

## SUPPRESSIVE ACTIVITY OF BIOMASS WASTE AGAINST PLANT DISEASES IN HORTICULTURE

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**ABSTRACT:** Soil borne plant disease suppression can be attributed to the microbial activity of microflora, which is related to the decomposition processes of organic matter of soil. Composting is used as a renewable resource that contributes to recycling waste. Since it varies considerably in chemical, physical and biotic composition, its effectiveness to control some soil borne diseases may remain limited. To produce biofertilizers of required quality, product oriented bioconversion processes could be applied in the next generation waste management systems. The biomass waste is used in potting mixes for horticulture-container grown crops, where normal soil/compost is partially replaced by it. The purpose of this research work was to evaluate the effect of *Miscanthus* waste, produced by an innovative technological process of Steam-Explosion-Wood, on disease suppressiveness of some key horticultural crops in Italian market artificially inoculated with four soil-borne plant pathogenic fungi.

**Keywords:** agriculture, biomass, pesticides.

### 1 INTRODUCTION

Compost is widely used in agriculture as an organic fertilizer to improve the soil fertility. It has also been found to be suppressive against various soil-borne plant pathogenic fungi causing wilting and decaying in many cropping systems. Several authors reported disease suppressiveness of composts [1, 2, 3], but the extent to which they are effective, is largely unpredictable. Specific disease suppression of compost could be guaranteed when compost is colonized by specific antagonistic microorganisms [4]. Preliminary studies conducted on the biological control means with compost indicate that it could lead to fortified substrate able to control a wide range of soil-borne plant pathogens [5].

A wide spread diseases of horticultural crops are caused by several soil-borne plant pathogenic fungi, which are responsible of various disease symptoms on roots and vascular tissues in presence of susceptible hosts and under favorable environmental conditions [6]. The use of chemical pesticides for their control, has now become a matter of great concern because of health and environmental problems. Moreover, many intervention practices, e.g. fungicides and methyl bromide fumigants, focus on the control of pathogens after their effect becomes apparent. Chemical interventions also make things worse over the time. Therefore, more emphasis should be given to find the methods that help making the environment less disease-favorable and the host plant less susceptible.

Amongst various processes for biomass use, steam explosion for ethanol production has been the object of great interest since 1980s. However, regarding its use for other productive technologies, there is still a lack of information in terms of energy, chemicals etc. Steam explosion can be used to obtain several products depending upon the chemical composition of different biomass crops.

Keeping these facts in view, the preliminary experiments have been conducted to evaluate the use of steam exploded biomass of *Miscanthus x giganteus*, a renewable biowaste, in compost amendments. The present studies are focused to examine its effect on the

natural disease suppression on three different cropping systems, really significant for the Italian market.

### 2 MATERIALS AND METHODS

#### 2.1 Industrial Biomass

Production of biomass has become an important industry due to growing interest in sustainable fuel sources that includes various types of plants, annual and perennial ones and many tree species. The present research trials were conducted using the biomass samples of a perennial biomass crop, *Miscanthus x giganteus*, after its explosion during pre-treatment process in the steam explosion plant. This plant is available at the ENEA Research Centre in South Italy (Basilicata) and is used for biomass pre-treatment to study the production of ethanol and biomass-based materials. Steam explosion is described as a thermo-mechano-chemical process. In the reactor, the steam under high pressure penetrates the lignocellulosic structures by diffusion, it condenses under high pressure, thereby wetting the material. The moisture in the biomass hydrolyses the acetyl groups of the hemicellulose fractions, forming organic acids, such as acetic, and uronic acids. The process description highlights the importance of optimizing the two governing factors: retention time and temperature. The amount of time the biomass spends in the reactor helps to determine the extent of hemicelluloses hydrolysis by the organic acids [8]. Excessive conditions, i.e. high temperatures and pressures, however, also promotes the degradation of xylose to furfural and glucose to 5-hydroxymethyl furfural [9]. Since furfural inhibits microbial growth, therefore it may be undesirable in a fermentation feedstock. Regarding the chemical composition of the exploded biomass, it varies widely depending on the process conditions, raw material composition depending on many factors. The exploded biomass is composed of carbohydrate polymers (cellulose 30-40% and hemicelluloses (25-30%), lignin (15-20%) and a remaining part of protein (1-4%), ash content (8-10%), acetic acid (3%), furfural (1%) and about 0,6% of light solvent [10]. Less attention has been paid to exploit the uses of *Miscanthus* biomass, other than the bioethanol

production, after its explosion in the steam reactor. In the present research, exploded of *Miscanthus* biomass was used in the potting mixes to study its suppressive effect on several soil-borne plant pathogenic fungi causing wilting and decaying of pepper, tomato, melon, watermelon and lettuce in the fields and in the greenhouses, as well.

## 2.2 Bioassays to assess disease suppressive effect of biomass

Disease suppression in potting mixes against plant pathogenic fungi was tested in different bioassays on different host plants. For this purpose, a series of artificial cross inoculations were performed using four species of the soil-borne plant pathogenic fungi (*Sclerotinia sclerotiorum*, *Rhizoctonia solani*, *Fusarium oxysporum* f. sp. *lycopersici* and *Fusarium oxysporum* f. sp. *melonis*). The fungal species used for the experimental trial are diffused in the areas where different horticultural species are cultivated. Three commercially important horticultural crops (lettuce, tomato and melon) were used in the tests as host plants. The biomass waste was added in different doses (0, 10, 20 and 30% of fresh wt) to the substrate normally used in horticulture. A randomized complete block design with a total 10 pathosystems fungus/plant were used and disease suppressiveness of steam exploded waste was assessed in four different trials, as described in Table 1. Each bioassay was replicated three times, each containing 10 plants.

The experimental trials were carried out in the climatic room for 3-4 days and successively transferred into the greenhouse under controlled environmental conditions set at 26±2°C of temperature and 80±3% of relative humidity range. The data regarding disease symptoms on the plants has been recorded 15–20 days after artificial inoculations. For each fungus/plant pathosystem, a mean percentages of diseased plants was calculated.

## 2.3 Statistical analysis

Analysis of variance (ANOVA) were carried out with the statistical programme for Windows version 6.0. Duncan's test was applied when ANOVA revealed significant differences in the percentage of diseased plants (probability P<0.05).

## 3 RESULTS AND DISCUSSION

Table 1 shows the percentage of diseased plants of lettuce, tomato and melon, artificially inoculated with four different fungi, for the non-amended mix/substrate (0%) and for the biomass amended mixes (10, 20 and 30%).

The number of healthy plants in the potting mixes at a 20% fraction of steam exploded biomass, resulted significantly higher in all the three cropping systems inoculated with *Sclerotinia sclerotiorum* and *Rhizoctonia solani*. The disease suppression was more evident in case of *Rhizoctonia solani* as compared to *Sclerotinia sclerotiorum*, where the suppressive effect was not very evident. It was also observed that the increasing or decreasing amount of exploded biomass in the potting mixes did not correspond to the disease intensity. Biomass addition in other two doses (10 and 30%) did not influence in reducing the disease percentage of these species, showing that the different biomass fractions used

in trial for the substrate amendment and the disease intensity were not statistically correlated.

Instead, no any suppressive effect has been observed in case of *Fusarium oxysporum* f. sp. *lycopersici* on tomato and *Fusarium oxysporum* f. sp. *melonis* on melon. Moreover, the present research revealed that the fungus *Fusarium oxysporum* f. sp. *lycopersici* did not cause any disease symptom in melon and *Fusarium oxysporum* f. sp. *melonis* did not attack the tomato plants, confirming the high level of parasitism of these fungi.

**Table 1:** Effect of biomass waste on the disease suppression of 10 pathosystems composed of 10 combinations of 4 soil-borne plant pathogenic fungi and 3 horticultural species

Biomass exploded waste (%)	Diseased plant (%)									
	1×a	1×b	1×c	2×a	2×b	2×c	3×b	3×c	4×b	4×c
0	100a	100a	97 a	100a	90a	89a	98a	0a	0a	100a
10	80 a	90 a	98 a	90 a	82a	95a	93a	0a	0a	90 a
20	69ab	73ab	68ab	58 b	62b	52b	82a	0a	0a	82 a
30	85 a	95 a	92 a	80 a	88a	88a	80a	0a	0a	90 a

Note: For each column, different letters represent significant differences between doses of biomass used, according to Duncan's test (P<0.05).

Legend:

1. *Sclerotinia sclerotiorum*
2. *Rhizoctonia solani*
3. *Fusarium oxysporum* f. sp. *lycopersici*
4. *Fusarium oxysporum* f. sp. *melonis*
- a. Lettuce (cv Iceberg)
- b. Tomato (cv Rutgers)
- c. Melon (cv Rugoso di Cosenza)

There were significant differences in disease suppression for the three levels of biomass addition to the potting substrate. It is clear that disease suppression increases with 20% dose of biomass that might be attributed to the presence of furfurals in the steam exploded waste (unpublished data). Since increasing or decreasing the dose did not prove to be effective to decrease plant disease intensity, it can be considered as the ideal dose for disease control in three cropping systems evaluated in present trial. Hence, no strong correlation has been found between the amount of biomass fraction used in the potting mixes and the level of disease suppression. Further research on long term basis is required, as it is of great importance for the commercial growers to be sure if the natural disease suppression provided by the substrate amendments is reliable enough to replace chemical disease control.

## 4 CONCLUDING REMARKS

The present research work was conducted to investigate the possibility to restrict the use of chemical fungicides in horticulture, since they are pollutant for the environment and harmful for the consumers health.

Use of steam exploded biomass waste in the experiment was aimed to evaluate its effect on the

incidence of some fungal diseases that frequently attack lettuce, tomato and melon plantings in greenhouse.

Addition of *Miscanthus* biomass obtained from an innovative technological process, to the substrates normally used for cultivation in greenhouse, has demonstrated a significant suppressive activity against two pathogenic fungi commonly transferred in the plantings through the soil, as confirmed by other authors [7].

Significant differences were recorded with a 20% biomass dose added to the normal potting soil. It was noted that the suppressive effect on disease was stimulated when the plants were inoculated with *Rhizoctonia solani* and *Sclerotinia sclerotiorum* and a significant reduction of the percentage of diseased plants on all horticultural species tested, was recorded.

Biomass fraction, when applied in 20% dose to the potting-mixes, resulted synergistic to the plant growth. However, the application of biomass used at 10 and 30% dose resulted antagonistic, rather than synergistic to plant growth.

Integrated use of traditional fungicides at low level together with biomass exploded wastes is recommended, as it might help to reduce the incidence of some fungal diseases that frequently attack many horticultural crops having great economical impact on the Italian market. However, more detailed studies are required regarding the supplementation of exact concentrations of biofertilizers to the potting mixes.

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