PROBIO
Integrated promotion of the biodiesel chain

# GUIDELINE FOR TRAINING

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## ***PROBIO*** *Project*

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# *1. INTRODUCTION*

The challenge of agricultural scientists to increase food production to meet food security needs still persists 40 years after the start of the Green Revolution as population growth continues to increase.
However, today such production is more focused on the bio fuel plants, which must also be accomplished in a sustainable manner through:

- higher yield;
- better adoption of the best agronomic practice;
- improved culture of crop rotation and;
- minimizing negative environmental effects.

Cultivation of energy crops has been shown even in developed nations with good agricultural extension services and well-educated farmers. Significant effort will be needed to foster the cultivation of energy crops thorough adoption of conservation agriculture in low-resource areas. This has the potential to provide large, long-term positive environmental effects, but it will require long-term investment in research, development, demonstration and extension to farmers, their suppliers and information networks.

Energy Crops for biodiesel chain (i.e.: sunflower, canola and soybean) and Conservation Agriculture (CA) can provide significant and provable reductions in Greenhouse Gas (GHG) emissions via reduced mechanical energy inputs. Research demonstrating the mechanisms of a large GHG emission reductions as a result of improved nitrogen fertilizer efficiency is already available, but has not yet been brought together to demonstrate the integrated effect of CA systems. Some of the initial research requirement might usefully be carried on in the developed nations, particularly in relation to conservation agriculture impact on water logging and split fertilizer application, and the consequent effects on nitrogen use efficiency, nitrous oxide and methane emissions. Involvement of developing nation scientists in this work would be critical.
Positive impacts of using the no-tillage technology are manifold in the different Italian regions where adoption has been greatest. The changes in farm production methods from conventional to no-tillage systems have reversed the former trend of declining crop productivity and led to an economically, ecologically and socially sustainable form of cropping in all countries and regions that have had significant rates of adoption.

CA has great potential to increase carbon sequestration and decrease net emissions of carbon dioxide and other greenhouse gases, but policy makers have not widely recognized this potential.

The widespread adoption of CA results in a win-win situation for farmers and for society as a whole. The farmer wins by reducing tillage operations thus reducing fossil fuel consumption, also by reducing erosion and thus protecting and improving his soil, while at the same time producing higher yields at lower costs. This way, farmers are increasing profitability and sustainability of their farming operation. The consumer wins by receiving a healthier product at lower cost on his table. Society wins by conserving water and soil resources and contributing significantly to reduce carbon dioxide emissions to the atmosphere. And finally our children will win, as no-tillage technologies are leaving a better world for future generations.

There is evidence that CA has had a significant impact in terms of relevant millennium goals as reducing the threat of desertification, mitigating hunger, contributing to food security, poverty alleviation, income generation and environmental objectives such as carbon sequestration and climate change, improving the quality of life of adopters and their families and improving the environment for all.

A global effort is needed to increase the adoption of no-till farming practices soon and governments need to support the adoption giving incentives to farmers in the form of financial resources for buying equipment as well as for agricultural research and extension. Aid programs should place far greater emphasis in supporting a rapid diffusion of the no-tillage system in developing countries.

This guideline tries to be a reference document for developing and organizing training courses for farmers aimed at promoting this kind of crops and practices.

## *2. BENEFITS AND LIMITS*

The benefits of conservation agriculture applied at the sunflower crop, can be measured both in agro-environmental and in production terms.
Due to the great diffusion of the sunflower in the clay soils of the central Italy, the most common tillage technique practiced is represented by the deep or medium plugging. The first

and the simplest conservative technique are represented by the ripping, much appreciated by the farmers because of its good effect on the soil mass (specially on clay soils). The good adaptation of the sunflower production to this technique is shown by the minimum difference of yield comparing this technique with plugging at a variable depth between 30 – 50 cm.
Results observed in Spain from Murino et al. (1998) showed an increase in term of yield of about 23%, while in Argentina an average yield increase of about 5% and a maximum of 25% using a subsoiler instead of chisel (Botta *et al*., 2006). Regarding the minimum tillage, in favorable climatic conditions (such as in France), the implementation of this simplified technique has produced a slight increase of the sunflower yield respect to the ploughing conventional tillage technique, both on the clayed soils (3,1 t/ha of grain vs. 3,00) and on sandy soils (3,82 t/ha of grain vs. 3,42) Perny (1993). In Italy the adoption of minimum tillage for sunflower crop has given results, due probably to the frequently use of inappropriate equipments to apply this conservative technique. The research carried out by the Crop Science Department of the University of Perugia (1986-1990) has shown, on heavy soils well structured, an average reduction of the sunflower yield of about 9-13% with respect to the deep ploughing. In three of five years of research, the sunflower yields were not statistically different from those obtained with ploughing. Working in the same environment, a 4 years research (1987-1990) conducted on a flat heavy soil characterized by a scarce presence of "montmorillonite" clay, deep ploughing has shown a reduction of sunflower yields (about 18%) with minimum tillage respect to the deep ploughing. In two years no differences between the two techniques were significantly noticed (Bonari *et al*., 1996).

Regarding the possibility to seeding the sunflower in a no - tillage soil, currently on account of the few experiences done in Italy, it is difficult to know the response of the oleaginous to this process, strongly depending on the soil and climate conditions. Little research has been done about the phosphor-potassium and organic fertilization issues in no-tillage systems. Generally, when these nutrients are not buried they concentrate on the soil superficial layers (first 10 cm) with a reduction in deeper layers, and consequently a lower availability to the crop. It should be studied the possibility of progressing impoverishment of the sub-superficial layers and the consequent yield reduction of sunflower. According to the information and consideration above mentioned, it is reasonable to consider the possibility of increasing the adoption of the conservative techniques for the sunflower production in Italy. Because of the diffusion of this oleaginous on hilly areas, the adoption of conservative techniques should be considered a valid instrument to limit the water erosion and to enhance the soil moisture conservation.

The reduction of time and fuel use, associated to these techniques, must be considered as a benefit for sunflower production because of the reduction of cost inputs.

It would be advisable to verify in detail the productive response of the crop to the conservative techniques in the Italian environments, characterized by not particularly drought conditions and scarce availability of post-emergency herbicides.

For the application of these conservative techniques on sunflower production, it should be applied a full research of the entire production chain, such as: weed control, seeding modality and crop defense and fertilization.

## *3. TOPICS TO INCLUDE IN THE TRAINING*

The training for farmers should involve the following basic topics:

- Guide of best practices for $CO_2$ sequestration
- Training manual
- Experimental-demonstrative plots in open field
- Field visit
- Questionnaire

The main contents to be included in the training are presented in a 20-hour training scheme, but they can be adapted for 15-20 hour duration courses.

**Hour 1**

PROBIO project: presentation

In this introduction hour the importance, facts and the importance of the PROBIO project for local community, farmers, producers of biodiesel and energy sustainability is going to be introduced by the regional PROBIO partners. The production of bio fuels plants is an integrated part of the bio diesel chain in a particular region, thus it represents only the first stage to the final product – biodiesel. The current state of bio fuel plants production among the partnership regions of the PROBIO project differ significantly. On the one side there is Abruzzo Region, in which no cultivation of energy crops for the biodiesel chain is reported yet. In all other regions the production has been already running, but the oil plant varieties and the total amount of oil seed depends from particular regions. From those reasons only general guidelines for the bio plant cultivation will be given in the next paragraphs, which should be later adapted to the local conditions.

**Hour 2**

Analysis of the current bio diesel production

The importance of biofuels (bioethanol, biodiesel and synthetic biofuels) for transport on the regional, country's and European level should be presented to the audience, whereby a special attention must be pied to the role of farmers in this bio diesel chain. A significant part of this hour should show and explain the trends in bio diesel production, EU legislation and the biggest bio diesel producers.

**Hour 3**

The importance of the regional biofuel production for the local biodiesel production

In this chapter the general concepts in producing of currently biodiesel crops and new species crops for biofuels will be explained, whereby the role and importance of the locally produced oil seed for independent energy supply of the particular region should help in encouraging the local politicians, government, farmers and bio fuel producers to stimulate higher produce of oil plants, biodiesel production and the use of local energy.

**Hour 4**

Biological fundaments for the oil plant produce. Morphology of the plant

In this hour the taxonomy, classification of the particular oil plant is going to be presented to the audience. Among the taxonomy the plant appearance, shape of flowers, leaves and the crop is going to be presented very carefully, since there is a very big similarity among the oil plant of the ordo Brassica.

**Hour 5**

Rotation from crops

All oil plants demand a lot of mineral nutrition for photosynthesis of oils, therefore in this hour the importance of 4 years-crop rotation should be carefully presented to the farmers. Additionally all the problems in increasing the pest and diseases control caused by the reduction of the rotation are going to show the importance of the wide rotation.

**Hour 6**

Natural conditions for the oil plant production

The natural conditions play the most important role in choosing the proper oil plant for seeding in the particular region or province. The whether and soil is the basis for high and quality yield of oil seeds, which is the fundament for the later biodiesel production. Precise description of growing conditions, the influence of temperature, humidity and the land should

help farmers in selecting the proper soil and parcel for growing of oil plants. In most regions joined to the PROBIO project the sunflower represents the most important biofuel plant, except for Slovenia. In the Abruzzo region the oil rape could be a potential energy crop for biodiesel chain if the new genotypes adapts to the particular environmental conditions of rainfed hilly area of. However, it is necessary to apply a new research program for the evaluation of the adaptability and yield response in joint with new agronomic practices that preserve soil fertility and reduce soil erosion with positive impact on $CO_2$ balance.

Sunflower represents the main potential energy crop for the all Spanish as well as Italian region, due to the suitability to be cultivated on rainfed conditions and for its introduction in the rationale farming systems model. The oleic acid content in sunflower oil seems to be a suitable character for biofuel production with regard to fuel oxidative stability. For the same reason, the high oleic varieties are considered particularly promising.

As other herbaceous field crops for renewable energy, the sunflower response to sustainable practice can vary depending on pedo-climatic conditions, cultivation techniques (time of sowing and period of weed control) and the extent and quality of changes, at short and long term, induced by these same techniques on the agro-ecosystem.

In the case of sunflower, it is possible to apply the conservative practices (as minimum tillage and no-tillage), but it should be considered the crop peculiarities in order to improve the eventually positive interactions between them and the new techniques adopted.
Sunflower completes its own biologic cycle in relatively short time with respect to other crops as maize and sorghum. Thanks to its lower thermal needs for germination, it is possible to anticipate seeding (half of March) with a consequent earlier harvesting (half of September). As consequence, sunflower flowering happens in June, a period when temperatures are not yet particularly high and there is the possibility of precipitations. Therefore, the stage of sunflower could allow a minor risk of hydraulic stress respect to other renewal crops.

During the selection of the agronomic techniques to be adopted, we have to consider the sunflower strong and deep roots which focus on a taproot able to grow beyond 1 m depth. This powerful root system, guarantee the sunflower a full use of water and nutritional resources even in clay soils, although the crop shows a little ability to penetrate in layers of compact soil that may encounter along the soil profile due to natural causes or as a consequence of tillage.

The excellent colonizing ability of root allows the sunflower to use, in a profitably way, the nitrogen in soil thus resulting in low efficiency response to nitrogen fertilization compared with other renewal species. With this regard, the availability of nitrogen to the crop would be particularly important in raise phase (that normally happens in May) to support the rapid development of the crop. At this phase, that corresponds at 4 – 6 leaves stage, the availability of nitrogen in the soil would increase the amount of fertile flowers and the potential yield of the crop.

Before introducing the interaction between the conservative agriculture techniques and the sunflower characteristics, it is important to make a brief summary on the role of the sunflower as renewal crop in Italy.

The productivity of the sunflower is strictly linked to the soil fertility and the water availability (groundwater, spring/summer rainfall). In fact, although sunflower is considered a drought–resistant crop, its water seasonal consumption is similar to those crops that need a relevant amount of water. Therefore the increase of the water availability has a decisively influence on the productivity of sunflower 3 t/ha.

The choice of the agronomic practices has been always directed to improve the soil water retention in order to prevent crop water stress. During the past centuries, deep tillage has been considered as the best practice to conserve water in soil during the rainy months. On the other hand, it has been shown that deep tillage can impact negatively on the physic characteristics of soils. The loss of structure stability can produce, over time, a progressive compaction of soils with the consequence of reduced water infiltration. Moreover, the loss of structure can contribute to increasing the run-off risk.

An adequate soil water infiltration of rainfall could be obtained using alternative techniques to the conventional ploughing, i.e. minimum tillage and no-tillage. Implementing the conservative techniques, water infiltration can be enhanced thanks to the reduction of the run-off due to crop residues on soil surface.

Regarding the reduction of soil moisture evaporation, the minimum tillage techniques have shown to maintain for longer period the soil moisture (especially on superficial layers) thanks to the vegetal mulching, natural or artificial, on the soil and the higher percentage of micro pores.

Therefore, the conservation agriculture can have a positive effect on sunflower production in two ways:

(i) Giving to this crop a better capacity for using the water resource

(ii) Limiting the environmental impact of its cultivation in hilly environment through the reduction of the erosive phenomenon.

**Hour 7**

Selection of the appropriate oil seed variety

In all regions at least one institution provide field trials for selection of the most suitable varieties of most important oil plants annually, which help farmers to select best varieties adopted to the local pedo-climatic conditions.

**Hour 8**

Soil preparation - special requirements

Since in practical all regions joined to the PROBIO project the lack of water is permanently presented, the application of conservative techniques of seeding must be accurately processed in relation to the agro-pedo-climatic conditions of the cultivation area. In this analysis we will refer to the “more extreme” conservative techniques from minimum tillage and then further step by step even to no-tillage technique.

However, the application of any tillage technique on the field, should guarantee an efficient hydraulic system. This is particularly important, during the winter and spring, to avoid the water excess in order to permit a quick heating of the superficial soil layers. This is crucial for renewal crops in sod seeding because sod soil temperature is lower than the traditionally tillage soil. In sunflower early seeding, delay crop emergence has the consequence of increasing seed predation by birds. A little delay of the sod seeding period could offer greater guaranty for a quick and uniform emergence of the plant.

In this context, it is fundamental that the sunflower in sod seeding must be preceded by a crop that does not cause compaction on the superficial layers of soil. Therefore it would be opportune to prefer species with early summer harvesting at end of June. A bad superficial settlement of the soil in sod seeding represents a risk for the good development of the sunflower under no-tillage cultivation because soil could be affected by superficial water stagnation during the early spring.

The selection of the previous crop is very important because it represents the definition of the "sod system" in term of the quantity of crop residues that can be released on soil surface with harvesting ratio. With this respect, crop residues with high C/N ratio (cereals normally) requires more time to be degraded. The release of crop residues on the soil surface could enhance the eventually allelopathic effect of some species (rye, sorghum, etc.) on the sunflower seed during germination.

The conditions derived from the no-tillage technique on soils favours the development of many biological activities determining a certain risk of parasitism of the seed and/or the plant and the development of fungi diseases. Therefore it is required to ensure the quality of the seed, the nature of the fertilizer and the possibility to use insecticides. To overcome this problems, it could be introduced cover crops into the "sod system" appropriately seeded at the end of the summer. The use of cover crops could:

(i) reduce the seed predation by birds

(ii) reduce the development of infesting flora during the winter season and spring-summer season

(iii) reduce the soil moisture evaporation during the spring-summer season

Moreover, the presence of a compact vegetal cover until the sunflower sod seeding could improve the state of aggregation of the soil, favoring the formation of an adequate bed-seeding.

**Hour 9**

Basic and spring fertilization

All oil plants are known on its great demands on all major and micro nutrients as shown in the table. In this hour precise description of all macro and micro fertilizers, required for the seed and oil production. The minimum of 2°C must be fulfilled for application in the spring fertilizers.

| Fertilizer requirements | **SUNFLOWER** | **OIL RAPE** | **SOYEAN** |
|---|---|---|---|
| (N - P - K) kg/ha | 80 - 120 -70 | 150 - 115 - 80 | 120 - 80 -70 |

**Hour 10**

Application of growth regulators

Descriptions of growth regulators for strengthen and lower of stalk, reducing the quantity of water and preventing the lodge of plants. Regulators for improving the evenness of seed ripening and preventing the early opening of the raps shell.

**Hour 11**

Disease and pest control in biofuel plants

Appearance and life cycle description of most important agents causing diseases of biofuel plants and damaging insects will be presented. Chemical control measures of most important plant pathogens *(Sclerotinia sclerotiorum, Phoma lingam, Alternaria brassicae spp., Plasmodiophora brassicae,… )* and pests (aphids, moths, weevils, flea beetles, click beetles, wasps, …) will be discussed in a concise way in terms of economy and efficacy of chemicals. Locally adopted systems of determination of economic thresholds (computer supported decision tools - threshold programmes) for diseases and pests will be given. The availability of the new internet diseases prognose methods will practically be demonstrated by online presentations of interactive internet sites. Since there are several pathogens that are able to infect all of the biofuel crops a great attention will be given to broaden the knowledge on correlations between crop rotation systems, soil cultivation and preparation systems and disease development. The measures for prevention of drift of plant protection chemical and of hazardous side effects on environment (p.e. bee poisoning) will be discussed.

**Hour 12**

Weed control

In this chapter detail description of locally adopted approaches for control of most important perennial weeds (Convolvulus arvensis L., Cirsium arvense L.) and annual weed (Capsella bursa-pastoris L., Gallium aparine L., Sinapis arvensis L., Raphanus raphanistrum L., Matricaria sp., Lamium sp., Apera sp., Avena sp., Alopecorus sp., … ) will be given. Herbicide application programs will be analyzed in terms of efficacy, costs - benefit relations and ecological acceptability. Also the cost benefit analysis for mechanical weed control measures will be given. Since biofuel plants many times become weeds (volunteer canola or sunflower) in the fallowing crops, some options for their chemical control will be presented. This is especially very important in case of growing GMO biofuel plants.

**Hour 13**

Harvesting and drying of biofuel plants

Optimal time for harvesting oil plants by the implementation of the universal combine harvester depends in the first case from the content of the moisture in the seeds. When moisture falls beyond 15% the farmers should start with harvesting. However, before the processing one must not forget to adapt the combine harvester with a special cutting unit for oil plants.

**Hour 14**

The inner quality of oil seeds

After harvesting is done, the oil seed must be usually artificially dry to the storage moisture of 9%, which can later assure the optimal chemical content of the oil raps seed required for the biodiesel production.

**Hour 15**

Economy of biofuel plants produce

The crop economic analysis showed that the costs differences are more due to the practices used in each cropland than because of their geographical and weather condition. For the Spanish agricultural practice in rape production the costs variation are mainly due to the preparation of land depth and the irrigation. Subsequently, the rape cultivation break-even point for Avila, Burgos and Huelva shows that it will not be profitable to returns under 1.141,5 Kg/ha in unirrigated land and under 1.768,5 Kg/ha in irrigated lands, before grants. For Pomurje the rape cultivation break-even point under unirrigated land lies under 1.536,8 Kg/ha. Since the sunflower usually reaches higher market prices, the cultivation break-even point for Avila, Burgos and Huelva lies below rape and it will not be profitable to returns already under 787,50 Kg/ha in unirrigated land and under 1.305,7 Kg/ha in irrigated lands, before grants. For Pomurje the sunflower cultivation break-even point under unirrigated land lies under 1.136,8 Kg/ha. The calculation of cost in production of conventional versus ecological produce of oil raps for Pomurje region has shown cultivation break-even point under 1.006,8 Kg/ha. The comparison with other crops in the rotation shows that the oil raps with the average yield of 2.750 Kg/ha brings twice a profit of wheat (5.500 Kg/ha), barley (5.000 Kg/ha) or maiz (8.000 Kg/ha).

**Hour 16**

Biodiesel production, potentialities and barriers

Differ from region to region considerably and represent the sum of the whole producers' ability from every industrial facilities existing. At the moment, the factories production abilities in Avila are 70000 t/year, in Burgos 80.000 t/year, and Pomurje 6.000 t/year. However, in

2007 only about 2800 ha of sunflower and approximately 90 ha of rape will be processed into biodiesel in Burgos, 2.727 ha in Pomurje. In Abruzzo region there are no producers for biofuel production at the moment. The most important barriers for the production of biofuel plants and the later biodiesel can be summarized into following lines:

i) the shortage of appropriate land (Pomurje, Abruzzo) due to the four years rotation
ii) expensive production of biodiesel from the oil seed is possible only by a local or state financial support and legislation
iii) smaller biodiesel producers can not buy and storage enough seed for the annual biodiesel production and are forced to loan expensive money, which also effect the economy of the production
iv) in some regions (Pomurje) the annual money deposit must be given to the Agency for the agricultural produces as a proof that the oil seed will be sent directly for the biodiesel production. That kind of caution certainly represents a lot of money for all producers, which can be loaned only in banks.
v) the lack of biodiesel promotion on the local level represents very important barrier for increasing the use of biodiesel for vehicle application, therefore all kind of knowledge from the primary schools to universities would be suggested
vi) whenever growing biofuel plants we must omitted the additional $CO_2$, nitrates, herbicides and pesticides impacts on the local environment, by introducing integrated or even sustainable production of biofuel plants

**Hour 17**

Effects on rural development

The introduction of biofuel chain can significantly improve the economical profit of the farmers that are growing the biofuel plants but also the producers of biodiesel and not least the consumers of biodiesel themselves by reducing the $CO_2$ pollution of the local environment and making them independent from the imported mineral oil.

**Hour 18**

Contracts between producers and industry

Since at the moment there is a big demand on all agricultural produces in the world, only in time contracts between producers and industry can assure enough repro material for producing the biodiesel on the long term.

**Hour 19**

Support policies

Currently, the positive economical balance in biodiesel production is possible only with the additional state or local subsidy, thus each country or region should support the biodiesel chain as its contribution to the $CO_2$ and GHG reduction, which would on the long term have the crucial impact on the global warming.

**Hour 20**

Questionnaire

In the last hour the questions about all important topics will be given to the audience, which will grade the seminar according A B C scale and will certainly help the organizations of the training in improving, adding and renewing any topic till the very first next meeting.