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Challenge the roots. Moving toward a sustainable agriculture

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Abstract. The research would demonstrate how to reduce the total input in a forage system (i.e. fuel, pesticides, chemical nutrients), as well as in any other agricultural system, without decreasing the production. Since 2009 the field test has been carrying out in Sardinia, Italy. An integrated forage system, including leguminous and cereals, deals with minimum and no tillage techniques. The collected data, such as chemical and physical characteristics of the soil, forage quality and quantity at various steps (pasture, hay and grain) represents the input to develop and calibrate a model, or to extend the results to a large scale, in a similar environment. The results determine the feasibility to extend this approach, in several agricultural areas, characterized by a Mediterranean climate, and similar pedological feature

Keywords. Forage system – Leguminous – Minimum tillage – Modelling.

Défier les racines. Évoluer vers une agriculture durable.

Résumé. *La recherche a montré comment réduire les entrées totales dans un système fourrager (combustible, pesticides, nutriments chimiques) ou dans n'importe quel autre système agricole, sans diminuer la production. Depuis 2009, des essais sur le terrain ont été effectués en Sardaigne, Italie, sur un système fourrager intégré, incluant les légumineuses et les céréales, avec des techniques de non-labour et de labour réduit. Les données recueillies telles que les caractéristiques chimiques et physiques du sol, la qualité de forage et des quantités aux différents stades (pâturage, foin et grain) représentent l'information permettant de développer et de calibrer un modèle, ou pour étendre les résultats à une plus grande échelle, dans un environnement similaire. Les résultats déterminent la faisabilité de l'application de cette approche à plusieurs autres regions agricoles bénéficiant d'un climat méditerranéen et ayant des caractéristiques pédologiques similaires.*

Mots-clés. *Système de fourrager – Légumineuses – Labour réduit – Modelisation.*

I – Introduction

The total decoupling application to the aids for the farmers, ratified by the EU CAP (Common Agricultural Policy) in 2003 mid-term review, caused, in Italy, a progressive reduction of the cultivated areas and a progressive land quitting. Moreover, the new European CAP is oriented toward a conversion of the extensive agricultural systems and toward cropping techniques with a lower input and more sustainable from the environmental point of view (Carboni *et al*., 2007).

Nevertheless an increasing employ of the tillage techniques with a reduced energetic input as the "minimum tillage" or the "no tillage" all over the world, in Europe and especially in Italy, these techniques do not seem to have the same extension and impact (Carboni *et al*., 2006).

The goal of the research project, started in 2010, is to demonstrate that it is possible to reduce the total inputs (i.e. fuel, pesticides, chemical nutrients) in a forage system, managed both in an integrated and in an organic way, with techniques of minimum or no tillage. This without having a production decrease and, at the same time, reducing the agriculture pressure on the environment. Moreover, the role of the soil as "carbon sink" and its chemical and physical modifications under a correct land-use change will be investigated.

The experimental data will be used to develop a simulation model by which verify the efficacy, or the potential efficacy, of some actions made in the local Rural Development Plan. The model calibration, based on the soil characteristics of the experimental plots, will allow, with the aid of a GIS analysis, to predict the efficacy of the interventions made in areas with the same pedological characteristics (Carboni, 2010).

II – Materials and methods

The field tests, in plots of 150 m^2 adopting a randomised block experimental design with 3 replications, are carried out in Sardinia. An integrated and an organic forage system with leguminous and cereals (self-seeding annual alfalfa, barley, consociation of vetch grass and oat) is managed using both the minimum and the no tillage techniques in two identical grounds placed one near the other with the purpose of making the comparison more efficient. The soil of the whole plots will be sampled at the beginning of each cropping cycle as vegetal samples, during their life cycle, for the quali-quantitative determinations on forages and grains.

The activity has been studying the potential impact on the soils, determining which are most important chemical-physical characteristics, of the different agronomic techniques. The research started from the soil classification, according with the Soil Taxonomy (Soil Survey Staff, 2010), made with the execution of some pedological profiles, and a contemporary sampling of the soil in each plots in order to know the "point zero" of their chemical-physical characteristics. The monitoring of the leading soil physical characteristics: structure stability, bulk density, infiltration capacity, penetrometric tests will be made every 2-3 years.

Yearly soil sampling will be executed with the purpose of studying: the evolution of the organic matter content in the soil, the allotment of the major nutritive elements, the pH modifications and the cation exchange capacity (Ministero Risorse Agricole, Alimentari e Forestali, 1994). These sampling will be made at two different depths: 0-5 cm and 5-20 cm, to satisfy two different research objectives:

(i) to underline the chemical modifications of the soil system that being a "buffer system" needs years to show some substantial modifications, starting from the surface and moving toward the deepness,

(ii) the collected data: chemical and physical characteristics of the soil, forage quality and quantity at various steps (pasture, hay and grain) will be used to develop and calibrate a mathematical model to extend the results to a large scale.

Following the soil evolution under different cultural systems, we will try to answer to the exigency of recovering the fertility, compromised by years of a non-sustainable and unguarded agriculture, and to verify its resiliency capacity. Finally the role of the soil being one of the major "carbon sink" especially under a correct land-use that allows it to accumulate organic matter will be also studied.

III – Results and discussion

The analytical data of the first year of trials are: the physical chemical data of soil profiles, the physical chemical data of soil samples at the "point zero", the productive data of the various cuttings simulating the pasture or the hay, the productive data of the barley grain and the quality data of the barley grain.

The first approach was to apply a cross tabulation matrix to understand the relationship among the soil constituents. This analysis reveals interesting values, bringing to the attention the correlation between components, sometimes not clear. For instance in the first profile, the correlation between the pF4.2 and Ca and Mg, is pretty tight and the Sodium and Copper. While

in the profile 2 the Zn is strongly associated with the pF4.2. Weak correlation is listed for exchange Mg against Bore. These preliminary results confirm that a further analysis is expected to better investigate in the relationship among matrix components.

All productive data were analysed by ANOVA. The qualitative data of the forages productions are, at the moment going on and will be analyzed in the next months. As a first comment, and synthetically, examining the productive data (see the following tables) it could be observed that they seem to be quite good both in the integrated plots and in the organic ones (with the exception of the barley in the organic trial because of a fungal pathology caused by an excess of humidity). Moreover the organic plots have productions very similar to the integrated ones and this result could allow us to suppose that during the years it will be possible to improve them and to clean the grounds without weed killing actions and to avoid the use of chemical fertilizer.

Table 1. Self/seeding annual alfalfa productivity as forage

	Integrated management DM q/ha	Organic management DM q/ha
No tillage and disk seeding machine	49.8 a	48.1 a
No tillage and seeder blade seeding machine	53.8 a	52.3 a
Minimum tillage	38.2 b	48.6 a

In the column means followed by the same letter are not different at P=0.05 (Duncan's test).

Table 2. Barley total productivity as forage and hay

	Integrated management DM q/ha	Organic management DM q/ha
No tillage and disk seeding machine	45.1 a	17.9 a
No tillage and seeder blade seeding machine	39.8 a	21.7 a
Minimum tillage	39.6 a	14.4 a

In the column means followed by the same letter are not different at P=0.05 (Duncan's test).

Table 3. Consociation vetch-oat total productivity as forage and hay

	Integrated management DM q/ha	Integrated management only for hay DM q/ha	Organic management DM q/ha
No tillage and disk seeding machine	33.0 a	47.4 a	25.8 a
No tillage and seeder blade seeding machine	30.4 a	55.4 a	25.3 a
Minimum tillage	34.0 a	81.5 b	39.6 b

In the column means followed by the same letter are not different at P=0.05 (Duncan's test).

Table 4. barley grains productivity and quality parameters

	q/ha	Proteins (%)	Moisture (%)	Hectoliter weight (kg/100 l)	1000 seeds weight (g)
No tillage and disk seeding machine	47.6 a	10.0	13.2	59.20	36.3
No tillage and seeder blade seeding machine	41.3 b	9.9	13.1	59.50	36.0
Minimum tillage	42.0 b	10.7	13.0	58.40	34.3

In the column means followed by the same letter are not different at P=0.05 (Duncan's test).

IV – Conclusions

The fact that the minimum tillage techniques do not compromise a harvest good result if made promptly and with the proper variety should be underlined. As an example the barley grain harvest data, of about 4.8 tons for hectare, is absolutely relevant for our area (south Sardinia) and for the cropping technique. The results are also analysed through the cross tabulation function to put in result the correlations among the components. As expected, the correlations are tight for those elements conditioning the fertility of the soil, weak for those threatening the soil depletions.

Further investigation will be carried out through statistical analysis and data mining.

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