ORGANIC FERTILIZERS OF MICROBIAL ORIGIN ENHANCE GROWTH AND REDUCE INFECTION OF SWEET CORN BY *FUSARIUM MONILIFORME*

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Abstract

Two field experiments were conducted to evaluate the effects of organic fertilizers of microbial origin on growth and yield of sweet corn and on the development *Fusarium moniliforme* in corn plants and in the soil. In the first experiment four products (Dry mycelium, Biosol, Agrobiosol, and Bactosol) were amended to the soil at various doses and *F. moniliforme* was applied before sowing. In the second experiment only one product (Dry mycelium) was amended, no artificial infestation took place, and half of the plots were solarized, with the aid of air-tight plastic covers, for 35 days after organic amendment, before sowing. Experiments showed that organic amendments enhanced growth and yield of corn in a significant manner, similar to, or better than, a mineral fertilizer. They enhanced saprophytic fungal population in soil and reduced soil colonization with the pathogen. Plants growing in amended soils exhibited reduced incidence of stalk and kernel infection with *F. moniliforme*. The combination of organic amendment and solarization resulted in higher yields compared to organic alone but disease control was not enhanced.

Key words: Soil-borne pathogens; *Zea mays*; Organic amendment; Solarization; Plastic mulch; Organic farming.

Introduction

Waste materials from industrial and agricultural sources are used as resources of organic fertilizers, e.g. activated sewage sludge (33), used mushroom compost (32), and fermentation residues from insulin and biopharmaceuticals industry (24). Organic fertilizers produced from fungal and/or bacterial waste biomass of the pharmaceutical industry are used in Europe and USA since 20 years (S. Naschberger, Biochemie, Kundl, Austria, personal communication). They contain about 90% organic matter, are free of seeds and heavy metals, and applied in lower quantities as compared to animal manure, natural humus or composts. These products have been used for diverse purposes such as revegetation of clay soil slopes (31), reforestration, revitalization of forestry, amelioration of degraded forest ecosystems (1, 2, 13, 16, 20, 19), as well as pasture-land farming, viticulture and fruit orchards.

In intensive farming systems with narrow rotations, soilborne plant pathogens frequently reach high inoculum densities, thus threatening the profitability of crops. A crucial factor in the management of diseases caused by these pathogens is to reduce their inoculum level below the critical threshold level before a susceptible crop is planted. Since the 1950s, chemical soil disinfestation has commonly been used for this purpose. In recent years, however, it has been recognized that soil disinfestation by chemicals is incompatible with sustainable agriculture and therefore its use is becoming increasingly restricted. As a consequence, the interest in alternatives has increased (7).

Soil solarization, either alone or in combination with organic amendments, was reported to serve as an effective alternative for the control of soilborne plant pathogens in subtropical areas. Several authors reported inactivation of fungal pathogens in soil by cruciferous tissue amendments (21, 27, 35). This evaluation has been attributed to toxic, volatile products of glucosinolates present in those amendments (25, 34).

In recent years, organic amendments are applied to the soil in combination with airtight plastic cover. For example, broccoli residues + airtight plastic cover was reported to largely reduce the number of microsclerotia of *Verticillium dahliae* and verticillium wilt severity (35). With fresh broccoli or grass + airtight plastic cover survival of *Fusarium oxysporum* f.

sp. *asparagi*, *Rhizoctonia solani*, and *V. dahliae* in inoculum samples buried 15 cm deep in soil was strongly reduced (7).

Studies of soils suppressive to fusarium wilts have indicated that the phenomenon is fundamentally microbiological in nature, resulting from complex microbial interactions between the pathogen and all, or a part of, the saprophytic microflora (3). Many groups of microorganisms have been proposed as having a role in this process. The most consistent results show that non-pathogenic *Fusarium oxysporum* and fluorescent Pseudomonas are the main agents for biological control. Each group has been effective in reducing the severity of fusarium wilt diseases in several crops under experimental conditions.

Our preliminary studies have indicated that organic fertilizers composed of killed *Penicillium chrysogenum* biomass could suppress the development of pathogenic *Fusarium oxysporum* spp. in soil. Studying their effect on *Fusarium moniliforme* was the major objective of the present research.

F. moniliforme commonly infects a wide range of crops throughout the world and is a major parasite of the Gramineae, particularly in tropical and subtropical regions. *F. moniliforme* Sheldon (*Gibberella fujikuroi* (Savada)) is a nonobligate pathogen of corn (*Zea mays* L.) and has been recovered from sorghum, wheat, rice, oats, bean, fig, cotton, asparagus, banana, sugar beet, sugar cane, stone fruits and several forages (28). It is the major species that causes ear, stalk and root rot on corn in Israel. In 1994 and 1995, the disease was so severe that in some fields the entire crop had to be discarded (15). Soil and seeds are apparently the main primary inoculum sources (14, 26) with corn plant residues in the soil being the major overwintering sites. During the growing season, wind and insects might also carry conidia. It is known that airborne spores of the fungus are usually abundant in corn field during the reproductive growth stage (29, 30).

F. moniliforme is translocated systemically, and exists in all the parts of corn plants including ear, stem and root even in non-inoculated fields (10, 22). Fungicides serve as a major tool to control the disease. Several fungicides were shown to control blight caused by the disease (4, 36). Galperin et al. (8) evaluated the efficacy of four fungicides in controlling

F. moniliforme in vitro and in corn plants. Prochloraz showed a high efficacy in reducing seedling blight due to reducing the rate of penetration and colonization of *F. moniliforme* in the seedlings. Galperin and Kenigsbuch (9) also found that prochloraz essentially limited the soil population of *F. moniliforme* as well as plant infection by the fungus.

Since fungicides have high toxicity to corn plants (4) biological control of *F. moniliforme* was performed. Bevivino et al. (6) evaluated the ability of maize-rhizosphere isolate of *Burkholderia cepacia* as a seed coating, to promote maize growth in both uninfested soil and soil infested with a maize pathogenic strain of *F. moniliforme* in greenhouse condition. They showed that *B. cepacia* MCI 7 displaced, or negatively affected, the population of *F. moniliforme* throughout plant growth, and obtained a significant increase of maize plant growth in both uninfested soil and soil infested with *F. moniliforme* ITEM-504, as compared to uninoculated plants.

The high nutritional efficacy of organic fertilizers of microbial origin on plant growth in the semi-arid condition of Israel was reported recently (12) but their possible effects on soil-borne fungal pathogens was never evaluated. We therefore examined: (a) the effect of four such organic fertilizers on growth and yield of sweet corn grown under field condition in Israel, and (b) their effects on stem and kernel infection with *F. moniliforme,* a common, devastating disease of corn in this country.

Materials and Methods

Two experiments were conducted during April - October 2000 in the farm of Bar-Ilan University, Ramat-Gan, Israel in a sandy-loam soil in 2 fields, which were not cultivated in the past 20 years. Crops were drip irrigated so as to keep soil moisture at full field capacity during the growing season.

Four microbial waste products of the pharmaceutical industry (Biochemic, Kundle, Austria) were used as organic fertilizers. In the first experiment four products were used: Dry mycelium, Agrobiosol, Biosol and Bactosol, whereas in the second only Dry mycelium was

used. All products are made of killed *P. chrysogenum* except Bactosol, which contains *P. chrysogenum* and several killed bacterial species.

Experiment 1

Fertilizers application and F. moniliforme inoculation

Three long ridges of 60×0.5 m were prepared (two meter apart), in the field (sandy-loam soil pH 6.75). Each ridge was divided into 17 plots (2×0.5 m, with 1 m space between plots). A total of 51 plots were arranged randomly for different fertilizer treatments.

Four organic fertilizers and one mineral fertilizer as a reference treatment were used. Each fertilizer was applied to 3 replicate plots at 3 rates each of 0.25, 0.5 and 1 kg/plot on May 2, 2000. Fertilizers were mixed into the soil to 20cm depth. The weight equivalents of nitrogen, phosphorus (P_2O_5) and potassium (K_2O) applied are given in Table 1. The application rates of the mineral fertilizer corresponded to the content of nitrogen in Biosol.

Inoculation

Fusarium moniliforme was grown on perlite particles (No. 3) supplemented with potato dextrose broth (15 g perlite + 30 ml of 2.4% potato dextrose broth + 1ml spore suspension containing 8×10^6 spores in a 200 ml sterile plastic box). One inoculum box was applied to each of fourty-eight plots (except 3 unfertilized non-inoculated control plots). Number of *F. moniliforme* infested perlite particles introduced was 9082 /plot. Inoculation was done on May 14, 2000, 12 days after fertilizer application. The *F. moniliforme* inoculum was applied along the middle part of the ridge and mixed into the soil to about 10 cm depth.

Seed sowing

Sixteen seeds of sweet corn (cv. Jubilee) were sown in each plot on May 16, 2000, 2 days after inoculation.

Cob harvest and determination of kernel infection

Four plants were chosen randomly in each plot 56 days after sowing, and their height (including tassel) was measured.

Cobs were harvested on July 31, 2000, 76 days after sowing. Their number and weight was determined. After removing their leaves one representative cob was chosen from each plot based on the general infection with *F. moniliforme.* Total kernel number and % infected kernels were determined.

Stalk infection

One stem section was taken from the bottom part of 4 randomly selected plants from each plot at 82 days after inoculation, and the incidence of infection with *F. moniliforme* was determined as described below.

F. moniliforme *density in soil*

Three soil samples were taken from each plot from 10cm depth at 98 days after inoculation. Soil infestation with *F. moniliforme* was determined as described below.

Experiment 2

Fertilizer application and plastic cover

Two plots (0.5 m × 2 m each) were each treated with Dry mycelium at a dose of 0, 0.25, 0.50, 1.00 and 1.50 kg/plot on June 15, 2000. One replicate-plot was tightly covered with transparent plastic film (0.1 mm thick) after application. All plots were drip-irrigated equally. At 35 days plastic cover was removed, and 16 seeds of sweet corn (cv. Jubilee) were sown in each plot (July 20, 2000). No fertilizer was applied during the growing season. No artificial inoculation with *F. moniliforme* was done in this experiment.

Plant growth and chlorophyll determination

At 53 days after sowing eight plants were randomly chosen in a plot and their height (including tassel) was determined. Third leaf (below tassel) was removed from these 8 plants and chlorophyll content was determined according to Inskeep and Bloom's (17). Briefly, 0.2 g leaf sample was homogenized with liquid nitrogen in a mortar, placed into a test tube containing 10 ml 80% acetone for 20 h, and absorbent of the extract was determined using Varian DMS 100S UV Visible Spectrophotometer at three wavelengths of 647.0, 664.5 and 750 nm. Chlorophyll content was calculated using the formula:

Total chlorophyll (g/g fr.w) = (17.95×(OD647-OD750)+7.9×(OD664.5 - OD750))×dilution times/leaf fresh weight.

Cob harvest and kernel infection

Cobs were harvested 60 days after sowing, their number per plot was counted and the weight of each cob was taken. After removing the leaves % kernel infected by *F. moniliforme* was visually determined.

Plants were cut off at 20 cm above soil level on the same date, and the fresh weight of each plant was taken. One stem section (5 cm length from the stem base 15-20 cm above soil level) was taken from these 8 plants for *F. moniliforme* determination.

***Determination of stalk infection by* F. moniliforme**

Two slices, 0.5cm thick each, were taken from each stem section, surface sterilized, and placed on Komada agar medium (23). Dishes with the stem slices were incubated at 25°C under fluorescent light (30 $\mu E.m^{-2}.s^{-1}$) for 12 h/day. The number of slices showing growth of *F. moniliforme* was counted after 10 days.

Density of* F. moniliforme *and other fungi in soil

Three soil replicate samples were taken from each plot from 10cm depth on October 3, 2000, 14 days after harvest. Two g of each soil sample were placed in a test-tube containing 30 ml glass distilled sterile water, vortexed for 1 min, and 0.3 ml of the extract were streaked on 4 plates of Komada agar medium in 9 cm Petri-dishes. Plates were incubated at 25°Cas above for 10 days when *F. moniforme* and other fungal colonies were counted in 4 Petri dishes per soil sample (12 per plot).

Results

Experiment 1

Table 2 presents data on yield components of sweet corn as taken 76 days after sowing. All fertilizers significantly enhanced plant growth, cob weight, cob number and total cob yield per plot as compared to non-fertilized, uninoculated plots. Mineral fertilizer treatments increased

yield by 56-73% above that of the controls. Organic fertilizers exhibited up to 2 fold increase in total yield. Of the 4 organic fertilizers, Biosol performed best.

In general, no significant differences were found between mineral and organic fertilizers in their effects on yield components except for the high dose of Biosol and Agrobiosol (Table 2). It was interesting to note that soil infestation with *F. moniliforme* had no significant effect on yield components in non-fertilized plots.

The rates of infection by *F. moniliforme* are given in Table 3. A large and significant difference was detected between inoculated and non-inoculated plots: whereas 14.2% of the kernels in a cob were infected in uninoculated plots, 47.1% were infected in cobs grown in inoculated plots. A similar difference was seen also with the stems. These differences may be attributed to the 14-fold difference in colonization of the soil with the pathogen, vis. 162 as against 2206 CFU in non-inoculated and inoculated plots, respectively. All fertilizers, except Bactosol, suppressed pathogen colonization in the inoculated soils (Table 3). The extent of suppression has generally increased with increasing the dose of the fertilizer applied. The strongest suppression (~9 fold) was observed with Dry mycelium.

Percentage stems infected with *F. moniliforme* was significantly reduced, relative to the control-inoculated plots in only 6 out of 15 fertilizer treatments. Dry mycelium at medium and high rates reduced stem infection by 57 and 71%, respectively. Second best performing organic fertilizer was Agrobiosol with 43-57% reduction at the two higher doses. Noteworthy is the fact that a high dose of mineral fertilizer showed a 57% reduction in stem infection incidence.

Kernel-infection incidence was very high in all treatments. Nevertheless, a significant lower incidence was seen in all fertilized plots, except with Agrobiosol. The reduction in kernel infection was more prominent with higher doses of the fertilizers.

Experiment 2

Dry mycelium only was used in this experiment, with half of the plots solarized with the aid of 0.1 mm plastic film cover for 35 days before seeding. No artificial inoculation of the

soil was done in this experiment. Growth and yield data are presented in Table 4 and data concerning soil colonization and infection with *F. moniliforme* are given in Table 5.

Dry mycelium enhanced growth and increased cob yield at almost all doses applied relative to non-fertilized plots, regardless of whether solarization was performed or not. However no clear dose-dependent yield increments were observed (Table 4). Also, no significant differences were detected between yield components in solarized vs. non-solarized fertilized plots (Table 4). In spite of the fact that plots were not artificially inoculated, *F. moniliforme* was detected in soil as well as *in planta* (Table 5). Dry mycelium amendments significantly reduced pathogen population in soil in a dose-dependent manner. Surprisingly, the rate of decrease was not significantly different in solarized vs. non-solarized plots. Saprophytic fungal population in soil increased in both solarized and non-solarized plots as Dry mycelium doses increased. However, saprophytic fungal populations were lower in solarized as compared to non-solarized soils except for the highest dose of Dry mycelium. Both stem infection and kernel infection were reduced in Dry mycelium-treated plots in a more-or-less, dose-dependent manner. In spite of the very high incidence of the pathogen in the stems only a few grains were infected. Solarization had no additive impact over that of Dry mycelium in reducing the incidence of infection in stems or kernels (Table 5).

Discussion

The awareness of farmers of the value of organic manures to plant health is nearly as ancient as farming itself. Organic amendment stimulate high populations of soil microorganisms, which limit the germination of pathogenic spores or growth of hyphae, or hasten the microbial digestion of propagules and pathogen-infested remains (5). Air-tight plastic cover of soil (solarization) is a common practice to control soil-borne pathogens in semi-arid location, with or without organic amendment (11, 18). Pathogens in soil were reported to be controlled by fresh plant amendment with airtight plastic cover not due to thermal inactivation but rather because of anaerobiosis and a decrease in redox potential of the soil (7).

Microbial wastes of the pharmaceutical industry contain 87-90% organic matter with about 7, 1 and 2% of N, P_2O_5 and K_2O, respectively. They serve, therefore as highly efficient organic fertilizers (12).

However, their value as organic amendment in controlling soilborne pathogens was never reported. Our preliminary experiments (Y. Cohen, B. Ben-Daniel and D. Gotlieb) in the greenhouse indicated that potting mixtures containing such organic fertilizers reduces the incidence of Fusarium wilt in melon and watermelon.

In the present study we report on the use of these microbial wastes to control *F. moniliforme* in sweet corn in the open field. The two experiments conducted provided evidence that amending the soil with these products not only accelerated crop growth and increased yield, but also suppressed *F. moniliforme* in the soil, and reduced the incidence of infection with *F. moniliforme* in stems and kernels. In the first experiment, Biosol and Agrobiosol applied at 1 kg per plot increased cob yield by about 2 fold compared to untreated plots (Table 2). In the other experiment Dry mycelium increased yield by 106-253% in non-solarized plots and by 158-341% in solarized plots, relative to control plots. These data stand in accordance with our studies with potato, tomato and wheat (12) which showed profound yield increments when treated with these microbial wastes.

To study the effect of organic fertilizers on a soilborne fungal pathogen, treated plots were artificially inoculated with *F. moniliforme*, and fungal and disease development were recorded in soil and plant tissues. Population of *F. moniliforme* in soil (Table 3) was significantly reduced by organics, as well as mineral fertilizers, except with Bactosol. It would be reasonable to assume that suppression resulted from the buildup of antagonistic microflora. However, it is hard to explain why Bactosol failed to induce such a suppression whereas a mineral fertilizer did. Stem and kernel infection were significantly reduced in treated plots, except Bactosol. Best performing was Dry mycelium (Table 3) which reduced stem infection from 58.3% to 16.7% and kernel infection from 47.1% to 20.8%.

The data (Table 3) suggest that the reduction in disease incidence may be attributed to the suppression of the pathogen population in soil. However, other mechanisms, such as induced

resistance (U. Neuschwander, personal communication) cannot be excluded. The data also show that in un-inoculated plots, infection did develop. Epidemiological studies have shown that airborne spores are usually abundant in corn fields during the reproductive growth stage and silk inoculation is an important pathway of the fungus to reach the kernels (up to 100%) (29, 30). It may be assumed, therefore, that uninoculated plots became infected by inoculation from airborne spores produced in the inoculated plots. It is also possible that soil particles carrying fungal propagules carried by wind amongst plots have infested the uninoculated plots (9).

While Experiment 1 was conducted in a field not exposed before to corn culture, Experiment 2 was done in a field adjacent to the former one. Plants of Experiment 2 were sown on July 20, 2000 while foliage in Experiment 1 was still intact (removed on August 4, 2000). We assumed that aerial inoculum would suffice to cause infection of plants in the second experiment, either directly or indirectly via the contaminated soil. Airtight plastic cover was applied to half of the plots to evaluate whether a combination of organic fertilizer plus solarization is more effective in controlling *F. moniliforme* as compared to organic fertilizers alone. It was clear that Dry mycelium significantly suppressed *F. moniliforme* population in the soil. In non-solarized soil suppression reached 62-99%, depending on the dose applied, relative to control (Table 5). Stem infection was significantly lower in treated plots but maximum reduction was 44%. Kernels were slightly infected, probably because available aerial spores at time of silking was already low. Solarizaton reduced *F. moniliforme* density in soil in the absence of Dry mycelium by about 50%. It was expected that the combination of solarization and organic amendment would be more effective compared to each treatment alone (11). The results indicated, however, some reduced efficacy of the combined treatments, probably due to the negative effect of solarization on the population size of the saprophytic fungi in the soil (Table 5). Smaller populations of saprophytes were recovered from solarized, Dry mycelium-treated plots, except with the highest dose (Table 5) indicating that the saprophytic fungi which are encouraged by Dry mycelium may bear antagonistic features towards *F. moniliforme*.

We conclude that organic amendment of fungal wastes of the pharmaceutical industry enhance growth and yield of sweet corn as well as reduces soil colonization with the pathogen *F. moniliforme* and stem and kernel rot by this fungus. Solarization further enhances the yield but not disease control.

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Table 1. NPK content and doses of organic fertilizers used in this study.

Treatment		NPK content (%) $N + P_2O_5 + K_2O$	Dose(kg/plot)
Untreated	CK1, non-inoculated		0
	CK2, inoculated		0
Dry mycelium	1	7 + 1 + 2	0.25
	2		0.50
	3		1.00
Agrobiosol	1	7 + 1 + 2	0.25
	2		0.50
	3		1.00
Biosol	1	6.5 + 1 + 3	0.25
	2		0.50
	3		1.00
Bactosol	1	8 + 3 + 2.5	0.25
	2		0.50
	3		1.00
Mineral	1	20 + 20 + 20	0.08
	2		0.16
	3		0.32

The NPK contents were supplied by the producer (Biochemie, Kundle, Austria).

Table 2. Effect of organic fertilizers on plant growth and cob yield of sweet corn cv. Jubille (76 days).

Treatment		Plant height(cm)	g fr.w/cob	Cob number/plot	Cobs yield/plot	
					(g fr. w/plot)	(%)
Untreated	Noninoculated	196 a	231 a	11.5 a	2671 a	100
	Inoculated	206 b	231 a	12.5 ab	2886 a	108
Dry mycelium	1	221 cde	254 bc	16.5 cd	4205 cdef	157
	2	225 de	262 bc	16.5 cd	4324 cdef	162
	3	222 cde	264 bc	17.0 cd	4495 def	168
Biosol	1	227 defg	247 ab	16.0 cd	3953 bcd	148
	2	219 cde	258 bc	17.5 d	4518 def	169
	3	227 defg	265 bc	20.5 e	5437 g	204
Agrobiosol	1	213 bc	270 c	13.0 ab	3496 b	131
	2	237 gh	263 bc	14.5 bc	3802 bc	142
	3	240 h	259 bc	20.5 e	5316 g	199
Bactosol	1	218 cd	268 bc	15.5 cd	4156 cde	156
	2	221 cde	263 bc	16.0 cd	4183 cdef	157
	3	236 fgh	294 d	17.0 cd	4756 f	178
Mineral	1	226 def	267 bc	16.5 cd	4405 def	165
	2	230 efgh	260 bc	16.0 cd	4167 cde	156
	3	236 fgh	264 bc	17.5 d	4622 ef	173

Fertilizers were applied on May 2, 2000. Soils were inoculated by *F. moniliforme* (9082 CFU/plot except CK1) on May 14, 2000. The area of each plot was 2 m×0.5 m. Sixteen seeds were sown in to each plot on May 16, 2000, and cobs were harvested on July 31, 2000. The results of correlation were: Plant height to cob weight R=0.761**; Cob weight to weight/cob R=0.631**, to cob number R=0.978**.

Table 3. Effect of organic fertilizers on infection of sweet corn (cv. Jubille) by *F. moniliforme*

Treatment		*F. moniliforme* density in soil (colonies/g soil)	% stems infected	% kernels infected in a cob
Untreated	Noninoculated	162 a	16.7 a	14.2 a
	inoculated	2206 i	58.3 d	47.1 j
Dry mycelium	1	825 ef	50.0 cd	43.5 hij
	2	375 abc	25.0 ab	26.9 bcd
	3	256 ab	16.7 a	20.8 b
Biosol	1	756 def	50.0 cd	33.7 efg
	2	668 cdef	33.3 abc	27.2 bcde
	3	456 bc	41.7 bcd	22.0 bc
Agrobiosol	1	943 f	50.0 cd	45.0 ij
	2	575 cde	25.0 ab	39.4 ghi
	3	481 bcd	33.3 abc	46.1 ij
Bactosol	1	2168 i	58.3 d	31.7 def
	2	2212 i	50.0 cd	28.2 cde
	3	1762 h	50.0 cd	25.1 bcd
Mineral	1	1337 g	50.0 cd	43.9 hij
	2	556 cde	41.7 bcd	37.8 fgh
	3	593 cde	25.0 ab	24.1 bc

Plots were inoculated with *F. moniliforme* on May 14, 2000.

The sampling dates were: cobs July 31, stems Aug 4, soils Aug 20, 2000 (78, 82 and 98 days after inoculation, respectively).

The results of correlation analysis were % kernels infected to % stems infected R=0.543*.

Table 4. Effect of Dry mycelium and soil solarization on yield components of sweet corn (cv. Jubille)

Treatment		Plant height (cm)	Chlorophyll content (µg/g. fr.w)	Tillers/plot	Foliage g. fr.w/plant (n=10)	Foliage g. fr.w/plot	Cobs g. fr.w/cob (n=6)	Cobs yield g. fr.w/plot	%
Soil solarization	Dry mycelium (kg/plot)								
-	0.00	132 a	1076 bcd	18	226 a	2811	124 ab	876	100
	0.25	163 bc	1216 cde	22	317 bc	3863	135 ab	926	106
	0.50	176 de	1206 cde	24	334 bc	4429	225 de	2218	253
	1.00	170 cd	1154 cde	21	316 bc	3546	185 cd	1408	161
	1.50	178 de	1107 bcd	37	349 bc	4582	197 cde	1717	196
+	0.00	156 b	630 a	23	238 a	3813	102 a	610	70
	0.25	167 bcd	896 b	24	283 ab	3597	163 bc	1385	158
	0.50	171 cd	1140 cde	32	335 bc	4162	226 de	2043	233
	1.00	180 de	1268 de	32	379 c	4484	222 de	2314	264
	1.50	186 e	1303 e	40	391 c	6057	244 e	2987	341

Dry mycelium was applied on June 15, 2000. Half of the plots were covered with plastic film on the same date. 16 seeds of sweet corn (cv. Jubille) were sown in each plot on July 20, 2000, 35 days after Dry mycelium application and plastic film covering. Eight plants were chosen randomly for plant height (including tassel) determination, and eight third leaf were taken from each plot for chlorophyll content determination on September 11, 2000, 52 days after sowing. Cobs were harvested on September 19, 2000, 60 days after sowing. Tiller number, foliage weight and cob weight were determined for 6 cobs and 10 plants in each plot.

The results of correlation analysis were:

1) Non-solarized: Plant height to cobs g.fr.w/plot R=0.750; chlorophyll content to cobs g.fr.w/plot R=0.291. Dry mycelium dose to tillers/plot R=0.828*, to foliage g.fr.w/plant (n=10) R=0.721, to foliage g.fr.w./plot R=0.639; to cobs g.fr.w/cob (n=6) R=0.621, to cobs g.fr.w/plot R=0.502.

2) Solarized: Plant height to cobs g.fr.w/plot R=0.984**; chlorophyll content to cobs g.fr.w/plot R=0.973**.

Dry mycelium dose to tillers/plot R=0.948**, to foliage g.fr.w/plant (n=10) R=0.943**, to foliage g.fr.w/plot R=0.928**; to cobs g.fr.w/cob (n=6) R=0.848*, to cobs g.fr.w/plot R=0.957**.

Table 5. The effect of Dry mycelium and soil solarization on soil colonization with *Fusarium moniliforme* and saprophytic fungi, and on infection of corn (cv. Jubille) with *F. moniliforme*.

	Treatment	*F. moniliforme* density (colonies/g soil)	Other fungal density (colonies/g soil)	% kernels infected	% stems infected
Soil solarization	Dry mycelium dose (g/m^2)				
-	0	494 c	2525 ab	2.0 c	100 d
	250	188 b	6425 c	0.6 ab	81 c
	500	19 a	9169 d	0.2 a	75 bc
	1000	31 a	8622 d	0.1 a	63 ab
	1500	6	12450 e	0.1 a	56 a
+	0	225 b	1313 a	8.4 e	100 d
	250	429 c	1669 a	3.6 d	100 d
	500	94 ab	4413 bc	1.6 bc	81 c
	1000	38 a	5569 c	0.6 ab	81 c
	1500	13 a	16475 f	0.5 ab	56 a

The results of % kernels infected were calculated for 6 cobs/treatment.

The results of % of stems infected were determined for 8 stems/treatment.

The results of *F. moniliforme* and fungal densities were calculated from 3 soil samples/treatment.