SOYBEAN BORNE FUNGI AND THEIR CONTROL
2- EFFECT OF SOIL AMENDMENTS ON THE INCIDENCE OF
FUSARIUM ROOT ROT AND CHLAMYDOSPORES
GERMINATION

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Abstract
The addition of mature (high C:N ratio) plant residues, and two
immature (low C:N ratio) residues of barley and sorghum to soil, signifi-
cantly reduced Fusarium root rot of soybean. Disease rating was posi-
tively correlated with total soil inorganic nitrogen and nitrate. Soil
amendment with residues of mature or immature barley and mature oat
appreciably increased stem length and fresh root weight of Clark soy-
bean. Mature and immature residues of barley or oat decreased Fusarium
population in soybean roots or rhizosphere, especially after 80 days
from addition of these residues; however, other residues had no effect.
Addition of soybean residues to the soil increased the incidence of soy-
bean seed infected by Fusarium oxy sporum, while soil amendment with
barley or oat residues had a reverse effect.
Decomposing mature residues were more inhibitory to chlamy-
dospore germination in vitro and in soil than the corresponding immature
residues. Failure of chlamydospores to germinate in vitro and in soil was
related to nutrient deficiency in the soil as well as to the formation of an
inhibitory material from the decomposing residues. Fungistasis due to
nutrient deficiency, but not toxicant production, was overcome in soil in
the presence of nutrients.

To improve physical, chemical and other soil properties for any
soil contaminated with Fusarium root rot, the addition of mature crop
residues of high C:N ratio is recommended.

INTRODUCTION

Wilt of soybean [Glycine max (L.) Merr.] caused by Fusarium oxy sporum
Schlech, emend. Snyder & Hansen has been investigated (Leath and Carroll, 1985 and
Lee 1986). F. oxy sporum has been studied as a primary pathogen and as a part of the
root rot complex (French and Kennedy, 1963). Although this disease has caused
great crop losses in the soybean-growing areas of Upper Egypt for many years, its
control is still in its infancy. Chemical control currently is either not available or is
too costly. Cultural control which employs a reduction of soil compaction in conjunc-
tion with appropriate irrigation has been a successful method (Burke et al, 1972;
Khalifa, 1983 and Yehia et al, 1994). Fortunately, methods for control which in-
Decomposing plant residues can significantly affect soil-borne plant pathogens by alteration of pathogen inoculum level. Of major importance in this respect is the carbon: nitrogen (C:N) ratio of the amendments (Adams et al, 1968; Papavizas et al., 1968 and Toussoun et al., 1963). Population levels, in turn, are affected by the extent of pathogen chlamydospore germination. In soils amended with residues that contain stimulatory nutrients, chlamydospores germinate and can form replacement chlamydospores so that the numbers increase (Lewis and Papavizas, 1977). Some amendments of high C:N ratio, such as cellulose or oat straw, allow only slight, or no chlamydospore germination (Papavizas et al., 1968). The inhibition of chlamydospore germination due to decomposing mature amendments generally has been attributed to soil fungistasis arising from nutrient deficiency (Watson and Ford, 1972). In this respect, Subba Rao (1975) reported that the rate of immobilization of nitrogen depends on the C:N ratio of the organic matter added. The critical balance between mineralization and immobilization may be upset if the C:N ratio is less than 25 when mineralization is likely to exceed immobilization leading to accumulation of ammonium and nitrate forms of nitrogen.

This work provides additional information on the effect of decomposing some plant residues of Fusarium root rot, stem length, fresh root weight of soybean and population of the pathogen in the root or soil rhizosphere of soybean and the effect of residues extracts on chlamydospore germination in vitro and in soil.

MATERIALS AND METHODS

A. Soil, isolate and residues:

The soil used was sandy loam having a pH of 7.6, containing 31 and 27 ug of NH$_4$N and NO$_3$N/g soil, respectively, and the organic matter content was 2.6%. One isolate of *F. oxysporum* was previously isolated from discolored soybean. Plant residues, composed of leaves, stems and roots were air-dried and ground in a mill to pass a 0.84-mm (20 mesh) screen. Total carbon and nitrogen contents were determined as described by Jackson (1958). This was performed at the Laboratory of
volve plant residue incorporation into the soil has met varied success. In spite of the difficulties inherent in this approach, the stress on the importance of preserving the environment requires continued exploration into the area of biological control for the suppression of soil-borne plant pathogens. For many years, various organic amendments and plant tissues applied to soil were shown to reduce Fusarium root rot of beans in the laboratory and greenhouse (Cook and Watson, 1969; Papavizas et al., 1968 and Arafa, 1994).

Decomposing plant residues can significantly affect soil-borne plant pathogens by altering of pathogen inoculum level. Of major importance in this respect is the carbon: nitrogen (C:N) ratio of the amendments (Adams et al 1968; Papavizas et al., 1968 and Toussoun et al., 1963). Population levels, in turn, are affected by the extent of pathogen chlamydomspore germination. In soils amended with residues that contain stimulatory nutrients, chlamydomspores germinate and can form replacement chlamydomspores so that the numbers increase (Lewis and Papavizas, 1977). Some amendments of high C:N ratio, such as cellulose or oat straw, allow only slight, or no chlamydomspore germination (Papavizas et al., 1968). The inhibition of chlamydomspore germination due to decomposing mature amendments generally has been attributed to soil fungistasis arising from nutrient deficiency (Watson and Ford, 1972). In this respect, Subba Rao (1975) reported that the rate of immobilization of nitrogen depends on the C:N ratio of the organic matter added. The critical balance between mineralization and immobilization may be upset if the C:N ratio is less than 25 when mineralization is likely to exceed immobilization leading to accumulation of ammonium and nitrate forms of nitrogen.

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**MATERIALS AND METHODS**

**A. Soil, isolate and residues:**

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Soil, Water and Plant Analysis, Faculty of Agriculture, El-Minia. The residues of each plant consisted of 5 sets of plant tissues; one of each pair being immature (low C:N ratio), and the other being mature (high C:N ratio). Plants included in this study and their respective C:N ratios were: oat (Avena sativa L.) 8 and 73; sorghum (Sorghum vulgare L.) 10 and 58; corn (Zea mays L.) 8 and 70; barley (Hordeum vulgare L.) 8 and 76. 76 and soybean [Glycine max (L.) Merr.] 10 and 56.

Available NH$_4$-N and NO$_3$-N in soil were determined by steam distillation with magnesium oxide-Devarra alloy method (Bremner and Keeney, 1965). The equivalent of 10 g dry weight of each treatment replicate soils were analyzed prior to planting.

B. Effect of plant residues on soybean root-rot, stem length, fresh weight and population of pathogen in both soybean roots and rhizosphere.

Soil was infested with *F. oxysporum* by adding microconidial suspension (200 ml) to the soil and keeping it moist for 5 weeks in order to convert conidia to chlamydospores (Nash et al., 1961). Number of propagules of the pathogen in the soil was determined by the dilution method and plating onto Nash and Snyder medium (1965) amended with chloramphenicol (300 μg/mL). Plant residues of the previously mentioned crops were added and mixed thoroughly with the infested soil at a rate of 1.0% (w/w) and moistened to 50-60% of their moisture holding capacity. After 3 weeks, infested and treated soil was placed in 6.5 cm square plastic pots and planted with 10 Clark soybean seeds per pot. Four replicates were used for each treatment. Soil containing *F. oxysporum* only served as control. Disease rating, stem length and fresh root weight were recorded after 7 weeks from planting. Populations of *F. oxysporum* were determined after 50 and 80 days following the addition of plant residues both in the roots and rhizosphere of Clark soybean.

At the time of harvest, 25 seeds of each treatment were shaken in 1.25% Na OCl for 3-4 minutes, rinsed in sterile distilled water, and cultured on Difco potato-dextrose agar (PDA). Incubation was made at 20-22°C, usually for 7 to 10 days (Ferrant and Carroll, 1981), when counts of infected seeds were made and growing fungi were identified.

C. Effect of decomposing barley and corn residues on chlamydospore germination.

Chlamydomspore preparations were tested for germinability by the method of
Adams et al. (1968), which is a modification of Jackson's agar disk technique (Jackson, 1958). 20-g aliquot of soil amended with (mature or immature residue of each of barley and corn or nonamended soil) was mixed with 10 ml of warm (50°C) 0.5% agar with or without 0.1% potato dextrose broth (PDB) powder. The soil agar mixture was placed in petri dishes and after it had set, three disks (1x10 mm) of 2% agar, with or without 0.1% PDB powder, were placed on the soil-agar surface, kept at 5°C for 48 hr, then a drop of diluted chlamydospore suspension (50,000/ml) was placed on each disk. After incubation at 26°C for 18 hr, disks were transferred to microscope slides, stained with lactofuchsin, and examined.

D. Effect of residue extracts of barley and corn on chlamydospore germination.

Extracts of residues decomposing in soil were prepared by extracting 1 kg portions of amended soil (2%) with chloroform: methanol (1:1 v/v) for 24 hr. The extracts were concentrated under vacuum to a brown, viscous material. Non-amended soil, soil amended with immature barley and corn, and with mature barley and corn yielded 140, 280, 310, 450 and 420 mg of extract/kg of soil respectively. Extracts were homogenized with water in a blender so that an amount equivalent to that found in 2% nonextracted residue was added to the soil containing chlamydospores. Glucose and NH₄Cl were added to the soil to stimulate germination. Germination of F. oxysporum chlamydospores was determined by the propagule assay method 16 hr after the extract was added to the soil (Lewis and Papavizas, 1977).

RESULTS

A. Effect of decomposing plant residues on:

A. 1. Soybean root rot and soil inorganic N content:

All mature residues reduced disease below those recorded in the nonamended control soil (Table 1), whereas only two immature residues (barley and oat) were effective in this respect. Barley and oat residues were the most effective mature amendments to reduce the disease rating in Clark soybean plants. Similar results were obtained when the experiment was repeated.

At the time of planting, soil inorganic N content varied between 34.5 ug/g in mature oat-amended soil and 93.3 ug/g in immature corn-amended soil. Soil NH₄-N contents were approximately the same in all amended soils, with the exception of
immature corn-amended soil which contained a significantly greater amount than soils amended with other residues. In contrast, soil NO3-N varied considerably among treatments. There was generally less of this form of N in soils amended with mature than immature residues.

Two of the five plant residues (barley and oat) which reduced disease in a significantly lower content of NO3-N in the soil than the other three (Table 1). Disease rating was positively correlated with total inorganic nitrogen and NO3-N content. The correlation between disease rating in Clark soybean and NH4-N content was not significant.

Table 1. Effect of decomposing immature and mature plant residues on root rot of Clark soybean caused by F. oxysporum and the total inorganic nitrogen content of soil at the time of planting.

<table>
<thead>
<tr>
<th>Plant residues (a)</th>
<th>Disease rating after 7 weeks for planting (b)</th>
<th>Inorganic N (µg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NH4-N</td>
</tr>
<tr>
<td>Barley</td>
<td>immature</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>mature</td>
<td>1.4</td>
</tr>
<tr>
<td>Oat</td>
<td>immature</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>mature</td>
<td>2.0</td>
</tr>
<tr>
<td>Sorghum</td>
<td>immature</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>mature</td>
<td>2.8</td>
</tr>
<tr>
<td>Corn</td>
<td>immature</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>mature</td>
<td>4.5</td>
</tr>
<tr>
<td>Soybean</td>
<td>immature</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>mature</td>
<td>4.6</td>
</tr>
<tr>
<td>No residue (control)</td>
<td></td>
<td>7.4</td>
</tr>
<tr>
<td>L.S.D. immature (A)</td>
<td></td>
<td>2.01</td>
</tr>
<tr>
<td>5% mature (B)</td>
<td></td>
<td>1.70</td>
</tr>
<tr>
<td>A x B</td>
<td></td>
<td>0.92</td>
</tr>
</tbody>
</table>

a. Added to soil at rate of 1% (w/w)
b. On a 1-10 scale where 1 = healthy plant, 10 = dead plant.

A.2. Stem length and fresh root weight of Clark soybean:

Data in Table (2) indicate that soil amendment with residues of mature or immature barley plants and mature oat significantly increased fresh root weight and stem length of Clark soybean plants, while residues of other plants were of no ef-
fect. Highest increase was experienced with mature barley-amended soil.

At the time of harvest, percentage of infected seeds were determined for each treatment. All mature and immature residues decreased the percentage of seeds, infected with *F. oxysporum*, when compared with nonamended control soil. Adding barley residues both mature or immature had the most effect in decreasing the percentage of seeds infected with *F. oxysporum* (4.4 and 6.4 respas compared to the control (32.4), while the residues of both mature and immature soybean had the least effect in decreasing this percentage (22 and 30.2 resp. as compared with control (32.4)). Other residues had intermediate effects.

Table 2. Effect of decomposing immature and mature plant residues in soil infested with *F. oxysporum* on stem length, fresh root weight and percentage of infected seeds of Clark soybean var.

<table>
<thead>
<tr>
<th>Infested soil amended with plant residues</th>
<th>Stem length (cm.) (a)</th>
<th>Fresh root weight (g)</th>
<th>%, Infected seed harvested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley immature</td>
<td>17.2</td>
<td>2.1</td>
<td>6.4</td>
</tr>
<tr>
<td>Barley mature</td>
<td>20.4</td>
<td>2.8</td>
<td>4.4</td>
</tr>
<tr>
<td>Oat immature</td>
<td>15.5</td>
<td>1.1</td>
<td>6.2</td>
</tr>
<tr>
<td>Oat mature</td>
<td>16.4</td>
<td>1.9</td>
<td>9.0</td>
</tr>
<tr>
<td>Sorghum immature</td>
<td>12.3</td>
<td>0.8</td>
<td>16.8</td>
</tr>
<tr>
<td>Sorghum mature</td>
<td>13.7</td>
<td>0.9</td>
<td>18.6</td>
</tr>
<tr>
<td>Corn immature</td>
<td>14.6</td>
<td>1.2</td>
<td>14.5</td>
</tr>
<tr>
<td>Corn mature</td>
<td>15.3</td>
<td>1.4</td>
<td>12.1</td>
</tr>
<tr>
<td>Soybean immature</td>
<td>10.4</td>
<td>1.6</td>
<td>30.2</td>
</tr>
<tr>
<td>Soybean mature</td>
<td>9.7</td>
<td>1.2</td>
<td>22.0</td>
</tr>
<tr>
<td>No residue control (control) (c)</td>
<td>12.1</td>
<td>1.0</td>
<td>32.4</td>
</tr>
</tbody>
</table>

a. Mean of four replications of five plant each.
b. Mean of four replications of three plant each.
c. No plant residues was amended with soil infestation.


Data in table (3) show that soil amended with residues of immature and mature barley and oat significantly decreased *F. oxysporum* population recorded in both
soybean roots and rhizosphere after 50 and 80 days from addition of residues, whereas soil amended with soybean residues increased fungal population at the same dates. Other treatments were of no effect, except in immature and mature corn amended soil where a reduction of fungal population in the rhizosphere was recorded after 50 days only.

A significantly larger *F. oxysporum* population was isolated after 80 days either from roots or the rhizosphere of Clark soybean than those isolated after 50 days from addition of residues. Mature barley residues caused the highest decrease in fungal population in Clark roots and rhizosphere at the two periods; however, mature or immature residues of soybean resulted in the opposite.

Table 3. Effect of decomposing immature and mature plant residues on isolation of *F. oxysporum* from Clark soybean roots and rhizosphere soil.

<table>
<thead>
<tr>
<th>Plant residues (amended with soil infestation a)</th>
<th>Population of <em>F. oxysporum</em> from Clark soybean after addition of plant residues</th>
<th>Rhizosphere soil of plants (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Roots (b) after 50 days</td>
<td>after 80 days</td>
</tr>
<tr>
<td>Barley immature mature</td>
<td>21.0</td>
<td>32.4</td>
</tr>
<tr>
<td>Oat immature mature</td>
<td>18.4</td>
<td>25.6</td>
</tr>
<tr>
<td>Sorghum immature mature</td>
<td>26.0</td>
<td>37.2</td>
</tr>
<tr>
<td>Oat immature mature</td>
<td>23.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Sorghum immature mature</td>
<td>36.0</td>
<td>46.5</td>
</tr>
<tr>
<td>Sorghum immature mature</td>
<td>34.9</td>
<td>44.2</td>
</tr>
<tr>
<td>Sorghum immature mature</td>
<td>38.4</td>
<td>43.8</td>
</tr>
<tr>
<td>Corn immature mature</td>
<td>37.2</td>
<td>41.6</td>
</tr>
<tr>
<td>Corn immature mature</td>
<td>40.0</td>
<td>66.4</td>
</tr>
<tr>
<td>Soybean immature mature</td>
<td>45.2</td>
<td>70.2</td>
</tr>
<tr>
<td>Soybean immature mature</td>
<td>38.0</td>
<td>48.5</td>
</tr>
<tr>
<td>No residue (control)</td>
<td>2.95</td>
<td>3.92</td>
</tr>
<tr>
<td>L.S.D. immature mature (A)</td>
<td>5.23</td>
<td>4.82</td>
</tr>
<tr>
<td>5% A x B</td>
<td>7.01</td>
<td>5.23</td>
</tr>
</tbody>
</table>

a. Initial inoculum density of *F. oxysporum* (2x10^3 propagules/g soil).

b. Mean frequency of isolation from 100 root section averaged over four replicates and two sampling dates.

c. Mean number of propagules (1: 100 dilution) averaged over four replicates and two sampling dates.
B. Effect of decomposing barley and corn residues on chlamydospore germination.

Barley and corn residues were selected for further study taking into consideration that mature barley was the most effective amendment in disease reduction, while the mature residues of corn was the least effective.

With the agar-disk assay method, both mature residues significantly reduced germination of *F. oxysporum* chlamydospore on agar over a 15-wk period (Fig. 1). However, mature barley amendment was more superior in its effect. Barley immature residues reduced germination by approximately 22.5%, while reduction was 16.0% in case of immature corn. Reduction in germination occurred in the presence of nutrients (PDS powder) supplied to the assay media (Fig 1-A). When these nutrients were not supplied, chlamydospore germination was high at the time the amendments were added, but not during the remainder of the 15-wk test period (Fig 1-B).

C. Effect of residue extracts on chlamydospore germination.

Extracts from decomposing mature barley and corn residues inhibited chlamydospore germination in soil even in the presence of nutrients (table 4). Significantly greater inhibition occurred with mature barley than with mature corn. For decomposing immature residues, corn and barley had a little effect on germination of indicated *F. oxysporum*.

<table>
<thead>
<tr>
<th>Plant residue extract</th>
<th>Nutrients</th>
<th>Germination (%) of chlamydospores</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (0)</td>
<td>+</td>
<td>88</td>
</tr>
<tr>
<td>Control</td>
<td>+</td>
<td>86</td>
</tr>
<tr>
<td>Barley (CN 8)</td>
<td>+</td>
<td>66</td>
</tr>
<tr>
<td>Barley (CN 76)</td>
<td>+</td>
<td>20</td>
</tr>
<tr>
<td>Corn (CN 8)</td>
<td>+</td>
<td>79</td>
</tr>
<tr>
<td>Corn (CN 76)</td>
<td>+</td>
<td>50</td>
</tr>
</tbody>
</table>

LSD 95% 12.32

a. Residues extracted 3 wk after addition to soil.
b. Added at a rate equivalent to that found in 2% soil amendment.
c. Glucose and NaCl each added at 140 mg/g of soil.
d. "None" indicates no extract from nonamended or amended soil was added.
"Control" indicates extract from nonamended soil was added.
DISCUSSION

The importance of high C:N ratio materials such as mature barley, corn and sorghum residues in the suppression of *Fusarium* root-rot of bean was shown experimentally as early as 1959 (Cook and Watson, 1969). However, relatively little work has been done to unravel possible mechanisms of control by these amendments.

From the obtained results in table (1) it may be stated that low root rot severity resulted from a decrease in population of the fungus in both soybean roots and rhizosphere is brought about by high C:N ratio residues. These results are also positively correlated with low total inorganic nitrogen and low NO$_3$-N. These actions can be attributed to nitrogen immobilization by soil microbial competitors to *Fusarium*, which was thought to be the mechanism of action of high C:N ratio residues (Lewis and Papavizas, 1977; Papavizas et al, 1988). Subba Rao (1975) reported that the rate of immobilization of nitrogen depends on C:N ratio of added organic matter.

Disease rating was shown to be positively correlated with NO$_3$-N content of soil. This result is in agreement with the finding of Huber and Watson (1974) and Paulitz and Burke (1987). However, some mature residues (oat and barley) were more effective than others (sorghum, corn and soybean). Soil N content alone could not account for disease suppression or increase (Lewis and Papavizas, 1977). In this study, decomposing mature barley and oat which have high C:N ratios (76 and 73 resp.) resulted in nearly the same amount of inorganic N (34.4 and 38 ug/g), but each of the two materials had a different disease rating (1.4 and 2 resp). Burke (1969) suggested that the N status of soil may not be the major determinant in amendment effectiveness for suppression of *Fusarium* root rot.

As shown in table (2) soil amendment with residues of mature and immature barley plants and mature oat significantly increased fresh root weight and stem length. Subba Rao (1975) attributed the effect of humic substances as a final products of organic matter decomposition on improving root growth and reported that the growth stimulatory activity of humus complexes on plant root may be attributed to the increase in cytochrome oxidase activity in the root system. Similarly, humic acids are known to increase the activity of glutamic acid transaminase and phosphatase enzymes and also the synthesis of deoxyribose and ribose nucleic acids.

Since N content of soil could not explain why some amendments were more effective than others, attempts were made to determine whether amendment decom-
position in soil had any adverse or beneficial effects on chlamydospore germination. With the agar-disk method, the lack of germination as a result of amendment decomposition was due to fungistasis arising from nutrient deficiency (Fig 1-B). Both barley and corn residues, regardless of maturity, resulted in a fungistatic soil. This agrees with earlier observations (Adams et al, 1968; Bristow and Lockwood, 1979 and Papavizas et al, 1968), who reported that decomposing cellulose and other organic materials prevented chlamydospore germination in soil.

As nutrients were added as POB powder to both agar disks and to the soil agar mixture after 15-wk of amendment decomposition, chlamydospore germination ranged between 67.5% and 73% with immature residues of barley and corn respectively, compared to 91.5% in the control; however, this decrease was most pronounced with mature residues of these crops (Fig 1-A). Lewis and Papavizas (1977) found that adequate nutrients for germination were present in agar disk over mature rye and corn amended soil. Despite this, germination was poor in these treatments. This poor germination may be due to some other reasons.

The possibility of formation of a toxic principle was investigated. Previous evidence for production of an extractable toxicant against soil borne plant pathogens has been minimal (Watson and Ford, 1972). Evidence based on our data with agar-disk method, suggests that a factor toxic to chlamydospore germination was associated with mature amendment decomposition in soil. In the present study, a direct evidence for a toxicant was made by extracting a crude preparation of the toxic material from decomposing mature barley and corn residues and demonstrating its inhibitory effect on chlamydospore germination with the propagule assay method (Table 4). Other reports attributed the inhibition of chlamydospore germination by decomposing mature amendments to soil fungistasis arising from nutrient deficiency (Griffin et al., 1975; Lewis and Papavizas, 1977).
EFFECT OF SOIL AMENDMENT ON ROOT-ROT OF SOYBEAN

Fig. 1. (A-B). Effect of decomposing barley and corn residues on chlamydospore germination of *F. oxysporum* determined with agar-disk method. A) Nutrients as potato dextrose broth powder (0.1%) added to disks and soil agar mixture. B) No nutrients added. Assays performed, 0, 4 and 15 wk after addition of residues (1%) to soil. Germination represents percentage of that on agar plates alone with nutrients (73%) and without (60%).
REFERENCES


دراسات على الفحصية الساحية لبيذور قول الصويا وطرق مقاومتها

1. تأثير إضافة بقايا بعض المصابيح إلى التربة على إصابة
الجراثيم الكلاسيكية للفحصية قول الصويا

كلاسيكية للفحصية قول الصويا.

إضافة بقايا بعض المصابيح الساحية والبقاء في نسبة الكربون للمفتاحين
وذلك بقايا محسوساً في التربة والذرة الرياحية القربة ساحية والمتفاوتة في نسبة
الكربون للمفتاحين إلى التربة أدت إلى حدوث خسائر معنوية والإصابة بمرض عفن النجور
الفحصية قول الصويا، كما وجد ارتباط بين نسبة الإصابة بالمرض وكلا من
الكربون والمفتاحين في التربة وعند النجور وصرف الفحصية أدنى سطح النجور.

إضافة بقايا الناجحة والغير ناجحة لسفوح الشعر في بعض البقايا الناجحة فقط
لحصول التوفيق أدت إلى زيادة في كل من طول النجور ووزن النجور المطرود الصرف قول
الصويا سكاكر.

إضافة بقايا محسوساً في التربة والذرة الناجحة أو الفارق الناجحة أدت إلى
نقص في أعداد جراثيم الفحص في نجور قول الصويا أو منطقة الريوزفري والأخص بعد
8 يوم من إضافة هذه البقايا، بينما ما إنما الذي الناجحة الأخرى لم يكن لها أي تأثير.

تحلل بقايا للفحصية الساحية كانت أكثر تأثيراً في تشبيه أنواع الجراثيم
الكلاسيكية سواء في العامل أو في التربة عند ارتباط بتأثير المصابيح الفارق ناجحة.

التحسن في الصفح الكيميائية والبيئية وأيضاً العوامل الأخرى للجودة الملوحة بفطر
الفحصية قول الصويا، لوصول بقايا للفحصية الساحية ذات النسب عالية من
الكربون للمفتاحين.