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**ARTICLE**

# Effect of organic fertilizers combined with benzo (1,2,3) thiadiazole-7-carbothioic acid S-methyl ester (BTH) on the cucumber powdery mildew and the yield production

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**ABSTRACT** Organic fertilizers such as compost, compost tea and seaweed extracts (Algean) combined with benzo (1,2,3) thiadiazole-7-carbothioic acid S-methyl ester (BTH)) showed significant effect on the powdery mildew-infected cucumber leaves with Sphaerotheca fuliginea. We have shown that spraying the infected cucumber leaves with the BTH (0.05 mM) combined with the organic fertilizers strongly decreased the disease severity of the cucumber powdery mildew fungus from 85.1% to 3.4% as compared to the control leaves which infected only with the pathogen. Furthermore, organic fertilizers combined with BTH increased significantly vegetative growth characters of cucumber (stem length, number of leaves /plant, leaf area /plant and chlorophyll content) especially at the earlier stage of growth as compared to the control plants (chemical fertilizer only). Also, most of the organic materials produced the highest cucumber early yield and fruit quality, but total yield was equal or less than the chemical fertilizers. Interestingly enough, that organic fertilizers combined with BTH elevated the ascorbic acid content (chemical quality of cucumber fruits) and decreased the nitrate content which very harmful as well as increased the fruit yields as compared to the control plants.

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**KEY WORDS**

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Cucumber (*Cucumis sativus L.*) is a favorite commodity exports for markets and local consumption and represents one of the most important and economic vegetables in Egypt. It is grown in Egypt in the open field from March to November and under plastic houses from September to May. The total cultivated area of cucumber in Egypt was about 66640 feddan (6664 hectares) in 2005 according to the statistics of FAO.

Powdery mildew of cucumber caused by the fungus *Sphaerotheca fuliginea* (Schechtend Fr) Pollacci, is one of the most dangerous foliar disease, attacking cucumber plants, in Egypt and other countries (Harfoush and Salama 1992; Mosa 1997; Reuveni et al. 1997; Verhaar et al. 1997).

Fungicides and resistant or tolerant cultivars used to control this disease, however, each of these control methods has its limitations (McGrath 1991). Therefore, powdery mildews of cucumber plants (*Cucumis sativus* L.) remain the major problem for greenhouse producers worldwide.

The use of alternative control methods of diseases can effectively replace chemical fungicides. The application of safety chemicals to activate systemic acquired resistance (SAR-type reaction) provides novel alternatives for disease control in agronomic systems. Salicylic acid (SA) is the only plant-derived substance that has been demonstrated to be an inducer of SAR (White 1979; Antoniw and White 1980; Ward et al. 1991).

The synthetic chemical benzo (1,2,3) thiadiazole-7-carbothioic acid S-methyl ester (BTH) was also demonstrated to be a potent SAR activator (Friedrich et al. 1996; Görlach et al. 1996; Lawton et al. 1996) that supplies protection in the field against some diseases in several crops. Thus, BTH seems to be proper compounds for practical agronomic use (Hafez et al. 2004).

Geetha and Shetty (2002) found that chemical induction of resistance in pearl millet against downy mildew disease (*Sclerospora graminicola*) is possible by treating seeds of highly susceptible cultivars with the resistance activator benzothiadiazole (BTH) (CGA 245704), calcium chloride ($CaCl_2$) and hydrogen peroxide ($H_2O_2$). BTH in 0.75%, 90 mM $CaCl_2$ and 1.0 mM $H_2O_2$ were effective in managing the disease by giving 78%, 66% and 59% protection, respectively.

There is no doubt that chemical fertilizers are essential in most cropping systems. However, in long-term field experiments where mineral fertilizers have only been used, some problems could arise, especially increased soil erosion, soil compaction, environmental pollution and public health risk (Top et al. 2002). Therefore, it is essential to adopt a system of organic farming in vegetables due to increasing the objectives

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against the conventional farming as a main source of soil and water pollution as well as food products. As defined by the US Department of Agriculture (1980), organic farming is a system that excludes the use of synthetic fertilizers, pesticides and growth regulators.

Some investigators indicated that addition of organic manures as opposed chemical fertilizes increased vegetative growth characters, yield and fruit quality of vegetable crops (Ozoros-Hampton et al. 1994; Hsieh and Hsu 1995; Yousef et al. 2001; Poudel et al. 2002; Aly 2002).

On squash, Ozores-Hampton et al. (1994) showed that plants had increased yields when planted in municipal solid waste compost amended soil in spite of application of NPK fertilizers at recommended rates. On pepper, Hsieh and Hsu (1995) stated that early and total yields of all organic sources were significantly higher than that of chemical fertilizer. In the same line on cucumber, Aly (2002) found that organic treatment (compost) produced significantly greater early yield (1.85 kg/m$^2$) and total yield (4.49 kg/m$^2$) than chemical treatment which produced 1.38 kg/m$^2$ and 3.51 kg/m$^2$ for early and total yields, respectively.

Organic fertilizers are claimed to produce higher nutritional quality of vegetables in forms of vitamin C, TSS, dry matter and acidity (Vogtmann et al. 1993; Youssef et al. 2001; Bayoumi 2005). For nitrate content, Clark et al. (1999) found that nitrate content in tomato fruits was lowest in the organic system and highest in the conventional system as the differences were highly significant.

Hence, our investigation aimed to study the effect of BTH combined with compost with or without compost tea or seaweed extracts, on the growth, yield and fruit quality of cucumber crop comparing with the mineral fertilizers under plastic houses.

## Materials and Methods

The experiments were carried out in the experimental farm of the Faculty of Agriculture, Kafr El-Sheikh University, Egypt during the winter season of 2005 and the early summer season of 2006 using cucumber hybrid (Prince) under plastic houses. Seedlings were transplanted on October 3$^{rd}$ (winter season of 2005) and February 5$^{th}$ (early summer season of 2006) on one side of the ridge (6 meters in length and 1 meter in width) at spacing of 30 cm between plants within the row. Plant density were 3.33 plants per square meter. Surface irrigation method was used.

Cucumber plants were infected with powdery mildew (*Sphaerotheca fuliginea*) spores naturally under greenhouse conditions. The control plants were heavy infected naturally.

The synthetic chemical benzo (1,2,3) thiadiazole-7-carbothioic acid S-methyl ester (BTH) in 50% sprayed to cucumber leaves in different concentrations (0.05, 0.075 and 0.1 mM). BTH sprayed three times on cucumber in the ages (30 days seedlings after transplanting immediately, 7 and 15 days after transplanting).

The experiment in each season included five organic and mineral treatments as follows:

1. Organic manure (compost) with 0.05 mM of BTH: Compost was added at the rate of 5 kg/m$^2$. Chemical analysis of compost was estimated immediately before its application (Table 1).

2. Compost accompanied with compost tea + 0.05 mM of BTH: Compost tea was a tea made from compost and water by soaking compost in water (1:1 v/v), it sprayed directly on the plants and applied also to soil with irrigation 5 times at fortnightly interval, starting three weeks after transplanting.

3. Compost combined with seaweed extracts (Algean) + 0.05 mM of BTH: Algean is a biological fertilizer, contains appreciable quantities of nutrients, hormones, amino aids and vitamins. It was used a foliar spray (2 ml/L) five times at two weeks intervals, starting three weeks after transplanting.

4. Mineral fertilizers with 0.05 mM of BTH: the recommended NPK fertilizers were used according to the recommendation of Ministry of Agriculture in Egypt.

Mineral fertilizers alone (control), as mentioned above without BTH.

Data recorded:

1- Disease severity % of the cucumber powdery mildew fungus.

2- Vegetative growth: stem length (cm), number of leaves/plant and leaf area/plant (dm$^2$) were determined at 45 and 60

**Table 1.** Chemical properties of compost used in 2005 and 2006 seasons.

| Chemical analysis | | Seasons | |
|---|---|---|---|
| | | 2005 | 2006 |
| EC (dSm$^{-1}$) | | 4.1 | 4.1 |
| pH | | 7.5 | 7.6 |
| O.M | (%) | 33.9 | 32.7 |
| Moisture | (%) | 25.6 | 22.9 |
| N | (%) | 1.71 | 1.69 |
| P | (%) | 0.91 | 0.94 |
| K | (%) | 1.40 | 1.23 |
| Fe | (ppm) | 3380.4 | 3845.6 |
| Zn | (ppm) | 250.5 | 296.1 |
| Mn | (ppm) | 501.1 | 448.3 |

**Table 2.** Effect of BTH on disease severity percentage of cucumber powdery mildew.

| Treatments | disease severity percentage % | |
|---|---|---|
| | 2005 season | 2006 season |
| Control | 85.1 | 75.4 |
| BTH 0.05 mM | 3.4 | 4.4 |
| BTH 0.075 mM | 5.6 | 4.8 |
| BTH 0.1 mM | 9.8 | 10.88 |

days after transplanting.

3- Chlorophyll content in the leaves: relative green colour of one most recently matured leaf per plant was measured with SPAD meter (Minolta Corp, Ramsey, N.J.) after 45 and 60 days from transplanting.

4-Fruit yield: early yield was considered as the number and weight of fruits per square meter of the first four pickings. Total yield was determined as number and weight of fruits /$m^2$ of all pickings.

5-Fruit chemical quality:

a. Total soluble solids (TSS%): TSS % in juice of cucumber fruits was estimated by a hand refractometer according to A.O.A.C. (1965).

b. Ascorbic acid content (mg/100 g f. wt). It was estimated by titration with 2, 6-Dichlorophenol blue according to A.O.A.C. (1965).

Nitrate content (ppm): It was estimated by rapid colorimetric determination in fruits by nitration of salicylic acid according to Cataldo et al. (1975).

Experimental design and statistical analysis:

The experiment included five treatments, which were arranged in a randomized complete block design with three replications, as the treatments were distributed at random in the plots. Data were tested by analysis of variance (Little and Hills 1972). Duncan's multiple range test was used for comparison among the treatment means (Duncan 1965).

## Results and Discussion

### 1. Effect of BTH on the disease severity % of the cucumber powdery mildew

When we sprayed the cucumber leaves with BTH in different concentrations (0.05, 0.075 and 0.1 mM), we found all the concentration increased the resistance against the powdery mildew. However, BTH in 0.05 mM was the best. BTH (0.05 mM) was able to decrease the disease severity from 85.1% to 3.4% in the both seasons 2005 & 2006 (Table 2).

### Effect of organic fertilizers and BTH on vegetative growth characters and early and total fruit yields of cucumber

### 2-Vegetative growth

Data in Table 3 showed that stem length in cucumber plants was significantly affected by applying the different organic and mineral treatments at the two sampling dates (45 and 60 days after transplanting) in both seasons.

Applying the combination of compost + seaweed extract + 0.05 mM of BTH treatment (Tr.) No. 3, produced the long plants having both highest number of leaves and largest leaf area at 45 days after transplanting followed by Tr. No. 2 (compost + compost tea + 0.05 mM of BTH). Tr. No. 1 (compost + 0.05 mM of BTH) or Tr. No. 4 (mineral fertilizers + 0.05 mM of BTH) in both seasons. On the other side, Tr. NO. 5 (chemical fertilizers alone) produced the lowest values of stem length, number of leaves and leaf area/plant at the first stage in both seasons.

Dealing with the second sampling date, the results were varied compared to that of the first date, though Tr. No. 4 (Mineral fertilizers with 0.05 mM of BTH) produced the highest values of growth characters followed by Tr. No. 3 (compost + seaweed extract + 0.05 mM of BTH ) or Tr. No. 5 (mineral fertilizers alone), Tr. No. 2 (compost + compost tea + 0.05 mM of BTH) and finally Tr. No. 1 (compost + 0.05 mM of BTH ) which gave the lowest values of such vegetative growth parameters.

**Table 3.** Effect of organic and mineral treatments on some vegetative growth characters of cucumber plants in 2005 and 2006 seasons.

| Treatments | Stem length (cm) | | No. of leaves/plant | | Leaf area ($dm^2$/plant) | | SPAD green colour reading | |
|---|---|---|---|---|---|---|---|---|
| | Days after transplanting | | | | | | | |
| | 45 | 60 | 45 | 60 | 45 | 60 | 45 | 60 |
| | 2005 season | | | | | | | |
| 1. Compost + BTH | 62.2 b | 83.4 d | 16.3 b | 16.9 d | 17.04 b | 20.87 c | 44.1 b | 37.4 c |
| 2. Comp. + Comp. tea + BTH | 72.6 a | 97.2 c | 18.0 ab | 22.6 c | 20.87 a | 24.67 ab | 45.8 a | 42.7 b |
| 3. Comp. + Seaweed ext. + BTH | 73.4 a | 100.5 b | 19.8 a | 23.6 bc | 21.30 a | 24.96 ab | 46.4 a | 45.3 a |
| 4. Mineral fertilizers + BTH | 62.7 b | 105.3 a | 15.1 b | 26.7 a | 16.93 b | 25.07 a | 42.1 c | 46.5 a |
| 5. Mineral fertilizers alone (control) | 56.0 c | 100.5 b | 15.0 b | 24.2 b | 16.66 b | 24.2 b | 41.9 c | 37.1 c |
| F-test | ** | ** | ** | ** | ** | ** | ** | ** |
| | 2006 season | | | | | | | |
| 1. Compost + BTH | 77.3 c | 95.8 d | 18.0 b | 20.2 c | 20.01 b | 23.91 c | 47.3 b | 38.4 d |
| 2. Comp. + Comp. tea + BTH | 84.8 a | 106.9 c | 19.8 a | 26.9 b | 23.31 a | 26.01 b | 50.6 a | 47.3 b |
| 3. Comp. + Seaweed ext. + BTH | 84.9 a | 110.3 b | 20.1 a | 29.9 a | 23.54 a | 27.95 a | 50.1 a | 49.1 ab |
| 4. Mineral fertilizers + BTH | 79.9 b | 114.5 a | 17.8 b | 30.2 a | 20.05 b | 28.18 a | 44.6 c | 50.5 a |
| 5. Mineral fertilizers alone (control) | 68.2 d | 110.1 b | 17.2 b | 27.2 b | 18.81 c | 25.40 b | 42.8 d | 39.9 c |
| F-test | ** | ** | ** | ** | ** | ** | ** | ** |

Means designed by the same letter are not significantly different at the 5% level according to Duncan's test.

**Table 4.** Effect of organic and mineral treatments on early and total fruit yields of cucumber plant in 2005 and 2006 seasons.

| Treatments | Early yield No. of fruits/m² | Kg/m² | Total yield No. of fruits/m² | Kg/m² |
|---|---|---|---|---|
| | 2005 season | | | |
| 1. Compost + BTH | 9.2 b | 0.82 bc | 28.5 d | 2.20 c |
| 2. Comp. + Comp. tea + BTH | 11.6 a | 1.00 b | 36.9 b | 2.21 c |
| 3. Comp. + Seaweed ext. + BTH | 11.6 a | 1.67 a | 36.5 b | 3.14 b |
| 4. Mineral fertilizers + BTH | 7.8 c | 0.69 c | 38.9 a | 3.53 a |
| 5. Mineral fertilizers alone (control) | 7.3 d | 0.64 c | 33.5 c | 2.89 b |
| F-test | ** | ** | ** | ** |
| | 2006 season | | | |
| 1. Compost + BTH | 10.9 b | 1.06 b | 32.8 d | 2.65 d |
| 2. Comp. + Comp. tea + BTH | 12.8 a | 1.49 a | 40.1 b | 3.60 b |
| 3. Comp. + Seaweed ext. + BTH | 13.0 a | 1.47 a | 43.0 a | 4.09 a |
| 4. Mineral fertilizers + BTH | 9.9 c | 0.85 c | 44.2 a | 4.05 a |
| 5. Mineral fertilizers alone (control) | 9.1 c | 0.82 c | 37.8 c | 3.14 c |
| F-test | ** | ** | ** | ** |

Means designed by the same letter are not significantly different at the 5% level according to Duncan's test.

The favorable effect of organic treatments on vegetative growth, especially at the early stage of plant growth may be due to that compost made from biosolids contains almost all of the macro- and micro-nutrients essential for plant growth (Table 2), in addition to humic substances which increased soil fertility and cation exchange capacity, thus increased the availability of certain nutrients (Seyedbagheri 1999). Also, applying compost improved physical conditions of soil, providing energy necessary for microorganisms activity and increasing the availability and uptake of nutrients, which positively reflected on vegetative growth (Awad 1998, Romero et al. 2000, Bayoumi 2005; Ehaliotis et al. 2005). The stimulation of plant growth by using compost + compost tea or seaweed extracts may be attributed to the combined effect of compost, compost tea (which contains humic acids, vitamins, amino acids and both of macro and micro nutrients which enhanced cucumber growth) and seaweed extracts which contains some growth regulators such as cytokinins (Brain et al. 1973), auxin (Temple and Bomke 1989) and gibberellins (Williams et al. 1981).

## 3- Chlorophyll content

Data in Table 3 indicate that, chlorophyll content (SPAD green colour reading) was highly significant influenced by different organic and mineral treatments at the two sampling dates (45 and 60 days after transplanting) in both seasons. At the first date, both of Tr. No. 2 (compost + compost tea + 0.05 mM of BTH) and Tr. No. 3 (compost + seaweed extract + 0.05 mM of BTH ) showed the highest values of chlorophyll content in leaves in both seasons. In contrast, the lowest values were obtained from applying Tr. No. 5 (mineral fertilizers alone) which sometimes don't differed with Tr. No. 4 (Mineral fertilizers with 0.05 mM of BTH).

At 60 days after transplanting, the highest values were obtained from Tr. No. 4 (Mineral fertilizers with 0.05 mM of BTH) and Tr. No. 3 (compost + seaweed extract + 0.05 mM of BTH), but the lowest values were showed from Tr. No. 1 (compost + 0.05 mM of BTH) and Tr. No. 5 (mineral fertilizers alone) in most cases.

The superiority of organic treatments (No. 2 & 3) in chlorophyll content at the early stage may be due to the higher

**Table 5.** Effect of organic and mineral treatments on chemical quality of cucumber fruits in 2005 and 2006 seasons.

| Treatments | Ascorbic acid content (mg/100 g fresh wt.) | Total soluble solids (%) | Nitrate content (ppm) | Ascorbic acid content (mg/100 g fresh wt.) | Total soluble solids (%) | Nitrate content (ppm) |
|---|---|---|---|---|---|---|
| | 2005 season | | | 2006 season | | |
| 1. Compost + BTH | 13.9 b | 4.3 | 110.2 b | 15.2 b | 4.2 | 95.6 b |
| 2. Comp.+ Comp. tea + BTH | 14.7 a | 4.5 | 110.5 b | 16.2 a | 4.4 | 96.2 b |
| 3. Comp. + Seaweed ext. + BTH | 14.1 ab | 4.6 | 112.0 b | 15.9 a | 4.3 | 105.4 b |
| 4. Mineral fertilizers + BTH | 12.1 c | 4.9 | 253.1 a | 14.6 b | 4.7 | 233.4 a |
| 5. Mineral fertilizers alone (control | 11.6 c | 4.8 | 236.4 a | 13.3 c | 4.6 | 220.9 a |
| F-test | ** | N.S | ** | ** | N.S | ** |

Means designed by the same letter are not significantly different at the 5% level according to Duncan's test

biological activity of soil which encouraged the availability of nutrients and produced high energy helping in root development (Li et al. 2000). Also, compost, compost tea and seaweed extracts contain considerable amounts of macro- and micro-nutrients, amino acids, vitamins and hormones as mentioned before which possibly increased chlorophyll content leading to higher rates of photosynthesis. In this concern, Mengel and Kirkby (1987) stated that Mn and Fe play an important role of porphyrine structure of chlorophyll. On the other hand, the favorable effect of chemical treatment on chlorophyll of cucumber leaves at the late date may be due to more availability of inorganic N form for uptake by plants.

### 4-Fruit yield

It is obvious from Table 4 that, significant differences in early and total yields (number and weight of fruits/$m^2$) were noticed among the used five treatments in both seasons. Using both of Tr. No. 2 and 3 resulted in an increase in early yield (number and weight of fruits/$m^2$) in most cases compared to chemical treatments especially without 0.05 mM of BTH, which produced the lowest early yield in both seasons.

Applying chemical fertilizers with 0.05 mM of BTH (Tr. No. 4) produced the highest number and weight of fruits/$m^2$ of total yield. On contrast, using organic treatment No. 1 (compost combined with 0.05 mM of BTH) showed the lowest total fruit yield in both seasons.

The performed higher early yield from organic treatments (No. 2 & 3) than chemical treatments (No. 4 & 5) may be due to their higher nutritional contents, particularly Fe, Zn and Mn in compost (Table 1) and K, Ca, Mg, S and Fe in seaweed extract. These elements can encourage the vegetative growth and total chlorophyll (Table 3) and the photosynthetic rate which enhance flowering and fruiting leading to an increase in early fruit maturity.

These results agree with those of Hsieh and Hsu (1995), Abd-Allah et al. (2001), Aly (2002), Bayoumi (2005) and Ehaliotis et al. (2005), they showed that applying of organic treatments increased early yields compared to using chemical fertilizers. Also, Rotenberg et al. (2005) reported that Additions of organic amendments (composts) to agricultural soils can lead to improved soil quality and reduced severity of crop diseases as well as increased cucumber yield.

The greater cucumber yield with chemical treatment with 0.05 mM of BTH (No. 4) may be a result from increased N concentration or accumulation as suggested by Sainju et al. (2001). Also, the present study indicate that organic Tr. No. 3 can produce higher fruit yield comparable with those of chemical treatment. These results agreed with those of Montagu and Goh (1990) and Poudel et al. (2002).

### 5- Fruit quality

Data presented in Table (5) indicate that both of ascorbic acid and nitrate contents were significantly affected by treatments. Therefore, any of either Tr. No. 2 or Tr. No. 3 showed the highest content of ascorbic cid followed by Tr. No. 1, while using chemical Tr. No. 4 or No. 5 led to give the least values. On the other hand, chemical Tr. produced fruits having the highest nitrate content compared to organic Tr. No., 1,2 and 3 which produced fruit having the lowest nitrate values. Similar conclusions were drawn by Yacheva et al. (1982), Vogtmann et al. (1993), Abou-Hussein (2001) and Poudel et al. (2002).

The highest nitrate content due to chemical fertilizers may be attributed to that mineral fertilizer salts are soluble and nitrogen is immediately available for plant uptake soon after fertilizer application. Otherwise, organic N fertilizers release nutrients slowly (Haworth 1961).

For TSS %, data show that, it was non-significantly influenced by treatments. However, chemical treatments (4 &5) tended to produce higher values of TSS than the other organic treatments (1,2 &3) in both seasons.

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