 1982



- ✓ High yield and quality potential
- In Serbia there is no adequate genotypes resistant or tolerant to diseases
 - Growing technology is still not sufficiently developed



Growing sainfoin

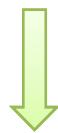
- In temperate region – spring and autumn sowing time

Spring sowing

- p.l. produce poor yield during establishment year
- weed problem!

Late summer/early autumn sowing

- higher yield in subsequent year
- rain-fed production - drought stress can occur establishing



INTERCROPPING?



Intercropping?

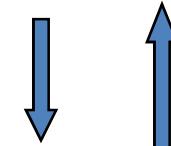
- is the simultaneous growing of two or more crop species in the same field without necessarily sowing and harvesting them together (Willey, 1979).
- is a practical application of ecological principles based on biodiversity, plant interactions and other natural regulation mechanisms.





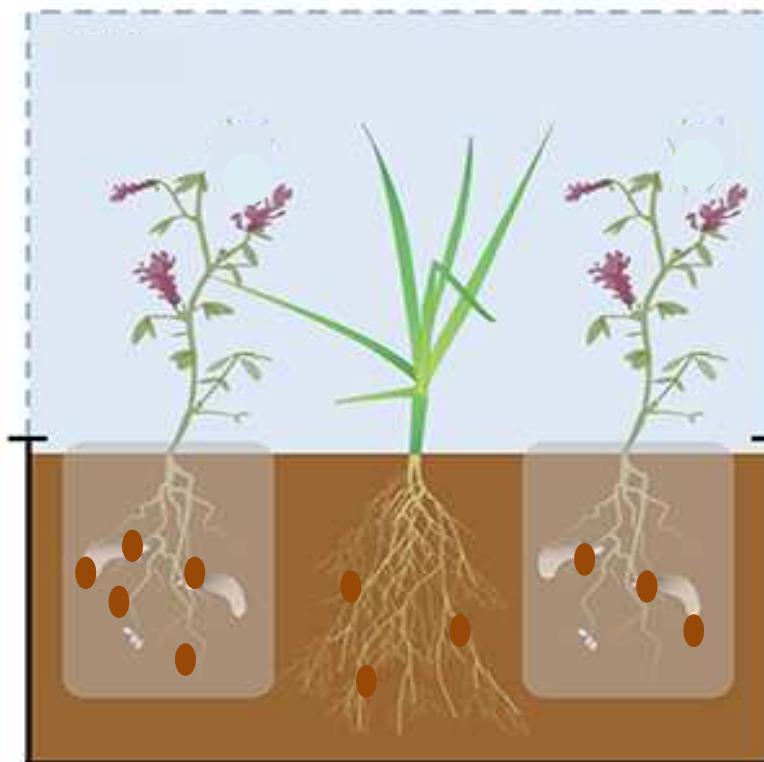
The use of available resources is much more efficient than in sole crops

Aboveground interactions



Crop characteristics

- Leaves position
- Photosynthesis
- Light penetration



Belowground interactions

Root characteristics

- nitrogen fixation
- density
- area
- depth
- penetration
- availability of water and nutrients



The success of intercropping depends on

- Selected species/cultivars
 - Crop density





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Intercropping for establishing perennial legumes

Traditional way



Yield
Quality?

Weed control?

sainfoin + grasses/ cereals

Alternative way

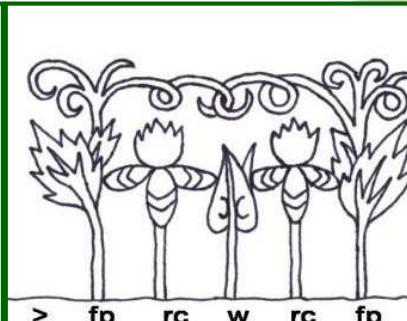
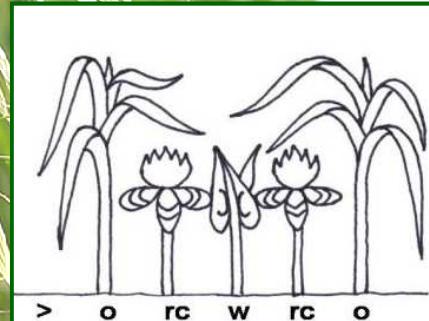


sainfoin + field pea



grasses/cereals vs. field pea

- High yield
- Lower quality-digestibility
- Efficiently reduce weeds
- High yield
- High quality protein feed
- Nitrogen fixation
- Reduced weeds
- Better re-growth of the perennial legume





The objective was to determine...

- the suitability of field pea as a companion crop in intercropping with sainfoin,
- the most suitable field pea genotype and number of pea plants,
- how field pea affects yield, quality, physiological and morphological properties of sainfoin in intercropping,
- what is the impact of two-legume intercropping on microbiological activity and nitrogen content in the soil,
- the impact of companion crop on the sainfoin yield in the full harvest year.



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Material and method

Rimski Šančevi - Experimental Field of the Institute of Field and Vegetable Crops, Novi Sad

2010-2014



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Two-factorial field trial

undersown crop - sainfoin – cultivar Makedonka



FACTOR A

Field pea cultivar



Afila leaf type
cv. JEZERO



Normal leaf with
reduced leaflets
cv. JAVOR

FACTOR B

Field pea plants per m²



30



60



90



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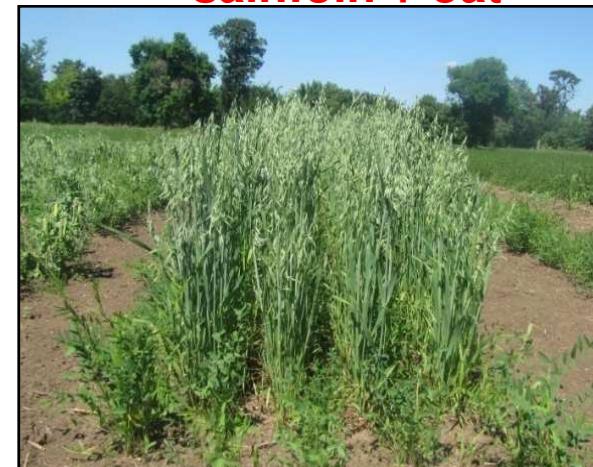
Control 1

sainfoin -pure stand



Control 2

sainfoin + oat



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Spring sowing

Sowing and cutting dates

Year of establishment	Sowing date	Cutting			1 st in the full harvest year
		1 st	2 nd	3 rd	
2010.	12.4.2010.	16.6.2010.	29.7.2010.	8.10.2010.	12.5.2011.
2011.	4.4.2011.	20.6.2011.	18.8.2011.	-	11.5.2012.
2012.	26.3.2012.	20.6.2012.	-	-	16.5.2013.
2013.	17.4.2013.	3.7.2013.	11.8.2013.	-	12.5.2014.





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Evaluated parameters:

Aboveground parameters

- Dry matter yield of the I cut ($t \text{ ha}^{-1}$)
- Total-annual dry matter yield ($t \text{ ha}^{-1}$)
- I cut yield in the second year ($t \text{ ha}^{-1}$)
- Weed proportion (%)
- Physiological parameters of the sainfoin in the I cut (LAI, chlorophyll and carotenoids content, intensity of photosynthesis, intensity of transpiration, water use efficiency)
- Quality parameters of the I cut (CP, CF, Ash content, BEM, NDF, ADF)



Belowground parameters

- Microbiological activity (number of *Rhizobium* nodules, total number of bacteria, total number of fungi, number of *Azotobacter* sp.)
- Nitrogen content





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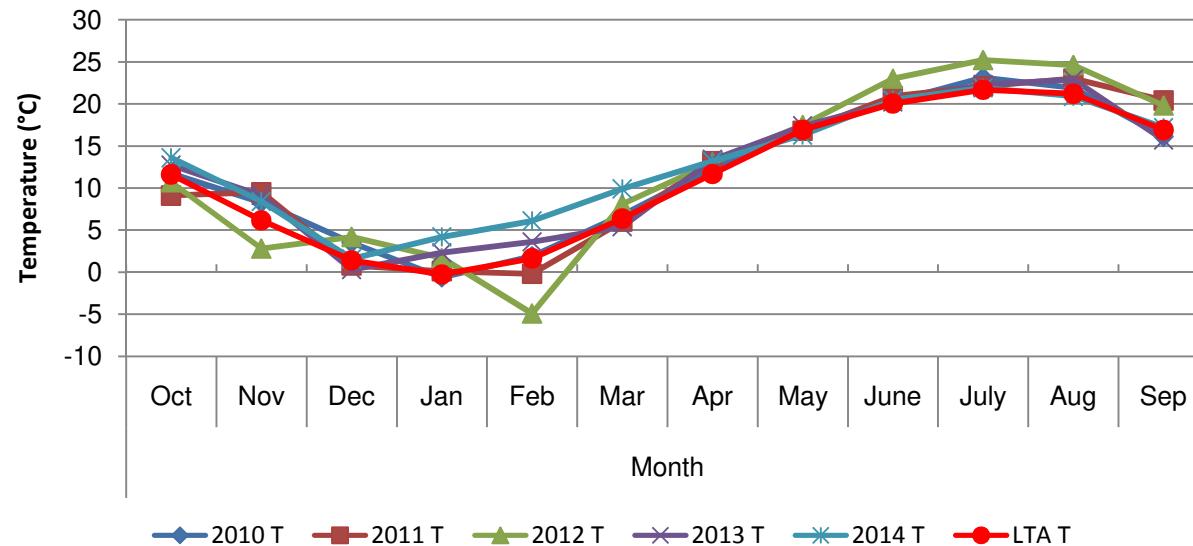
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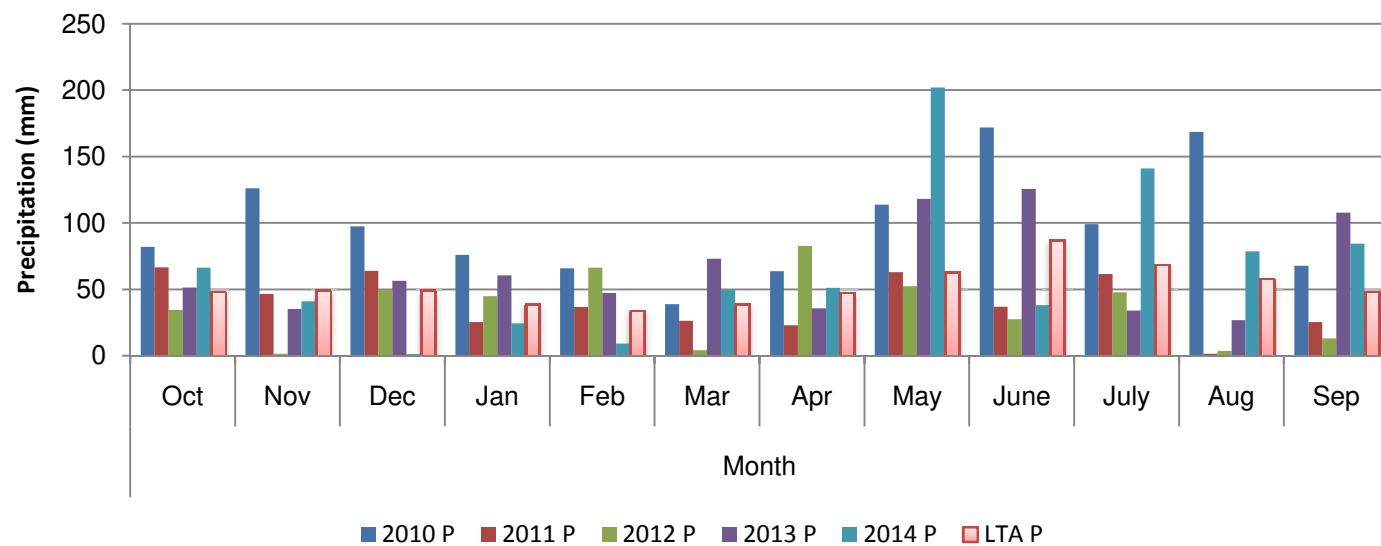
Soil properties

Depth (cm)	pH in KCl	pH in H ₂ O	CaCO ₃	Organic matter (%)	N (%)	mg 100 g ⁻¹ soil	
						P ₂ O ₅	K ₂ O
0-30	7,5	8,3	5,2	2,72	0,133	52,0	39,1
30-60	7,5	8,3	8,7	1,87	0,093	35,9	29,4
60-90	7,6	8,5	19,0	1,54	0,077	13,2	19,0





Weather conditions 2010-2014





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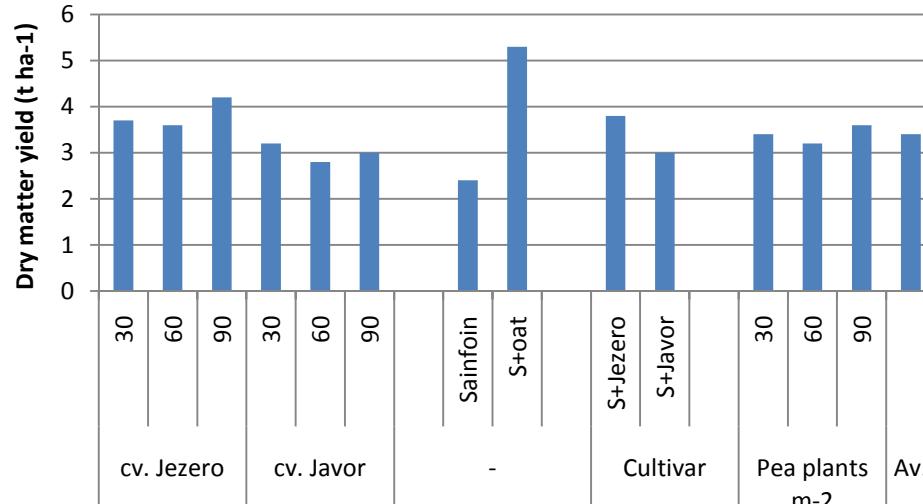
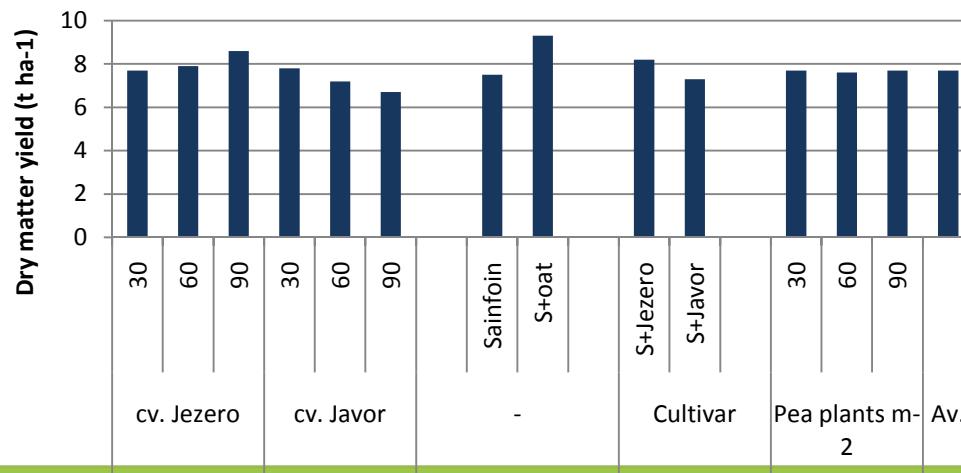
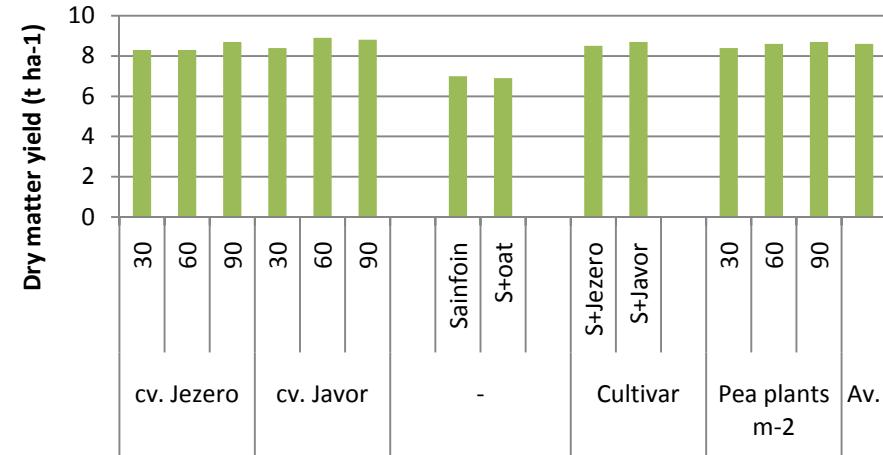
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Results

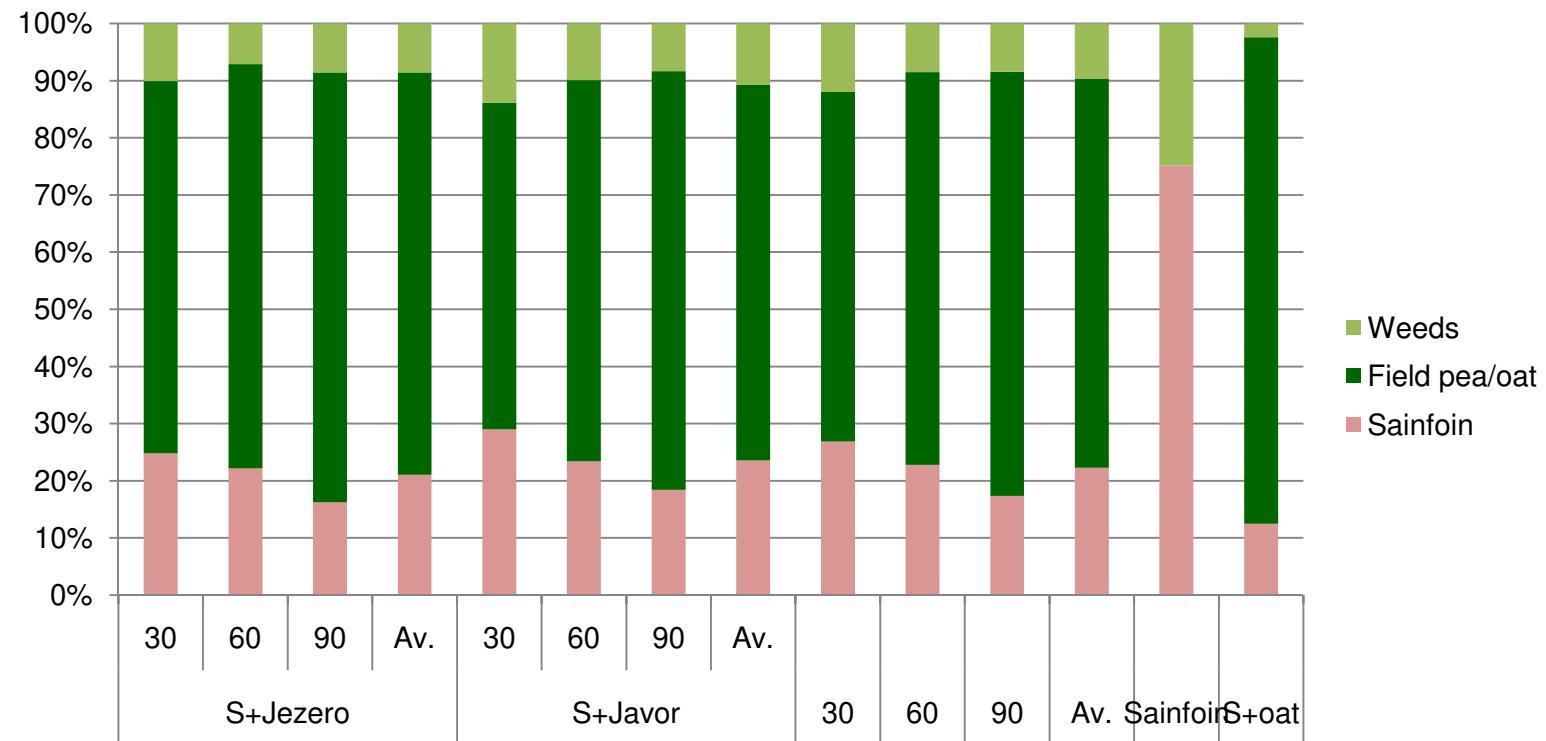


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**I cut (t ha⁻¹)****Total annual yield (t ha⁻¹)****I cut in the full harvest year (t ha⁻¹)**



The proportion of sainfoin, companion crops and weeds in the first cut dry matter yield (2010-2013)



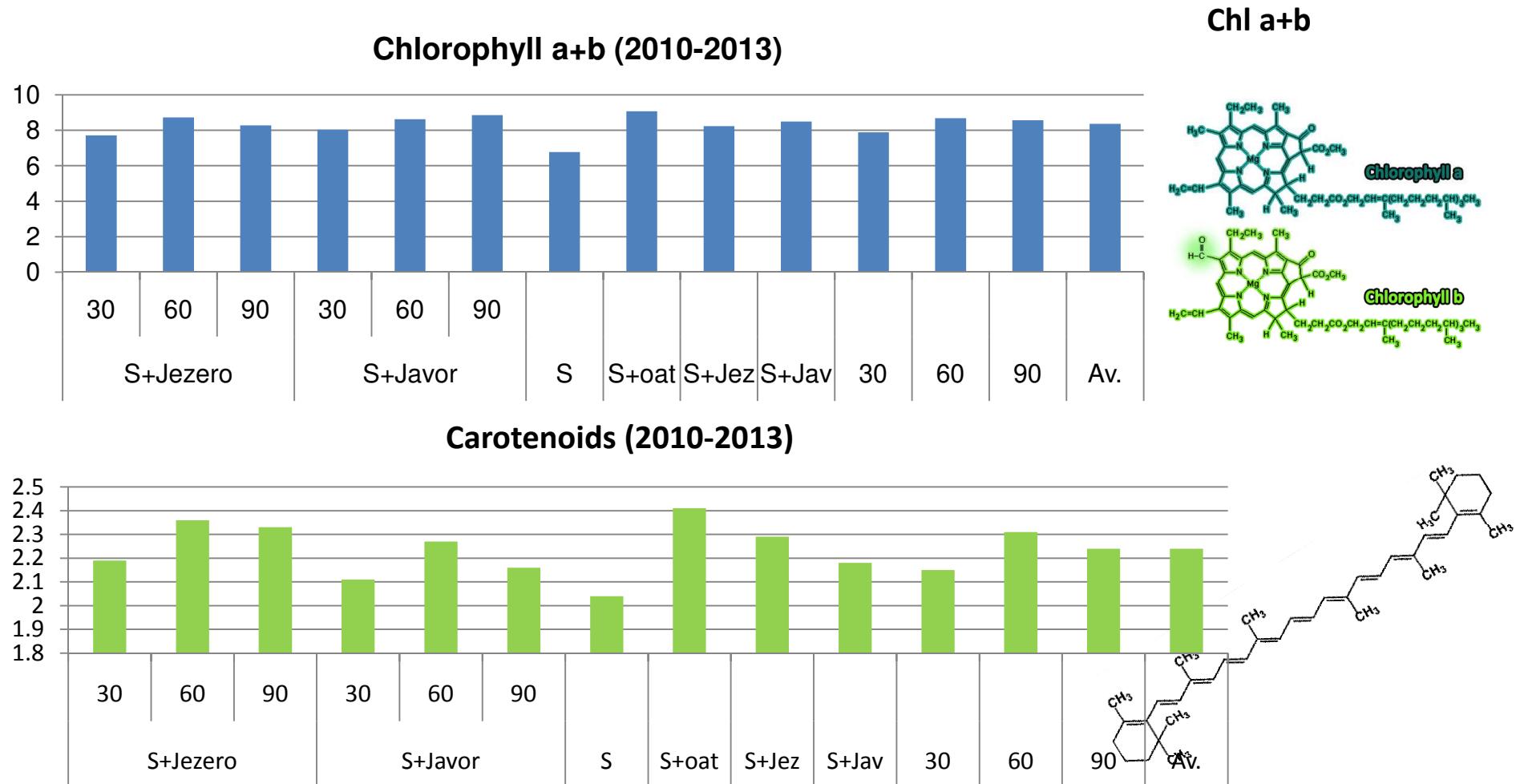


Leaf area index of sainfoin ($\text{m}^2 \text{ m}^{-2}$) in the first cut (2010-2013)

Cultivar × Pea plants m^{-2}	2010.	2011.	2012.	2013.	Average
Jezero	30	2,59 bcd*	1,80 abc	2,00 abc	2,33 A**
	60	2,46 cd	2,05 ab	2,06 ab	2,38 A
	90	1,99 d	1,47 cd	1,29 c	2,30 A
Javor	30	3,43 a	1,86 abc	1,68 abc	2,61 A
	60	2,84 abc	2,22 a	1,74 abc	2,42 A
	90	2,41 cd	2,17 a	1,59 bc	2,37 A
Sainfoin		3,25 ab	1,59 bcd	2,32 a	2,59 A
Sainfoin + oat		1,41 e	1,16 d	0,56 d	1,34 B
Cultivar					
S + Jezero		2,35 b	1,77 a	1,78 a	2,34 A
S + Javor		2,89 a	2,09 a	1,67 a	2,47 A
Pea plants m^{-2}					
30		3,01 a	1,83 a	1,84 a	2,47 A
60		2,65 ab	2,14 a	1,90 a	2,40 A
90		2,20 b	1,82 a	1,44 a	2,34 A
Average		2,62 B	1,93 C	1,73 C	2,40



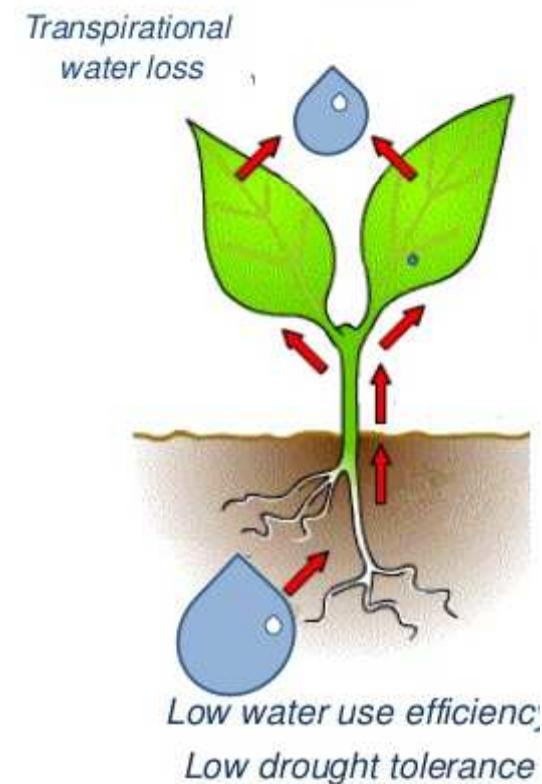
Chlorophyll and carotenoids content (mg g^{-1}) in sainfoin in the first cut





Water use efficiency of sainfoin ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}/\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$) (2010-2013)

Cultivar × Pea plants m-2		WUE
S+Jezero	30	4,35
	60	5,02
	90	4,93
S+Javor	30	3,58
	60	4,60
	90	2,81
Sainfoin		3,08
Sainfoin+oat		4,25
Average		3,99





Number of Rhizobium nodules



Treatment	Field pea	Sainfoin
S+Jezero	30	24,0
	60	28,3
	90	32,8
S+Javor	30	30,8
	60	30,8
	90	32,9
Jezero		30,9
Javor	26,1	Sainfoin 21,6
Cultivar		S+oat 19,1
S+Jezero		28,4
S+Javor		31,5
Pea plants m ⁻²		
	30	19,8
	60	21,9
	90	20,2
Average	29,9	20,6

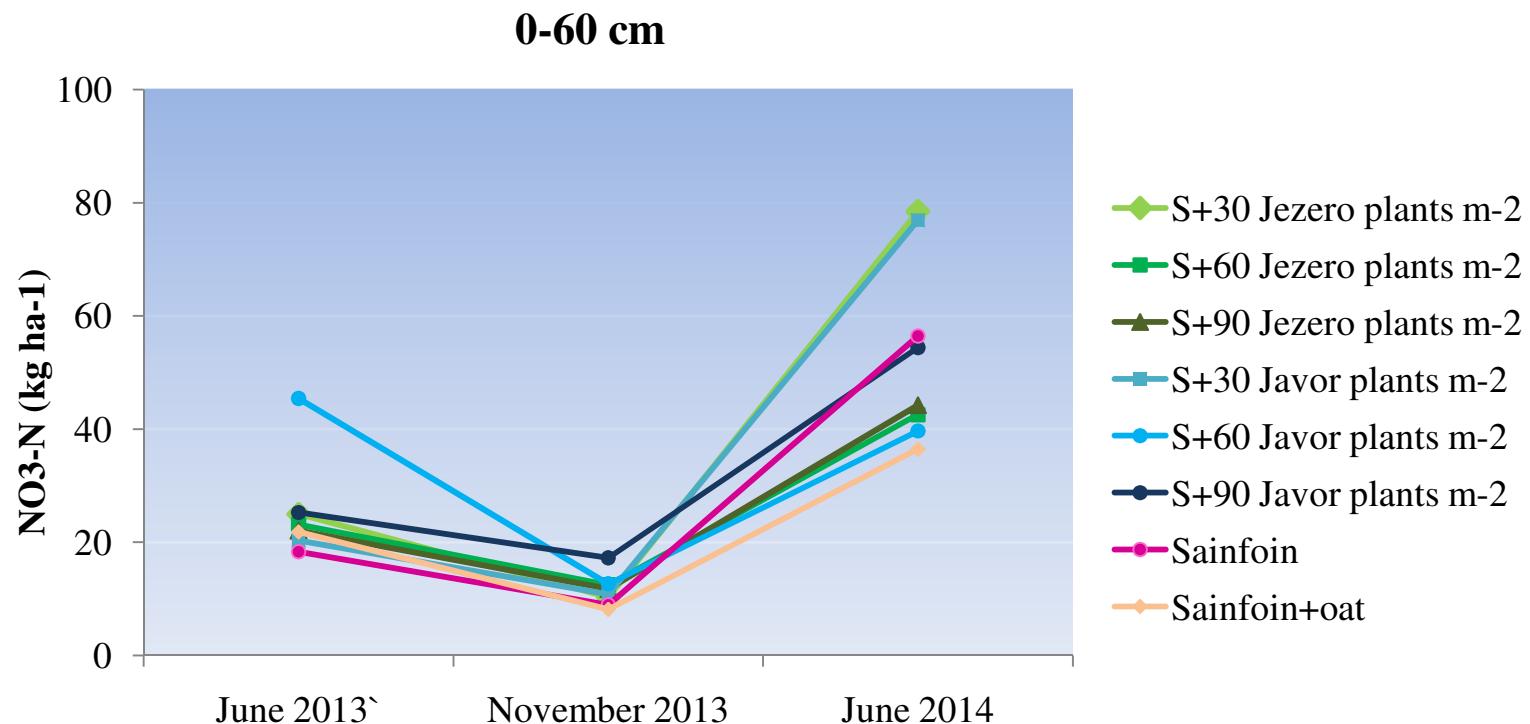


Number of
Azotobacter sp.
($\times 10^2$ g $^{-1}$ soil)

Treatment	Field pea		Sainfoin
S+Jezero	30	47,40	50,64
	60	50,22	37,83
	90	44,50	51,59
S+Javor	30	59,72	59,12
	60	58,72	54,55
	90	52,05	54,66
Jezero		59,47	Sainfoin 43,02
Javor		52,28	S+oat 49,49
Cultivar			
S+Jezero		47,38	46,69
S+Javor		56,83	58,67
Pea plants m $^{-2}$			
30		53,56	54,88
	60	54,47	47,02
	90	48,27	53,13
Average		52,10	52,65



Dynamic of soil mineral nitrogen (kg ha^{-1})





FORAGE QUALITY of the I cut in 2010 (%)

Cultivar × Pea plants m ⁻²	CP	CF	NDF	ADF	Lig
Sainfoin	19,2	36,4	48,3	46,2	11,5
Sainfoin+oat	12,4	36,8	58,5	42,0	7,6
Cultivar					
S+Jezero	20,4	31,5	43,4	37,2	9,4
S+Javor	21,3	32,9	43,8	38,8	10,5
Pea plants m ⁻²					
30	20,8	32,0	43,7	37,2	9,3
60	20,5	32,8	42,6	37,7	9,4
90	21,2	31,9	44,6	39,0	11,2



Conclusions

- Weather conditions had significant impact on yield performance and yield components
- The dry matter yield in the first cut was higher in intercropping of sainfoin and cv. Jezero, while there were no differences between 60 and 90 pea plants m^{-2}
- In the full harvest year companion crops did not affected obtained sainfoin yield
- The highest weed proportion was in the pure sainfoin stand, and in average cv. Jezero had higher competitive ability in intercropping mixture



- The obtained results show that sainfoin can be successfully established with field pea in intercropping
- Intercropping can be considered as a reliable and ecological practice for sainfoin establishment, which provides the possibility for increasing production of this species.