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POSTER PRESENTATION

New approaches in pest and disease control in Sicilian greenhouses*

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Abstract

Results of trials on mechanical methods to release beneficials and on new techniques to apply sulphur are reported. The former were carried out on two predators, a phytoseiid mite and an anthocorid bug. Laboratory and greenhouse tests were conducted with the aim of evaluating the vitality and the damage eventually caused and setting the machine. The latter dealt with new techniques of sulphur application on tomato crops using dispensers transforming granular sulphur into vapour. In order to evaluate the effects of sublimated sulphur both on fungal diseases and arthropod pests, different trials have been carried out. The incidence and the severity index for airborne pathogens were bi-weekly evaluated and the infestations caused by some of the most relevant pests have been regularly monitored. Moreover, the incidence of the viral disease TYLCD has been evaluated.

During the trials on mechanical methods, no physical damage to the beneficials was observed. The distribution in laboratory seems to be suitable for applications in biological control programs, and the results on protected sweet pepper crops showed a better spatial distribution and a more effective interaction beneficials/preys in the “mechanically released” plots than in the “manually released” ones.

The trials on sublimated sulphur confirmed the good effectiveness of the technique in controlling natural infection of tomato powdery mildew as well as a moderate efficacy on tomato late blight. A good protection has been registered in the case of arthropod pests: the tomato russet mite was totally controlled; appreciable results were also obtained on phytophagous insects. A significant reduction in viral infections was also observed.

Keywords: integrated pest management, mechanical device, sublimated sulphur.

Introduction

Integrated Production is “a farming system that produces high quality food and other products by using natural resources and regulating mechanisms to replace polluting inputs and to secure sustainable farming” (Boller *et al.*, 2004). In this context plant protection is a key factor and it is based on the use of biological, technical and chemical control methods carefully balanced.

In Sicily, among Mediterranean crops, a leading role is played by protected vegetables which cover an area of about 8,800 hectares with a production of around 430,000 tons per year (Bucca & Chinnici, 2008). The intensive exploitation of land, together with the altered environmental conditions and the very short cultivation cycles make this agro-ecosystem

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extremely unstable and therefore highly susceptible to attacks by biotic agents, both pathogens as well as insect and mite pests. The control of these noxious organisms is often performed by applying phytosanitary measures which are unacceptable from an ecological and toxicological point of view. The research on alternative ecologically sustainable control techniques is therefore fundamental to ensure high quality and safe products.

In Sicily, new experiences focused on one side on methods to improve biological control through mechanical releases of beneficials and on the other side on new techniques to apply sulphur as vapour phase against fungal diseases and pests.

Material and methods

Mechanical distribution of beneficials

Studies on potential mechanization of biological control are rather limited, then a first version prototype (Fig.1), based on the centrifugal principle (Blandini *et al.*, 2006) was designed by the “Dipartimento di Ingegneria agraria – Sezione Meccanica” at the University of Catania. The device was then evaluated for the mechanical release of *Phytoseiulus persimilis* Athias-Henriot and *Orius laevigatus* (Fieber), that control respectively *Tetranychus urticae* Koch and *Frankliniella occidentalis* (Pergande). These beneficials are normally commercialized mixed with vermiculite or buckwheat husk in plastic bottles and they are manually distributed on the infested plants. However, the manual-sprinkling method is time consuming and doesn't allow uniform spreading. The machine was used to release the beneficials which were placed, together with the carrier material into a hopper equipped with a distributor.

Trials were conducted under laboratory and greenhouse conditions to evaluate the vitality and the damage eventually caused to the predators, to determine the range of action of the machine at different working rates and to verify the distribution uniformity and effectiveness. Before being used in the trials the natural enemies were subjected to standard quality control tests (van Lenteren *et al.*, 2003).

The effects of the mechanical distribution were evaluated using 150 cm³ of product (carrier material plus natural enemies) per each trial. Mortality of the antagonists was assessed both as they came out from the hopper and after the release. In the trials concerning the effects of the hopper, the material was collected into a container, while the release tests were conducted spreading the product on a horizontal surface (140 cm wide and 180 cm long), placed 40 cm below the level of the release device. This kind of distribution was selected as it simulates a field release on crops at the right stage to receive beneficials. The material was observed under a dissecting microscope to record the number of live and dead individuals and to detect the presence and degree of eventual physical damages caused by the mechanical release.

Subsequent tests were carried out to evaluate the quantity of beneficials collected after the release and their distribution on the same surface employed in the previous trials. This was subdivided into 15 sectors (5 contiguous rows made of 3 sectors each) using rectangular plastic trays (36×47 cm) for collecting the released specimens and the carrier material. In *P. persimilis* release tests, the trays contained a thin layer of water in order to make the collection more effective. In this case, the content of each tray was filtered using a sieve (80 mesh) and the mites present in the separated material were then counted under a dissecting microscope.

The uniformity of distribution was evaluated collecting the material at the hopper every 10 seconds for *P. persimilis* and 30 seconds for *O. laevigatus*, due to the different size of dispersal

material fragments and to the different amount per bottle. Instead, the manual distribution was performed releasing the beneficials and the dispersal material in “sub-samples” of about 2 g each, gently rotating the bottle to mix the content between 2 releases. The number of beneficials released was scored and the dispersal material weighted for both kinds of distribution.

Trials aiming at evaluating the distribution with the device in motion were also conducted analysing the distribution of the material (substrate and beneficials) in relation to different speeds of the operator in covering a fixed distance, simulating real field spaces. A row of plastic trays of the same width of a plant row (around 50 cm), placed at a distance of about 30 cm from the machine pathway was employed. For the trials with *P. persimilis* a thin layer of water was poured in the trays for the already mentioned reasons.

The field tests were conducted on protected sweet pepper crops comparing, for both beneficials, mechanical and manual release plots. The doses applied were 10 specimens/m² for *P. persimilis* and 1 specimen/m² for *O. laevigatus*. The manual distribution was performed spreading the product on 3 to 6 plants in a row, randomly chosen at regular intervals walking along all or every other inter-row corridor; the mechanical release was carried out distributing the product proceeding along all or every other inter-row corridor.

For *P. persimilis* only one release was performed in both manual and mechanical treatments, while for *O. laevigatus* one and two releases (at 6 days interval) were compared. The trial with *P. persimilis* was conducted in a 1,000 m² greenhouse, infested by *T. urticae* and divided in 2 sectors (manual and mechanical release) separated by an untreated area. The observations were carried out on a sample of 150 leaves/sector, uniformly collected from all the rows. *O. laevigatus* trials were conducted in 2 greenhouses (A and B) extended 1,000 m² each, where 1 and 2 releases were performed respectively. Both greenhouses were divided in 2 sectors: “manual” and “mechanical”. The observations were carried out on a sample of 160 flowers/sector, uniformly collected from all the rows, scoring live thrips and predators.

Sulphur application

Studies on new techniques of sulphur application are based on the increased importance of agricultural and phytosanitary uses of this element in IPM, due to the recent knowledge on its physiological role and also on its reduced ecological impact. Curative activity is known for fungal diseases but only since last century this capacity was exploited in protection strategies also against arthropod pests.

Sulphur, even though solid at ambient temperature, is able to sublime when heated at more than 95°C and, in the vapour phase, it uniformly covers the plant surface. After heating it cools down and returns to the solid phase with particles between 5 and 14 microns, scattering on the whole crop surface, even on the inner areas of the plant not easily reachable with other spraying methods. Inside greenhouses sublimation is performed using dispensers constituted by a cylinder (ø 8 cm – h 20 cm) and a thermic device able to reach 190-200°C, transforming granular sulphur into vapour, without generation of SO₂. The device, made out of aluminium, stainless steel, porcelain and a resistor (70-100 W), is entirely composed by non-corrosive materials and it is alimented by an electric single-phase energy system (Fig. 2).

In order to evaluate the effects of this technique of supplying sulphur both on fungal diseases and arthropod pests, different trials have been carried out on Sicilian protected vegetable crops in comparison with control plots.

a) Fungal diseases

Two experimental trials were conducted in October 2006 through February 2007 and October 2007 through February 2008 in a typical Mediterranean greenhouse (900 m²) located at Marina di Ragusa (RG). The greenhouse was divided into five sectors, three of which with activated dispensers of sublimated sulphur placed between plant bines at 2.0÷2.5 m from the ground. Each dispenser covered a surface of 100 m² and was turned on 11 hours/night (from 19.00 to 06.00). In both trials transplant of tomato seedlings was performed within the first decade of October (2006 and 2007), the plant density was about 2.5 plants/m² and cultivars “Shannon” and “Ikram” were respectively used for the first and second trial.

Observations were periodically performed to evaluate the incidence and severity of infections caused by important airborne pathogens of tomato, as *Leveillula taurica* (Lév.) G. Arnaud, *Phytophthora infestans* (Mont.) de Bary, *Cladosporium fulvum* (Cooke), *Botrytis cinerea* Pers.:Fr.. The experimental design for both trials consisted in greenhouse subdivision into four randomized blocks (sectors), two with dispensers of sublimated sulphur and two without. Each sector was divided in two parts.

The disease incidence was evaluated as percentage of infected plants. An empirical 6-scoring points system was used to evaluate the severity of *L. taurica* natural infections on tomato: class 0 = healthy leaf; class 1 = 1-10% of infected leaf area; class 2 = 11-25% of infected leaf area; class 3 = 26-50% of infected leaf area; class 4 = 51-75% of infected leaf area; class 5 > 76% of infected leaf area. The severity of *P. infestans* natural infections on tomato was evaluated according to Barrat/Horsfall scale, consisting of 12 classes (index values from 0 to 11) (Horsfall & Barratt, 1945).

Analysis of variance was performed on the diseases parameters data using STATISTICS 7 (Statsoft Inc.). The data concerning disease incidence were previously transformed using the arcsine transformation (\sin^{-1} square root x).

b) Pests

Observations on protected tomato crops were carried out in 2004-2007 in greenhouses located respectively at Vittoria, Ispica and Marina di Ragusa (RG) in order to monitor arthropod pests. In all cases the cultivar was “Shannon” and the density was 2.5 plants/m². In the first two trials one greenhouse was considered as a single thesis and the device was turned on for 6 hours (August-November 2004) and 12 hours/night (October 2004-March 2005). The last trial (October 2006-January 2007) was performed in the same greenhouse used for the trials on pathogens where sublimated sulphur was supplied for 11 hours/night.

The infestations were regularly monitored: whitefly adults [*Bemisia tabaci* (Gennadius)] on the growing apex of 5% of the plants and leafminer adults (*Liriomyza huidobrensis* Blanchard) on yellow sticky traps placed inside the greenhouse were bi-weekly scored. Moreover, in the last trial, the evaluation of the damage caused by the tomato russet mite, *Aculops lycopersici* (Masse), was conducted by marking the number of plants with symptoms every 15 days, while TYLCD infection was monitored monthly counting the plants that showed clear viral evidence.

Results

Mechanical distribution of beneficials

During the trials, no physical damage to the beneficials was observed. The data obtained suggested to use the machine at a rotational speed of 600 rpm, that turned out to be optimal for the distribution of both beneficials tested, jointly avoiding waste of product. Also the distribution, evaluated first in the laboratory on a horizontal surface, seems to be suitable for applications in biological control programs.

The trials on the distribution uniformity showed that in the mechanical release *P. persimilis* was more abundant in the final release intervals; comparing this result with data on the amount of carrier material, which follow the same trend, a positive and significant correlation emerged between the 2 parameters ($y = -19.26 + 56.41 x$; $r^2 = 0.80$; $r = 0.90$; $p = 0.000$). In the same kind of distribution, the amount of *O. laevigatus* was instead higher at the beginning of the release. Also these data were positively and significantly correlated with the quantity of dispersal material ($y = -15.22 + 9.88 x$; $r^2 = 0.44$; $r = 0.66$; $p = 0.000$).

In the manual distribution the amount of *P. persimilis* was uniform among the sub-samples, with a positive and significant relation between the number of individuals released and the quantity of dispersal material ($y = -49.25 + 58.629 x$; $r^2 = 0.44$; $r = 0.66$; $p = 0.000$). The quantity of manually released *O. laevigatus* slightly increased in the last sub-samples and also in this case a positive and significant correlation with the weight of the dispersal material was recorded ($y = -1.94 + 16.56 x$; $r^2 = 0.57$; $r = 0.76$; $p = 0.000$).

The laboratory tests carried out with the device in motion aimed at making the necessary adjustments to the speed of the prototype in order to release the right amount of beneficials per area unit. The trials conducted in greenhouses on sweet pepper showed a better spatial distribution and a more effective interaction of the beneficials with the respective preys in the “mechanically released” plots than in the “manually released” ones.

The results of *P. persimilis* greenhouse trials were difficult to interpret because of the presence on the crop of an indigenous population of the predatory mite which somehow influenced *T. urticae* dynamics. But given the similar initial densities of both prey and predator in the 2 plots, the larger reduction in *T. urticae* infestation in the mechanically released area (Fig. 3) suggests a more efficient control of the pest after the release with the device.

The data collected in the *O. laevigatus* trials showed that in the greenhouse A (1 release) (Fig. 4a) the amount of predators was higher in the mechanically released plot, thus demonstrating that the more uniform the distribution is, the more rapidly the population density increases, possibly due to higher probability of sexes encounter and mating. In the greenhouse B (2 releases), calculating the percentage of rows where the presence of *O. laevigatus* was recorded, the predator was more widely spread in the mechanically released plot than in the manual one both after 6 days (35.29% vs. 11.76%) and at the end of the trial (70.59% vs. 41.18%) (Fig. 4b).

Sulphur application

a) Fungal diseases

In the 2006-2007 trial, the occurrence of powdery mildew infections (*L. taurica*) was detected on cv “Shannon” tomato since the first week of November. The final survey (30.11.2006) demonstrated a significant reduction of disease incidence and severity in the sectors where sulphur dispensers were activated (table 1). Tomato late blight (*P. infestans*) infections on leaves and stems were instead ascertained since the first decade of December. Two monthly surveys were performed on the treatments effectiveness. The results of the 1st survey

(19.12.2006) showed lower values of disease incidence and severity in sectors where sulphur was supplied as vapour phase. However, no significant differences were highlighted among treatments (table 1). Only following disease progression on the final survey (19.01.2007), it was possible to observe in the sectors treated with sublimated sulphur that tomato late blight incidence values were significantly lower than in the untreated sectors (table 1).

Table 1. Effectiveness of sublimated sulphur against *L. taurica* and *P. infestans* infections on protected tomato crops (cv "Shannon") in 2006-07 experimental trial

Treatments	Tomato powdery mildew (survey, 30.11.2006)			
	Incidence (%)		Severity	
Control	98.2 b		0.986 b	
Sublimated S	17.5 a		0.175 a	
Treatments	Tomato late blight			
	1 st survey (19.12.2006)		2 nd survey (19.01.2007)	
	Incidence (%)	Severity	Incidence (%)	Severity
Control	47.86	0.671	90.71 b	4.27
Sublimated S	3.21	0.036	40.71 a	0.563

Each value represents the average of 4 replicates each constituted by 70 plants. Values followed by different letters on the same column are significantly different at P=0.05. The analysis of variance on disease incidence was performed on percent values previously transformed in angular values. Severity was referred to Barrat/Horsfall scale.

In regard to the 2007-2008 trial, first infections of tomato powdery mildew were observed since late November but, because a very low disease level was detected, it was not possible to compare the treatments' effectiveness (*data not shown*).

Since the last decade of December 2007 it was also possible to observe the occurrence of tomato late blight, but only in control sectors. However four surveys were needed to evaluate the treatments' efficacy (on 24, 29 December, 5 and 19 January). For each survey the disease incidence and severity index were determined in all different treatment plots. The data analysis regarding the examined disease parameters has allowed to ascertain a good effectiveness of sublimated sulphur (significant data) already since the second survey and through all the remaining ones (table 2). In both trials no relevant *B. cinerea* or *C. fulvum* infections were reported on tomato crops.

Table 2. Effectiveness of sublimated sulphur against *P. infestans* infections on protected tomato crops (cv "Ikram") in 2007-08 experimental trial

Treatments	Tomato late blight					
	2 nd survey (29.12.2007)		3 rd survey (5.01.2008)		4 th survey (19.01.2008)	
	Incidence (%)	Severity	Incidence (%)	Severity	Incidence (%)	Severity
Control	7.5 b	0.16	31.25 b	0.56 b	83.96 b	2.25 b
Sublimated S	0.21 a	0.002	2.91 a	0.060 a	24.37 a	0.29 a

Each value represents the average of 4 replicates each constituted by 60 plants. Values followed by different letters on the same column are significantly different at P=0.05. The analysis of variance on disease incidence was performed on percent values previously transformed in angular values. Severity was referred to Barrat/Horsfall scale.

b) Pests

A good crop protection has been also registered in the case of arthropod pests. Appreciable results were obtained on leafminers and partially on whiteflies (Figg. 5a-e). The best results were

obtained with low numbers of pests and 12 hours of sulphur application especially in the case of whiteflies (Fig. 5c). In addition, a significant reduction in viral infections on the plants was also observed (Fig. 5g), probably due to a disturbing effect of sulphur on the behaviour of adult whiteflies. Further studies are therefore needed to investigate the mechanism of this interference. Preliminary observations didn't demonstrate also any harmful effect on pollination activity. The tomato russet mite has been totally controlled (Fig. 5f), obtaining a considerable saving of expenses, thanks to the absence of manual sulphur application.

Conclusions

The development of the device to mechanically release beneficials could be of great help to the farmers, ensuring better economic investment in terms of work, especially considering that no physical damage to the beneficials was observed and that the field trials showed a better spatial distribution and a more effective interaction beneficials/preys.

Sulphur in vapour phase has a good effectiveness in controlling tomato powdery mildew, although its activity in solid phase is already well known in literature. For the first time a collateral activity of sublimated sulphur against some airborne pathogens of tomato was observed. In detail this work showed an effectiveness, although moderate, of vapour applied in gaseous phase against tomato late blight infections on which a possible delaying effect has been observed. These encouraging results could suggest the employment of sublimated sulphur in mixture or alternation with other molecules or active ingredients authorized in biological production systems. The plots provided with the sulphur sublimation devices were protected against the arthropod pests considered, with a relevant reduction in expenses and levels of pollution. Moreover fruits didn't show any dusty sulphur residues in comparison with the traditional powdered application. Further investigations are in progress to verify the potential secondary effects on beneficials, the residues on fruits, in the environment, on the covering plastic films and the metallic structure of the greenhouses.

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Figure 1. Mechanical prototype



Figure 2. Sulphur dispenser

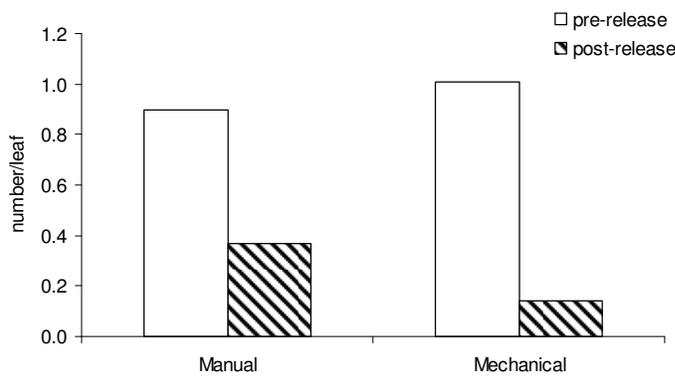


Figure 3. Mean number of *T. urticae*/leaf before and after the manual and mechanical release

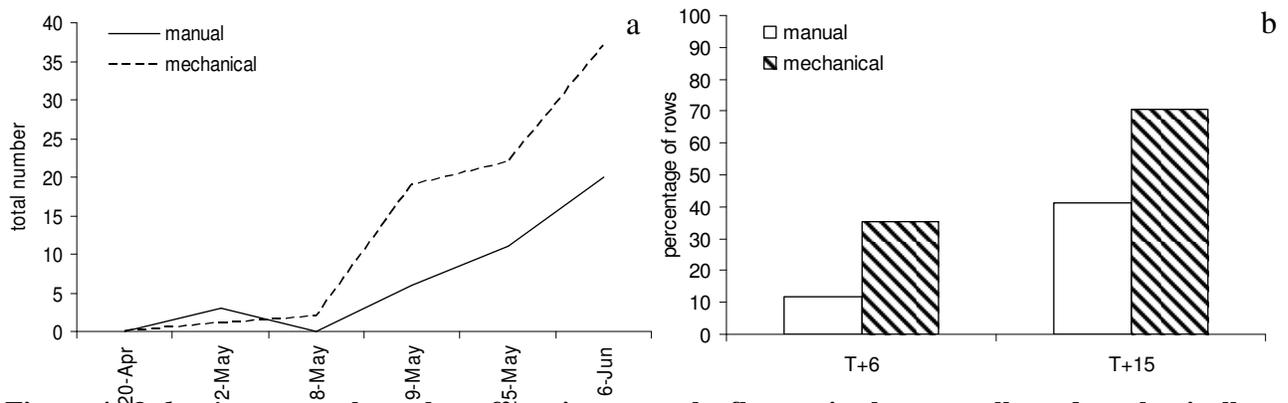


Figure 4. *O. laevigatus*: total number of specimens on the flowers in the manually and mechanically released plots (a); percentage of rows with presence of the beneficial in the manually and mechanically released plots, 6 and 15 days after the release (b)

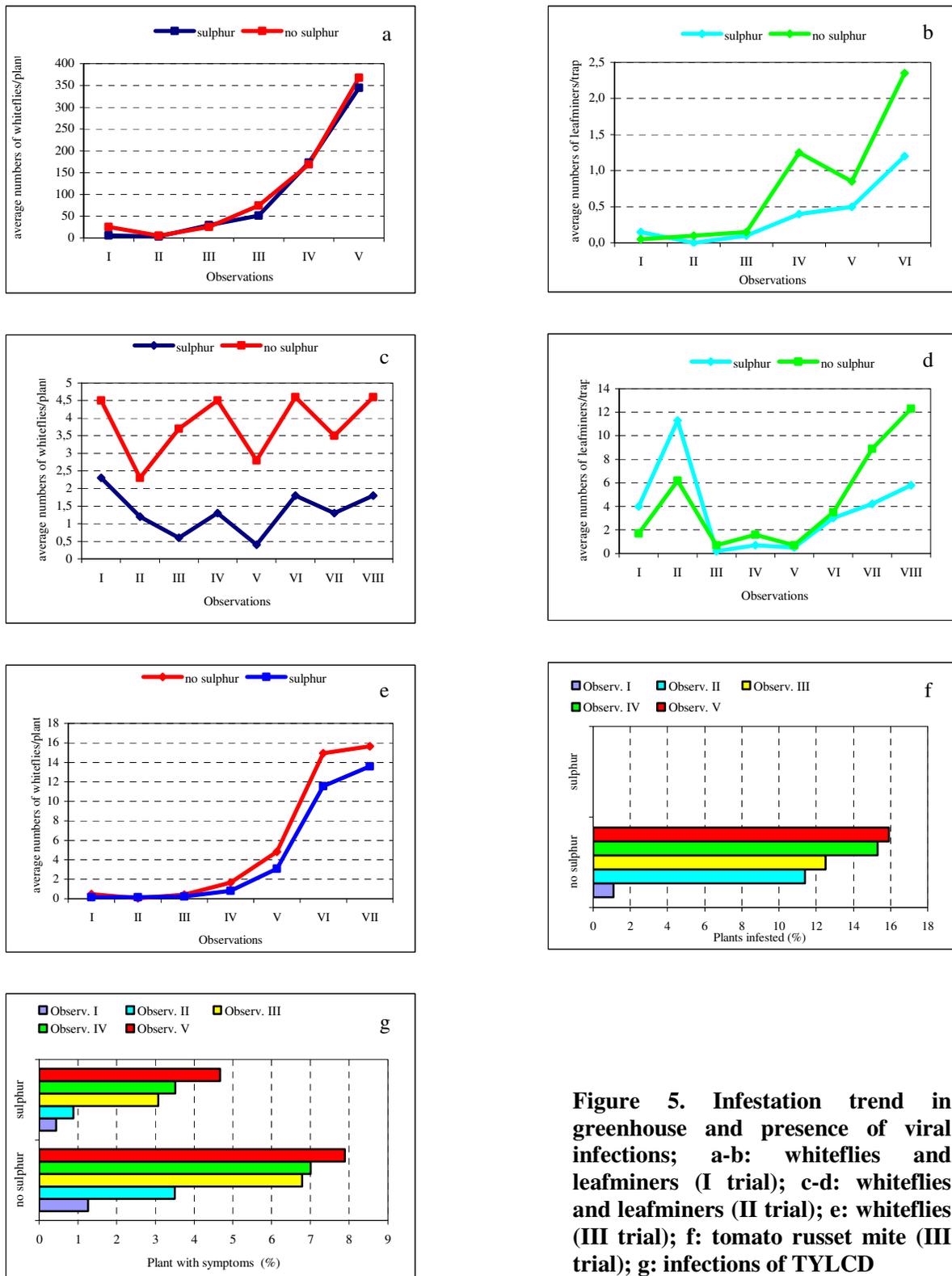


Figure 5. Infestation trend in greenhouse and presence of viral infections; a-b: whiteflies and leafminers (I trial); c-d: whiteflies and leafminers (II trial); e: whiteflies (III trial); f: tomato russet mite (III trial); g: infections of TYLCD

Analysis of a multifunctional experimental pilot plant for agricultural and dairy processing waste treatment

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Abstract

In this work a multifunctional experimental pilot plant with a reduced environmental impact which is able to process both fennel and liquid whey waste was developed and tested; such plant, using different thermal and filtration processes is able to recovery pectin and whey proteins in order to produce edible films.

An innovative feature of the proposed configuration is related to the possibility of a double type waste treatment, obtaining a final product with an higher economical value combining the two processing lines.

Keywords: Agricultural waste treatment, pectin, edible film, experimental pilot plant.

Introduction

In the past years, several changes occurred packaging industry in the food sector, following innovations and technologies of production systems. Important goals have been achieved in the production of composite multilayer films of synthetic polymers to protect foods, drugs and other products. But the accelerated growth of world population, increased consumption and the scarcity of resources, not mentioning environmental problems and climate, led research into new products equally or even more suitable in the context of renewable resources: in this framework an appealing goal is the production of edible and biodegradable films obtained from agri-food production waste that can even improve the quality of a food product, reducing the problems of resource availability and reducing the waste disposal problem. as agricultural and food processing waste disposal represents a major environmental problem for the large amount of waste produced and for their elevated BOD (Biological Oxygen Demand).

Edible films and coatings can be considered as "a thin layer of edible material, preformed or directly formed on food, used as a coating or inserted between the various components of the same" (Krochta and De Mulder-Johnston, 1997).

Available materials to form films and coatings are generally inserted in the categories of proteins, polysaccharides, fats and resins. A plasticizer agent must be often added to reduce film fragility, and a surface-active agent is often necessary to help the formation of films and coatings. Other constituent may include antioxidants and antimicrobials to improve its effectiveness.

In this context, this work aims to investigate the scale-up of a laboratory scale procedure (Giosafatto et al, 2007) for the extraction of pectin from fennel matrix (*Foeniculum vulgare* Mill. var. *azoricum* (Mill.) Thell.) and proteins recovered from the milk whey waste obtained from processing of buffalo milk. Materials used in polysaccharide films include starch and

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its derivatives, cellulose derivatives, alginates, carragenans, chitosan, pectates and different gums. Proteins can be combined with polysaccharides to change mechanical properties of film (Shih, 1994; Arvanitoyannis et al., 1996, 1997, 1998a 1998b; Arvanitoyannis and Biliaderis, 1998). Protein secondary, tertiary, and quaternary structures can be modified by various physical and chemical agents, including heat, mechanical treatment, pressure, radiation, lipidic interfaces, acids and alkalis and metal ions (Cheftel et al., 1985) and such agents are often used in the formation of films and coatings to optimize protein configuration and interactions, and properties of resulting films.

In the aforementioned categories, fennel and cheese production waste represent in Italy a significant problem, being the total amount of fennel waste estimated in Italy of 130x10³ t and cheese production generates 145x10⁶ t of liquid whey per year all over the world.

From an economical point of view, by-products are present in both wastes, and particularly fennel waste are rich of pectin and liquid whey contains a significant amount of proteins with an elevated biological value.

Many different processes have been developed in order to recovery nutrients or other components presenting an economical value, often with the aim of solving specific waste treatment problems.

Pilot plant description

The pilot plant is composed by a sequence of connected units and agitated tanks (6 jacketed tanks) in which is possible to perform mixing and mechanical breaking and degradation of agricultural and food waste matrices (variable speed rotating cutting blades are inserted into the tanks), thermal processes (heating and refrigeration units, and two plate heat exchangers), filtration processes (three different filtration units: a twin 100 µm metallic grid filter, and two polymeric variable size Millipore Polygard®-CR filtration cartridges), ultra filtration and concentration (a Millipore ultrafiltration unit with Millipore Pellicon2® cartridges).

All units are served by four peristaltic variable size pumps, with the possibility to reverse flow direction and to move products from any of the tanks to an other selected one, and temperature and levels are digitally controlled on the control console as well as blade rotation rate.



Figure 1. Comprehensive view of the experimental pilot plant.

Pectin extraction

Fennel cultivar was chosen for the great amount of agricultural waste as residual of transformation (Italy is one of the main world production) and the relevant pectin concentration in the fennel matrix.

As first step, the possibility of using a thermo-mechanical extraction without neutral pH was investigated. In fact, in fennel pectin are mechanically structured in the fennel matrix and for the relatively soft cellular membrane they can theoretically be extracted without using acid solutions.

At the beginning, industrial fennel waste from agri-food companies were used, and then for simplicity (being almost out of fennel production season) fennels from the market were used.

In order to setup an extraction protocol, thermo-mechanical process parameter were investigated, and more in details extraction time, temperature, and fennel matrix-water dilution ratio .

Tap water at pH=7 was used, warmed up to 80 °C in order to deactivate pectin degradation enzymes; once the temperature was set, the fennel matrix was inserted into the SA1 reservoir, where the rotating blade provides the mechanical action coupled with the thermal degradation.

A first difficulty appeared in thermo-mechanical degradation using fennel agricultural waste without preliminary cleaning treatment, due to the presence of green leaves tends to interact with the rotating blade, forming a capsule around it and strongly reducing the cutting capacity.

Moreover, as the aim of the project is to build edible films by combining pectins with proteins extracted from milk whey, in presence of low pH solution precipitation of the protein component may occur.

Acid treatment is usually required in literature to separate pectin from proto-pectins or in agricultural product with a thick epicarp like in Citrus or in tomato's skin.

Simple sugars, oligosaccharides, polysaccharides and their derivatives, including methylesters, which have free or potentially free reducing groups, give a yellow-orange color when they are treated with phenol and concentrated sulphuric acid. The reaction is sensitive and the color is stable.

Through the use of this reaction with phenol and sulfuric acid, was developed a method to determine infinitesimal quantities of sugar and related substances. In agreement with the paper partition chromatography , this method is used for determining the composition of polysaccharides and derivatives methylated (Dubois et al, 1955)

This procedure was used to determine pectin concentration in the samples extracted, because in previous studies has found a large amount of pectin extracted from fennel, and then polysaccharides found by reading the spectrophotometer were considered to belong to this category, not excluding the possibility that we can treat other simple sugars or complex. At first,

It was necessary to build a line of action and then analyze the samples extracted. Industrial pectins were used as a reference with a concentration of 15 µg /µl.

In Fig.2 the extraction yield of pectin vs. time is reported for two different mass dilution ratio (fennel kg/water kg, yellow = 1/5, blue = 1/10).

In the first dilution experiments 10 kg of fennel waste vs. 50 kg of water were used, and the solution was sampled fro 5 hours of thermo-mechanical treatment.

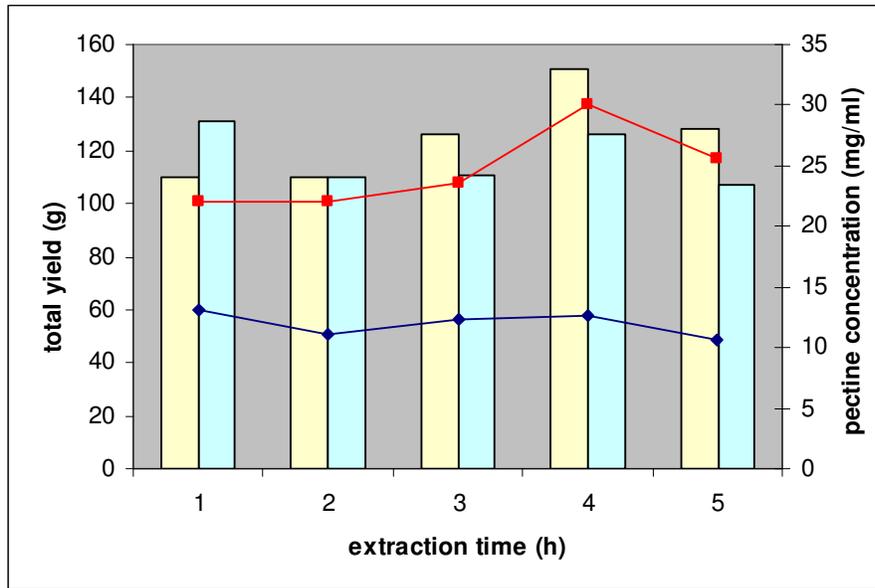


Figure 2. Total pectin yield and pectin concentration vs extraction time at 80°C

Results show that after one hour the extraction process is mostly completed, and that the final yield does not strongly depend on the dilution ratio, at least for the considered ratio.

Further reducing the initial ratio would result in a dense solution at the exit of SA1 tank used for fennel cutting and thermal degradation, increasing filtration problems in order to obtain a clean solution before reaching the ultra filtration unit for pectin concentration process.

In Fig.3 the effect of the presence of strong cellulose residual component formation in the fennel- water solution after thermo-mechanical maceration is shown.



Figure 3. Cellulose cake formation in the twin 100 µm filters

As a matter of fact the twin 100 μm metallic cartridge filter was not sufficient to clean the solution from this component, resulting in a cake formation around the filter with a lower cut-off scale, and consequently pectin entrapment in the cake before reaching ultra-filtration concentration process.

An interesting data emerging from Fig. 2 is a pectin concentration reduction after 5 hours of thermo-mechanical treatment, that can be consequence of a degradation process linked to enzymatic process of endogen de-esterification, precipitation due to the presence of Ca^{2+} in water, or b-elimination due to high temperature. In order to reduce Ca^{2+} concentration, a water column treatment unit was included in the pilot plant.

Time history of pectin extraction (see Fig. 4) shows that after 2 hours the concentration peak is reached, with constant concentration (results averaged of 5 extraction tests).

Several test were also conducted with different time-temperature configuration, showing that higher temperature then reported in literature are required to obtain a complete deactivation of pectinase enzymes to avoid polysaccharides reduction to simpler molecules.

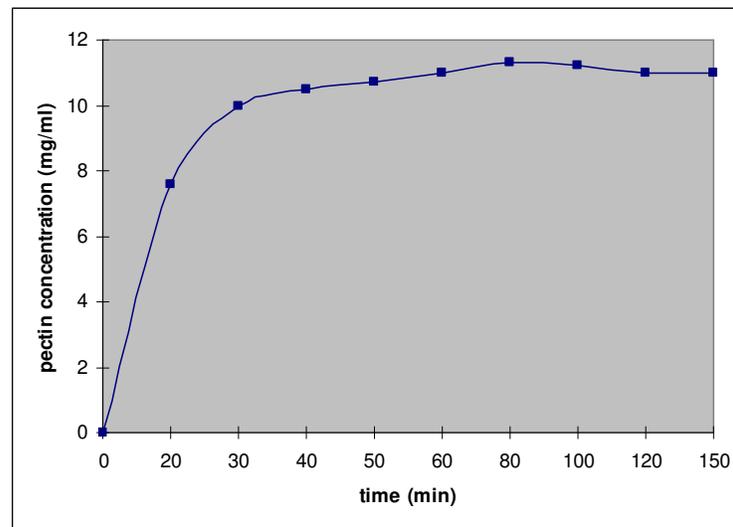


Figure 4. Time history of pectin concentration

Protein concentration

The second purpose of this type of experimental plant was to investigate the possibility of using the same configuration to extract proteins from dairy waste

Protein concentration was evaluated by using Bradford essay method (Bradford,1976, Stoscheck, 1990). Results are shown in Tab.1, where S_1 is the dairy hey at the initial concentration, S_2 after 100 mm filtration, S_3 after 25 mm filtration, P is the permeate, R_1 is the solution in the ultrafiltration tank at time $t=0$, R_2 at the end of filtering process.

Starting from a batch of 30 kg of dairy whey waste of buffalo milk used for mozzarella cheese production, after 1h30min ultrafiltrating with a membrane of 10k Da, 27 kg were discharged in the permeate.

Table 1 Protein concentration after ultrafiltration

Protein concentration after ultrafiltration	
Sample	g/l (min-max)
S1	0,804-1,54
S2	1,11-1,4
S3	1,05-1,4
P	0-0,06
R1	0,90.-0,96
R2	5,2-5.6

Edible film production

Combining together pectins extracted from fennel and protein obtained from dairy waste, under the action of the transglutaminase enzyme, it was possible to obtain an edible film (see Fig.5 a-b)



Figure 5 a-b. Edible film samples obtained by film casting

The first film (Fig. 5 a) was casted in a Petri plate by using pectin sampled after the thermo-mechanical treatment (before filtration), while the third using pectin obtained using concentrated and purified pectin after ultrafiltration.

As the main purpose of this work is to study the scale up properties of the experimental plant respect to the laboratory process, details of film permeability are not provided here.

Conclusions

The experiments conducted showed the possibility of using the proposed plant configuration for bio-products recovery from agricultural and food processing waste and biodegradable edible film production. Respect to the laboratory procedure, filtering and concentration seem to be relevant problems to address in order to switch from lab scale to industrial scale production, and a layout modification of the plant, inserting a centrifuge separation unit is probably required.

Moreover, an analysis of the permeability properties of the film is further required, in order to characterize a proper use of the product.

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Agricultural tire footprint shape correlation to treads penetration in different soils

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Abstract

Aim of this work is looking for a correlation between footprint and soil penetration volume of treads in agricultural tires.

Three tyres of different dimensions, fitted on the same tractor with different pressures and loads (N=not ballasted; Z=ballasted) were tested for defining the area of the single footprint shape (SF and SaF), of the multiple footprint shape (MF) and the volume of tyre in soil (V).

Footprints were obtained on rigid surface (SF and MF) and on soils (SaF: sand) with different penetration resistance (soil cone penetrometer value).

Contact area and void area (SF BW) were determined by a software that reads the footprint as an array of pixels in which black pixels and white pixels were distinguished. Volume of treads was measured from plaster mould.

The correlation between tires' footprint surface and volume of penetrated treads has been studied. Soil properties have effects on values but don't have influence on trend in test conditions. Volume of penetration is due mainly to the surface in which treads lean. In the same surface results are influenced by ballast and by inflation pressure. Like in previous study, the use of the ellipse method on image from sand doesn't allow to obtain high correlation with rigid surface, so this application, that with the volume could give the effective interaction between tire and soil, need more studies. The high correlation between data by volume on soil and data by multi-footprints give the possibility to read the interaction tire-surface by two different way.

Keywords: contact area, compaction, sand.

Introduction

In the manufacture of agricultural tires, tread design has particular significance on soil compaction, road behaviour and soil penetration. The problems of stressed soil after tire passages have been studied and pointed out. This effect depends by soil characteristics, vertical load on tyres and by the total pressure on the soil. Heavy vehicles running on soft, moist soils cause huge deflections of soil surface, which are irreversible and immediate after the first pass of a vehicle (Pytko *et al.*, 2005).

The measure of the tyre contact area on rigid surface has always been a reference for properties on soil and on road even if not faithfully representative of its real behaviour (Placckett, 1984). A procedure for defining the total area, the contact area and the void area has been pointed out from CRA-ING of Treviglio. Beside, footprint on rigid surface is not always sufficient to define the real behaviour on field. Aim of this work is looking for a correlation between footprint and penetration volume of treads in the soil.

Materials and methods

Tests have been conducted in Treviglio (BG) at the CRA – ING Research Laboratory during the last year. Three tyres of different dimensions (T1= 420/85R28, T2= 540/65R28,

T3=420/70R30) were fitted on the same tractor to tested in four different conditions. The experimental plan considered two inflation pressures ($p_1= 100$ kPa and $p_2= 160$ kPa) and two configuration of the tractor (CZ= with and NZ= without loads).

The tyres were fitted, in succession, on the rear axle of a 4WD agricultural tractor (tab.1).

Table 1. Tractor setting used in the tests

Tractor setting	Tractor mass (kg)		
	Front	Rear	Total
Not ballasted	1455	1810	3265
Ballasted	795	3440	4235

To obtain results about the four kind of contact area and the two kind of volume, the method consisted in placing the tyre on the rear axle of the tractor and applying static loads to obtain a deflection "footprint" on different surfaces. To prepare the tire to the single or multiple footprint on paper, treads were painted and placed on a contrasting surface such that a high contrast image of the deflected tread pattern was produced. To print the contact area on a sheet of paper set on the rigid surface the part of contact of the treads was covered with ink.

The footprint image (figure 1) was generated by statically loading the tyre on an appropriate surface, but for the multiple imprint (figure 2) the tyre was rotated in 5 different position in order to fill all the potential area that the tyre would cover. The footprint on the sand (figure 3), was obtained by means of single imprints.



Figure 1. Single footprint shape



Figure 2. Multiple footprint shape



Figure 3. Footprint shape on sand

After this step to generate the tyre footprint upon sheet or sand, a second step was applied for acquiring the image in digital size in which black regions correspond to tyre tread elements and void regions correspond to the space between the tread elements.

The elaboration of the digital image allowed determining the area of contact within footprint and the total area comprising an array of pixels of footprint.

In order to find the total area of the footprint image, a process of geometric construction was undertaken (Romano *et al.*, 2007).

Were defined the area of the single footprint shape on paper and on sand (SF and SaF), the treads area by black pixels (SF BW), the multiple footprint shape (MF) and the volume of footprint on sand and on soil (VOL SA and VOL TE). In this case before obtain each footprint was calculated the texture of the surface observing the penetration resistance by a soil cone penetrometer.

After obtained the footprint both on sand and on soil was prepared a plaster mould to keep the footprint and to extract the volume value.

Volume of treads were obtained from plaster mould shedding sand and by difference from a known volume (figure 4 and 5). In this case, volume sampler made by tread-shaped wood boxes with a known volume were placed on trends of plaster mould and were filled with sand.



Figure 4. Volume samplers placed on treads



Figure 5. A volume sampler is filling with sand

Results

At the light of all we said, four kind of data were obtained about area and two about volume.

But all collected data represent the same entity that is the interaction between the tire and the soil. So collected data were treated in a statistic model that considers these group of data (SF EL, SF BW, MF, SAF, VOL SA and VOL TE) like repetitions of the same test. In this way the elaboration could show the repeatability of results and the replaceability of a method on an other.

To this aim, was elaborated the table of correlations among all group of data that showed an high correlation (> 95%) between all group of data by paper (SF EL, SF BW and MF) and between data by volume on soil and on sand. Very interesting is the high correlation ($R=0,9022$) between data by volume on soil and data by multi-footprints that we understand like the possibility to replace a method on an other.

Values of contact area and of volume obtained in test are showed in figure 6 in which are indicated all conditions test and in which we can see trends of all group of data. All methods show different values but the same trend.

All values collected by paper show a low dispersion and the interpolation line in single and in multiple footprint have an $R^2 > 0,90$ (figure 7). Results on sand and in particular areas obtained from sand by the geometric method have too high dispersion ($R^2 = 0,33$) so the method doesn't show a good repeatability.

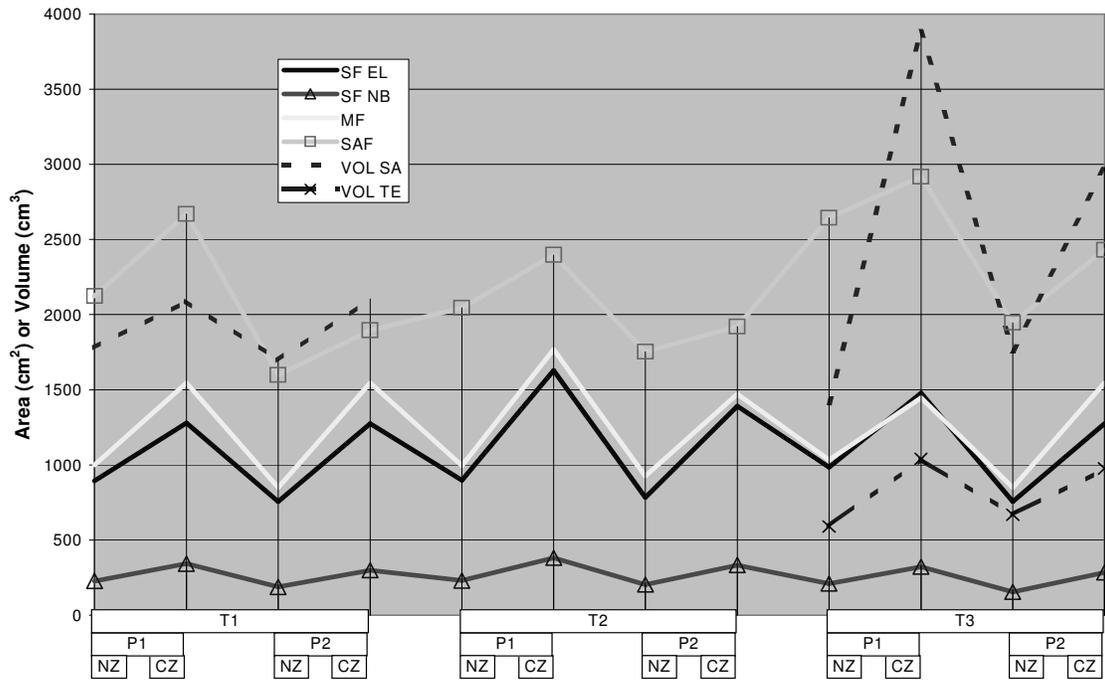


Figure 6. Values of contact area and of volume obtained in test

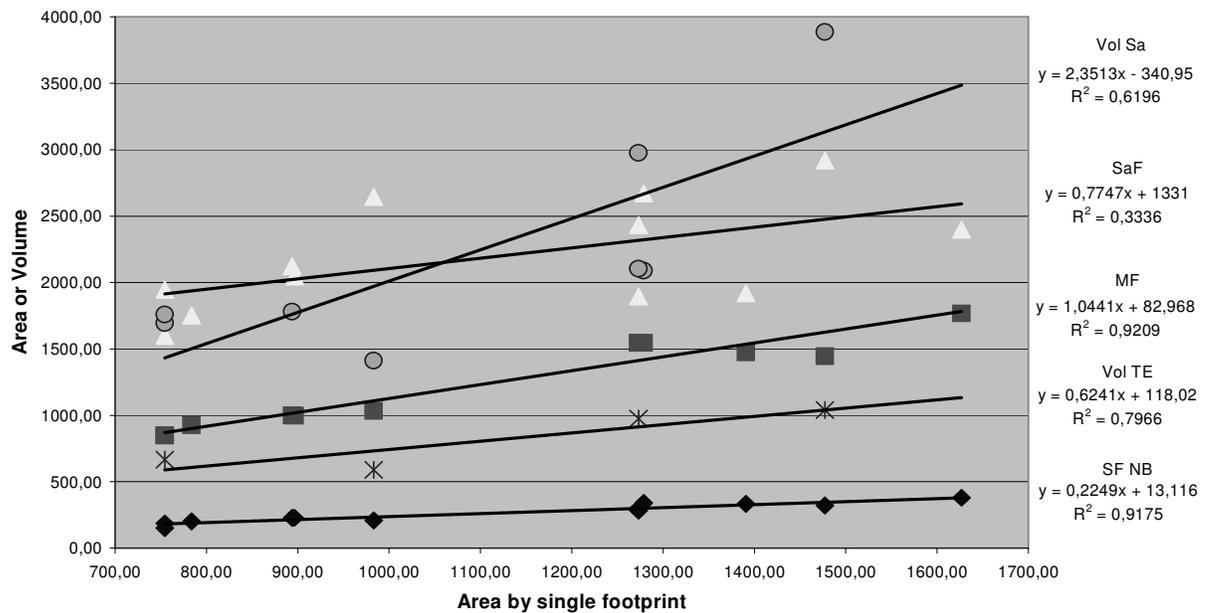


Figure 7. Dispersion of results obtained in all method applied in function of single-footprint ellipse method analysis

The Analysis of Variance to evaluate main effects and interaction among factors in tests, showed an high influence on results by inflation pressure ($p < 0,001$) and the loads of tractor ($p < 0,001$). However the dimension and the method didn't have influence on tests. Any interaction between factors didn't appear by this analysis.

So, with the support of the statistical significance, we can expose values of volume on soil and on sand instead of all results.

We can see how load and inflation pressure influences the penetration of treads on sand more than soil, but the trend in different condition is the same (figure 8).

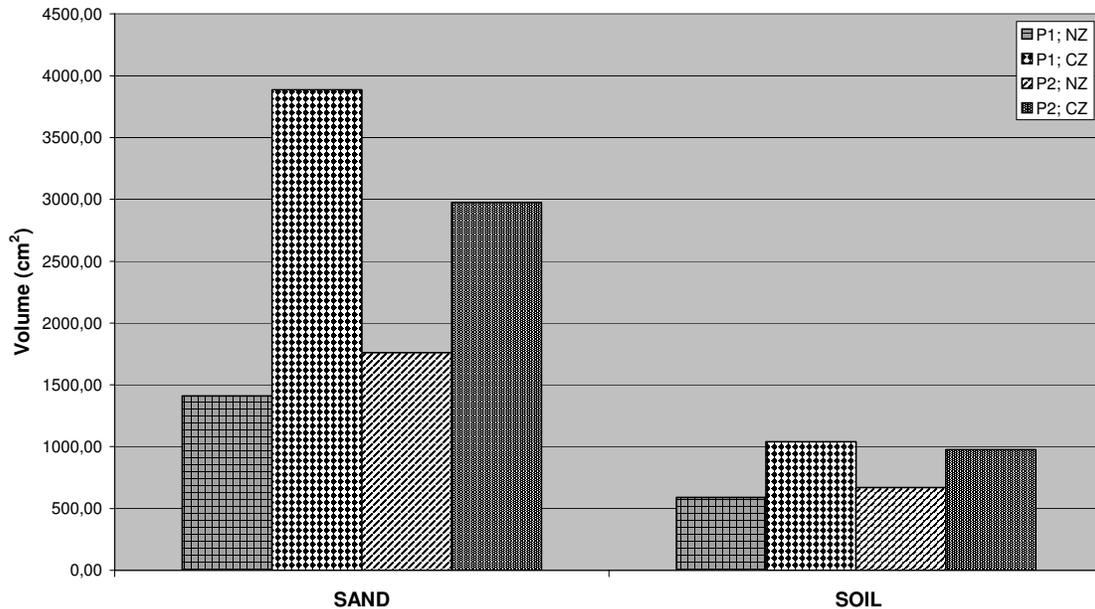


Figure 8. Volumes on sand and on soil

Conclusions

The correlation between tires' footprint surface and volume of penetrated treads has been studied. Soil properties have effects on values but don't have influence on trend in test conditions. Volume of penetration is due mainly to the surface in which treads lean. In the same surface results are influenced by ballast and by inflation pressure. Like in previous study, the use of the ellipse method on image from sand doesn't allow to obtain high correlation with rigid surface, so this application, that with the volume could give the effective interaction between tire and soil, need more studies. The high correlation between data by volume on soil and data by multi-footprints give the possibility to read the interaction tire-surface by two different way.

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Design of bakeries for the production of traditional Sardinian *carasau* crisp bread: features of the building and plant engineering

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Abstract

In this work the authors propose a method for the proper design of bakeries for the production of traditional Sardinian crisp bread known as *carasau*.

After examining the flow chart, they turn their attention to the sectors for raw materials (water, semolina, yeast, malt and so on), the production machinery and accessories (silos for storing the flours, fermenters, kneading machines, rollers, baking ovens and so on), spaces for manoeuvring and service areas for operators.

The study of the interconnections between the single elements leads to the idea of a plant and building layout which, depending on plant potential, can be applied to different production requirements. In this sense and as an example, the authors propose three typologies, all equally valid from the functional standpoint, but different as concerns architecture.

Keywords: design, traditional bakery.

Introduction

The food industry in general and in particular the small traditional bakery industry must supply the market with high-quality and safe products to meet the needs of consumers and at the same time must adopt standard and reliable procedures.

From the latest data available it emerges that in the two-year period from 2002 to 2004, Sardinia's baking industry saw a 17% increase in the number of persons employed, with an annual turnover of 73 million euros. The increase in employment is to be attributed to the increase in demand for this product on the national and European scales; despite the level of automation reached, this industry still presents a significant number of persons employed. From this arises the need to perform specific studies that take into account the needs of operators in relationship to the introduction of more efficient machinery and indicate solutions for buildings and plant engineering leading to an improvement in the efficiency of bakeries also through the design of specific layouts. For this reason it was considered important to study the problems connected with the setting up of small, efficient bakeries with the objective of finding certain objective criteria to which to refer, above all to avoid what has occurred in other sectors of the food industry, where spontaneous developments in plants and technology (wineries, oil presses and so on) have not always been accompanied by the necessary study of the buildings that house them.

Buildings for the production of *carasau* crisp bread

The drawing up of a plan for the production of *pane carasau* must therefore take into account first of all the organization of the production cycle by means of a detailed study of the single stages that characterize it and then verification of the activities that directly or indirectly enter into processing.

The study of the organization of work makes it possible to identify the functional areas that must be dimensioned to receive and store the raw materials (water, flour etc.), the

machinery necessary for production (ovens, fermenters, mills, filters, pumps and so on), storage containers with their accessories, as well as spaces for manoeuvring and service areas for operators.

The work cycle and layout of the building impact on the routes and interdependencies between the single sectors so as to arrive at the definition of dimensional standards.

In the same way, the study of interconnections between the single elements provides an approach to the schematic layout of the building.

Raw materials

The main raw materials used in the production of *pane carasau* are water, malt and yeast.

Work cycle

Technology for the production of *pane carasau*, also known as *carta da musica* ("musical bread") goes back to ancient times and has come down to us with relatively few changes in how it is made. The process includes the following stages: kneading, a first rolling out and beginning of fermentation, a second rolling out and then final fermentation. These stages are followed by shaping and cutting of the disks of *pane carasau*; then come the baking and separation by hand of the two layers obtained and then the *carasatura*, or second baking or finishing, of the end product. Production concludes with packaging in paper or plastic films for foodstuffs.

Plant 1 (Traditional)	Plant 2 (Simplified traditional)	Plant 3 (Continuous)
Spiral or fork bench blender	Planetary mixer	Planetary mixer
Roller and forming machine	Roller and forming machine with conveyor belt	Roller and forming machine with conveyor belt
1st Baking in a wood oven	1st Baking in a tunnel oven	1st Baking in a tunnel oven with automatic feed
Cutting and separating by hand	Cutting and separating by hand	Cutting and automatic separating
<i>Carasatura</i> (2 nd baking) in a wood oven and packaging by hand	<i>Carasatura</i> (2 nd baking) in a tunnel oven and packaging	<i>Carasatura</i> (2 nd baking) in a tunnel oven with automatic feed and automated packaging

Table 1. Work cycles with different levels of automation for different types of plants

Plants and equipment

Plant engineering for an efficient plant for the production of *pane carasau* is essentially composed of the following equipment:

- Storage silos (for semolina and water)
- Dosing machine
- Planetary mixer
- Fermenters
- Conveyor belt
- Rolling machine

- Shaping machine with conveyor belt
- Tunnel oven
- Automatic separators of the two halves
- 2nd tunnel oven (optional)
- Packaging machine

In traditional bakeries and those with a low level of automation the plant design can be further simplified by eliminating the conveyor belt rather than the shaper or the separator.

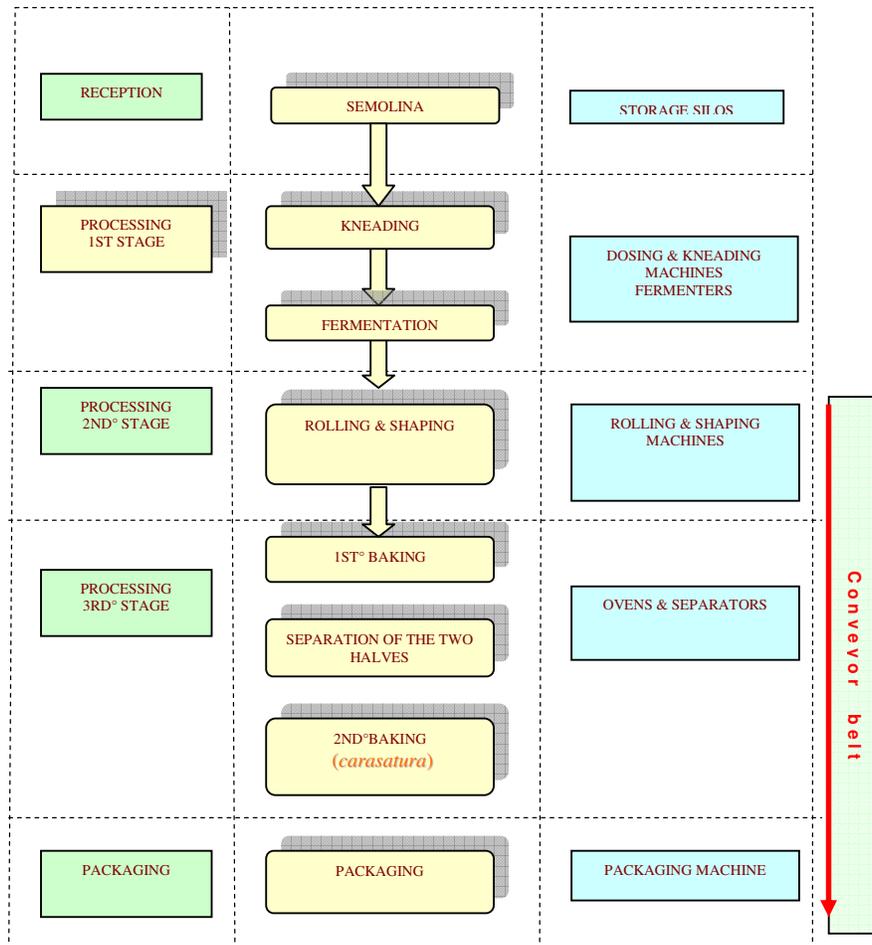


Diagram 1. Functional areas, work cycle and plant engineering in a small bakery

Planning method

Having studied the preliminary issues, it is opportune to proceed in the proper way through the design stage of a bakery by addressing the problems with a logical and consecutive order of priorities:

1. study of the production plan for a bakery having a potential of 300 kg/day;
2. overall consideration of problems involved in implementation and the subsequent preliminary stage of the project;
3. development of the various parts of the project from the functional and distributive

- profile;
4. elaboration on the basis of the chosen production cycle of the numerical values concerning times and production with respect to initial amounts of raw materials and potential in terms of kilos per week;
 5. choice of production machinery and storage containers on the basis of plant potential and all the other issues previously examined.

Thus we can state that the functional and organizational elements that go into the definition of a building structure for the production of *pane carasau* can be summarized in the following points:

a) work cycle

- Dosing of ingredients,
- Mixing,
- First rolling and beginning of fermentation,
- Second rolling,
- Final fermentation,
- Shaping and cutting of the disks of *pane carasau*,
- Baking,
- Separation by hand of the two layers obtained,
- Carasatura or second baking or finishing of the final product,
- Packaging.

b) definition of the functional sectors and the relative areas of:

- storage of raw materials,
- mixing, first rolling and beginning of fermentation,
- second rolling, final fermentation and cutting of the disks of *pane carasau*,
- baking and separation by hand of the two layers obtained,
- carasatura or second baking (finishing) of the end product,
- packaging.

c) operating spaces for:

- machinery and equipment,
- products,
- operators.

d) microclimatic and environmental needs.

The production plan

The hypothesis for a bakery arises from a feasibility study justifying its creation on the basis of the demand for traditional bread both in Sardinia, with noteworthy increases in the holiday season owing to the favour it enjoys among Sardinia's many visitors, and in the rest of Italy's larger market where it is now possible to find *pane carasau* all year round on the speciality shelves of supermarkets.

The necessary plants

To make the proper choice of equipment and establish the relative operational capacity, we drew up an executive plan by means of which it is possible to verify at every step the state and amount of product and the plants involved.

Through the study of the production cycle it is possible to dimension the necessary processing and storage plants and at the same time make a functional choice with respect to processing needs.

In detail the plants consist of:

- 1 stainless steel water tank, AISI 316, diameter 1.2 m, capacity 1000 litres
- 1 cloth silo for storage of at least 1000 kg of durum wheat semolina
- 1 water/semolina dosing machine, capacity 100 litres
- 1 planetary mixer, capacity 100 kg/hr
- 2 fermenters, capacity 80 litres each
- 1 shaping machine for disks of dough
- 1 conveyor belt, 10 m in length
- 1 rolling machine
- 1 tunnel oven
- 1 automatic separator of the two halves
- 2nd tunnel oven (optional)
- 1 controlled atmosphere packaging machine
- heat pump for conditioning of some areas
- forced-cycle air extractor with antibacteria filter
- 1 air compressor, capacity 200 l/min, max. pressure 10 bar
- 1 command and control electric panel
- pipes, accessories, ball and butterfly valves and so on.

Functional areas

The production structure must have the following functional areas:

- an area for storage of raw materials
- a fermentation area
- a rolling and shaping area
- an area for first and second baking
- a packaging and temporary storage area
- accessory areas

area for storage of raw materials

This is where raw materials, basically semolina, malt and water, are stored in steel and cloth silos. The surface of this area may be more or less large depending on the supplies to be kept on hand; when there are no local distributors of raw materials the area must be larger since the number of deliveries will be limited, with larger amounts delivered; if there are distributors nearby, the area may be smaller.

To be kept in mind is that this sector must be sealed and protected from humidity and parasites (insects and rodents).

fermentation area

Here is where we find the dosing machines for the automated preparation of the dough, the planetary mixers and the fermenters, together with auxiliary plants such as the heat pump required to control temperature and relative humidity.

rolling and shaping area

This can be adjacent to the previous functional sector since the activities performed here call for temperature and humidity conditions similar to the fermentation area. In this sector we have the rolling and shaping machines.

area for first and second baking

This represents the most characteristic sector of the bakery, since it is here that we find the tunnel ovens in which the first baking takes place, followed by separation of the two

layers which inflate like a balloon during baking; after separating the two layers they are left to cool and then baked a second time, the so-called *carasatura*, which gives the bread its characteristic shape of a rigid disk.

packaging and temporary storage area

After *carasatura*, the disks are packaged in bags and stored temporarily awaiting delivery to customers. In this area there is to be a packaging machine, also one with controlled atmosphere, and a series of shelves to temporarily hold the packages ready for delivery.

accessory areas

Here we have areas not closely connected with the production cycle, such as hygienic fixtures, dressing rooms, offices, heaters and air conditioners.

Functional arrangement

The first case, the simplest one, consists of maintaining the linearity of the flow chart by constructing a building with linear, rectangular modules, with entrance and exit opposite to one another situated on the two short sides. Among the advantages of this solution we have above all the simplicity of design and the full efficiency of the process since there are no obstacles between the different stages; among the disadvantages, the most important one is occupation of a large surface, with the consequent increase in volume and costs which can be offset only in the case of industrial production or in special cases in which no other solution is possible.

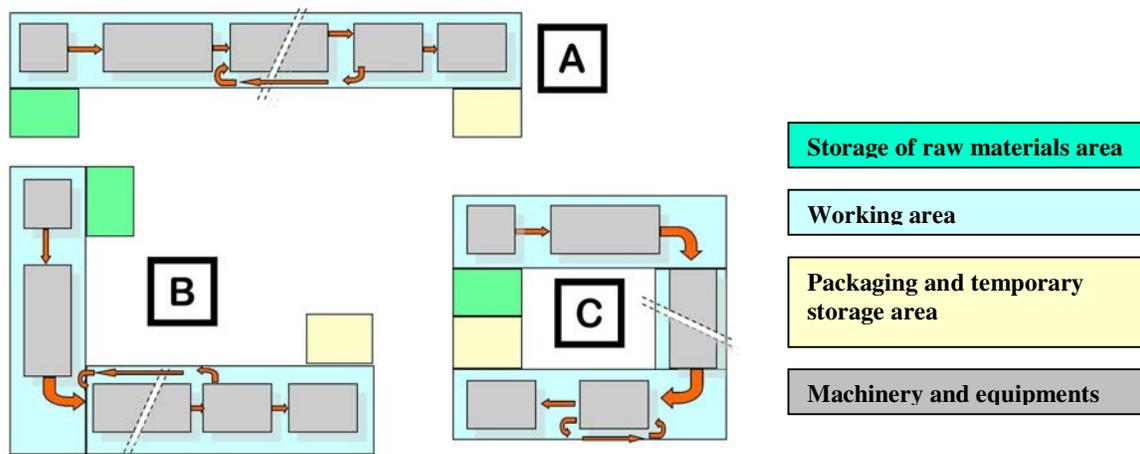


Figure 1. Possible functional configurations: A linear; B “L”- shaped; C circular

The second solution can be defined as an “L” or “U” configuration depending on whether the flow chart is divided into two or three segments respectively. Also in this case, as in the previous one, there are advantages and disadvantages: among the former we have the reduction in volume of the building and building costs; among the latter we have the presence of greater risks of obstacles owing to the presence of curves and junctions that lead to the creation of points common to two processes in the same module.

The third solution is represented by a ring in which, apart from the shape of the building, there is a circular movement of production with the entrance and exit (of raw materials and final products) that coincide. This design is undoubtedly the least expensive, but

it imposes organizational limits that cannot be overlooked, thus it is suitable for situations where economic capacity is limited.

Final considerations

The development of the subject leads to the following interesting conclusions:

- The necessary plant and equipment, although rather expensive at the time of purchase, are certainly of long duration thanks to the materials they are made of; they are easy to work with and clean and, for the type of plants examined herein, this work can be done by a single worker.
- The plant layout, once the needs of the specific work cycle have been satisfied, leaves great freedom in arranging the different functional sectors, the operative areas, the pathways and interdependencies, thus favouring a high standard of quality and genuineness.
- The layout allows a good degree of flexibility in use considering that for special market requirements it is possible to produce traditional bread of the *spianata* (flat) type with few changes to the plant.
- The buildings for use with this kind of bakery are fairly simple and the consequent floor plans do not create excessive difficulties from the structural standpoint.

In conclusion, we can state the validity of an initiative in this sector, keeping in mind that effective planning must include a careful analysis of every aspect of the work cycle adopted.

It is therefore auspicious a more widespread diffusion of these plants, realistically conceived for small and medium production units, which are reliable, simple and relatively cheap, as well as being capable of growing in step with a hopefully growing demand.

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Mechanization on golf course: comparison of two italian realities

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Abstract

In the last years a several golf courses were introduced in Italy thanks of the recent increase of golfers. At the same time there are many new machines and products now, and there will be in the next few years, to further mechanize golf course maintenance. Our study had the scope to analyze the grade of mechanization in two italian golf courses.

The chosen courses had a different location: the first in south of Italy and the second in the north of Italy. The comparison between the two courses have done particularly with regard to:

- **the amount of the machines available for the maintenance of the course;**
- **their technological standard;**
- **the best management practices in terms of minimizing water, fertilizer and pesticide through use of Integrated Pest Management and native or naturalized vegetation wherever practicable.**

Results showed the same number of machines available for both two courses.

Relating to the comparison about their technological standard it was clear that no one of the golf courses had machines with high technological standard.

Unfortunately the results showed also in both golf courses a waste of water, for the irrigation, an extreme use of pesticides and fertilizer. So for the future, a host of mechanical products will be forthcoming to help golf course operators reduce effort, time and costs. Moreover a number of best management practices to putting in practice might well be to prevent the pollution of the environment.

Keywords: machine, maintenance, environment.

Introduction

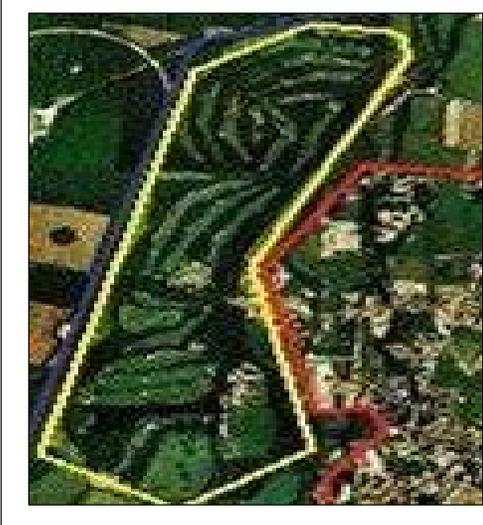
A current view of the less informed that golf is an elitist sport and only suitable for the elderly. Nothing could be further from the truth: there is evidence that golf is played at all ages and all seasons. From a health point of view golf is recommended as the best antidote to the physical problems caused by a sedentary life too. Based on a recent survey conducted by statistical CONI can assume that every 100.000 where there is average propensity to play golf at least 70 people: this average figure may rise even up to twice (140 inhabitants) in areas where socio-economic conditions and cultural facilitate further access to the game of golf. In Italy, during the last years, the number of the golf courses is strongly increased from few courses to 300 around thanks of the recent diffuse interest of italian golfers.

At the same time, that enthusiastic interest for the golf has improved the technological standard of the machines for golf course management and increased the sale of these products.

Materials and methods

The trials were carried out in two courses chosen because of their different location: the first in the South of Italy and the second one in the North of Italy.

Table 1 - Features of golf courses

		
Golf Course	Metaponto Golf Club	Monza Golf Club
Location	Metaponto (MT)	Monza (MI)
Date of birth	1991	1927
Number holes	18	27
Total area	70 ha	around 100 ha
Total lenght	6384 m	around 9120 m
Club house	yes	yes

The comparison between the mechanization of both golf courses have done particularly with regard to the main tasks:

- mowing;
- watering;
- fertiliser distribution;
- pest control;
- thatch removal;
- aeration;
- top-dressing;
- bunker raking and levelling.

In the following table it has been reported the usual equipment for the maintenance of a 18 hole golf course which has taken into account in order to evaluate the amount of machines of the courses examined and, at the same time their technological standard.

Table 2. Usual equipment in a 18 hole course

Task	Equipment
Mowing	3 mowers for green, tee and avantgreen with 3 cutting units
Aeration	2 green self propelled soil perforators and 3 soil perforators for fairway
Top dressing	3 machines to collect soil and 2 sand distributor
Thatch removal	1 self propelled or towed de-thatching
Pest control	2 dedicated sprayers
Fertilizer	Centrifugal distributor
Bunker raking and levelling	1 levelling blade and 1 rank

Moreover during the trials it have done a comparison of the frequency of the principal tasks considering the season and the respect of the best management practices, and the share, in terms of costs, of the principal tasks.

Relating to the best management practices in this paper we reported the timing of operations throughout the year.

Results

During the trials we registered the technical characteristics of the principal machines of both golf courses and collected the features of overall golf equipment.

Table 3. Features of walk green mower – Golf Club Monza

Machine	Golf Club Monza
Walk greens mower	Single cutting unit
Engine power	Kawasaki, 4 cycle, 2,8 kW
Weight	92,4 kg
Height of cut	2,0 - 25,4 mm
Width of cut	53,3 cm
Ground speed	2 - 5,6 km/h



Table 4. Features of riding fairway mower – Golf Club Monza

Machine	Golf Club Monza
Riding fairway mower	3 cutting units
Engine power	Kawasaki, 4 cycle, 20,9 kW
Weight	Around 500 kg
Height of cut	6 - 25,4 mm
Width of cut	254 cm
Ground speed	0 – 13 km/h



Table 5. Features of riding rough mower – Golf Club Monza

Machine	Golf Club Monza
Riding rough mower	3 cutting units
Engine power	26,1 kW, diesel
Weight	Around 500 kg
Height of cut	1,6 - 25,4 mm
Width of cut	150 cm
Ground speed	0 – 13 km/h



Table 6. Features of bunker rakes – Golf Club Monza

Machine	Golf Club Monza
Bunker Rakes	3 wheel drive
Engine power	13,4 kW, 4 cycle, diesel
Weight	368 kg
Width	150 cm
Ground speed max	17,7 km/h



Table 7. Features of aerators turf – Golf Club Monza

Machine	Golf Club Monza
Aerators turf	6 tine heads
Engine power	Tractor mounted, 18 to 26 kW
Weight	Around 560 kg
Aerating Width	152 cm
Ground speed	1,4 km/h



Table 8. Features of riding green mower – Golf Club Metaponto

Machine	Golf Club Metaponto
Riding green mower	3 cutting units
Engine power	4 cycle, diesel, 12 kW
Weight	426 kg
Height of cut	2 - 19 mm
Width of cut	150 cm
Ground speed	6 km/h



Table 9. Features of riding tee mower – Golf Club Metaponto

Machine	Golf Club Metaponto
Riding tee mower	3 cutting units
Engine power	4 cycle, diesel, 14,6 kW
Weight	659 kg
Height of cut	16 - 32 mm
Width of cut	157 cm
Ground speed max	14 km/h



Table 10. Features of riding fairway mowers – Golf Club Metaponto

Machine	Golf Club Metaponto
Riding fairway mowers	5 cutting units
Engine power	4 cycle, diesel, 27 kW
Weight	1346 kg
Height of cut	6,4 – 25,5 mm
Width of cut	350 cm
Ground speed	18 km/h



Table 11. Features of rough mower – Golf Club Metaponto

Machine	Golf Club Metaponto	
Rough mower	3 cutting units	
Engine power	Tractor mounted, 15 kW	
Height of cut	25 – 105 mm	
Width of cut	180 cm	
Ground speed	18 km/h	

Table 12. Features of bunker rake – Golf Club Metaponto

Machine	Golf Club Metaponto	
Bunker Rake	3 wheel drive	
Engine power	12 kW, 4 cycle, diesel	
Weight	422 kg	
Width	147 cm	
Ground speed max	16 km/h	

Moreover we analyzed the level of the mechanization and the maintenance of machines in both courses with particularly regard to the mowing equipment. The results have been described by the following table.

Table 13. Level of technical standard and maintenance

Technical standard	Green Rowing	Fairway mowing	Rough mowing	Tee and collars mowing
Golf club Monza	High	Medium	High	Medium
Golf club Metaponto	Medium	Medium	Medium	Medium
Maintenance				
Golf club Monza	Medium	Medium	Medium	Medium
Golf club Metaponto	Medium	Low	Medium	Medium

At the same time we reported in the table 14 the timing of the operation done during the year in the both courses in order to keep in evidence the different care in the maintenance of turf.

Table 14. Timing of the maintenance operations

Operation Timing	J	F	M	A	M	G	J	A	S	O	N	D
Greens mowing												
<i>Metaponto (6 times week)</i>		█	█	█	█	█	█	█	█	█	█	
<i>Monza (3 times a week)</i>	█	█	█	█	█	█	█	█	█	█	█	█
Fairways mowing												
<i>Metaponto (2 times a week)</i>		█	█	█	█	█	█	█	█	█	█	
<i>Monza (3 times a week)</i>			█	█	█	█	█	█	█			
Roughs mowing												
<i>Metaponto (3 times a month)</i>		█	█	█	█	█	█	█				
<i>Monza (2 times a month)</i>			█	█	█	█	█	█				
Tees and collars mowing												
<i>Metaponto (3 times a week)</i>		█	█	█	█	█	█	█	█	█		
<i>Monza (3 times a week)</i>		█	█	█	█	█	█	█	█	█		
Greens Aeration												
<i>Metaponto (once a year)</i>	█											
<i>Monza (twice a year)</i>			█						█			
Irrigation												
<i>Metaponto (every day)</i>		█	█	█	█	█	█	█	█	█		
<i>Monza (at least twice a week)</i>					█	█	█	█	█			
Pest control												
<i>Metaponto (2 times a month)</i>	█	█	█	█	█	█	█	█	█	█	█	█
<i>Monza (once a week)</i>	█	█	█	█	█	█	█	█	█	█	█	█

Conclusions

Concerning on the technological standard of the equipment, we are focused on the mowing equipment and the results showed better technological standard and maintenance in the Monza Golf Club than in the other one even if none of them was characterized by a high level of technology and maintenance of machines. Particularly we noticed a better conditions of use and maintenance of Monza Golf Club equipment probably stems from the high frequency of the operations.

Anyway with that level of mechanization in both courses also the time and effort required to do the job permits course operators to tath operation more often without damage to the green.

Relating to the maintenance operations it was clear that in the Monza Golf Club, because of longer rainy season usual in the north Italy, it was necessary a smaller amount of water than the Metaponto Golf Club where we calculated more than 800 m³ of water for green, tee and fairway.

The timing of the maintenance operations showed a higher frequency of pest control in a Monza Golf Club than the other course improving the risk of soil pollution.

The maintenance area is where pesticides are loaded into application equipment, mowers and other pieces of equipment are serviced, and pesticides, fuel, fertilizer, and cleaning solvents are stored.

This is where pollution of soil, surface water, or ground water is most likely to occur. Contamination can occur when pesticides are spilled, containers or equipment cleaned and the rinsewater dumped on the ground or discharged into surface water, or improperly cleaned containers are stockpiled or buried. Proper management of the maintenance area is an important part of responsible chemical and pesticide use.

So for the future, a host of mechanical products will be forthcoming to help golf course operators reduce risks, effort, time and costs. Moreover a number of best management practices to putting in practice might well be to prevent the pollution of the environment.

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Each author contributed in that paper in the same measure

Feasibility analysis of molten carbonate fuel cell – anaerobic digester power plant

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Abstract

The problem of electrical energy generation is a controversial topic which from a long time has attracted and still attracts the interest of many different research sectors. Problematic topics such as scarcity of fossil fuels or high CO₂ emissions directly related to worldwide energy consumption (estimated around 25000 million metric tons) lead to investigate new energy sources. In 2004, worldwide carbon dioxide emissions from energy consumption have been estimated around 25000 million metric tons (F.J. Friedrich et al. 1999). This huge amount of emitted carbon dioxide represents a strong threat for the environment and has pushed research efforts to the application of renewable energy sources.

These compositions present a remarkable amount of methane, thus the energy content of these gases is considerably interesting for energy recovery. Due to the large amount of fossil fuels employed for electricity and heat production, the use of biofuels is specially interesting for these applications.

Different technologies are currently available for combined production of electricity and heat. Even if internal combustion engines (I.C.E.) represent the most employed technology due to its high reliability widely demonstrated for decades, fuel cells is a very promising one.

Several system solutions have been proposed for integrating fuel-processing systems and MCFC (A. Moreno et al 2004) and the resulting performances are very high compared to traditional systems for energy conversion of biogas. The main goal of this work is focused on the production of electric power and heat through a MCFC system fed by biogas from anaerobic digestion. The main advantages of this system are:

- **Low environmental impact;**
- **High efficiency;**
- **Possibility of co-generation;**
- **Size flexibility;**
- **Replacement fossil fuels.**

Keywords: fuel cells, anaerobic digester, methane.

Introduction

Besides traditional approaches for the valorisation of biogas, the possibility of using biogas to run Molten Carbonate Fuel Cells (MCFC) for the production of combined heat and power (co-generation) is showing interesting results. The aim of this study is to assess the benefits and draw-backs of this energy system and to compare it with traditional biogas applications. Both technical and economical analysis of a real case-study are carried out. The selected case-study is a pig manure treatment plant located in Marsciano, near Perugia, Italy.

The performance of MCFC operating on biogas is assessed through experimental activities carried out at the Fuel Cell Group laboratory of the University of Perugia (Italy). Every test in which the MCFC has been run with biogas from an anaerobic digester, showed a highly satisfactory operation of the fuel cell. The economical analysis is based on the net present value (NPV) of an MCFC system and compared to an internal combustion engine

system. Costs for the MCFC system are assumed to be equal to 1500 €/kW, 2000 €/kW and 3000 €/kW and it has been analyzed the difference between them.

Different cases with or without economic incentives and with or without co-generation have been studied. Green certificates (i.e. governmental incentives due to the low emissions) are also taken into account for NPV calculation (P. Lunghi et al 2001).

Material and methods

System description

The case study is a farm in Marsciano (Perugia, Italy) where pig manure is treated in two anaerobic digester to produce biogas which will be fed into a MCFC system. It serves different customers in a territory of 36 km². As shown in figure 1, this plant is composed of: 1) waste adduction section; 2) sewage storage: that minimize the fluctuation of incoming sewage; 3) two groups of pumps, used for sending the sewage to the digesters; 4) two primary anaerobic digesters, that can work in series or in parallel configuration; 5) one secondary anaerobic digester working for sedimentation and for collection of biogas; 6) sludge dehydration system (centrifuge); 7) cleaning treatment of biogas (desulphurisation); 8) aerobic stabilization; 9) compost system; 10) two internal combustion engine (ICE: 374 kW and 511 kW). The energy recovery section is currently represented by two I.C.E.s with nominal power of 370 kW and 510 kW. The aim of the present study is to demonstrate the feasibility to replace I.C.E.s with M.C.F.C. system. After the adduction section, there is an equalizer system to avoid flow fluctuations of incoming sewage. Sewage is then sent through two groups of pumps to the anaerobic digesters, two primary and one secondary. The two primary digesters may work in series or in parallel. The secondary anaerobic digester is used to increase the efficiency of biogas production and also acts as biogas storage system. The plant has the sludge treatment line and the biogas treatment line (desulphurisation of biogas) (A. Moreno et al 2004).

Use of Molten Carbonate Fuel Cell System

This work analyzes the use of MCFC system instead of ICE system. An internal report of Marsciano's plant (S.I.A. Engineering, 2003) shows that (in 2003) 2,16 million m³ of biogas (chemical composition shown in table 1) have been produced. Taking into account the Low Heating Value (LHV) of biogas and the electric efficiency of the MCFC as 50%, the potential production of electrical power is 710 kW_e. Today, for ICE with an electric efficiency of 30%, the installed electrical power in the plant is 885 kW_e. MCFC system maximum power output can be calculated through the following relations:

$$W = B \cdot \frac{C}{100} \cdot L \cdot \frac{E}{100} \quad (a)$$

where:

B = volumetric flow of biogas [m³/h];

C = CH₄ in biogas composition [%];

L = LHV, Low Heating Value of CH₄ [kJ/m³];

E = electric efficiency [%];

W = maximum power [kW].

The values of these parameters used in this case study are shown in table 1.

Table 1. Values used in case study

B	C	L	E	P
[m ³ /h]	[%]	[kJ/m ³]	[%]	[kW]
246,58	58	34535	50	713

Results

The chemical composition of the biogas from Marsciano plant after passing through a reforming process has been simulated in the lab. This composition is supplied and controlled by using a software. The chemical composition after reforming is shown in table 2.

Table 2. Chemical composition (%) after reforming

CHEMICAL SPECIES	REFORMING COMPOSITION
H ₂	39.34
CO ₂	18.97
CO	9.14
CH ₄	0.27
H ₂ O	32.28
O ₂	0
N ₂	0

The tests have been executed on a single MCFC produced by Ansaldo Fuel Cells Spa. The test rig is composed of different parts as shown in figure 1.

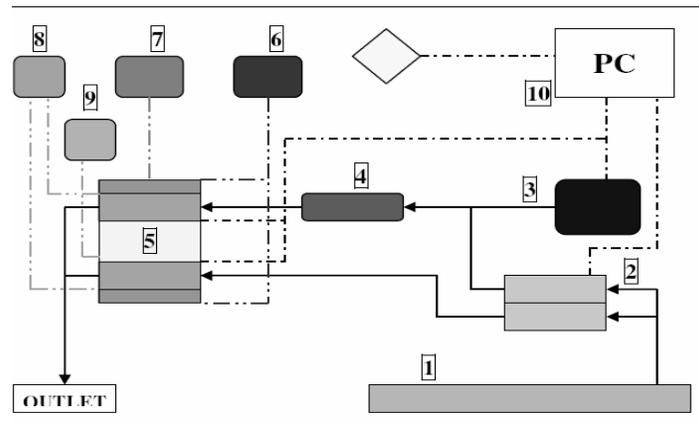


Figure 1. Outline of the laboratory: 1) Gas bottles box, 2) Digital mass flow meters, 3) Humidification system, 4) Heaters, 5) Single fuel cell, 6) Hotplate (temperature 650°C), 7) Pressure 4 bar, 8) Electric load, 9) Safety system, 10) Control system

An external box, containing different gas bottle, is connected to the lab. Inlet gas compositions are controlled by digital mass flow meters. The humidification system is fundamental to avoid carbon deposition (formation of solid carbon that could damage the FC).

Two hotplates increase the gas temperature, while the pressure system controls the pressure. The current for the polarization of FC is supplied by an electric load. The safety system is composed of sensors to detect leakages of H₂, CO₂ and others dangerous gases. The control system consists of a pc to control every part of the system and tests results. The first test generates the polarization curve, showing the variation of the fuel cell voltage in relation to the current density (b) for fixed inlet gas compositions. This polarization curve is shown in figure 2.

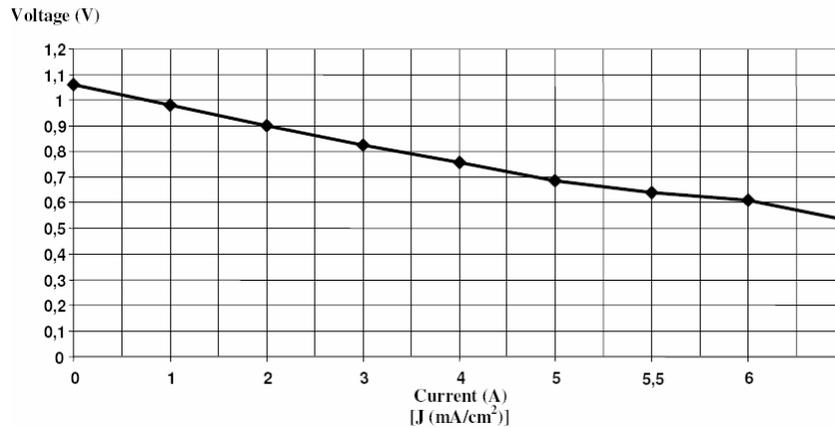


Figure 2. Polarization curve

The second test shows the voltage as a function of current density for a range of fuel utilization (c), shown in figure 3.

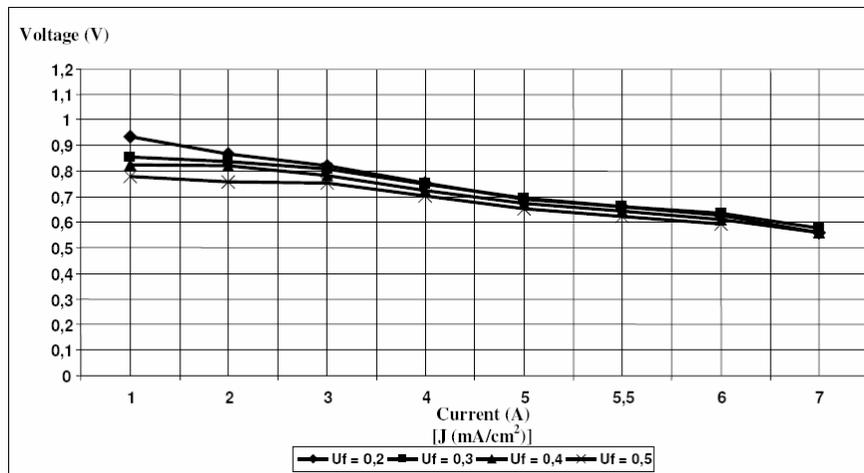


Figure 3. Voltage-Current - Uf

These curves show that biogas with these compositions is suitable for feeding fuel cells, after passing through clean-up process.

$$\text{CurrentDensity} = J = \frac{\text{Current}}{\text{ActiveArea}} \text{ [mA/cm}^2\text{]} \quad (\text{b})$$

$$\text{FuelUtilization} = U_f = \frac{\text{FuelConsumed}}{\text{Fuel Provided}} = \frac{e^-}{2(H_2 + CO)} \quad (\text{c})$$

where:

e^- = electron flow [mole/s]

H_2 = inlet hydrogen flow [mole/s]

CO = inlet carbon monoxide flow [mole/s]

The aim of experimental tests was to assess the possibility of using this alternative gas under different values of relevant input parameters i.e. total current, current density, utilization factor (P. Lens et al 2005).

Economical analysis

The essential part of this work is the economical analysis described as the relation between the current use of ICE and the use of MCFC. This relationship has been established using NPV (Net Present Value, (d)) under two different scenarios, with and without economic incentives, with a sensitivity analysis assuming three different initial investments, 1500 €/kW, 2000 €/kW, 3000 €/kW. Moreover, the relative importance of the cogeneration in both cases has been studied. After performing the technical analysis, the economical analysis using as term of comparison NPV is defined as:

$$NPV_n = -I_0 + \sum_{k=0}^n ACF_k \quad (\text{d}) \quad ACF_k = N_k \cdot \frac{1}{(1+i)^k} \quad (\text{e})$$

with:

I_0 = investment cost [€],

n = years.

i = discount rate,

N = cash flow [€/year],

ACF = Discounted Cash Flow [€/year],

The cash flow is the difference between the benefits (through the sale of the thermal and electrical power) and total cost ($P + M$):

$$N_k = R_k - (P_k + M_k) \quad (\text{f})$$

$$P_k = P_{k-1} \cdot (1+r) \quad (\text{g})$$

$$M_k = M_{k-1} \cdot (1+i) \quad (\text{h})$$

where:

R = benefits [€/year],

P = personal cost [€/year],

M = maintenance cost [€/year],

r = inflation rate.

Maintenance and personal costs aren't constants in the time, but in case study they are considered in relation of inflation and discount rates. In the case study the relation between the use of MCFC and present scenario (two ICEs) has been analyzed. In both cases, the possibility of co-generation has been considered. The goal of this analysis is highlighting the

most relevant parameters for the insertion of MCFC in fuel cell's market (A. Moreno et al 2004). A software for macro and micro economical laws has been used.

Table 3. Economic real data

Disc. rate %	Infl. Rate %	Thermal energy cost €/kWh	Electrical power cost €/kWh	Maintenance cost (% of Initial Investment)	Personal cost €/year
5	2	0,057	0,182 (8 years) 0,0516 (after 8 years) 0,031 (without incentives)	10	3443

The economic real data shown in table 3 has been used. Figure 4 shows the evolution of NPV with time for both scenarios: future use of MCFC and present use of ICE.

In this figure, it is shown that the payback-time of MCFC system with initial investment of 1500 €/kW and 2000 €/kW is about one year, as ICE present system; the payback-time of MCFC system for initial investment of 3000 €/kW is about two years.

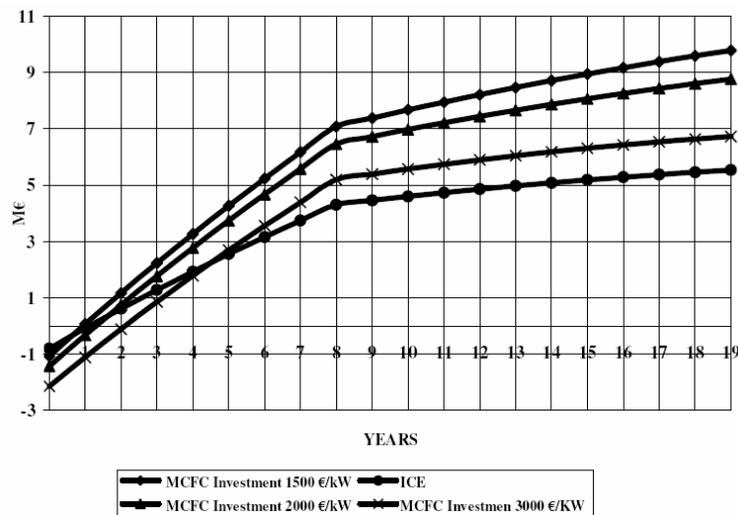


Figure 4. NPV with incentives and with co-generation

The slope of MCFC systems curves is the same or higher than the slope for ICE system curve. After the cross point of these curves, the higher slope of MCFC curves, the higher economical benefits for higher economical efficiency. In figure 5, the case without economical incentives is considered and it shows that the payback-time of CFC system with initial investment of 1500 €/kW and ICE system is the same, about two years; for MCFC system with initial investment of 2000 €/kW is four years and with initial investment of 3000 €/kW is twelve years. In figure 6, the case without co-generation and with economical incentives is considered showing the importance of cogeneration with different payback-time, between one and two years for MCFC system with initial investment 1500 €/kW, 2000 €/kW and for ICE system and of three years for initial investment of 3000 €/kW.

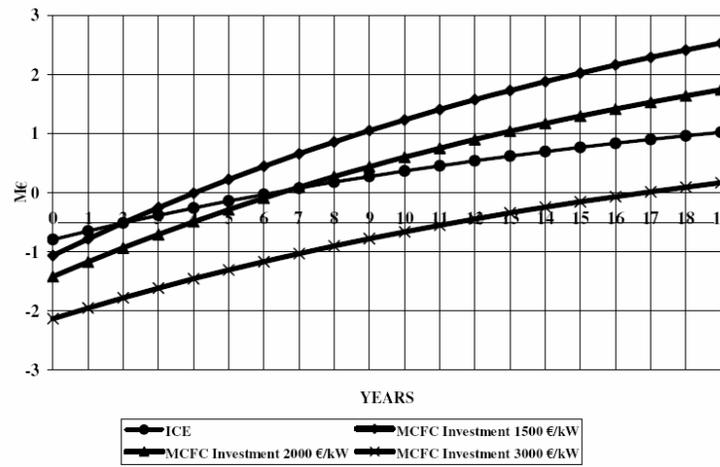


Figure 5. NPV without incentives and with co-generation

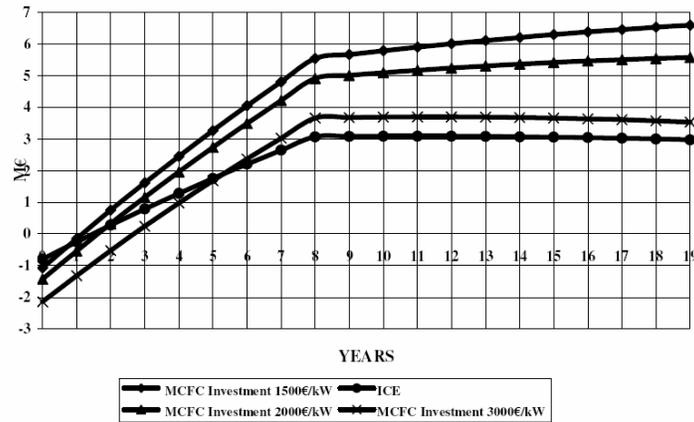


Figure 6. NPV with incentives and without co-generation

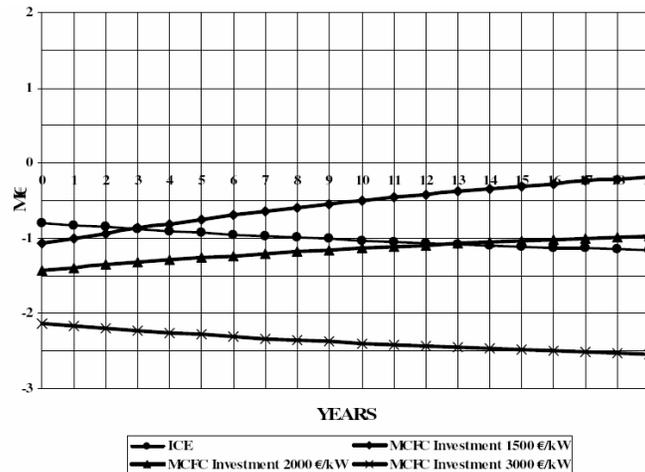


Figure 7. NPV without incentives and without co-generation

The case without co-generation and without economic incentives is not interesting because it has higher payback-times. It is shown in figure 7.

All these curves show that, with initial investment of 1500 €/kW, 2000 €/kW and 3000 €/kW, the use of MCFC is more economic than the ICE currently installed ICE. Moreover, economic incentives are very important, without them both configurations would have less advantages. Lastly, co-generation is essential for the economical and technical efficiency in both scenarios: use of ICE and use of MCFC system.

Conclusions

The conclusion of the study is that, although fuel cell systems diffusion is still limited due to the high manufacturing costs and the need of technology improvements, the possibility of integrating an anaerobic digester with an MCFC represents a potential business especially if the environmental benefits are translated into an economical saving. The tests carried out by Ansaldo dealing with single fuel cells, have been mainly focused on the use of biogas with low LHV (Low Heating Value) as biogas by anaerobic digestion. Their eventual use in MCFC involves a reduction of the emissions in atmosphere and higher electrical efficiency. In the last phase of the work, the economic analysis of the real case of Marsciano (Perugia) comparing new technologies (MCFC) to traditional ones (ICE) has been performed. This analysis, performed by using an Excel application, provides a number of diagrams that show the future possible use of fuel cell for thermal and electrical power production.

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The contribution to the programming and executing of this research must be equally divided by the authors.

Evaluation of the physical-mechanical properties of potatoes during conservation

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Abstract

The potatoes are traditionally submitted to cold storage to adapt their intake on the market. The time and storage conditions influence the potatoes quality and consequently their susceptibility to handling.

According to these considerations, it is important to determine how the storage might modify the physical-mechanical properties of the potatoes.

Laboratory tests were therefore carry out on two cultivars (*Solanum tuberosum* L.: Vivaldi and Primura) and during two years of harvesting. Potato tubers were held in controlled storage (temperature 4,5 °C, humidity 80%) over a period of 240 days. Quasi-static compressions were performed on the entire tuber for failure determination and on cylindrical specimens for Young's modulus and Poisson's ratio evaluation. The tests were periodically carried out.

The aim of this study is the evaluation of cultivar and storage time influence on physical-mechanical characteristics and quality of potatoes.

Keywords: potato, storage, mechanical properties, food quality.

Introduction

The quality of potato tubers, as in all horticultural produce, is closely connected to the chemical and structural characteristics of plant tissues and varies widely in relation to different factors such as climate, growing conditions, cultivar and maturity at harvest and harvesting method (Bentini et al., 2006). In the case of potatoes, storage conditions also influence these characteristics (Burton, 1989).

Quasi-static mechanical tests are widely used to obtain objective data on the mechanical characteristics and textural properties of vegetables (Rosenthal, 1999; Blahovec, 2001; Wihelm, 2004; Lu and Abbott, 2004).

The uniaxial compression test is the most common means of deriving stress-strain properties of fruit and vegetable products.

The storage type and time influence the level of evaporation and respiration of the tubers and therefore the tissue characteristics and product quality (Mohsenin, 1986).

The change in mechanical properties of stored potato tubers appears to be mostly determined by physiological changes involving the structural components of the tissues (cell wall, middle lamella) in relation to the loss of cell water by evaporation and the production of cell water by respiration (Alvarez and Canet, 2000; Brusewitz et al., 1989; Gao et al., 1989).

The aims of this research were to determine and compare the mechanical properties of two cultivars of potato kept in a cold-storage for 180 days through the application of mechanical tests.

The specific objectives were:

- to evaluate the physical-mechanical properties of the potatoes by means of quasi-static compression tests;

- to analyze the effect of storage time on the mechanical characteristics of the potato tissue.

Material and method

The tests were conducted using two potato cultivars (*Solanum tuberosum* L. cvs Vivaldi and Primura) two of the most widely-grown cultivars in the Po Valley, Italy. Both cultivars are for fresh consumption and were cultivated in the 2005 and 2006 crop seasons.

After harvesting, the tubers, stockpiled in wooden bins, were kept for three days in a pre-conditioning area at a temperature of 15 °C, before being stored at 4.5 °C and 85% relative humidity for a maximum period of 240 days.

A series of experiments was conducted to examine the mechanical properties of potatoes under quasi-static compression loading conditions. The tests were conducted on cylindrical specimens for the determination of Young's Modulus and Poisson's Ratio. The tests were repeated at intervals of 2-3 months; each time, the potatoes were reconditioned at room temperature during the night prior to testing.

The uniaxial compression tests on cylindrical core samples were done on a sample of 20 tubers per cultivar.

Cylindrical samples with a diameter of 25.4 mm (\equiv 1 inch) were cut from the central region of potatoes using a cork borer then trimmed to a height of 25.0 mm.

The loads were applied to each unrestrained specimen using the same tri-axial press (model TR 115, Tecnotest, Modena, Italy), fitted with a load cell (model S/AL, Deltatech, Forlì, Italy) with a range of 0 to 1000 N. The press was adjusted for mono-axial unrestrained compression at a velocity of 0.1 mm s⁻¹.

The compression of each cylindrical sample was stopped at load values, chosen within the deformation zone, where the slope of the load-deformation curve was approximately linear (Hayden et al., 1965). The diameter of the specimens was measured prior to loading and recorded for later computation of stress and strain. The behaviour of the specimen can be defined as elastic as long as the slope of the load-deformation curve remains approximately constant (Fig. 1).

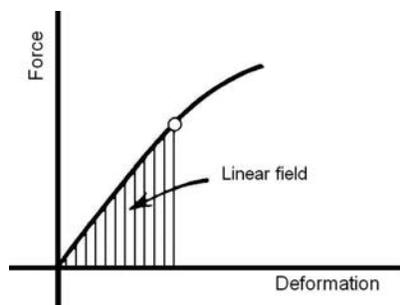


Figure 1 Linear field for a force-deformation curve of food materials

The press was fitted with a single 180 mm diameter steel plate contact, and the compression of each cylindrical sample was stopped at 150 N load level, where the slope of each load-deformation curve was approximately linear. Lateral deformation was measured by means of a gauge connected to an analogical indicator; the measurements had a resolution of 0.1 mm when the pointer became steady. Longitudinal deformation was acquired automatically by the displacement transducer LDTV connected to the previously described equipment.

Poisson's ratio (μ) was calculated by equation 1 (Sitkei, 1986):

$$\mu = \frac{\Delta\varepsilon_2}{\Delta\varepsilon_1} \quad (1)$$

where $\Delta\varepsilon_1$ is the absolute value of loading direction strain (or axial strain), and $\Delta\varepsilon_2$ is the transversal strain (or radial strain):

$$\Delta\varepsilon_1 = \left| \frac{\Delta L}{L_0} \right| \quad (2)$$

$$\Delta\varepsilon_2 = \frac{\Delta D}{D_0} \quad (3)$$

The Young's modulus (E) is defined by the equation 4:

$$E = \frac{\sigma}{\varepsilon_1} = \frac{F/\pi(D_0/2)^2}{\Delta L/L_0} \quad (4)$$

where D_0 and L_0 are the initial diameter and length of the specimens, respectively, σ is the stress and F is the normal load.

Results

The analysis of variance (ANOVA) was performed on the trial data to evaluate the influence of cultivar and storage time on the physical-mechanical parameters of the measured tubers.

Characteristics at harvesting

The results of the tests done on cylindrical specimens taken from newly-harvested tubers of the two cultivars and in both years of the trial are summarised in Tables 1 and 2.

The cultivar and harvesting year were considered as the main factors in the analysis (Tab. 1). For Young's Modulus, both the cultivar and year showed high statistical significance, while for Poisson's ratio only the harvesting year showed statistical significance. The interactions between the two factors were not significant for Young's Modulus and highly significant for Poisson's ratio.

The mean values of the elasticity modulus were higher for Primura than Vivaldi and there was a statistically significant reduction from 2005 to 2006 for both cultivars (Tab. 2). For Poisson's ratio, the two cultivars showed contrasting behaviour over the years: in Primura the value reduced, while in Vivaldi it increased from 2005 to 2006.

The higher values of Young's Modulus in Primura than Vivaldi highlight a greater deformability of Vivaldi.

Table 1. Analysis of variance of potatoes mechanical properties at harvesting

<i>Effects</i>		<i>P-Value</i>	
		<i>Young's Modulus</i>	<i>Poisson's ratio</i>
Main effects	Cultivar	0.0000	0.2994
	Year	0.0000	0.0047
Interactions	Cultivar_Year	0.4023	0.0000

Observation = 158.

Table 2. Mean values of potatoes mechanical properties at harvesting

<i>Cultivar</i>	<i>Year</i>	<i>Young Modulus MPa</i>		<i>Poisson's ratio</i>	
		<i>Mean ± SE</i>	<i>Homogeneous groups*</i>	<i>Mean ± SE</i>	<i>Homogeneous groups*</i>
Primura	2005	2.981 ± 0.051	B	0.458 ± 0.014	B
	2006	2.733 ± 0.036	A	0.391 ± 0.010	A
Vivaldi	2005	2.738 ± 0.072	B	0.328 ± 0.019	A
	2006	2.390 ± 0.072	A	0.488 ± 0.019	B

*Within each cultivar, means designated by the same homogeneous group letter were not significantly different based on Fisher's 95% LSD method.

Characteristics during storage

In the light of the observations at harvesting, the analysis of the mechanical characteristics during storage was conducted separately for the two cultivars.

Harvesting year and storage time were considered as the main factors in the analysis.

Primura: Analysis of variance demonstrates a high statistical significance of both year and storage time for Young's Modulus and Poisson's Ratio (Tab. 3).

Table 3. Analysis of variance of potatoes mechanical properties during storage (Primura)

<i>Effects</i>			<i>P-Value</i>	
			<i>Young's Modulus</i>	<i>Poisson's ratio</i>
Primura (Observations = 358)	Main effects	Year	0.0048	0.0000
		Days	0.0000	0.0000
	Interactions	Year_Days	0.0000	0.0000

Analysing the behaviour in storage, there is a substantial reduction in the average values with the increasing length of time in storage (Tab. 4), with the exception of Poisson's Ratio for the last period in 2006. The reduction of Young's Modulus evidences the increase in the deformability of the tubers with storage time.

Table 4. Mean values of potatoes mechanical properties during storage (Primura)

Year	Days	Young Modulus MPa		Poisson's ratio	
		Mean \pm SE	Homogeneous groups*	Mean \pm SE	Homogeneous groups*
2005	0	2.981 \pm 0.045	C	0.458 \pm 0.014	C
	90	2.526 \pm 0.045	B	0.295 \pm 0.014	B
	180	2.248 \pm 0.045	A	0.264 \pm 0.014	AB
	240	2.319 \pm 0.045	A	0.236 \pm 0.014	A
2006	0	2.733 \pm 0.032	B	0.391 \pm 0.010	C
	90	2.597 \pm 0.045	A	0.409 \pm 0.014	C
	180	2.554 \pm 0.045	A	0.285 \pm 0.014	A
	240	2.541 \pm 0.045	A	0.325 \pm 0.014	B

*Within each year, means designated by the same homogeneous group letter were not significantly different based on Fisher's 95% LSD method.

Vivaldi: Analysis of variance demonstrates a statistical significance of year, and high statistical significance of storage time for Young's Modulus, while for Poisson's ratio there is a high statistical significance of both factors (Tab. 5).

Table 5. Analysis of variance of potatoes mechanical properties during storage (Vivaldi)

	Effects		P-Value	
			Young's Modulus	Poisson's ratio
Vivaldi (Observations = 120)	Main effects	Year	0.0352	0.0000
		Days	0.0000	0.0000
	Interactions	Year_Days	0.0000	0.0000

Analysis of the behaviour in storage shows a reduction of the average values with the increasing of storage time (Tab. 6). As with Primura, the reduction of Young's Modulus expresses an increase in deformability as storage time increases.

Also during storage, the Young's Modulus for Primura is higher than for Vivaldi. This demonstrates that the behaviour of Vivaldi is more elastic than that of Primura.

Table 6. Mean values of potatoes mechanical properties during storage (Vivaldi)

Year	Days	Young Modulus MPa		Poisson's ratio	
		Mean \pm SE	Homogeneous groups*	Mean \pm SE	Homogeneous groups*
2005	0	2.738 \pm 0.060	B	0.328 \pm 0.017	B
	90	1.861 \pm 0.060	A	0.224 \pm 0.017	A
	180	1.887 \pm 0.060	A	0.260 \pm 0.017	A
2006	0	2.390 \pm 0.060	B	0.488 \pm 0.017	C
	90	2.216 \pm 0.060	A	0.333 \pm 0.017	B
	180	2.191 \pm 0.060	A	0.212 \pm 0.017	A

*Within each year, means designated by the same homogeneous group letter were not significantly different based on Fisher's 95% LSD method.

Conclusions

The cultivar and storage time are factors that influence the mechanical characteristics of potatoes.

The two cultivars considered present different mechanical properties prior to storage. Young's Modulus for Primura has higher values than for Vivaldi, evidencing a greater deformability of the Vivaldi.

In storage, for both cultivars, Young's Modulus reduces with the increase in the number of days of storage, whereas Poisson's ratio has less obvious behaviour. The reduction of Young's Modulus evidences an increase in the deformability of the tubers with the length of storage time for both cultivars.

For both fresh and stored tubers, Young's Modulus is higher for Primura than Vivaldi. This shows that Vivaldi has a more elastic behaviour than Primura.

These results demonstrate the importance of mechanical tests for characterising the tissues of tubers and differentiating the behaviour of different cultivars, for both the fresh and stored product, even if they cannot normally provide prediction indexes of the evolution over time of the tubers' mechanical characteristics.

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A low environmental impact system for beef cattle manure distribution on maize

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Abstract

An experiment was carried out in order to evaluate the applicability of a new technique for managing and distributing beef cattle manure during irrigation on maize when the crop is present in order to reduce the negative effects on air and water quality. Traditional manure distribution system was compared with a low impact management system using a side-move travelling system for the distribution of wastes (liquid separated) mixed with irrigation water (fertigation) on the soil surface. The first results show that the use of the new technique reduces the emissions of ammonia in the air and consequently the diffusion of bad odours in the atmosphere, with positive consequences for the local population. Provisional results of leaching water samples seem to indicate that also the percolation water quality is better due to a reduction in nitrate nitrogen losses.

Keywords: Side-Move irrigation system, LEPA, manure distribution, low environmental impact.

Introduction

The use of livestock wastes through agricultural irrigation systems has a potential positive impact on the environment, both reducing odours and seepage into groundwater and decreasing fertiliser use. The traditional distribution of livestock wastes is a cause for concern due to environmental issues and complaints of the local population, particularly if not directly involved in agricultural activities.

The most evident negative effect is given by nitrogen losses in the environment, since this element is usually applied in big amounts, as crop response to it tends to be major, and it is easily leached due to the high solubility of its nitrate form, not held by soil colloids.

Nitrogen losses may result in water bodies eutrophication, a process that causes algal and plant excessive growth and the eventual death of most organisms living in lakes, ponds, estuaries or slow streams and rivers. In order to reduce the impact of this phenomenon it is important to maximise nitrogen crop interception, and therefore to distribute fertilisers when crops need them and apply them in correct amounts. This may not be always possible, due to manure tanks dimensions that may require manure removal and use in different times of the year (Berti et al., 2006); further, after a certain crop development stage it is not possible to apply manure with the traditional fertilisation systems.

As for gas emissions, the expansion of urbanised areas in traditionally rural locations reduced the distance between residential and agricultural zones, causing clashes like those due to bad odours diffusion from livestock farms and during manure and slurry field distribution. Bad odours, even though they are not a source of toxicologic problems (Valli, 2001), are still associated by people with a scarce environmental healthiness; further, ammonia emissions are often connected to bad odours diffusion. This is particularly important as agriculture is responsible for 90% of ammonium nitrogen emissions into the atmosphere (Balsari and

Gioielli, 2003), a key factor in acid rain formation.

The use of livestock wastes in the high Veneto plain (Northern Italy), where soils tend to be rich in stones and gravel, thin (not more than 50 cm of depth) and therefore have a low water retention capacity, is problematic. Livestock farming in the area is widespread and it produces big amounts of manure that need to be disposed of, possibly incorporating them immediately after field distribution. Manure is usually applied in spring and in autumn, when rainfall is more abundant; summer application, which would favour nutrient mineralisation and plant uptake in a key period, is usually not possible as forage crops (mostly maize) are present in the field.

Irrigation is also an issue in this area, as maize cultivation would not be feasible without it, due to soil characteristics, but at the same time environmental risks are present: with sprinkler irrigation on average only 43% reaches directly the soil surface with a 20 cm in row spacing, while most of the rest is intercepted by the leaves and flows along the culm, concentrating at the bottom of the plant (Lamm and Manges, 2000). This is a probable cause for deep leaching and decreased irrigation efficiency; distributing water directly to the soil, under the canopy, would reduce this type of losses and therefore irrigation volumes could be smaller, still allowing sufficient forage productions for cattle feeding.

An experiment was carried out in order to evaluate the applicability of a new technique for managing and distributing beef cattle manure during irrigation on maize when the crop is present. The project aim is a comparison between a traditional manure distribution system and a low impact management system using a side-move travelling system for the distribution of wastes (liquid separated) mixed with irrigation water (fertigation) on the soil surface.

Material and methods

The experiment was started in June 2006 and it is still in progress. The experimental field (figure 1) is located in the high alluvial plain of the Veneto region (NE Italy) and is 2.2 ha, divided in two parts: the side-move system is used on an area 25 m wide and 160 m long, whereas in the remaining part a solid set irrigation system is installed and livestock wastes are

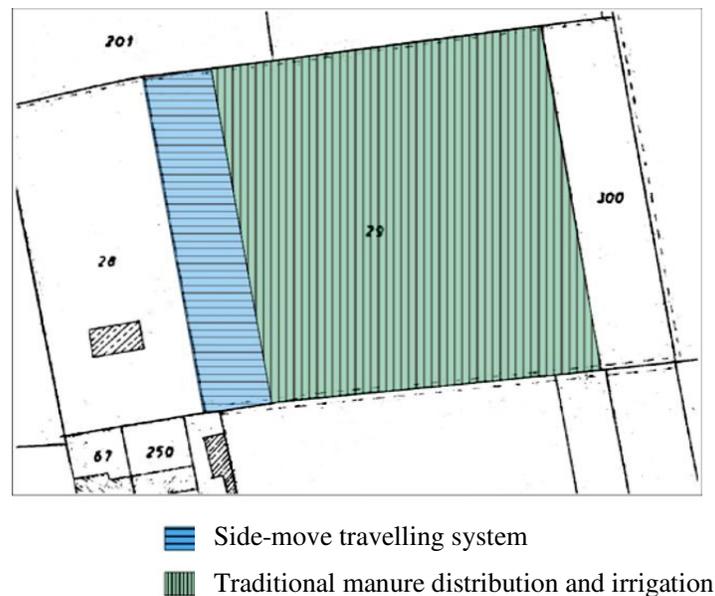


Figure 1. The two parts of the experimental field (NE Italy)

applied separately using a tank wagon equipped with splash plate. The location was chosen for its environmental importance, as it is situated inside the Venice Lagoon Watershed, and for the large diffusion both of maize cultivation and beef cattle which are one of the major cause of nitrate pollution of water in this area.

According to the de Martonne index calculated for the decade 1994-2003, the climate in the area is humid to perhumid, while soil type is alfic udarents loamy-skeletal, mixed, non acid mesic soils according to the USDA classification.

For the irrigation and fertigation (distribution of the liquid separated portion mixed with irrigation water) the boom of the hose-reel machine was equipped with drop tubes, similar to a LEPA system (Lyle and Bordowsky, 1981), to apply water directly on the soil surface under the canopy without leaf interception (figure 2 and 3) (Lamm et al., 2006).



Figures 2 and 3. The hose-reel machine and the boom equipped with the drop tubes

The manure was initially treated with a mechanical separator and injected before the turbine of the hose-reel machine by means of a Venturi injector. The separator did not give the expected results, due to the excessive quantity of suspended solids (mostly hay and fiber) in the liquid separated portion that blocked the holes of the hose-reel machine almost immediately. To overcome the problem, from May 2008 a new mechanical separator (figure 4) was installed and successfully used.



Figure 4. Separation of manure in liquid and solid portions with mechanical separator

From June 2007 leaching water samples were periodically taken with lysimeters to measure the content of nitrate nitrogen in percolation water, in order to evaluate the differences between the two thesis. These instruments did not prove to be reliable, possibly because of the scarcity of leaching water or of the characteristics of the soil. As a result, in 2008 also four water-catching metal plates (figure 5) were installed about 30 cm below the soil surface to collect leaching water samples; these new tools allowed collecting and analysing samples frequently during the season.



Figure 5. Water catching plate and flask for leaching water sample collection

During wastes application, air was monitored to evaluate the presence of bad odours with an instrument (figure 6) designed and built at the Agricultural Mechanisation Laboratory of the University of Padova. It consists of a Plexiglas tunnel and a fan to maintain temperature and humidity conditions similar to those outside; the air is sucked in by a pump through a small plastic pipe that contains a phial indicating the amount of ammonia in the air. This survey was carried out both when traditional manure and liquid separated distribution were taking place in order to compare the effects of the two systems.



Figure 6. Tool for the measurement of ammonia emissions

Manure, liquid and solid separated portions of manure, liquid and muddy filtered portions of manure were analysed in the following parameters: total nitrogen, ammonium nitrogen, phosphorous, potassium, suspended solids, humidity.

Results

In 2007 the two systems could not be compared, due to the malfunctioning of the mechanical separator. As a consequence, the portion of the field that should have received organic nitrogen along with irrigation lacked a considerable part of fertilisation; nevertheless, it is interesting to notice that at the end of the season the yield in the two parts of the field was almost identical: 8,95 t/ha for the traditionally managed maize and 8,93 t/ha in the experimental part. This indicates a probable excess in the amount of nitrogen usually distributed to the crop by the farmer.

The very scarce amount of water samples collected in 2007 did not allow to draw any conclusion concerning leaching water quality; however, it may still be pointed out that the highest concentrations of nitrate nitrogen (more than 330 mg/L and 80 mg/L) were found in the traditionally managed portion, whereas almost all the samples collected in the other part had a very low content of nitrate nitrogen.

As for 2008, the delay in fertigation due to the problems in finding the adequate separating machine caused a late distribution of nitrogen with the boom, which resulted in an obvious difference of growth speed between the two thesis in the first part of the season. Naturally, this will have to be taken in to account at the harvest.

Leaching water samples that have been analysed so far seem to indicate that nitrate nitrogen concentrations are higher in the traditionally managed part of the field (figure 7), with an average of 62 mg/L compared to an average of 33 mg/L, even though further investigation is necessary to reach more precise conclusions.

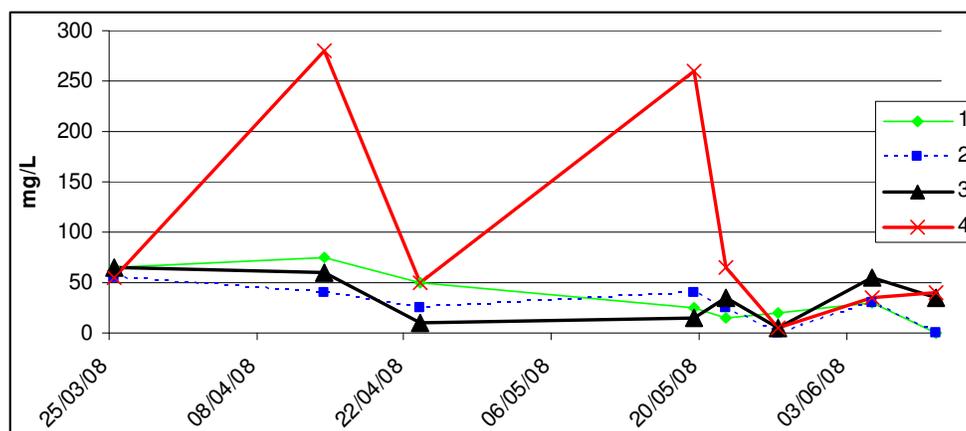


Figure 7. Nitrate nitrogen in leaching water collected from catching plates in 2008 (numbers 3 and 4 are located in the traditional manure distribution portion)

As regards the ammonia emissions, the measurements showed that the amount of ammonium nitrogen lost in the environment, and therefore the level of bad odours, is higher with the traditional system than in the case of the summer distribution of the liquid portion of manure, even though the application takes place in March with lower temperatures. Actually, placing the instrument near the distributing tank wagon four 30 ppm phials were consumed in

about 90 minutes, especially due to spray effect occurring at the moment of manure distribution; after the end of the application, 80 and 90 minutes were necessary to consume a 30 ppm phial in two different surveys that took place in March 2007 and March 2008, with a temperature of 18 °C and 16 °C respectively. On the other hand, placing the instrument near the distributing boom in July, when a temperature of about 30 °C favours ammonia volatilisation, about 150 minutes were necessary to consume a 30 ppm phial: concentration of ammonia were almost half while fertigation was carried out.

Conclusions

The first results show that the use of the new technique reduces the emissions of ammonia in the air and consequently the diffusion of bad odours in the atmosphere, with positive consequences for the local population.

Provisional results of leaching water samples seem to indicate that with the innovative technique also percolation water quality is better due to a reduction in nitrate nitrogen losses.

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Characterization of land use for environmental impact analysis of crop shelters

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Abstract

The sustainable use of the resources of a territory is a concern of the national authorities as well as the local ones (municipalities, provinces, region). The enhancement of production, from one hand, and the prevention of the risk of degradation of the environmental resources (soil, water, landscape, etc.), on the other hand are strictly connected to the definition of indicators that could allow the policy makers to maintain the risk under threshold values by means of Standards and Regulations. The analysis and quantification of the variables that could define the indicators constitute a basic knowledge necessary to be collected on large territories and thus as automatically as possible.

In this field, a methodology proposed for the automatic localization and analysis of territorial density of crop shelters was applied in order to obtain the characterization of land use. The methodology is built by using image processing analysis based on the supervised classification of aerial images refined by using neighbourhood and contiguity analysis algorithms.

In this study the methodology was applied to the territory belonging to a Municipality of the Province of Ragusa in Sicily. The results provided a basic dataset suitable to define indicators for the environmental impact assessment of crop shelters. In detail, the methodology allowed to determine the variation of crop shelter density from the seacoast towards the inner areas of the territory as well as other variables that characterize the indicators of the antropic load.

Keywords: greenhouses; image processing; supervised classification.

Introduction

As far as studies on environmental protection are concerned, there is a growing interest in automatic classification procedures applied on digital images acquired by satellites or aerial photographic surveys. As several environmental problems may be related to changes and/or degradation of soil, water, vegetation and air, it is essential to analyze and monitor these environmental factors in order to formulate a strategy for environmental protection. In detail, as regards soils, the classification of digital images may allow to analyze and monitor soil erosion, landslides, soil subsidence etc.; as regards water, instead, it is possible to analyze its color, turbidity, chlorophyll content, temperature, possible pollution due to hydrocarbon and/or chemicals; as regards air, the classification of digital images may allow to assess the dispersal and dilution of smoke plumes produced by factories and/or installations for energy production, etc.; as regards vegetation, lastly, the main applications of automatic classification of digital images concern the characterization of vegetation coverages, land clearance and deforestation, state of health of vegetation, fire prevention and control, etc.. Image classification may thus provide useful information for strategic choices regarding environmental and landscape protection, planning of rural development, management of natural resources, etc.

In the Mediterranean coastal area the crop shelters represent a widespread type of temporary construction mainly used for horticultural, floricultural or vineyard breeding. For these type of constructions there is no thematic cartography generally available mainly due to their temporary character. Their load on environmental resources (soil, water, landscape, etc.) is to be thoroughly monitored by local authorities in order to prevent pollution and degradation of the territory.

It is a well known fact that the effects of crop shelters on environment are various and influence several environmental factors such as soil morphology, its chemical and physical composition and structure, the water regime and the quality of the water-bearing stratum, the health of workers and consumers, the quality of agricultural landscape, etc. (Cascone & Di Fazio, 1992).

In order to develop techniques and methods for controlling and reducing these negative effects on environment, it is essential to know the localization, the planimetric area and the density of crop shelters by using appropriate thematic cartography that, when available, is difficult to update mainly due to the temporary character of these constructions.

With the aim to limit the effects of crop shelters on the environment it is necessary to define appropriate indicators that could allow the Local Authorities to maintain the impact of crop shelters on the environment above threshold values by means of Standards, Regulations and Guidelines. The analysis and the quantification of the variables that define these indicators constitute a basic knowledge necessary to be collected on large territories and thus as automatically as possible.

In a previous work (Arcidiacono & Porto, 2007), a methodology based on the supervised classification of aerial RGB images was found more accurate than that based on unsupervised classification, both qualitatively in terms of localization and quantitatively in terms of planimetric area.

In this study, this methodology was applied in order to automatically collect information on crop shelter coverage and analyze it in order to define possible indicators for the assessment of crop shelter environmental impact.

Materials and methods

The study area and the imagery

South-Eastern Sicily represents one of the most intensively cultivated areas with crop shelters. In detail, along the coastal area of the Province of Ragusa horticultural and floricultural protected cultivations cover an area of more than 7,000 hectares (tunnels and hard-covering structures), represent about the 67% of the total surface of protected cultivations in Sicily and the 17% of the whole national surface that amounts to about 29,000 hectares. The territories of the Municipalities of Acate, Vittoria, Marina di Ragusa, Ragusa and Scoglitti are the most intensively cultivated. The rapid development of protected cultivations has produced negative effects on environment, especially in areas where crop shelters present a high territorial density such as the coastal zone or the inner zones of the Municipalities of Acate and Vittoria.

A study area of about 10,200 hectares, constituting the territory of the Municipality of Acate, was selected within the Province of Ragusa in Sicily.

The aerial orthophotographs in raster format and the Technical Regional Cartography (CTR) of the study area in vector format were provided by the Technical Bureau of the Province of Ragusa. Thanks to accuracy enhancement processes and quality control of the image, the acquisition system allows to reach a geometric precision equal to 2 meters.

The geographical coordinates of these imagery were made consistent with each other by transformation. In detail, the image coordinate system was transformed into Gauss-Boaga Projection based on Roma40 Geodetic Datum in order to match up with the CTR coordinate system.

The classification method

A methodology defined and tested in a previous work (Arcidiacono & Porto, 2007) was applied in the present study. This methodology uses a supervised classification approach based on spectral signatures, extracted through the definition of training samples collected by means of areas of interest (AOI). The image processing commercial software Leica Erdas Imagine Pro^(R) was used to carry out the following image analyses and elaborations.

The image classification method requires the following steps: 1) selection of the sample image; 2) definition of the training samples and spectral signature extraction; 3) object recognition through supervised classification; 4) refinement by application of focal function analysis, thematic cartography and expert classification; 5) Accuracy assessment.

The training samples were defined as areas of interest. These AOI were collected in the Feature Space Image (FSI), which represents the scatterplot of one band (Red, Green or Blue) against another one (Erdas Field Guide, 2003), associated to the RGB image.

The classified image was then subjected to post-processing analysis. Class merging was carried out in order to obtain one single class representing the crop shelter areas. Majority and maximum focal filtering functions based on neighbourhood analysis of pixel were applied to the classified image, with the aim to clean "salt and pepper" effect and create more uniform areas. The thematic layers derived from the CTR, i.e. the thematic cartography of "roads" and "buildings", were overlaid to improve the classification. The application of the focal functions and the use of CTR thematic layers, reduced the misclassified pixels and improved the density of the crop shelter area.

The image was then subjected to contiguity analysis algorithms: contiguous pixels in the same class, called clumps, were grouped and numbered in order to be identified by their sizes and manipulated. Expert classification procedures were implemented in order to perform queries on the classified image to filter out the bad classified clumps. Finally, an accuracy assessment procedure was applied in order to evaluate the performance of the classification.

Indicator and weight definition

With the aim to adequately plan the construction of new crop shelters or to perform a wise strategy of displacement of the existing ones in areas with a lower anthropic load, a methodology suitable to define indicators for zone characterization was developed.

The methodology used to define those indicators is based on the following steps:

- 1) subsetting of the study area in n zones with the aim to highlight the different level of crop shelter coverage;
- 2) computation of the crop shelter areas $S_{cs}(i)$ in the different zones by using the classification results. The index (i) refers to the i -th zone of the study area;
- 3) computation of the percentages of the crop shelter areas over the i -th zone surface;
- 4) computation of the percentages of other anthropic load areas $S_{al}(i)$ (i.e. roads and buildings) over the i -th zone surface;
- 5) computation of the available surface $S_A(i)$ to the displacement of existing crop shelters or to the building of new ones, as follows:

$$S_A(i) = S_{tot}(i) - S_{al}(i) - S_E(i)$$

where $S_{tot}(i)$ is the surface of the i -th zone and $S_E(i)$ is defined as:

$$S_E(i) = \sum_{k=1}^q S_{E_k}(i)$$

where k is the number of already existing indicators $I_E(i)$ that characterize the areas $A_j(i)$ within the zone i -th. The total amount of the surface $S_{E_k}(i)$ characterized by a specific indicator is defined as:

$$S_{E_k}(i) = \sum_{j=1}^m A_j(i) - \sum_{j=1}^m \frac{I_{E_k,j}(i)}{I_{E_k,\max}} A_j(i)$$

where $I_{E_k,\max}(i)$ is the maximum value of the indicator $I_{E_k}(i)$ within the study area. The index $K_E(i)$ associated to the indicator $I_{E_k}(i)$ is then:

$$K_E(i) = \left(1 - \sum_{j=1}^m \frac{I_{E_k,j}(i)}{I_{E_k,\max}} \right)$$

so that:

$$S_E(i) = K_E(i) \sum_{j=1}^m A_j(i)$$

- 6) definition of the indicator $I_{SO}(i)$ that describes the soil occupancy by crop shelters in the different zones, as:

$$I_{SO}(i) = \frac{S_{cs}(i)}{S_A(i)}$$

The indicator of soil availability $I_{SA}(i)$ is then defined by the complementary of the $I_{SO}(i)$ indicator, as:

$$I_{SA}(i) = 1 - I_{SO}(i)$$

- 7) definition of the weight vector $\lambda(i)$ in order to establish a priority of zone occupation in relation to the different objectives of land planning (displacement of existing shelters or new shelter building), as:

$$\lambda(i) = \frac{I_{SA}(i) S_A(i)}{\sum_{i=1}^n [I_{SA}(i) S_A(i)]}$$

- 8) computation of the crop shelter surface to be displaced $S_{dis}(i)$ in each zone, as:

$$S_{dis}(i) = \lambda(i) S_{mov}$$

where $S_{mov}(i)$ is the crop shelter surface to be moved or built.

Results

The planimetric area of crop shelters located in the study area, resulting from the application of the described classification methodology, is about 1,624 hectares. From the thematic map, reported in fig. 1, the localization of crop shelters is mainly found in the coastal area, though other areas located into inner zones are also subjected to a considerable load. The territory of the Municipality of Acate was subdivided into 18 zones of 1 km width from the coastal area towards the inner part of the territory.

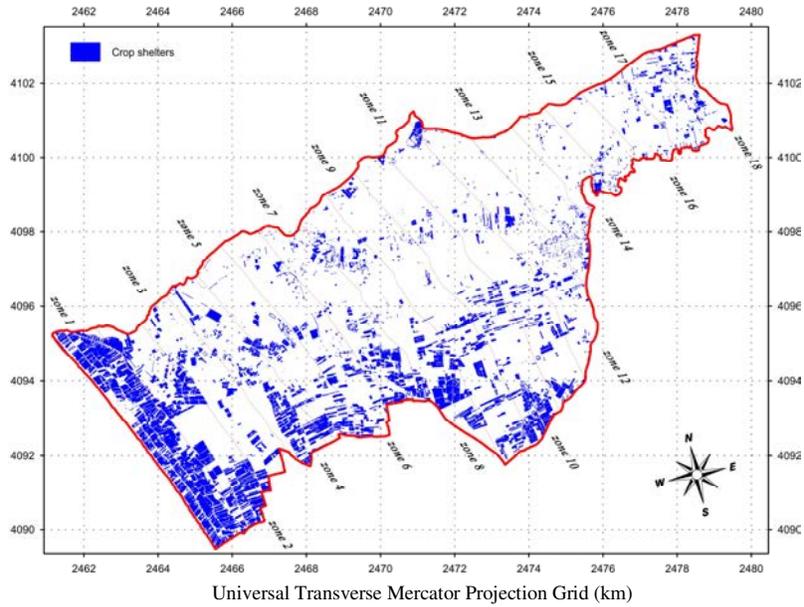


Figure 1. Thematic map of crop shelters within the Municipality of Acate.

The planimetric area of crop shelters, the one of other types of anthropic load (i.e. roads and buildings) as well as that of steep slopes were evaluated in each zone in order to calculate the percentages of these loads over each zone surface (fig. 2). In detail, the crop shelter area $S_{cs}(i)$ is obtained from the classification process; the anthropic load area $S_{al}(i)$ was computed by acquiring the thematic layer of road and buildings from the CTR; the steep slope area $S_{sl}(i)$, derived by the contour lines connecting points of equal elevation available in the CTR, was calculated as follows:

$$S_{sl}(i) = \sum_{j=1}^m A_j(i) - \sum_{j=1}^m \frac{I_{sl,j}(i)}{I_{sl,max}} A_j(i)$$

The indicator $I_{sl,j}(i)$ equals 1 if the slope of the soil exceeds a threshold value of about 10 % and 0 if it has a lower value.

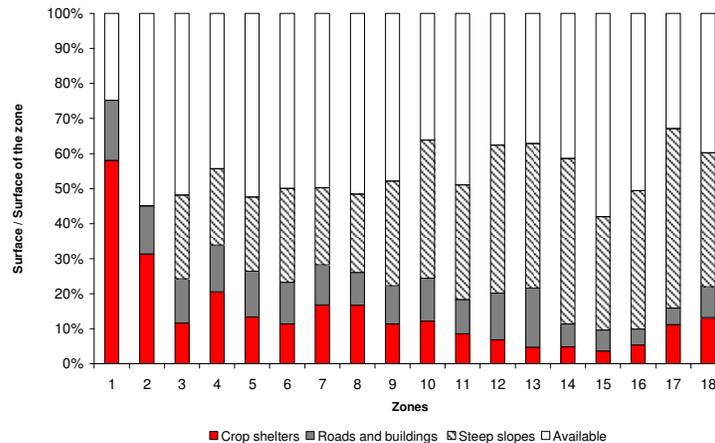


Figure 2. Incidence on the zones due to crop shelters, roads and buildings and steep slopes.

Generally, crop shelters are located mainly in the first two zones, reaching a maximum value of about 58% in the first zone and about 31% in the second one. In the other zones the percentage is lower than about 20% of the zone surface. The anthropic load due to roads and buildings is lower in the further zones from the coastal area (zones from 14 to 18), whereas zones 1 and 13 show the highest values, equal to about 17%. This occurrence can be explained as in zone 1 crop shelters are surrounded by small road and several small village are settled in the coastal area; in zone 13 rises most part of the town of Acate. In the remainder zones (2 to 12 km from the coast) the average anthropic load is about 13% of the zone surface. From the analysis of the CTR it comes out that steep slope area $S_{sl}(i)$ generally increases from the coastal area towards the inner part of the territory following its orography. Taking into account the incidence of various loads in each zone, the available surface $S_A(i)$ is minimum in the first zone, being about 25% of the zone surface, whereas in the other zones it varies between about 33% and about 58%. The description of soil occupancy by crop shelters on the basis of the available surface is summarized by the indicator $I_{SO}(i)$. Fig. 3 shows the different values of this indicator in the 18 zones of the study area. In this thematic map it can be highlighted that there are six zones with a value above 25% of the available soil and the incidence of crop shelter load is generally lower in the inner zones than in the coastal area. In detail, the planimetric area of the soil covered by crop shelters ranges from a minimum of about 10 hectares in zone 15 to a maximum of about 413 hectares in the first zone corresponding to an indicator ranging from about 6% to about 70% of the available soil, respectively.

The Guidelines contained in the Territorial Plan of Coordination of the Province of Ragusa (Fusero & Simonetti, 2005) propose the displacement of the crop shelters from the coastal area to the inner part of the territory. Under the hypothesis that the crop shelters located in the first two zones ought to be displaced to the other ones, allowing to release the coastal area from the load of these constructions, it is necessary to determine the crop shelter area to be displaced from the first two zones and to be distributed among the other 16 zones. In this case study, the crop shelter area S_{mov} located in the first two zones amounts to about 610,5 hectares. By applying the weight vector $\lambda(i)$ the computation of $S_{dis}(i)$ allowed to uniformly distribute the crop shelter area S_{mov} on the basis of the soil availability in each zone. The results are reported in fig. 4 where the percentages of soil occupation are within about 20% and about 42 %. From the comparison between figs. 3 and 4, the crop shelter load increases of about 10% ÷ 14% in the 16 zones, due to the release of the first two zones from this load. In this study, the displacement of the crop shelters to the other zones is based on a weighted distribution in relation to the available space. Besides the steep slope indicator, other indicators could be introduced that take into account the suitability of the different zones to the displacement. Some of them could regard: cultivated areas, neighborhood to forest areas, neighborhood to urban areas, availability of water resources, availability of transport infrastructures, fragmentation of productive settlements, etc. [Cloquell-Ballestrer *et al.*, 2006; Anton *et al.*, 2007].

The analyses reported in this study refer to the current situation that does not consider the development in time of the area. If the variable "time" is considered in the model then the anthropic load, made of roads and buildings, should comprehend the provisions of the Town General Plan as regards the planned road system and the building zoning. Moreover, the availability of previous territorial information could allow to take into account the variability of the indicator of crop shelter load with time, e.g. if a zone was subjected to a high value of the indicator since several years ago it could be considered that the zone receives a lower load increment than the other zones.

Conclusions

In the present study a methodology to find suitable indicators to describe the crop shelter load was developed and applied to reach some of the objectives contained in the Territorial Plan of Coordination of the Province of Ragusa.

The analysis of crop shelter along the coastal area of the Province of Ragusa was carried out applying a methodology based on a supervised classification algorithm, already tested in a previous work, in order to recognize and quantify crop shelter area. Both methodologies could provide useful information to the territory decision-makers (e.g. Region, Province and Municipalities) in order to create a decisional basis for territory planning of the area. In fact, the creation of a Territory Plan is also correlated to a precise knowledge of the areas subjected to the anthropic load related to protected cultivations. For instance, this knowledge is essential if there is the need to cope with pollution risks or to pursue objectives of land use transformation (e.g. enhancement of touristic value of an area). In this direction, the methodology described in this paper could be a reliable tool, suitable to acquire this knowledge and easy to be updated whenever necessary. In fact, the proposed methodology, applied to orthophotos of subsequent years, could result useful to investigate the modifications of the crop shelter location and density during years in specific areas. This additional information could allow to build dynamic indicators. Finally, the availability of other territorial information could allow to use different indicators to be applied within the methodology itself.

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