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LEGUME-BASED INTERCROPPING SYSTEMS

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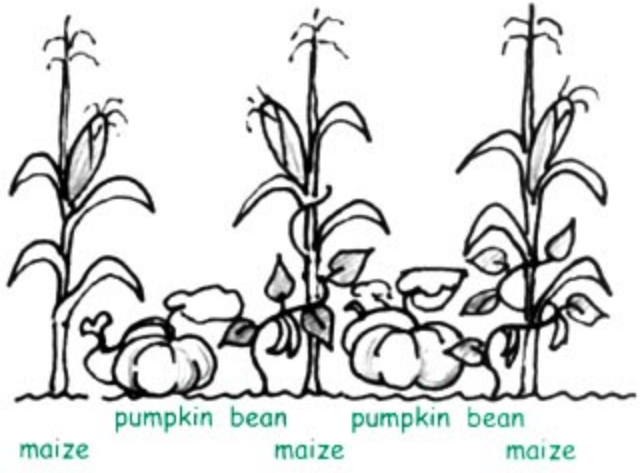
Intercropping?

- 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.



Intercropping concept

- **When two or more crops are grown together, each must have adequate space to maximize cooperation and minimize competition between them.**

- **To accomplish this, four things need to be considered:**
  spatial arrangement,
  plant density,
  plant architecture
  maturity dates of the crops being grown.

Intercropping patterns

- **Mixed intercropping:** Growing two or more crops simultaneously with no distinct row arrangement.
- **Row intercropping:** Growing two or more crops simultaneously where one or more crops are planted in rows.
- **Strip Intercropping:** Growing two or more crops simultaneously in different strips wide enough to permit independent cultivation but narrow enough for the crops to interact ergonomically.
- **Relay intercropping:** Growing two or more crops simultaneously during part of the life cycle of each. A second crop is planted after the first crop has reached its reproductive stage but before it is ready for harvest.

Intercropping/sole crops

- If the components are carefully selected, intercrops have potential advantages compared to sole crops:
  - → increased forage yield,
  - → enhanced weed control,
  - → decreased soil erosion,
  - → reduced incidences of pests and diseases etc.

Intercropping in the agro-ecosystem:

- greater competition towards weeds (low input of pesticides)

- reduced negative impact of arable crops on the environment

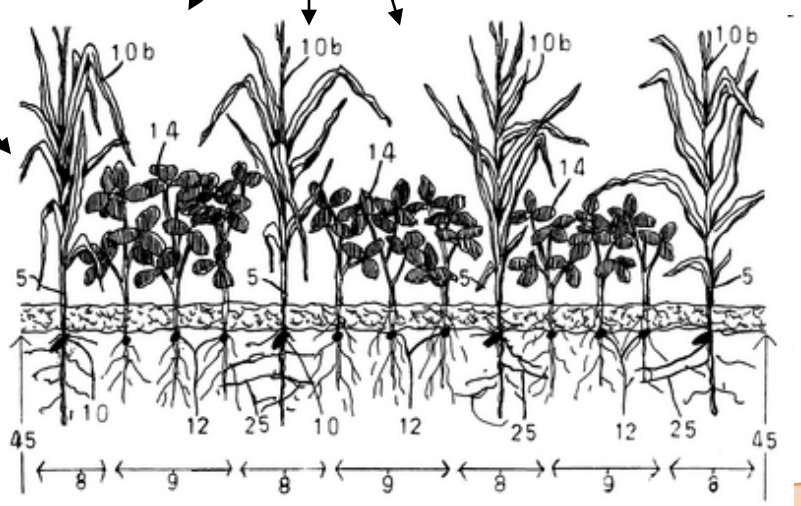
- biodiversity conservation
- nutrient cycling
- soil and water conservation
- carbon sequestration

Intercropping exploits the benefits of diversity, interactions between species, and other natural regulation mechanisms to use the available resources more efficiently than sole crops

Crop characteristics

- Leaves
position, phophotosynthesis
- Light penetration

Solar radiation



Aboveground interactions

Root characteristics

availability of water and nutrients

- density
- area
- depth
- penetration

Belowground interactions
nitrogen fixation
water and nutrients

Malézieux *et al.* (2009)

Intercropping in Europe

- **Despite all its advantages, during the last 50 years intercropping disappeared from many farming systems**
  - **the agricultural intensification (plant breeding, mechanisation, fertiliser and pesticide use)**

- **Clover/grasses in pastures are still widely used in European agriculture, but arable intercropping (cereals, grain and forage legumes, oil seeds) for food and feed is presently not so common.**

Re-introducing intercropping in European agriculture to a greater extent should not be reversion to old methodology, but rather considering the usefulness of this old and sustainable cropping practice in a modern, and technology-oriented agriculture.

Our research is mainly focused on legumes

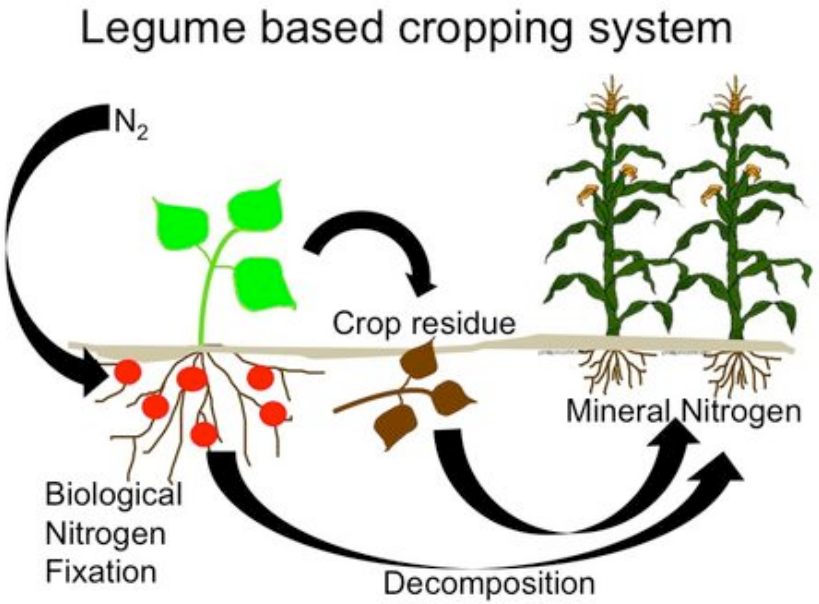
Serbia – Vojvodina Province

Why legumes?

Legumes in cropping system

ability to fix atmospheric nitrogen

Stimulating the productivity of the crops that follow



- There are a number of other benefits of legumes in a cropping system such as:

- reducing green house effect
- less potential for environmental degradation,
- improved soil physical conditions and water relations
- improve rotations for management efficiency and biodiversity
- increasing soil carbon content
- lower energy consumption in agriculture

Benefits vary depend on the conditions!

Jensen *et al*., (2011): Legumes for mitigation of climate change and the provision of feedstock for biofuels and biorefineries. A review, Agron. Sustain. Dev.

Intercropping for establishing perennial legumes

Late summer sowing

• higher yield in subsequent year!

• rainfed production-drought stress can occur emergence/establishing

Spring sowing

• p.l. produce poor yield during establishing year!

• weed problem!

Field peas: a cover crop in establishing perennial legumes (alfalfa, red clover, sainfoin)

field pea companion crop

establishing per leg

- short growing season/fast growing crop
- lower competition relative to small grains
- reduced weed competition

Companion cropping
- environmental friendly production (omit of pesticides)
- achieve higher land-use efficiency

Traditional

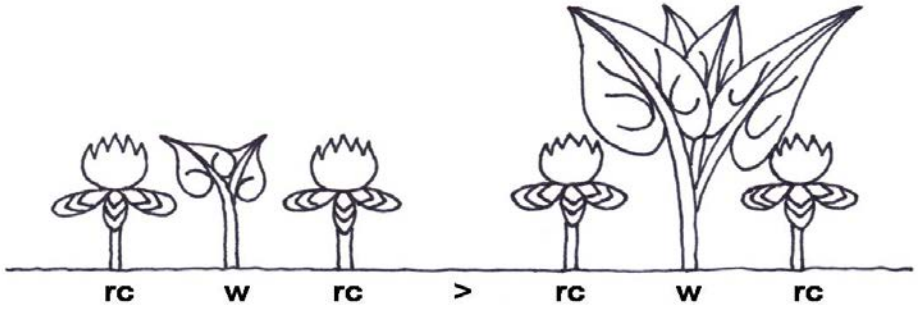
high yield
lower quality-digestibility

Alternative

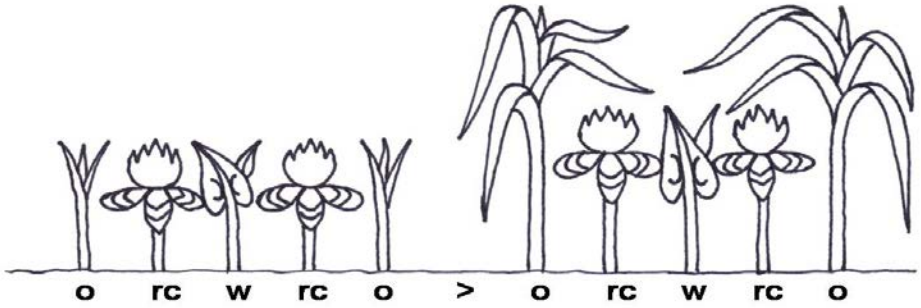
high yield
provide high quality protein feed

The information on alternative companion crops is limited

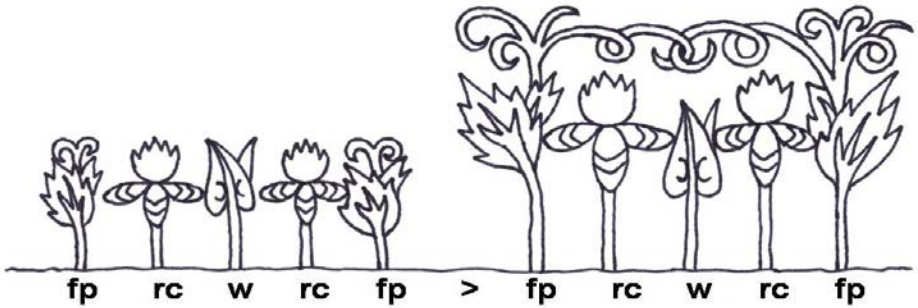
Different ways of the establishment of perennial legumes



Red clover (rc) is easily matched by weeds (w) in its <u>pure stand</u>



<u>Oats</u> (o) decreases weeds (w) but also red clover (rc)



<u>Field pea</u> (fp) decreases weeds (w) but enhances the growth of red clover (rc)

Cupina et al., 2011

OBJECTIVE

- **Determine the suitability of field pea for companion cropping with perennial legume,**
- **Selection of adequate field pea genotype,**
- **Workout a suitable agronomy determination of optimum stand, i.e., the number of plants of the cover crop is especially important in that respect.**

Establishing perennial legumes in intercropping

1 M.Sc. – Red clover

1 Ph.D. - Alfalfa

1 Ph.D. - Sainfoin

Establishment and productive and quality characteristics of sainfoin (*Onobrychis viciifolia* Scop.) in intercropping

(Vujić S. - PhD thesis, supervisor Prof.Dr. B. Ćupina)

Material and Methods

2-factor trial established under field conditions

Considering the field pea as the cover crop two factors were tested

Factor A-pea cultivar

Factor B-number of pea plants per m^2 in perennial legume

- **30 plants per m^2**
- **60 plant per m^2**
- **90 plants per m^2**

afila type, cv. Jezero

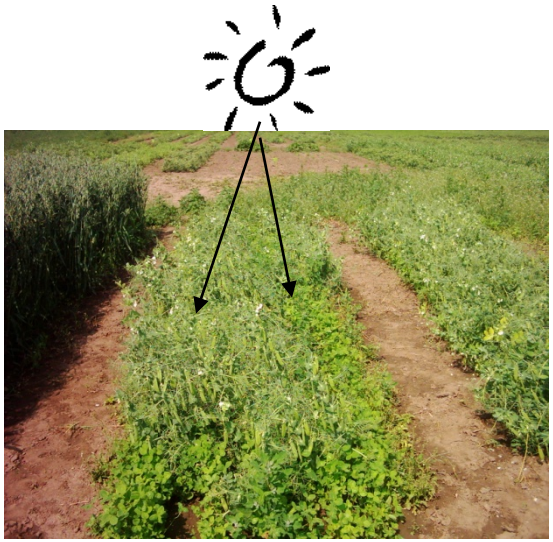
normal leaved type, cv. Javor

Regarding applicability of field pea as a cover crop selected genotypes so far differ in morphology

Plant height

Leaf structure

For companion cropping genotypes-short stem and reduced leaf lets/afila type



better light penetration through canopy (important for undersown crop)


Control-2
Oat/sainfoin
Control-1
pure sainfoin

- The pea was first planted at the row distance of 20 cm.
- Then sainfoin was sown between the pea rows, to achieve the final row distance of 10 cm, i.e. after I cutting 20 cm in sainfoin




Evaluated parameters:

Aboveground parameters

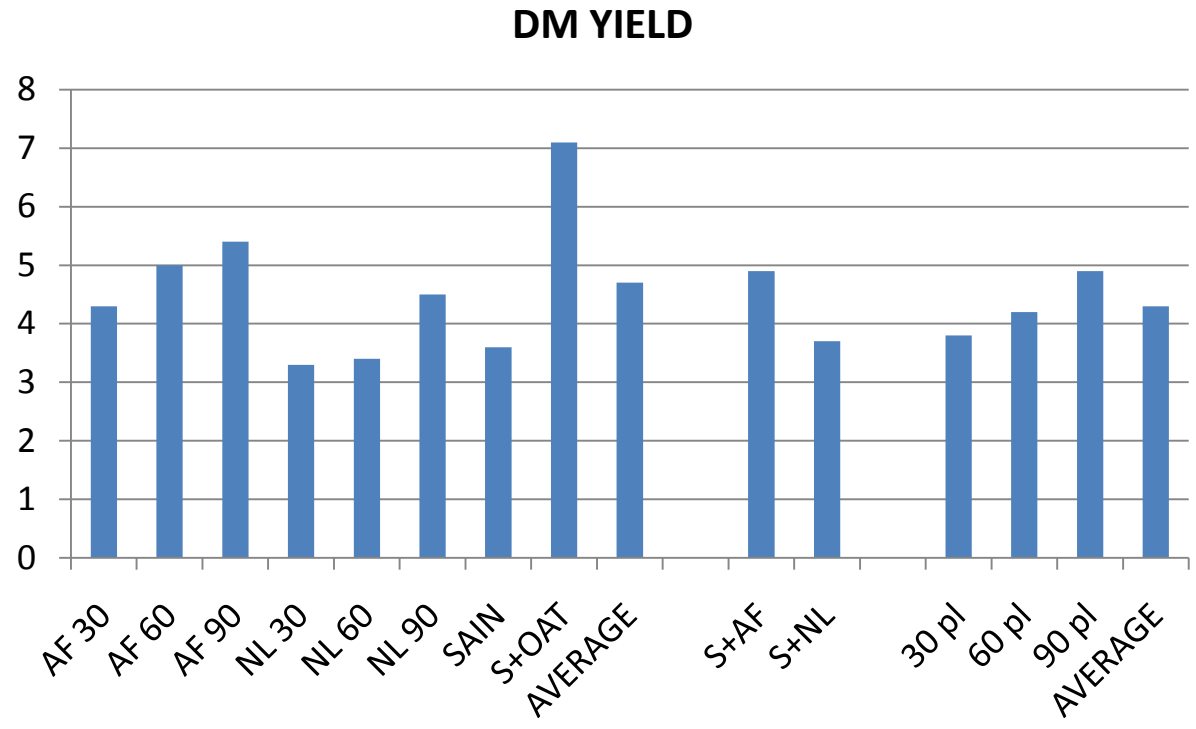
- total-annual forage yield (t ha^{-1})
- total-annual dry matter yield (t ha^{-1})
- I cut proportion in annual yield of the establishment year
- I cut yield in the second year (t ha^{-1})
- Weed proportion (%)
- Physiological parameters of the sainfoin in the I cut (LAI, chlorophyll and carotenoids content, intensity of photosynthesis, intensity of aeration)
- Leaf and stem anatomy (leaf cross section) – phloem, xylem, epidermis, collenchyma, sclerenchyma, parenchyma
- Quality parameters of the I cut (CP, CF, Ash content, BEM, NDF, ADF)

Belowground parameters

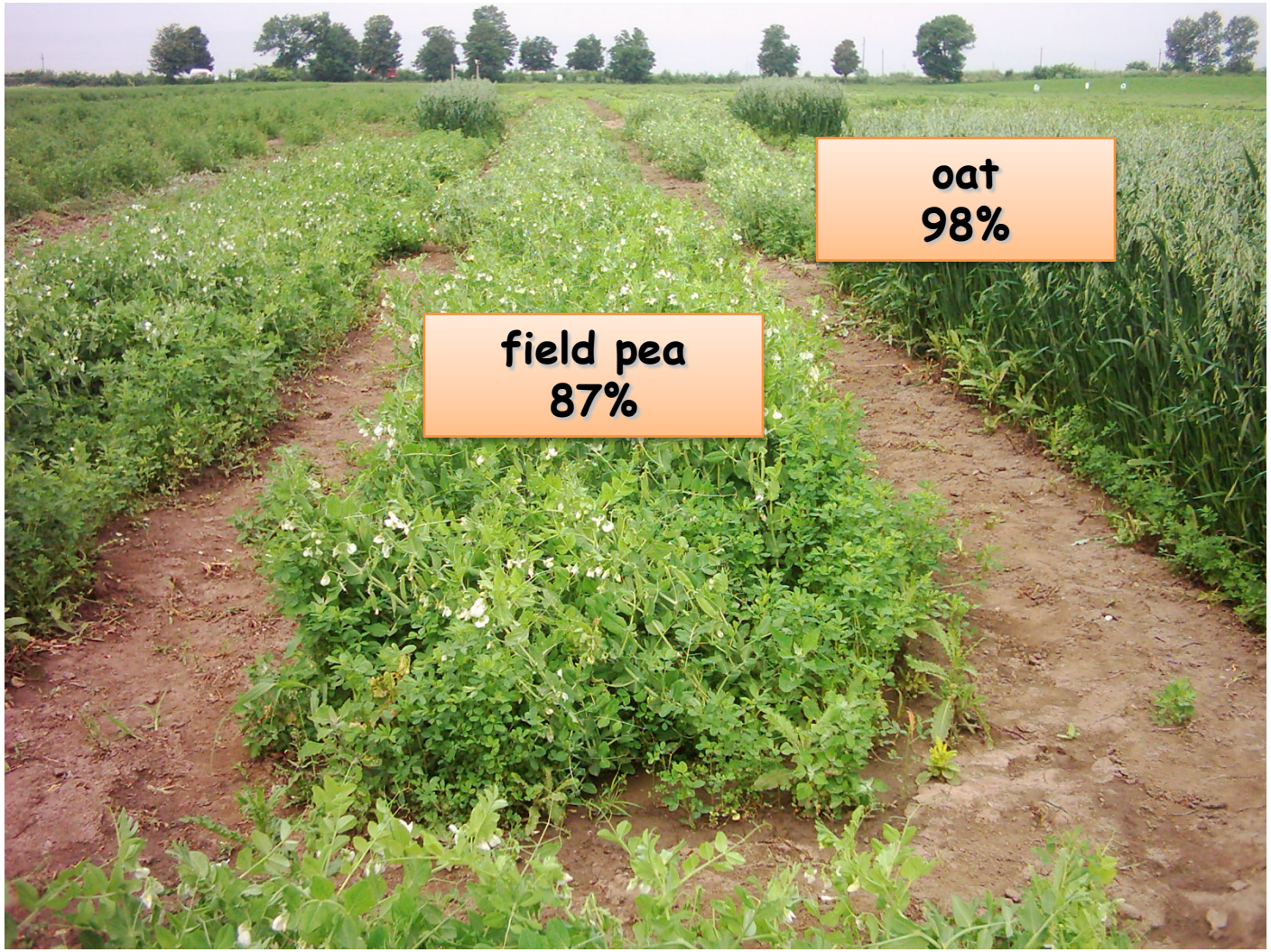
- Microbiological activity (total number of bacteria, total number of fungi, number of *Azotobacter* sp.)
- Nitrogen content

Results

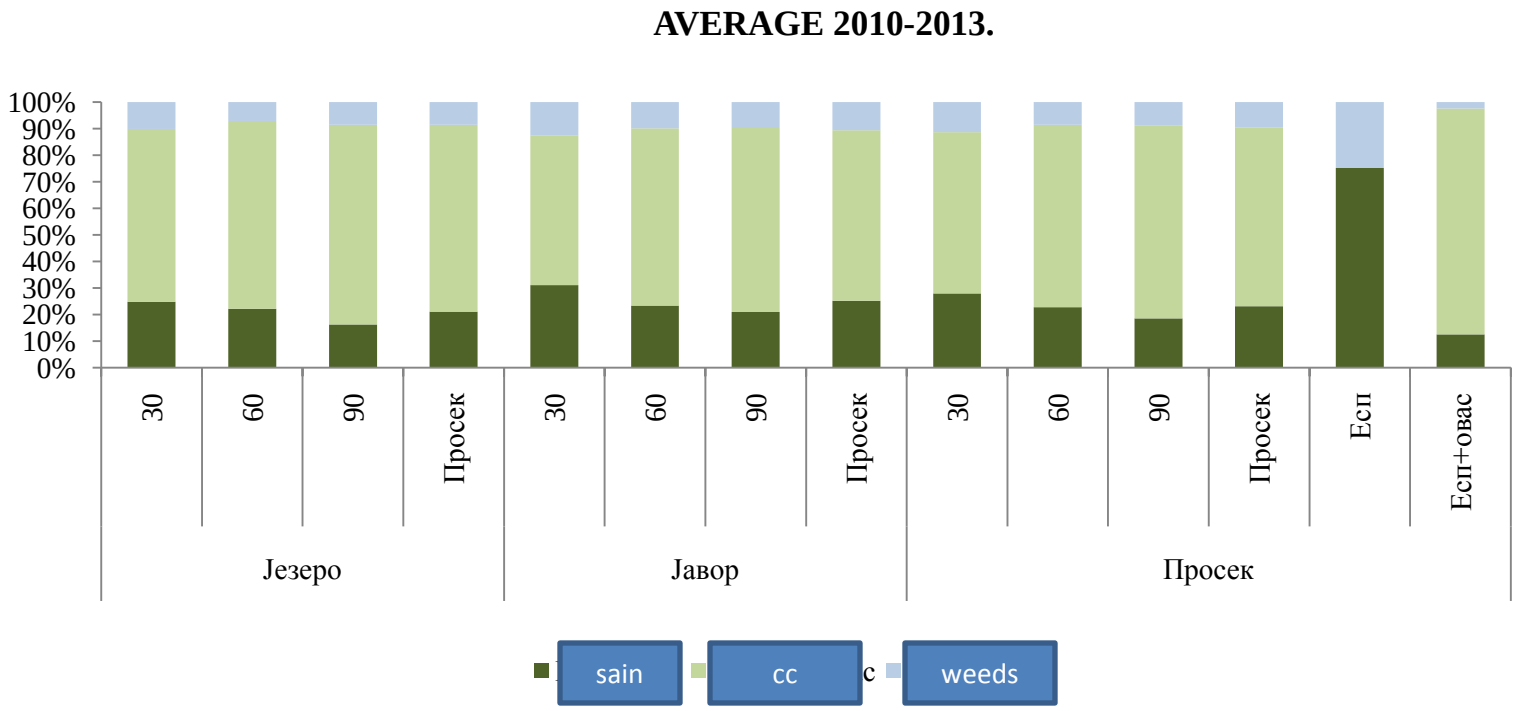
Effect of field pea variety and number of plants on forage yield (t ha^{-1}) in companion cropping with sainfoin (first cutting).



Average proportion of field pea and oat in yield in the first cut (average 2010/2014)



Weed proportion (%) in the first cutting of sainfoin intercropped with field pea



Discussion/Conclusion

- **Companion cropping should be regarded as complex status!**
- **Yield performance cannot be a sole relevant parameter for determining the suitability of the pea as cover crop.**

Digestibility

Field pea-79%

Sainfoin- 85%

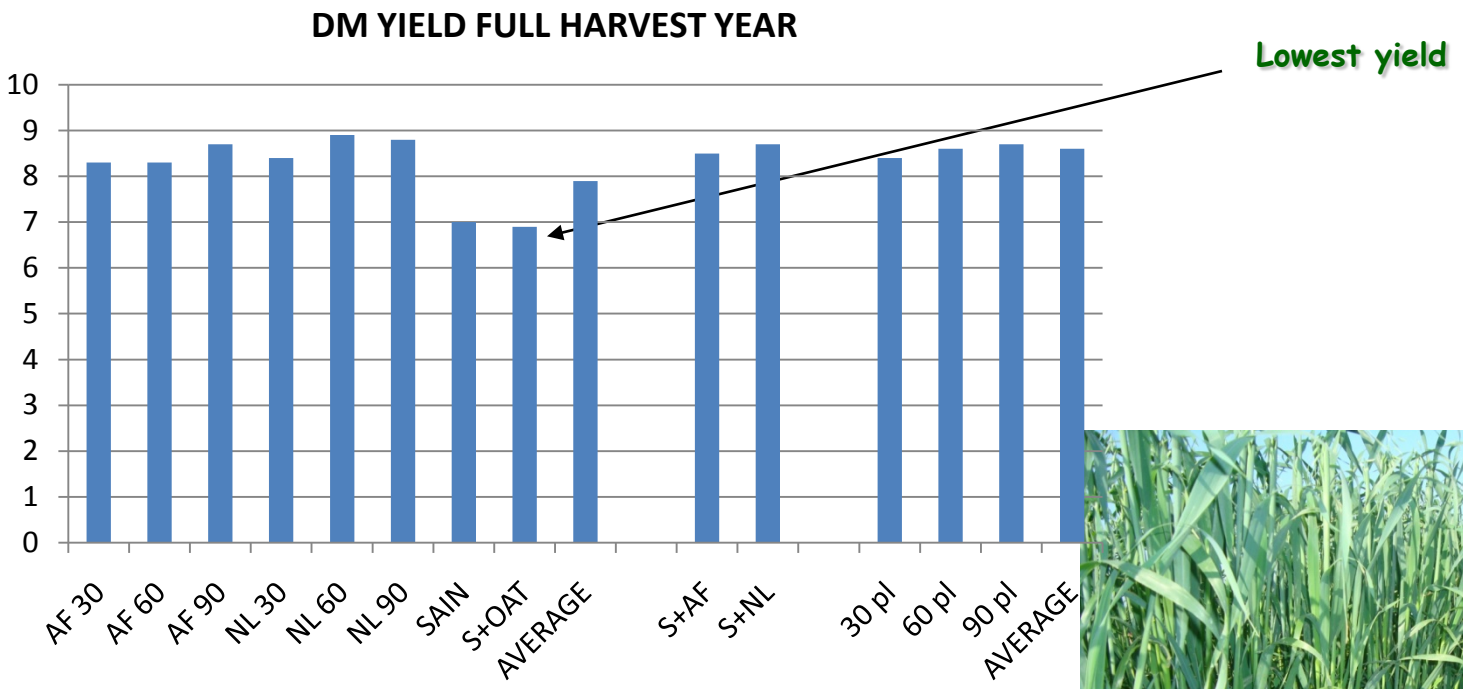
oat-54%

Protein content and quality

Comparing oat, field pea has more suitable morphological and biological properties for companion cropping

Those properties tend to eliminate the negative effects of the companion cropping on the condition and performance of the undersown crop in subsequent cuttings as well as in the subsequent year.

Effect of companion cropping according to variants applied in sainfoin establishing
Sainfoin forage yield in the second year of life



Legumes in Tropical agriculture

Common name	Botanical names	Other names	Areas available / consumed
Cowpea	*Vigna unguiculata*		Asia, Tropical Africa, West Indies
Blackeyed pea	*Vigna sinensis*	Catjan cowpea, Hindu cowpea, Kaffir bean	Asia, Africa, West Indies
Soybean	*Glycine max*		America, Asia, Africa
Groundnut	*Arachis hypogaea*	peanut	Tropical Africa, Central and South America
Pigeon pea	*Cajanus cajan*	Red gram, Congo bean	West Africa, East Africa, Pakistan, Middle East, Asia
Lentils	*Lens esculenta, Lens culnaris*	Split pea, red dhal	Central America, India, North Africa West Asia
Mung bean	*Phaseolus aureus*		East Asia, East Africa
African yambean	*Stenostylis stenocarpa*		West and East Africa
Lima bean	*Phaseolus lunatus*	Sieve bean, butter bean	Central America, Africa, Tropical Africa
Faba bean	*Vicia faba*	Broad bean, horse bean, windsor bean	Africa
Kidney bean	*Phaseolus vulgaris*	Navy bean, pinto bean, snap bean, black bean, haricot bean, pea bean	East Africa, Latin America
Chickpea	*Cicer ariethinum*	Lathyrus pea, grass pea, Khesari pea, Chickling pea	India, Pakistan
Lathyrus pea	*Lathyrus sativus*		
Bambarra groundnut	*Vigna subterranea*		Tropical Africa
Jack bean	*Canvalia ensiformis*		
Winged bean	*Psophacarpus tetragonolobus*		Tropical Asia, South East Asia

LEGUMES – AGRICULTURE - ENVIRONMENT





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