Sunflower sowing consociated with *Trifolium pratense* L., *Trifolium repens* L. or *Lotus corniculatus*. A productive alternative.

Sánchez Vallduví, G.E., L.N. Tamango, M.A. Eirin, J. Gomez, R. Taus, R.D. Signorio.
Course of Oleaginous Plants and Regional Crops. Course of Polygastrica. School of Agricultural Sciences and Forestry. UNLP. 60 y 119 CC Nº 31, La Plata, Buenos Aires. CP 1900. gvallduv@agro.unlp.edu.ar

ABSTRACT

- Sunflower cultivation in Argentina is set within a continuous increase in the grain production process known as "agriculturization". One of the undesirable consequences of this process is biodiversity reduction, which attempts on the sustainability of the agroecosystem. Mixed farming systems and consociated sowing are alternatives to improve sustainability. In our country, the sunflower is usually part of the agricultural-livestock rotation, and sunflower-forage legume intercropping systems can be considered as a strategy to enhance the quality of the mulch and contribute to the diversity. The objective of this work was to determine the crop yield and the aerial biomass production of commercial sunflower hybrid with *Trifolium pratense* L., *Trifolium repens* L. or *Lotus corniculatus* intercropping system.
- The experiment was carried out with a randomized block design. The treatments were: sunflower in monoculture, with and without herbicide, and intercropping sunflowers with red clover, white clover or lotus, at two sowing densities (normal and high). At harvest, the sunflowers' ripeness and total biomass, the crop yield, legumes and weed were evaluated. Results were statistically analyzed using ANOVA and LSD test ($p \leq 0,05$).
- The average grain yield of the sunflower in this trial was 4462 $kg.ha^{-1}$. The maximum value of this variable was achieved when herbicides were applied (5120 $kg.ha^{-1}$). Among the other treatments, the crop yield did not differ statistically: values ranged between 3940 and 4810 $kg.ha^{-1}$. In the treatment of sunflower in monoculture without herbicide application, the total biomass (sunflower + legume + weed) achieved at harvest ripeness was 17472 $kg.ha^{-1}$, a value which did not differ significantly from any other mixture. The number of legume plants obtained varied according to the species. The establishment of white clover was the lowest, making a poor biomass contribution. This variable was significantly higher in the treatment of sunflower with red clover at high density (1320 $kg.ha^{-1}$). Moreover, among the other treatments, it is worth mentioning the values reached by the mixture of sunflower with red clover at normal density and with lotus at high density (568 and 380 $kg.ha^{-1}$ respectively).
- The results obtained show that the sunflower intercropping with these forage legumes could be regarded as a productive alternative to improve the crop residues' quality. This could yield stubbles of a higher nutritional value or a better quality of plant biomass, which is incorporated to the soil after sunflower harvest. Furthermore, these systems could improve diversity by guaranteeing sunflower crop production.
- This study provides a breakthrough in the search for strategies which improve sustainability of extensive production systems through the reduced use of inputs, the greater biodiversity and the improved quantity and quality of stubble. However, bearing in mind that these results are from a single year of testing, it is important to continue evaluating the performance of these intercropping systems.

Keywords: diversity, intercropping, quality of stubble, sustainability, yield.

INTRODUCTION

The agriculturization and simplification processes which have been taking place, generally, in our country's agroecosystems and, particularly, in the Pampas entailed the abandonment of the crop-livestock rotation, among other things (Savilla and Pasinato, 2006). Among the emergent problems of this situation, biodiversity reduction stands out (FAO-AGLL Portal: Soil Biodiversity, 2002; Brusaard *et al.*, 2007; Zimmermann *et al.*, 2010). Consequently, the resilience capacity is reduced (UNEP, 1996; Stoate et al. 2001) and its long-term productivity and sustainability are called into question (Viglizzo and Frank, 2006). In this context, the need to combine the agricultural systems' productivity with the preservation of the environment and natural resources clearly arises (Parris, 1999).

Sunflower cultivation in our country is set within this continuous increase in agricultural production and is oriented towards maximizing its grain and oil yield per ha. Despite the strong rise of land sown with soybean, sunflowers are still an important alternative of production for extensive systems in Argentina and continue to outstandingly take part in the world market (CIARA, 2011).

In recent years, awareness about the environmental, social and cultural impact of the dominant model of production has increased, leading to reconsidering a more sustainable model. A tool to restore and increase the agroecosystems' biodiversity is the diversification of such (Viglizzo *et al.*, 2011). Mixed production systems are an alternative to improve this issue. Moreover, they can also enhance the economic outcome. Sunflowers are usually part of the crop-livestock rotations. However, one of the constraints is their low-quality stubbles for animal feed (INTA, 2004).

The sowing consociated with forage legumes might be considered as a strategy to improve the stubbles' quantity and quality. Furthermore, this intercropping is expected to bring other advantages to the agroecosystem (Sarandón, 2002), such as encouraging biodiversity (Malézieux *et al*, 2008). Additionally, the incorporation of crop residues to the soil can restore a greater amount of organic waste to the earth, thus, improving the organic matter content and its physical-biological properties (Lefroy and Craswell, 1997). Thereby, the consociated sowing is expected to be an alternative contributing to the conservation of productive resources and to the minimization of the external environmental impact, which is an essential requirement for achieving sustainability (Flores and Sarandón, 2003).

The selection of the companion species depends on the production area and it is an important factor which determines the consociation's behaviour. Certain sowing experiments mixing sunflowers with other crops have been cited (Putman and Allan, 1992). In our country, it was noted that the sowing mixing sunflowers with red or white clovers sown in two different systems (sunflowers' line-seeding or broadcast seeding) did not modify the crop's productivity, preserved the stubbles' availability and enhanced their protein content (Eirin et al, 2009). However, there is not much information available about the sunflowers' behaviour during the consociation and about the diverse determining factors, such as the companion species and the chosen sowing system.

The goal of this work was to evaluate the yield and production of the biomass in a consociation of a commercial sunflower hybrid with *Trifolium pratense* L., *Trifolium repens* L. or *Lotus corniculatus*.

MATERIALS AND METHODS

A field test was carried out in the Experimental Station "Julio Hirshorn", located on Los Hornos, city of La Plata. The climate is mild with an average temperature of 15.9º C; being January the warmest month and July, the coldest. The rainfall pattern is isohygric with a homogeneous rain distribution throughout the year, whose average value is 1045.4 mm.

The sowing took place on October 12, 2010, by means of an experimental Agrometal seeder of five grooves, in a plot whose surface horizon (0-20 cm.) analysis was: pH, 5.6; MO, 4.01 %; total N, 0.197 % and P, 19.6 ppm (Bray Kurtz I).

The randomized block design of the experiment included four replications, and the treatments were the following:

1- Sunflower in a monoculture: control.
2- Sunflower intercropped with red clover sown at a normal density.
3- Sunflower intercropped with red clover sown at a high density.
4- Sunflower intercropped with white clover sown at a normal density.
5- Sunflower intercropped with white clover sown at a high density.
6- Sunflower intercropped with lotus sown at a normal density.
7- Sunflower intercropped with lotus sown at a high density.
8- Sunflower sown in a monoculture, with the use of herbicides.

The sunflower hybrid DK4050 was employed. The plots showed five 8-metres-long grooves, spaced about 0.7 m from each other. The sunflower was sown at a density of 4,5 $pl.m^{-2}$. (52,000 $pl.ha^{-1}$). Legumes' seeds were scattered. The red clover (*Trifolum pratense* L.) was sown at a normal (10 $kg.ha^{-1}$) and high (16 $kg.ha^{-1}$) density. The white clover (*Trifolium repens* L.) was sown at a normal (6.5 $kg.ha^{-1}$) and high (10 $kg.ha^{-1}$) density. As regards the lotus (*Lotus corniculatus*), the densities were of 10 $kg.ha^{-1}$ and 16 $kg.ha^{-1}$ respectively. Normal densities are advised for the sowing areas of legumes as pure crops.

The climatic conditions regarding temperature and precipitations during the set-aside period and the crop cycle were recorded, as well as the crop phenology, according to the Schneiter and Miller scale (1981).

Concerning the crop's ripeness, the yield, aerial biomass, sunflower crop index, the total aerial biomass of the system (sunflower + legumes + spontaneous vegetal community) and the N in crop residues were evaluated. The plant tissues' nitrogen content was established by the micro-Kjeldahl method (AACC, 1983). Results were analyzed with ANOVA and test LSD (P: 0,05) for a comparison of averages.

RESULTS AND DISCUSSION

The average sunflower's grain yield of the test was 4462 $kg.ha^{-1}$. The highest value of this variable was achieved in the monoculture with herbicide application. By analysing the remaining treatments, it can be observed that the yield of the pure sunflower did not differ statistically from the ones of the mixtures and that the values remained close to the ones recorded in the tests of the national crop assessment network (ASAGIR, 2010). In this test, the mixtures did not enhance the yield, as opposed to what Putman and Allan (1992) recorded regarding sunflowers sown with mustard. Nevertheless, these results suggest that the consociation with legumes might be regarded as an acceptable, productive alternative, since it guarantees enough productivity of the sunflower, one the requirements cited by Sarandón and Sarandón (1993) for agriculture to be considered sustainable.

In reference to the treatment of the sunflower in the monoculture without herbicides, the system's total biomass (sunflower + legumes + spontaneous vegetal community) reached in the crop did not vary statistically from the one achieved by any of the mixtures.

Table 1: Grain yield, aerial biomass, crop index (CI) and total biomass of the sunflower system sown in a pure state or mixed with red clover, white clover or lotus, at a normal or high density. La Plata, Argentina. 2010-2011.

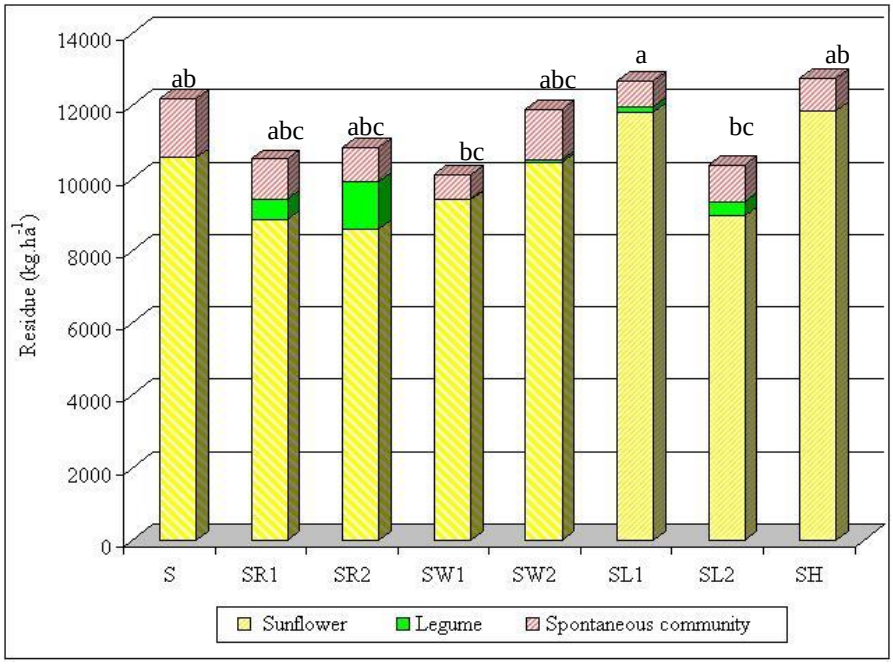
Treatments	Sunflower yield ($kg.ha^{-1}$)		Sunflower's total biomass ($kg.ha^{-1}$)		Crop Index		System's total aerial biomass ($kg.ha^{-1}$)	
Sunflower	4680	abcd	15251	abc	0.31	a	17472	abc
Sunflower-red clover, normal density	3940	d	12802	c	0.32	a	15239	abc
Sunflower-red clover, high density	4160	bcd	12720	c	0.33	a	13289	c
Sunflower-white clover, normal density	4250	bcd	13657	bc	0.32	a	14412	bc
Sunflower-white clover, high density	4700	abc	15141	abc	0.31	a	16692	abc
Sunflower-lotus, normal density	4810	ab	16623	ab	0.29	a	17736	a
Sunflower-lotus, high density	4040	cd	12993	c	0.32	a	14040	c
Sunflower with herbicide	5120	a	16695	a	0.30	a	17906	a
CV %	11,5		18,5		22,5		17,4	

The values followed by the same letter inside each column do not differ significantly according to LSD (P 0,05).

The introduction of legumes differed according to the species. The white clover establishment was the most deficient one; a low biomass contribution was recorded at both of the densities employed. The red clover was the legume species which accumulated a larger amount of biomass, a variable which was significantly higher in the treatment regarding sowing at high density.

Although the absolute value of the crop residue in the sunflower-red clover mixture at high density was the lowest one of all treatments, it was the one with the highest legume proportion (7 %) (Figure 1). This established a crop residue with more N content and, thus, a higher-nutritional-value stubble is expected, which coincides with what Eirin et al (2009) pointed out while observing a better protein content in sunflowers consociated with red or white clover.

Figure 1: Sunflower's biomass, legumes, spontaneous community in the crop residue of a sunflower cultivation sown in a pure state or mixed with red clover, white clover or lotus, at a normal or high density. La Plata, Argentina. 2010-2011.



The values followed by the same letter inside each column do not differ significantly according to LSD (P 0,05).

References: S: sunflower in monoculture; SR1: sunflower-red clover at normal density; SR2: sunflower-red clover at high density; SW1: sunflower-white clover at normal density; SW2: sunflower-white clover at high density; SL1: sunflower-lotus at normal density; SL2: sunflower-lotus at high density; SH: sunflower in monoculture with herbicide.

It can be expected that the crop residue's quality, given its possible incorporation to the soil, is better in the sunflower consociated with red clover, white clover or lotus due to its larger amount of N and because there is greater diversity than in the sunflower monoculture with herbicide. This improvement in the residues incorporated to the soil would foster its physical and biological properties conservation (Lefroy and Craswell, 1997). Moreover, by integrating a residue with more N, the sunflower-legume consociation may be regarded as a strategy determining a lower demand of nitrogen replenishment of the earth so as to preserve its fertility, minimizing the environmental impact, which is a necessary requirement to reach a sustainable agriculture over time (Flores and Sarandón, 2003).

The test's results indicate that the sunflower sowing consociated with these forage legumes might be taken as a productive alternative to enhance the crop residues' quality. On the other hand, these systems could improve diversity, guaranteeing sufficient productivity of the sunflower cultivation (Viglizzo, et al, 2011). In the systems which do not employ herbicides, the physical and biotic properties are expected to be more preserved, which is related to, among other factors, the quality of the residues incorporated to the

soil after the harvests, combining the agricultural system's productivity with the environmental preservation (Parris, 1999).

This work contributes to the progress in the search of cropping strategies which enhance the extensive production systems' sustainability through a lower use of inputs, greater biodiversity and through the stubbles' quantity and quality.

Taking into account that these results were achieved in only a one-year trial, it is important to continue assessing the sunflower's behaviour in consociated sowing.

REFERENCES:

AACC. 1983. Approved Methods, 8th Ed. America Association of Cereal Chemist: St. Paul, MN.Vol II: 13-46.

Asociación argentina de girasol (Asagir). 2010. Red Nacional de evaluación de cultivares comerciales de girasol del INTA. Cuadernillo de información Nº 18.

Brusaard, L., P.C. de Ruiter y G.G. Brown. 2007. Soil biodiversity for agricultural sustainability. Agriculture, Ecosystem & Environment 121: 233-244.

Cámara de la Industria aceitera de la República Argentina (CIARA). 2011. www.ciaracec.com.ar.

Eirin, M.A., G.E. Sánchez_Vallduví; L.N. Tamagno; D. Murúa; J.I. Intagliata y J.L. Molina. 2009. Girasol en monocultura e intercultivo con trébol rojo o trébol blanco: rendimiento en grano, producción y calidad forrajera del rastrojo. Revista de Producción Animal Vol. 29 Suplemento 1: 422-423.

Flores, C.C. y S.J. Sarandón. 2003. ¿Racionalidad económica versus sustentabilidad ecológica? El ejemplo del costo oculto de la pérdida de fertilidad del suelo durante el proceso de Agriculturización en la Región Pampeana Argentina. Revista de la Facultad de Agronomía. Universidad Nacional de La Plata. 105 N° 1: 53-68.

Food and Agriculture Organization of the United Nations FAO-AGLL. 2002. Portal: Soil Biodiversity, Soil Biota and Biodiversity: the "Root" of Sustainable Agriculture. En: www.fao.org. Visitado el 23/6/02.111.

Instituto Nacional de Tecnología Agropecuaria. 2004. INTA Rafaela, Proyecto Regional de Lechería. Disponible en www.inta.gov.ar/rafaela/info/documentos/.

Lefroy, R.D.B., y E.T. Craswell. 1997. Soil as a filter for nutrients and chemicals: sustainability aspects. www.agnet.org/library/article/tb146.htm.

Malézieux, E., Y. Crozat, C. Dupraz, M. Laurans, D. Makowski, H. Ozier-Lafontaine, B. Rapidel, S. De Tourdonnet y M. Valentin-Morison. 2008. Mixing plant species in cropping systems: concepts, tools and models. A review. Agronomy Sustainable Development. www.agronomy-journal.org. Pp: 1-20.

Parris, K. 1999. Environmental indicators for agriculture: overview in OECD countries. En: Browe, F.M. & J.R. Crabtree, (Ed), Environmental Indicators and Agricultural policy. CAB International 25-44 pp.

Putman, D.H. y D.L. Allan. 1992. Mechanisms for overyielding in a sunflower/mustard intercrop. Agronomy Journal 84. 2: 188-195.

Sarandón, S.J. 2002. La agricultura como actividad transformadora del ambiente. El impacto de la Agricultura intensiva de la revolución Verde. Capítulo 1 en Agroecología. El camino hacia una agricultura sustentable. S.J. Sarandón (Editor). Ediciones Científicas Americanas. Pp: 23-47.

Sarandón, S.J. y R. Sarandón. 1993. Un enfoque ecológico para una agricultura Sustentable. En: Goin J y C. Goñi (editores). Elementos de Política Ambiental. H Cámara de Diputados de la Pcia. de Buenos Aires, Capítulo 19: 279-286.

Savilla, G. y A. Pasinato. 2006. El rol de la ganadería en los sistemas mixtos. E.E.A. Concepción del Uruguay. En Sitio Argentino de Producción Animal. Agosto 2006. pp 35-36.

Schneiter, A.A. y J.F. Miller. 1981. Description of sunflower growth stages. Crop Science. 21: 901-903.

Stoate, C., N.D. Boatman, R.J. Borralho C. Rio Carvalho G.R. De Snoo y P. Eden 2001. Ecological impacts of intensification in Europe. Journal of Environmental Management 63: 337-365.

United Nations Environment Programme (UNEP). 1996. Convention on biological diversity. Disponible en http://www.biodiv.org/doc/meetings/sbstta/sbstta-02/official/sbstta-02-10-en Pdf 29 pp.

Viglizzo, E.F. y F.C. Frank. 2006. Land-use option for Del Plata Basin in South America: Tradeoffs analysis based on ecosystem service provision. Ecological Economics 57: 140-151.

Viglizzo, E.F., F.C. Frank, L.V. Carreño, E.G. Gobbágys, H. Pereyra, J. Clatt, D. Pincén y M.F. Ricard. 2011. Ecological and environmental footprint of 50 years of agricultural expansion in Argentina. Global Change Biology 17: 959-973.

Zimmermann, P., E. Tasser, G. Leitinger y U. Tappeiner. 2010. Effects of land-use and land-cover pattern on landscape-scale biodiversity in the European Alps. Agriculture, Ecosystems and Environment 139: 13-22.