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INFLUENCE OF PLASTIC MULCH SYSTEM ON AGRO-CLIMATIC FACTORS AND STRAWBERRIES DISEASES IN ORGANIC SYSTEM

Mihai-Avram MAXIM[1], Teodor RUSU[1], Ludger LINNEMANNSTÖNS[2], Ileana BOGDAN[1], Adrian Ioan POP[1], Paula Ioana MORARU[1], Ovidiu MAXIM[1]

[1]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Manastur Street, Cluj-Napoca, Romania
[2]Landwirtschaftskammer Nordrhein-Westfalen Auweiler-Köln, 11 Gartenstrasse, Auweiler, Germany

Corresponding author email: mihai.maxim90@gmail.com

Abstract

The desire for sustainable agriculture has begun to spread in the las decades. The main issues of growing strawberries in organic system are represented by the control of diseases and pests and weeds control. Their appearance and development is directly influenced by agro-climatic factors, being, in this case, necesarry to use the most effective techniques and methods to control them. Thus, for the control of weeds the soil was mulched with black plastic. The soil temperature and humidity was monitorized in fieldd and tunnel using two HOBO microstations. The sensors were placed at 10-15 cm depth. In field were registered the rainfalls and air temperature at a heigh of 1m. Durring the study (March-June 2018), the highest values of soil temperature and moisture were recorded in tunnel. From phytosanitary point of view, the fluctuations of agro-climatic factors influenced both the variety and the amount of strawberries affected by fungal diseases. The highest quantity of strawberries was affected in field.

***Key words**: agro-climatic factors, monitoring, organic system, soil, strawberry disease.*

INTRODUCTION

Due to the high demands of consumers for organic products, especially in North America and Europe, gouvernments of many countries make efforts to encourage farmers to make the transition from conventional farming to organic farming system (Willer et al., 2009).
Sustainable agriculture is based on the intensification of ecological processes, thus prohibiting the use of all synthetic inputs (FAO/WHO Codex Alimentarius Commission 1999).
Globally, agricultural area under organic management has increased significantly, with an area of 50.9 milion ha in 2015, compared to 11 milion ha in 1999 (Willer & Lernoud, 2016; 2017).
Increasing interest for this type of agriculture has led to a deepening of research, being developed effective practices for the development of sustainable agriculture (Graf & Häselli, 1991; Röser, 1992; Neuweiler, 1997a;1997b).
Thus, the control of diseases, peststands weeds is a major concern for farmers who are practicing this type of agriculture.
The strawberry crop (*Fragaria x annanasa* Dutch.), due to the high content of C vitamin, ß-caroten and other nutrients that are beneficial for health, has become one of the most popular crops worldwide, the total surface cultivated in 2017 being estimated, according to FAO, 395.844 ha (Monda, 2017).
The performances of different mulch systems on plant health and fruit yield are often inconsequent, and their effect seems to be related to the changes in microclimate (Passos, 1997; Maas, 1998).
Having a high susceptibility to water stress, the use of black plastic mulch plays an important role in soil moisture conservation, weed control and keep the fruits clean (Kasperbauer, 2002). In the same time adjusts the soil temperature, reduces water loss caused by evaporation, thus decreasing irrigation frequency, enhance nutrients absorption and provides a better growth and development of the roots compared to organic mulch or white polyethylene (Gupta

& Acharya, 1993; Khadas, 2014; Sharma, 2002; Ramakrishna, 2006).
Compared to other irrigation systems, to ensure the water requirements, drip irrigation presents a number of advantages which contribute to avoid formation of a humid microclimate favorable to diseases development, especially the fungal ones (Howard et al., 1992; Madden et al., 1993; Tanaka et al., 2005; Tanaka, 2002).
An important management tool against diseases and pests is soil solarisation, which is a process that increases the soil temperature due to the solar radiation using a plastic material. High temperatures will therefore be at the expense of pathogens from the soil (Katan, 1981).
The purpose of this paper is represented by the influence of mulch system on development of fungal diseases on strawberry crop and on agro-climatic factors.

MATERIALS AND METHODS

The experience was set up at the research station **Landwirtschaftskammer Nordrhein-Westfalen Köln-Auweiler**, Germany.
Köln area is bordered in West by the Bergisches Land mountainous region and in South by Eifel mountains and is characterized by a temperate climate with high humidity during the summer and gentle winters with oceanic influences. The pluviometric regime is characterized by an annual rainfall average of 676 mm.
According to german literature, the type of soil present in Köln-Düsseldorf region is represented by "Parabraunerde". This type of soil has been formed by the terraced deposition of alluviums, followed by the flooding of the area, by Rhein river, the upper layer having a clayey texture (Ameldung et al., 2018; Leitgeb et al., 2013).
In Federal Republic of Germany "Parabraunerde" together with "Fahlerden" belong to Luvisol (Lessivés) class within "Terestriche Böden" department (Landböden). "Parabraunerden" may also be known as loamy-illuvial brown soil.
These are characterized by an A humic horizon, intermediate horizon (AlBv) with a low content of clay, Bt loamy horizon and C horizon which is limestone with rich sediments of quartz and silicate.
After the analise of the soil profile of Landwirtschaftskammer Nordrhein-Westfalen Köln-Auweiler, the 0-200 cm layer is composed of roughly equal amounts of clayey and loamy soils.
The biological material used in the trial was represented by the varieties Rumba, Sonata and Clery, which belong to *Fragaria* x *ananassa* Dutch. species, wide spread in countries with advenced agriculture.
Planting was done on asparagus dam on 14.07.2017. Due to the large width of the dam, planting was done on two rows. The distance between plants was 30 x 30 cm and the distance between dam was aproximately 170 cm. To combat weeds between plants, the dam was covered with black polyethylene. Between dams, after plantig, was used against weeds, My-Pex, which is a waterproof material.
During the winter, in periods of near-frost temperatures, the plants were coated with a white microporous textile, to protect the strawberries against frost. In January 2018, one of the experimental fields was covered with transparent polyethylene, which is intended for protected field.
In March 2018 two microstations HOBO-MAN-H21-002 were installed, in both fields. The sensors for temperature and moisture were placed at 10 cm depth in soil. In field were recorded air temperature and rainfall too.
The recording of climatic parameters took place every 10 minutes and the data was downloaded at the end of the harvest period.
During the harvest period, observations were made on the following: the occurrence and evolution of strawberry diseases analyzing the fruits at each harvest, the monitoring of agro-climatic factors using the HOBO microstations, the amount of fruits affected by *Sphaeroteca macularis, Botrytis cinerea, Phytophtora fragariae* and *Colletotrichum fragariae.*

RESULTS AND DISCUTIONS

A. Climatic parameters

The thermal regime of the soil is influenced by a complex of factors, especially by the intensity of solar radiation and its periodic variations over time. In addition of these factors, the physical properties of the soil, composition, texture, degree of moisture or dryness of the soil, specific heat, thermal conductivity and the degree of soil cover with vegetation influence the evolution of soil temperature.

The soil temperature present significant variations between day and night in field, throughout the study period (figure 1). Thus, the black plastic mulch under the influence of solar radiation favors the increase of soil temperature during the day but its capacity to conserve it over night is low.

In tunnel, a better temperature preservation occurs, with monthly averages, higher than in the field. This is influenced by the presence of the second layer of plastic, used to create the protected space.

In tunnel, the temperature average in March starting with the station's installation date was 10.70°C, with a maximum of 16.25°C and a minimum of 7.16°C. In field, the mothly average recorded a value of 6.87°C while the maximum temperature was 21.17°C and the minimum was 0.88°C. In April, the monthly average recorded in field was 14.93°C, while in tunnel was with 1.30°C higher. The differences are also visible from the point of view of minimum and maximum temperatures.

The therrmal parameter of soil had also changed in May, when the monthly average was 20.23°C in tunnel and 19.71°C in field. Maximum temperatures registered have values between 21.61°C and 30.20°C, while the minimum temperatures are between 8.69°C and 12.61°C.

In June, monitoring and recording of agro-climatic factors did not took place throughout the entire month due to the end of harvest period. Thus, the monthly average recorded in tunnel until the 9th of June 2018, when the field were abolished, is 23.57°C with a maximum of 29.11°C and a minimum of 20.17°C. In open-field, until the crop abolish (16th June 2018), the monthly average was 21.58°C, with a minimum of 15.10°C and a maximum of 29.92°C.

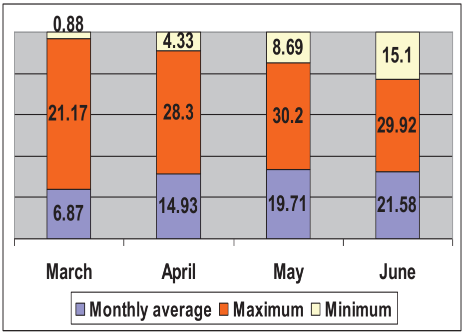

Figure 1. Evolution of soil temperature (°C) (Field, 2018)

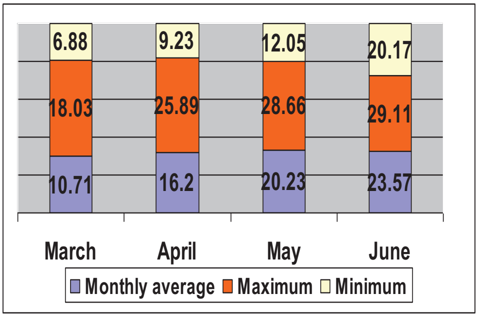

Figure 2. Evolution of soil temperature (°C) (Tunnel, 2018)

In this situation we can say that in case of tunnel, the use of second layer of polyethylene has the effect of reducing the temperature losses inside the dam both during the day and during the night, compared to field.

As regarding the soil moisture, there is a decrease of recorded values in both experimental fields starting with the microstation's installation date and ending with the moment of abolishing the fields, even if a constant irrigaton occurred.

The monthly averages recorded in tunnel had values between 0,197 m^3/m^3 and 0,174 m^3/m^3,while in field the values were between 0,191 m^3/m^3 and 0,153 m^3/m^3 (Figure 3). The influence of the second layer of plastic in case of the tunnel can also be observed in the evolution of soil moisture. Thus, the high temperatures inside the dam, in field have a direct impact on soil's moisture evolution.

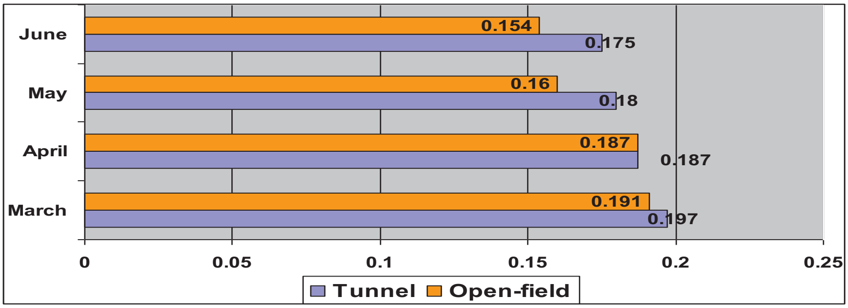

Figure 3. Monthly average of soil moisture (m^3/m^3) - 2018

The rainfalls peaked a maximum in March (56.40 mm), followed by April (48.60 mm) and June (42.31). From this point of view, the lowest amount of rainfall was recorded in May, with a volume of 18.60 mm.

The influence of precipitations on soil's humidity can be observed in April, when, with an amount of 48.60 mm, the soil moisture in field was close, as value, to the tunnel, compared with May and June.

The air temperature was monitorized only in field at a hight of 1 m. The monthly averages were between 6.17°C in March and 19.67°C in June. In April and May the monthly averages had values of 13.53°C respectively 17.73°C (Figure 4). The highest daily average was recorded in May (23.55°C).

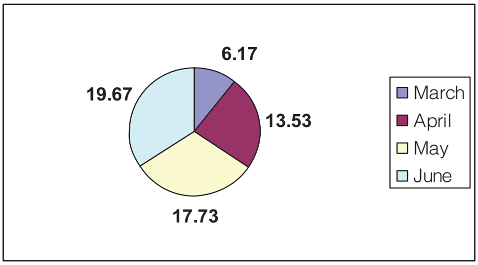

Figure 4. Air temperature in open field °C (2018)

B. Phytosanitary analysis

The most common strawberry diseases are caused by pathogens of a fungal nature, such as: leaf scorch, powdery mildew, anthracnose, grey mould, strawberry crown rot, strawberry red core. Their severity depends on the susceptibility of the variety, meteorological conditions and the degree of source infection (Müller, 1995; Jarvis, 1964; Meszka & Bielenin, 2011).

In the present study, during the vegetation period, were made observations on the attack of: *Botrytis cinerea, Phytophtora fragariae, Sphaerotheca macularis* and *Colletotrichum fragariae.*

According to the literature, the optimal conditions for germination of conidia and development of viruses are temperatures between 15-25°C, high relative moisture during the flowering and fruiting period, rainfall and excesive irrigation (Howard, 1972; Devaux, 1978).

Taking into account the mulching with black plastic, the higher incidence of diseased plants could be associated to a higher soil temperature compared with the clear plastic. For example, in case of anthracnose *(Colletotrichum fragariae)*, the high degree of attack using this system of mulching was attribute to the high soil temperature compared to other studied mulch systems (Camargo & Igue, 1973; Passos, 1997).

Fluctuations of agro-climatic factors influence the appearence and development of fungal diseases from a harvest to the other varying both the amount, in grams (g), and strawberry variety, in both trials (Tables 1, 2).

Due to the agro-climatic variations, the bigest amount of strawberries affected by *Phytophtora fragariae* and *Sphaeroteca macularis* were in tunnel. In field, due to the rainfall, was favorized the development of *Botritys cinerea*, being recorded the bigest amount of strawberries affected, followed by the attack of *Colletotrichum fragariae*.

Table 1. Response of the studied strawberry varieties to the diseases appeared in TUNNEL

Variety	Date of harvest	*Phytophtora fragariae* (g)	*Colletotrichum fragariae* (g)	*Botrytis cinerea* (g)	*Sphaeroteca macularis* (g)
Sonata	07.05.2018	290	0	64	0
Rumba	07.05.2018	507	0	0	0
Clery	07.05.2018	382	312	0	0
Sonata	10.05.2018	308	0	0	0
Rumba	10.05.2018	360	188	28	6
Clery	10.05.2018	44	158	10	0
Sonata	17.05.2018	94	142	34	118
Rumba	17.05.2018	105	203	21	10
Clery	17.05.2018	24	26	0	0
Sonata	29.05.2018	0	30	26	1,002
Rumba	29.05.2018	16	64	0	196
Clery	29.05.2018	0	12	0	0
Sonata	01.06.2018	0	62	0	184
Rumba	01.06.2018	0	10	0	6
Clery	01.06.2018	0	0	0	0
Sonata	05.06.2018	0	0	0	6
Rumba	05.06.2018	0	0	11	0
Clery	05.06.2018	0	0	0	0

Table 2. Response of the studied strawberry varieties to the diseases appeared in FIELD

Variety	Date of harvest	*Phytophtora fragariae* (g)	*Colletotrichum fragariae* (g)	*Botrytis cinerea* (g)	*Sphaeroteca macularis* (g)
Sonata	24.05.2018	57	47	74	21
Rumba	24.05.2018	442	26	90	24
Clery	24.05.2018	20	194	158	0
Sonata	29.05.2018	55	473	277	0
Rumba	29.05.2018	94	166	342	0
Clery	29.05.2018	0	286	568	0
Sonata	29.05.2018	55	473	277	0
Rumba	29.05.2018	94	166	342	0
Clery	29.05.2018	0	286	568	0
Sonata	01.06.2018	0	42	120	0
Rumba	01.06.2018	0	90	144	0
Clery	01.06.2018	10	180	412	0
Sonata	05.06.2018	178	575	824	5
Rumba	05.06.2018	48	126	1,018	0
Clery	05.06.2018	0	0	3,284	0
Sonata	08.06.2018	331	427	83	16
Rumba	08.06.2018	228	414	132	14
Clery	08.06.2018	372	230	148	2
Sonata	12.06.2018	0	6	96	0
Rumba	12.06.2018	0	18	292	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

In tunnel, during the harvest period, the bigest ammount of fruits were affected by *Phytophtora fragariae* at the begining of ripening due to the high moisture from the soil, while at the middle of harvest period, due to the increase of soil and ai temperature, were observed the highest attack of *Sphaeroteca macularis*. Comparing the field with the tunnel can be observed that, due to the rainfall, the ammount of strawberries affected by *Sphaeroteca macularis* is lower, while the attack of *Botrytis and Colletotrichum* is more pronounced to all varieties studied. The influence of agro-climatic factors and mulching system on the evolution of the studied diseases, is more pronounced in field over the entire period, from quatitive point of view (grams) as shown in Table 3. Also it vary, in the same time, the variety affected by each diseases studied.

Table 3. Total amount of strawberries affected by phytopathological agents

Variety	***Phytophtora cactorum* (g)**		***Colletotrichum fragariae* (g)**		***Botrytis cinerea* (g)**		***Sphaeroteca macularis* (g)**	
	Tunnel	**Open field**	**Tunnel**	**Open field**	**Tunnel**	**Open field**	**Tunnel**	**Open field**
Sonata	692	621	234	**1,571**	**124**	1,474	**1,310**	**41**
Rumba	**988**	**812**	465	840	60	2,018	218	38
Clery	450	402	**508**	890	10	**4,624**	0	0
TOTAL	**2,130**	**1,835**	**1,207**	**3,301**	**194**	**8,116**	**1,528**	**79**

CONCLUSIONS

Mulching with black plastic influences directly the evolution of soil moisture and temperature both in field and tunnel.

The conservation capacity of the studied agro-climatic factors and their fluctuations are influenced, in case of the tunnel conditions, by the presence of the second layer of plastic used to create the protected space.

Analyzing the optimal conditions for development of phatogenic agents, the use of black plastic favors their evolution in field, due to the highest temperatures over the day in relation with atmospheric humidity.

From phytosanitary point of view, the most pronounced attack of *Phytophtora fragariae* and *Sphaeroteca macularis* was in tunnel, while the strongest attack of *Colletotrichum fragariae* and *Botrytis cinerea* was in field.

The greatest amount of strawberry affected by fungal diseases was recorded in field compared to the tunnel.

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