LogistEC

Logistics for Energy Crops' Biomass

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Collaborative project (small or medium-scale focused research project targeted to SMEs)

SEVENTH FRAMEWORK PROGRAMME

Priority: Food, Agriculture and Fisheries, and Biotechnology

Deliverable D1.5

Recommendations for the management of biomass crops-legume intercropping for biomass production

Due date: M24

Actual submission date: M25

Project start date: September 1st, 2012 **Duration:** 42 months

Workpackage concerned: WP1

Concerned workpackage leader: INRA

Dissemination level: PU

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Summary

Objectives:

The aim of this deliverable is to give recommendations for the management of cereal-legume intercrops for the production of biomass for bioenergy, as part of the demonstration on intercropping cereals with legumes in WP5 of Logist'EC (Task 5.1).

Rationale:

Based on the experimentation conducted by INRA Agronomie in Grignon (T1.3), a phone meeting and e-mail exchanges between CENER, ACCIONA and INRA-UMR Agronomie allowed us to clarify the recommendations needed by the WP5. Following the recommendations, a protocol has been written by CENER for the demonstration.

Teams involved: INRA, CENER, Acciona

Geographical areas covered: Versailles-Grignon (France), Miajadas (Spain)

1. Introduction

An experiment was set up by INRA-UMR Agronomie in Versailles (Paris Basin, France) for three years (2010-2013) to assess the agronomic, environmental and energetic performances of grass-legume intercrops. The aim was to test the hypothesis that intercropping (multi)annual energy crops with legumes could offer the opportunity to reduce the use of N fertilizer while maintaining yields, thus improving environmental and energetic performances, as it has been already observed for grain and forage production. Various grass-legume intercrops were tested and compared to the corresponding sole crops. Several species were sown: annual winter crops (triticale, forage pea, vetch and red clover) and multi-annual crops (tall fescue, orchard grass, alfalfa). Two N fertilizer treatments were applied on sole grasses and grass-legume intercrops (without and with, half rate on intercrops compared to sole grasses), no N on sole legumes. Agronomic performances were measured (biomass production and quality) as well as the N_2O emissions on non-fertilized treatments (using static chambers) and the nitrate leaching risk (based on residual soil mineral N content after harvest). The energetic cost of production was calculated (using the INDIGO® method). A part of this experiment was funded by the LogistEC project (T1.3).

Within the WP5 task 5.1 (Demonstration of combined supply chain for herbaceous and woody energy crops to a power plant) it was planned to demonstrate in Miajadas (Spain) the intercropping of triticale and legumes, following the recommendations of WP1, based on the experiment carried out in France.

The aim of this deliverable is to list the recommendations that have been given to the WP5 for the field management of cereal-legume intercrop for the production of biomass for bioenergy.

2. Materials and methods

Based on the experiment conducted by INRA Agronomie Grignon, and on a document describing the local context in Miajadas written by CENER in November 2011, a first document was sent by INRA-UMR Agronomie to CENER and Acciona with a first set of recommendations for the demonstration in Miajadas (March 2013). Between March and September 2013, e-mails were exchanged and a phone meeting was organized between CENER, ACCIONA and INRA-UMR Agronomie (June 7, 2013) to clarify the recommendations needed. Following the recommendations, the protocol was written by CENER and the first year of demonstration was set up in Miajadas in October 2013.

3. Results: list of recommendations

3.1. Choice of species

Legumes: Legumes that would be possible to grow in Miajadas and that are also tested in the French trials include winter pea (*Pisum sativum*), winter vetch (*Vicia sativa*), and red clover (*Trifolium pratense*). As red clover is not a common crop in the region of Miajadas, pea and vetch were chosen as legume species.

Cereal: triticale is a species of interest in LogistEC, widely spread in the Miajadas area and tested in the French trials. In addition, as oat is usually grown in Miajadas, it was also tested in the demonstration.

Triticale-pea and oat-vetch were finally tested as well as the sole cereal as control.

3.2. Management

Varieties: local cultivars (forage cultivars), adapted to local conditions

Sowing:

- Usual sowing date of triticale and oat for energy use
- Sowing density: half compared to the usual sowing density of sole crops in Miajadas (50-50 replacement design, i.e. in the intercrop, each species is sown at half the sowing rate used for the sole crop)
- Use a cereal sowing machine, mixing seeds of both species in the sowing machine (both species are sown mixed in the row).

Nitrogen fertilization: as one of the advantages of intercrop cultivation is to reduce the N fertilization while maintaining the yield, it was recommended to test two N treatments: no nitrogen fertilization, and N fertilization applied at half rate compared to the usual rate applied to sole triticale or oat.

Pesticides: fungicide and insecticide should be used only if high pressure of pest and/or disease occurs. The same rate should be used for intercrop and sole cereal. For herbicides, It was recommended to check if some active ingredients are allowed on both species of the intercrop (in France, no herbicide is allowed in pea-triticale for instance). To reduce weed infestation, a plowing before sowing was recommended.

Harvest date: as sole triticale/oat

3.3. Measurements proposed

Yield at harvest (biomass yield, both species together), as well as moisture content.

If possible, some measurements during the crop growth could be interesting. For instance: counting after emergence to estimate the proportion of emergence of each species, biomass of each crop at flowering (around 15 may in France, maybe earlier in Miajadas), biomass of each crop at harvest.

It could be also interesting to analyze the quality of the mixed biomass, in order to see if the legume penalizes the biomass compared to sole triticale/oat, for storage and for use (combustion).

4. Conclusion

Recommendations have been used for a first year of demonstration in 2013-2014. Due to the dry conditions, legumes did not survived in the intercrop. A second year of demonstration will be sown this year (2014-2015).

5. Appendices: protocol written by CENER based on the INRA-UMR Agronomie recommendations

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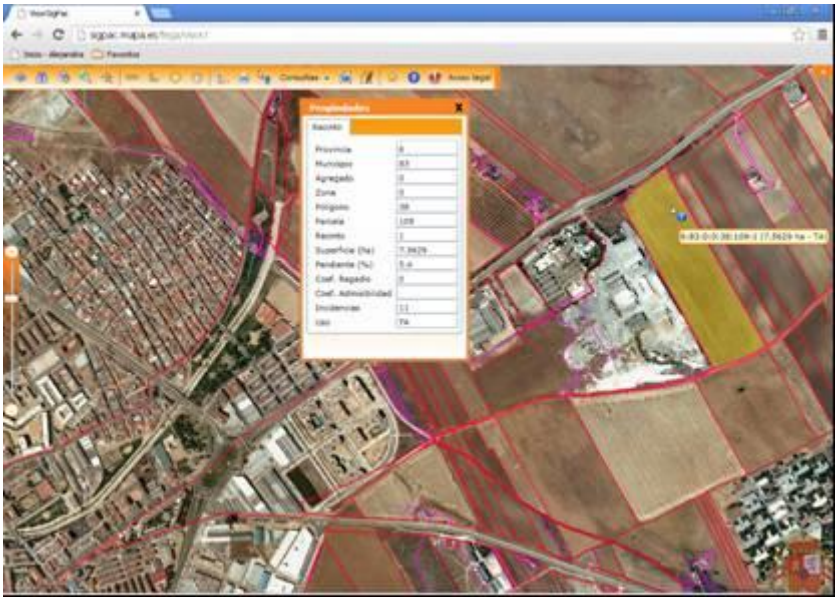
WP5 - TEST PROTOCOL

Task:	5.1.2.- Demonstration of new supply chains for grassy energy crops
Test:	Intercropping of cereals and legumes 2014
Crops:	Triticale-Pea / Oats-Vetch
Location:	Mérida (Badajoz)

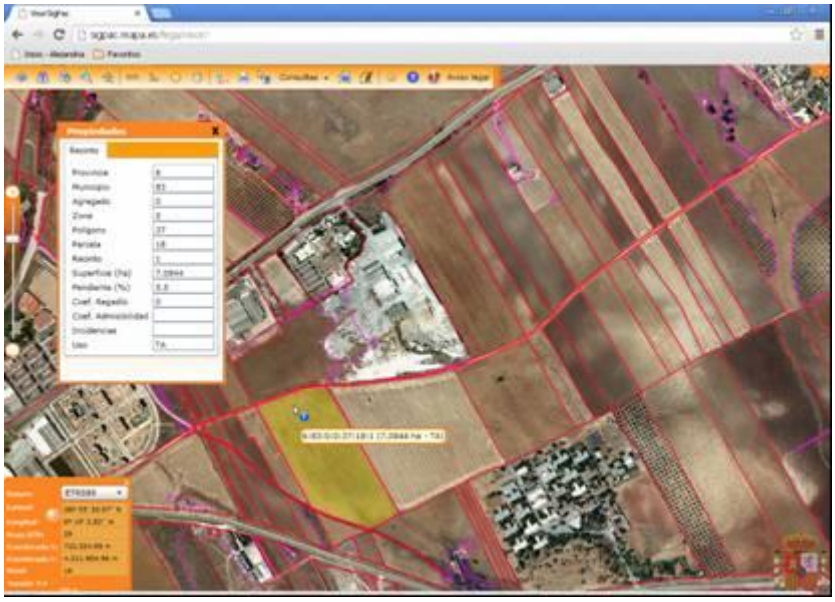
1. Cultivation tests

1.1. Location data

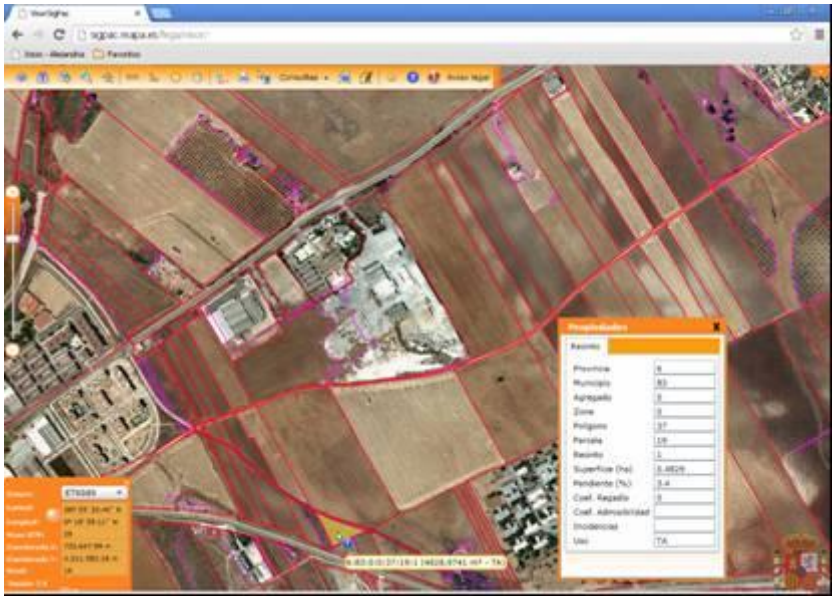
- Municipality = Mérida (Badajoz)
- Cadastral reference = Polygon 38, Parcel 109
- Total area = 7.56 ha
- Not irrigated



- Municipality = Mérida (Badajoz)
- Cadastral reference = Polygon 37, Parcel 18
- Total area = 7.08 ha
- Not irrigated



- Municipality = Mérida (Badajoz)
- Cadastral reference = Polygon 37, Parcel 19
- Total area = 0.48 ha
- Not irrigated



1.2. Climatic data

- Annual monthly averages for air temperature and rainfall in Mérida (Badajoz)

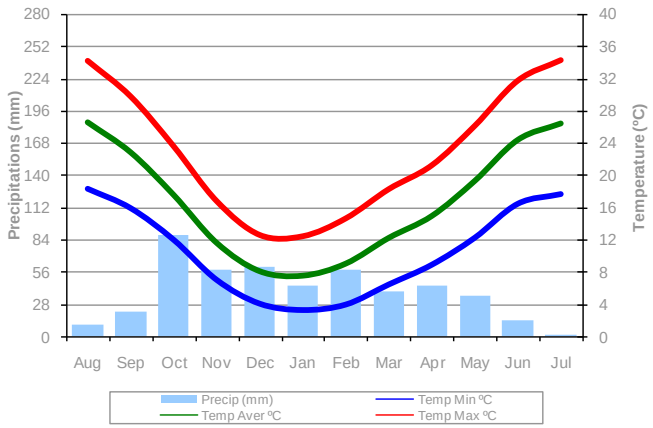


Figure 1. Mérida climograph. 2004-2014 Average.

- During last crop cycle.

Year	Month	Temp Max °C	Temp Aver °C	Temp Min °C	Precip (mm)
2013	Aug	34,7	27,2	18,7	2,0
	Sep	30,9	24,0	16,7	16,2
	Oct	24,0	18,1	12,7	118,0
	Nov	15,9	10,1	4,7	3,4
	Dec	14,0	7,9	2,4	76,4
2014	Jan	13,9	10,0	6,4	61,4
	Feb	13,9	9,8	5,8	61,8
	Mar	18,0	12,0	6,2	17,8
	Apr	22,5	16,3	10,4	49,8
	May	27,2	19,9	11,9	13,8
	Jun				
	Jul				

Table 1. Mérida climatic data during the crop cycle (2013-2014)

1.3. Sowing data

Two treatments.

1.- Triticale-Pea

- Location: Mérida 38/109
- Soil test:
  - Texture: clay loam
  - Organic matter: very low (0.59%)
  - pH: basic (7.93)
  - P content: very low (<2ppm)
  - K content: low (0.47 meq/100 g)

Nº 13_03411 (Referencia: 3810)

FERTILIDAD	Ud. Medida	DATO	INTERPRETACIÓN
TEXTURA			Franco-arcilloso
Arena		31,72	
Arcilla		38,84	
Limo		29,44	
PH en agua 1:2,5		7,93	Alcalino
CE 1:5 20	mmhos/cm	0,100	No Salino
Materia Orgánica oxidable	%	0,59	Muy Bajo
Fósforo asimilable	ppm	< 2,00	Muy Bajo
Na	meq/100 gr	0,12	Muy Pobre
Potasio (K)	meq/100 gr	0,47	Bajo
Capacidad de Inter. Catiónico	meq/100 gr	16,5	Normal
Calcio Asimilable	meq/100 gr	10,2	Pobre
Magnesio Asimilable	meq/100 gr	2,61	Medio
Carbonatos	%	2,39	Muy Bajo
Cloruros	ppm	< 20,0	Bajo

Table 2. Soil Tests. Triticale-pea plot.

- Sowing date:
  - *Usual sowing date of triticale for energy use (first week of November)*
- Varieties:
  - *INRA recommendation: local cultivars (forage cultivars), adapted to local conditions*
    - Triticale: Seconzac (RAGT Seeds)
    - Pea: Luna (AGROSA Seeds)
- Sowing density: half seed rate of the usual input as sole crops (50-50). So:
  - Triticale: 125 kg/ha
  - Pea: 75 kg/ha

2.- Oats-Vetch

- Location: Mérida 37/18 and 37/19
- Soil test:
  - Texture: sandy clay loam
  - Organic matter: very low (0.64)
  - pH: neutral (6.75)
  - P content: low (10 ppm)
  - K content: low (0.25 meq/100 g)

Nº 13_03410 (Referencia: 37118)

FERTILIDAD	Ud. Medida	DATO	INTERPRETACIÓN
TEXTURA			Franco-arcillo-arenoso
Arena		53,70	
Arcilla		20,84	
Limo		25,46	
PH en agua 1:2,5		6,75	Neutro
CE 1:5 20	mmhos/cm	0,117	No Salino
Materia Orgánica oxidable	%	0,64	Muy Bajo
Fósforo asimilable	ppm	10,0	Bajo
Na	meq/100 gr	0,11	Muy Pobre
Potasio (K)	meq/100 gr	0,25	Bajo
Capacidad de Inter. Cationico	meq/100 gr	16,4	Normal
Calcio Asimilable	meq/100 gr	9,64	Pobre
Magnesio Asimilable	meq/100 gr	4,64	Muy Rico
Carbonatos	%	< 1,00	Muy Bajo
Cloruros	ppm	< 20,0	Bajo

Table 3. Soil Tests. Oat-vetch plot.

- Sowing date:
  - *Usual sowing date of oats for energy use (first week of November)*
- Varieties:
  - *INRA recommendation: local cultivars (forage cultivars), adapted to local conditions*
    - Oat: Prevision (AGROSA Seeds)
    - Vetch: Libia (RAGT Seeds)
- Sowing density: half seed rate of the usual input as sole crops (50-50). So:
  - Oats: 125 kg/ha
  - Vetch: 100 kg/ha

1.4. Fertilization data

Two treatments for each crop.

1.- Triticale-Pea

1a.- Triticale-Pea. Half N rate of the usual input for sole triticale

- N: 15 kg/ha pre-sowing, 55-60 kg/ha in Jan-Feb
- P: 15 kg/ha pre-sowing
- K: 15 kg/ha pre-sowing

1b.- Triticale-Pea. No N input.

- N: 0 kg/ha
- P: 15 kg/ha pre-sowing
- K: 15 kg/ha pre-sowing

2.- Oats-Vetch

2a.- Oats-Vetch. Half N rate of the usual input for sole oats

- N: 15 kg/ha pre-sowing, 55-60 kg/ha in Jan-Feb
- P: 15 kg/ha pre-sowing
- K: 15 kg/ha pre-sowing

2b.- Oats-Vetch. No N input.

- N: 0 kg/ha
- P: 15 kg/ha pre-sowing
- K: 15 kg/ha pre-sowing

	Triticale-Pea		Oats-Vetch	
	1a Half N	1b No N	2a Half N	2b No N
N (kg/ha)	15 + 55-60	0	15 + 55-60	0
P (kg/ha)	15	15	15	15
K (kg/ha)	15	15	15	15

Table 4. Fertilization treatments for 2014 Intercropping trials

1.5. Cultivation practices

INRA recommendation: common practices in the region (soil preparation, weed management, crop protection…). If possible, plowing before sowing to limit weeds and herbicides use

No irrigation practices

1.6. Measurements

Common visual controls during crop cycle (taking photos)

INRA recommendation: some measurements during the crop growth could be interesting

- *After emergence: counting plants, estimate the proportion of emergence of each species*
- *At flowering: check biomass yields, estimate the proportion of each species (samples taking, sort, dry and weight both species separately)*

2. Harvesting tests

- In situ evaluations
  - Yield (kg/ha)
  - Moisture content (%)

- Photos

- Sampling: a sample per treatment (samples codification)
  - Biomass yields
    - Sort, dry and weight both species separately
  - Mixed biomass
    - Energy characterization (in order to check if the legume reduces the energy outputs of crops compared to sole cereals)