DISINFECTION OF AGRICULTURAL SOILS BY USING SPECIAL PLASTICS

INTRODUCTION.

Disinfection of soils has become one of the first actions a farmer has to carry out at the beginning of each season.

Nematodes, bacteria, fungi, virus, …, are pathogens which must be exterminated in order to avoid negative effects they have on the crops and the most effective way to control them is by disinfecting the soil. Unless these pathogens are kept under control, the viability of the crops will be in danger. It is also important to point out that the soil disinfection lets us control the presence of weeds which steal the nutrients from the crops.

These parasites/pathogens we want to control find their ideal habitat in greenhouses due to their temperature conditions and dampness. These conditions are favourable for them and stimulate their growth in a considerable way. Moreover, single crop farming or scarce rotations, high density of plants in a small space, …, increase bacteria attacks causing a progressive rise of parasites populations which leads to progressive decrease in the crops productivity.

The soil treatments intended for fighting against micro fauna and micro and macro flora are generally called disinfectants. Their objective is to destroy pathogenic agents in the soil (Nematodes, Fusarium, Pythium, Phytophthora, Verticillium, Sclerotinia, etc.) which are likely to affect the crops development in a negative way.

TYPES OF DISINFECTION

A farmer can choose from a variety of types of disinfection. In all of them it is important to use adequate means and products. If we are going to use a chemical disinfection, we need a barrier film; in case of a solarization, it's essential to use a plastic film which could reach and maintain high temperature in the soil for a long time.

- TECHNIQUE OF SOLARIZATION: Use and exploitation of solar energy, temperature and water. Solarization is a disinfection technique which consists in solar energy exploitation by using special plastics. It is environment-friendly and very cost-effective and also avoids chemical products negative effect on the cover plastic.

In solarization we have to cover the soil previously irrigated with a sheet made of special plastic at a period of the year when the intensity of solar radiation is appropriate (in Almeria it's the period from the end of April to the end of September) in order to increase the temperatures which would allow us to destroy the majority of pathogens, insects and weeds. Solar radiation passes through the plastic sheet, turns into heat and leads to physical, chemical and biological changes in the soil.

The effectiveness of solarization is mainly due to the increase and maintanance of the temperatures in the soil at extremely high levels. The survival chances of the majority of pathogens and weeds are reduced when the temperature rises up to 40 C. If we maintain this temperature for some time, a great amount of pathogens we want to exterminate will be destroyed.

- CHEMICAL DISINFECTION TECHNIQUE: It consists in the use of chemical compounds as disinfectants together with plastic films to seal the land and avoid gases escape in order to make the disinfection more effective.The most common disinfectants are: Cloropicrine, Dichloropropenes, Metam-sodium, Metam-potassium, Methyl tioisocyanate, Agrocelhone or some combination of them.

Chemical soil disinfection is the most popular technique because of its easy application and effectiveness against insects, nematodes, fungi and weeds.

Chemical products used in the soil disinfection turn into gaseous state the moment they are released, therefore, it's necessary to cover the soil with an adequate plastic sheet to prevent the gases form escaping. Traditional plastic has certain porosity (even though it is minimum) that allows the gases pass through its microholes, leading to the escape of disinfectants from the soil. This gases escape makes disinfection more expensive. In addition, the air in the greenhouse gets poisoned putting the people who are exposed to it at risk of intoxication and affecting negatively the greenhouse cover whose useful life gets shorter. With a special sheet for disinfection we can minimize these negative effects and at the same time reduce the time needed for a proper disinfection.

- BIOFUMIGATION. Biofumigation has appeared as a new technique alternative to the soil disinfection with chemical products. It lets us use both organic material and products of its descomposition to control the pathogens present in the soil. It is similar to solarization but in this case we add manure, vegetable remains of previous crops, fertilisers, etc. The microorganisms activity in the organic material during its descomposition produces a big amount of products which take part in controlling the pathogens in the soil: ammonia, nitrates, sulphhydrous acid, organic acids and other volatile substances.

As a result of this chemical reaction together with high temperatures which are achieved and maintained for a determined period of time, we get an effective soil disinfection in less time.

FIELD TESTS

Disinfection is extremely important, that's why here in Sotrafa we think that it deserves special attention and research. For many years and in collaboration with prestigious laboratories we have carried out analysis/soil tests which have provided us with some valuable information for the development of specific products for disinfection.

Several plantations collaborators of Sotrafa made several experimental tests last year. The level of infestation of each of them was different but all of them had problems which needed solutions.

Objective of the tests:
The objective of the tests was to prove the efficacy and the effectiveness of our special products for disinfection that fight against fungi, bacteria and nematodes present in the plantations that participated in the experiments.

In addition, we wanted to find a solution for some problems and give an answer to the following questions:

- Is it possible to obtain an effective disinfection in a short period of time without using chemicals?
- Is it possible to reduce the dose of disinfectant in chemical disinfections?
- Is it possible to reduce the time needed to obtain an effective disinfection?

A positive answer for these questions would have important environmental benefits for the society in general and economical benefits for farmers in particular.

Plants pathogens – objects of study.

It is important to point out that not all the pathogens affect all the crops in the same way. It is true that there is a group of them which are harmful for the majority of the crops, but depending on the type of the crop special attention should be paid to those which could interfere with its growth in order to eliminate them and avoid their negative effects on this crop.

TOMATE	
HONGOS	*Fusarium oxysporum*
	Botrytis cinerea
	Sclerotinia sclerotiorum
	Verticillum dahliae
	Phytophthora spp.
	Alternaria
	Pyrenochaeta lycopersici
	Rhizoctonia
	Colletotrichum
	Pythium spp.
	Stemphylium sp.
NEMÁTODOS	*Globodera pallida/rostochiensis*
	Meloidogyne incognita
BACTERIAS	*Xanthomonas*
	Clavibacter
	Pseudomonas
	Ralstonia solanacearum
	Pectobacterium
VIRUS	*Tobacco Mosaic Virus (TMV)*
	Tomato Mosaic Virus (ToMV)
	Pepino Mosaic Virus (PepMV)
	Eggplant mottle dwarf virus (EMDV)
	Potato Virus Y (PVY)
	Tomato yellow leaf curl virus, (TYLCV) y especies relacionadas (TYLCSV, TYLCMalV y TYLCAxV)
	Tomato spotted wilt virus, (TSWV)
	Tomato chlorosis virus, (ToCV)
	Tomato torrado virus,(ToTV)
	Cucumber Mosaic Virus (CMV)
	Parietaria mottle virus, (PmoV)
	Beet western yellows virus (BWYV)
	Tomato Bushy Stunt Virus (TBSV)

PIMIENTO	
HONGOS	*Fusarium oxysporum*
	Botrytis cinerea
	Sclerotinia sclerotiorum
	Verticillum dahliae
	Phytophthora spp.
	Pythium spp.
	Rhizoctonia
	Pyrenochaeta lycopersici
NEMÁTODOS	*Meloidogyne incognita*
BACTERIAS	*Xanthomonas*
	Clavibacter
	Pseudomonas
	Ralstonia solanacearum
	Pectobacterium
VIRUS	*Pepper Mild Mottle Virus (PMMoV)*
	Tobacco Mosaic Virus (TMV)
	Tomato Mosaic Virus (ToMV)
	Potato Virus Y (PVY)
	Tomato spotted wilt virus, (TSWV)
	Tomato yellow leaf curl virus, (TYLCV) y especies relacionadas (TYLCSV, TYLCMalV y TYLCAxV)
	Tomato torrado virus,(ToTV)
	Tobacco mild green mosaic virus, (TMGMV)
	Cucumber Mosaic Virus (CMV)
	Parietaria mottle virus, (PmoV)
	Alfalfa Mosaic Virus (AMV)
	Broad bean wilt virus (BBWV)
	Tomato spotted Wilt Virus (TSWV)
	Tomato Bushy Stunt Virus (TBSV)
	Eggplant mottle dwarf virus (EMDV)

PEPINO	
HONGOS	*Fusarium oxysporum*
	Botrytis cinerea
	Sclerotinia sclerotiorum
	Didymella Bryoniae
	Pythium spp.
	Alternaria
	Phytophthora spp.
	Rhizoctonia
NEMÁTODOS	*Meloidogyne incognita*
BACTERIAS	*Xanthomonas*
	Pseudomonas
	Pectobacterium
	Acidovorax citrulli pv. Citrulli
VIRUS	*Cucumber Mosaic Virus (CMV)*
	Squash mosaic virus, (SqMV)
	Cucumber green mottle mosaic virus (CGMMV)
	Melon Necrotic Spot Virus (MNSV)
	Cucumber vein yellowing virus,(CVYV)
	Cucurbit yellow stunting disorder virus,(CYSDV)
	Zucchini yellow mosaic virus, (ZYMV)
	Watermelon mosaic virus, (WMV)
	Papaya ringspot virus, (PRSV)
	Cucumber fruit mottle mosaic virus, (CFMMV)
	Beet western yellows virus (BWYV)
	Cucurbit aphid–borne yellows virus (CABYV)
	Eggplant mottle dwarf virus (EMDV)

CALABACÍN	
HONGOS	*Fusarium oxysporum*
	Botrytis cinerea
	Sclerotinia sclerotiorum
	Didymella Bryoniae
	Pythium spp.
	Phytophthora spp.
	Alternaria
NEMÁTODOS	*Meloidogyne incognita*
BACTERIAS	*Xanthomonas*
	Pseudomonas
	Pectobacterium
	Acidovorax citrulli pv. Citrulli
VIRUS	*Cucumber Mosaic Virus (CMV)*
	Squash mosaic virus, (SqMV)
	Cucumber green mottle mosaic virus (CGMMV)
	Melon Necrotic Spot Virus (MNSV)
	Cucumber vein yellowing virus,(CVYV)
	Cucurbit yellow stunting disorder virus,(CYSDV)
	Zucchini yellow mosaic virus, (ZYMV)
	Watermelon mosaic virus, (WMV)
	Papaya ringspot virus, (PRSV)
	Cucurbit aphid–borne yellows virus (CABYV)

These are some of the fungi, bacteria and nematodes that affect vegetable crops (tomato, pepper, cucumber, courgette, …..) in an especially negative way reducing their output and quality.

Selected plantations.

For the tests we have chosen greenhouses situated in different farming areas of Almeria and Murcia.
At the time the tests were carried out the crops prior and subsequent to the disinfection were also taken into consideration. This aspect is very important as depending on the type of the crop, one or another type of pathogens is to be fought. It is equally essential to know what crop will be grown during the next season in order to keep under control those pathogens that are very likely to attack the new crop.

Initial work and land preparation:

- Remove from the land all the residues from the previous harvests that might be a source of infection.
- Get an adequate structure for the land (loose and free from clumps) and flatten by means of rollers the surface of the farmed land to facilitate the later contact of the film with the soil.
- Seal hermetically the land with a plastic sheet to prevent the heat and/or chemical products from getting away.
- Water the land up to its capacity to achieve good thermal transmission, next place a plastic sheet. It is very important to keep the area of the root system of the crops wet to provide a good disinfection of this critical area.
- While the soil disinfection takes place, the greenhouse must be kept closed and the plastic film of the cover clean (not whitewashed) to get the highest possible radiation and temperature. It is advisable to check the cover and make sure there are no slits or cracks on it because they could interfere with the disinfection. In case the cover is damaged, it should be fixed to avoid the cooling of the greenhouse and the entrance of air which could lift the disinfection plastic sheet from the soil.

Disinfection carried out and the means used.

In the same greenhouse three different types of soil disinfection have been carried out.

1.-Chemical disinfection by using the recommended dose of a chemical product. During this disinfection our special plastic film for chemical disinfection was used (DS PLUS **NEW**)
2.-Chemical disinfection reducing the dose of a chemical product by 60 %. As in the previous case, our product DS PLUS **NEW** was used.
3.-Solarization. Solarization was carried out with our special product for solarization ECO PLUS **NEW**.

The procedure of picking up soil samples.

- A soil sample is taken from the area where the crop is planted; sand and the first layer of the soil are moved aside since the best solution is to take the soil at the depth of 15-20 cm.
- We take a sample from at least five different sites in each area. The ideal sites are the four corners and the central part of the area. It's necessary to obtain minimum four kilos of soil from these five sites and then mix them together in a bag. Each site should be perfectly marked since after the soil disinfection we take a soil sample from each of them again for analysing.
- The sample should be kept refrigerated to avoid the beginning of disinfection/solarization inside the bag during its transportation and until the start of the analysis. For this purpose we use a fridge with ice sheets.
- 15 days after the beginning of the disinfection we take a sample again from the area of the greenhouse where we are carrying out the disinfection with ECO PLUS (solarization). The aim of this action is to check the results achieved during this period of time (we shouldn't forget that by using our ECO product we want to reduce the time needed for solarization together with disinfection).
- When the disinfection is over, we take samples again using the same procedure. We compare the results before and after the disinfection in each area.

Evaluation of tests.

The tests we have carried out were to resolve several doubts we considered as the object of study. We have achieved a total disinfection of the land reducing the time needed for doing it by two weeks and the dose of the chemical product by 60 % thanks to the special properties of DS PLUS. The analysis of the soil carried out after the disinfection shows the total absence of pathogens and there is not a trace of fungi, bacteria or nematodes.

Regarding the solarization, we have achieved equally good results as well and proved that thanks to the special properties of our product ECO PLUS it has been possible to reduce the time necessary to carry out the solarization by three weeks. The problems related to solarization have been overcome and nowadays we don't need long periods of time to get a good solarization.

Two systems of disinfection with equal effectiveness.

CHEMICAL DISINFECTION	SOLARIZATION
DS PLUS	ECO PLUS

The results of the tests are important but we also consider that the information provided by the farmers and agricultural engineers who we usually collaborate with and based on their own experiences is of great

importance as well. These people are excellent promoters of agricultural development on the whole as their experience is really valuable and helps us improve.

The evaluation of the tests have allowed us to modify the formula of our special products for disinfection by adding additives and the latest generation raw materials with improved specific properties for this use (permeability, thermal characteristics, condensation, etc.).

NEW PRODUCTS FOR DISINFECTION.

The latest advances will be put at a farmer's disposal in this season and a farmer will have two new special products for disinfection.

DS PLUS. CHEMICAL DISINFECTION. New formula.

Improvements added to the product:

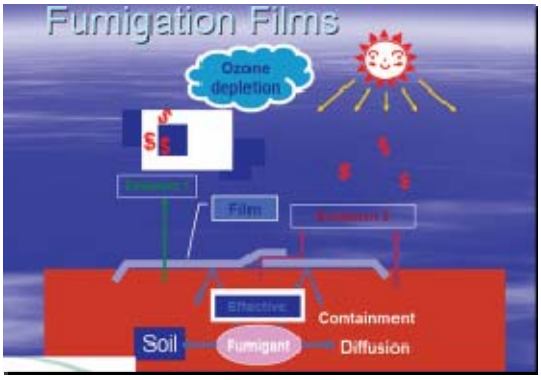
- Thermal properties.
- Better impermeability.
- Resistance to ultraviolet (UV) radiation and chemical attacks.

We have obtained the best possible product for the soil disinfection using a considerably inferior dose of chemicals with excellent results. The disinfection plastic sheet DS PLUS is especially made to achieve 100 % of efficiency in soil disinfection.

Advantages:

- Lower loss of disinfectant leading to consequent economical savings.
- Rise of the temperature in the soil thanks to its thermal properties.
- Increase in disinfectant action efficacy.
- Risks of intoxication in the greenhouse are avoided.
- Chemical deterioration of the greenhouse cover is avoided.
- Proved effectiveness.
- Considerable reduction in the time needed for the disinfection, between 2 and 3 weeks.

PERMEABILITY (g/m2 h)					
FILM	**DENSITY (µ)**	**MeBr**	**Cloropicrine**	**MITIC**	**1,3-DP**
LDPE/LLDPE	**40**	**65**	**109**	**186**	**174**
DS PLUS	**40**	**28**	**52**	**84**	**77**



ECO PLUS. SOLARIZATION. New formula.

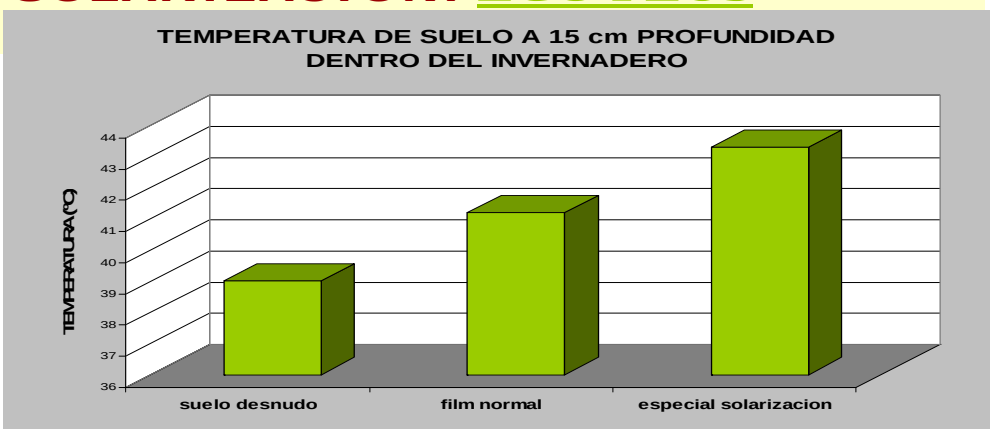
Improvements added to the product:

- We have obtained a more thermal product, taking advantage of the long infrared radiation, that is to say, the energy the land emits during the night is retained and used, this way we avoid the cooling which takes place at night when the solar energy is not present (short infrared radiation).
- Resistance to ultraviolet radiation (UV) and chemical attacks (biofumigation).

Advantages:

- It increases the soil temperature up to 60 % compared to normal plastics.
- It increases the efficacy of solarization reaching 97 % of pathogenic mortality.
- It reduces considerably the time needed for solarization, excellent results are achieved in 3 weeks.
- It reduces the effect of condensation (dripping), letting us make the most of the solar radiation.
- It doesn't destroy certain organisms beneficial for the crops which impede the later invasion of pathogenic micro-organisms.

SOLARIZACIÓN: ECO PLUS



CONCLUSIONS

It is obvious that one of the first and most important decisions that a farmer must make at the beginning of each season is the soil disinfection since the success of the crop and the season on the whole will depend on it to a great extent.

Prices, weather conditions, … are the factors beyond our control but it is possible with the others such as the soil disinfection. Nematodes, fungi, bacteria … are worrying factors at the beginning of each cultivation and especially important if they were present in the previous season.

Sotrafa is a company that is concerned about providing solutions to the farmers. We have been aware of the important role of the plastic films in soil disinfection for a long time and, for this reason, we have been working hard to develop good products which could help to carry out an effective disinfection.

In conclusion, we can say that the choice of adequate film for disinfection implies:

- Effective disinfection.
- Economical savings.
- Less time needed to carry out the disinfection.
- Work and health safety.
- Protection of the environment.
- Protection of the greenhouse cover.

We improve by looking for a farmer's benefit and respect for the environment. With our new products for disinfection we contribute to its protection by promoting ecological disinfections by means of an effective solarization and reducing the dose of disinfectants in chemical disinfections harmful both for the environment and a farmer in particular.