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Silver Thiosulfate Effects on Yield and Growth of Plastic House Tomato in Root-Knot Nematode Infested Soil.

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ABSTRACT :

Tomato yield and growth in response to soil drench (SD), single spray (SS) and multiple spray (MS) of 4, 8 and 12 mM of silver thiosulfate (STS) treatments were studied under plastic house conditions for two seasons. The soil was naturally infested with the root-knot nematode, Meloidogyne javanica. A glasshouse pot experiment was conducted to study the effects of these treatments on early growth of tomato plants under artificial soil inoculation with the root-knot nematode.

MS of 4 mM STS resulted in slight increases in marketable yields and fruit numbers of both seasons. Average weight per fruit, however, was significantly decreased by the 12 mM MS in the 1987 season only.

The MS treatment of 4 mM STS increased the shoot dry weight at the end of both seasons. Twenty one days after planting, the 8 and 12 mM STS SD treatments decreased plant growth, while 42 days and 63 days after planting the 12 mM STS SD and the MS treatments resulted in reduced plant growth.

Gall formation and nematode reproduction were significantly reduced by all STS treatments. Nevertheless, "residual effects of STS" and "STS effects" on early plastic house tomato,

Key words : Lycopersicon esculentum Mill. ; Meloidogyne javanica; Nematode; Silver thiosulfate; Tomato.

where conditions are more favourable for nematode reproduction, remain to be thoroughly investigated before any practical recommendation is released.

Abbreviations : A3M = After three months; Ag = Silver; C = Centigrade; d = day; L2= Second stage juvenile; LSD= Least significant difference; M= Marketable; m= meter; mM=millimole; MS= Multiple spray; R= Root; SD= Soil drench; SH= Shoot; SS= Single spray; UNM= Unmarketable; 4x= Four times.

INTRODUCTION

Though considerable research has been done to improve tomato yields in Jordan, tomato productivity is still low. Infection with the root-knot nematodes, especially M. javanica, lies among the most important factors that limit productivity Abu-Garbieh, 1977; Abu-Gharbieh, 1978; Abu-Gharbieh et al., 1978). To combat the ill-effects of this parasite several practices were adopted (Abu-Gharbieh, 1982; Stirling, 1984; Sasser and Carter, 1985) including soil fumigation, under plastic houses, with methyl bromide; the treatment which proved to be effective for only one season but very expensive.

Depending upon the rate of soil infection, the root-knot nematode reduces (Abu-Gharbieh, 1977; Glazer et al., 1984), has no effects or slightly stimulates (Atieh, 1986) shoot growth in tomato. Infection with nematode (M. incognita) can result in severe losses in tomato yields (Vito et al., 1981); large population densities of M. incognita resulted in poor fruit quality of canning tomato.

Ethylene production was found to be closely associated with root-knot nematode infection and gall formation (Glazer et al., 1984; Glazer et al., 1985). Using silver, an ethylene inhibitor, as STS, partially (Glazer et al., 1985) or completely (Glazer et al., 1984)eliminated pathogenicity symptoms of root-knot nematode under laboratory conditions. The ethylene inhibitors and stimulants did not alter normal growth and development of tomato roots in culture (Glazer et al., 1985).

STS effects on yield and quality of tomato has never been studied. Hence, this research was initiated to investigate the combined effects of three application methods and three levels of STS on growth, yield and quality of tomatoes and on the incidence of the root-knot nematode under plastic house conditions in the Jordan Valley where the nematode M. javanica is a serious problem. A pot experiment was also conducted on tomatoes artificially infected with the nematode and grown under glasshouse conditions to assess the effects of these treatments on nematode reproduction and tomato growth.

MATERIALS AND METHODS

Plastic house experiment. - This experiment was carried out for two consecutive seasons, 1986 and 1987, at the Jordan University Farm in the Jordan Valley in a 50 x 9 m plastic house. The effects of STS on growth, yield, yield components and nematode reproduction were studied. A randomized complete block design with 3 replicates was used. Treatments were: control; SD with 10 ml of 4, 8 and 12 mM STS; SS, at time of planting, using 4, 8 and 12 mM STS; MS (4x) at 3-week intervals using 4, 8 and 12 mM STS. Solutions of STS were prepared according to Reid et al (1980); a molar ratio of 1:4 was always maintained between silver and thiosulfate for all concentrations used. Plants were sprayed to the run off. Each treatment consisted of four 2 m rows 0.8 m apart with plants set at 0.2 m within the row.

Twenty five to 30 day old "special back" tomato transplants were set in a non-fumigated plastic house on the first of January of both seasons. Plants were trained to one stem and cultural practices other than the differential treatments were those normally used for tomato production under plastic houses in the Jordan Valley.

After three months from planting (second season only) two plants from each treatment were taken for nematode assessment. Galling, rotting and nematode reproduction were then determined.

Red ripe tomato fruits were harvested from the middle 16 tomato plants (first season) and 14 tomato plants (second season) of each treatment at 3 to 5 day intervals. Harvest season started mid April of both seasons and continued throughout June 24 and June 9, respectively.

Collected field data included yield and number of marketable and unmarketable fruits (small < 50 g, cracked, blossom end rot, sunscald) as well as the average weight of individual tomato fruits. Representative shoot samples were dried to a constant weight at 75°C and dry matter contents were determined. Representative root samples were also taken for nematode identification (perineal pattern) as described by Hooper (1970).

Glasshouse experiment - This experiment was carried out during the 1986/1987 season at the University Campus.

Effects of STS on growth of tomato plants and nematode reproduction were studied using a completely randomised design with 4 replicates.

Treatments were : non-infected control, infected control, SD with 10 ml of 4, 8 and 12 mM+ STS, SS at time of planting using 4, 8 and 12 mM STS and MS (4x) at 3-week intervals using 4, 8 and 12 mM STS solutions.

Thirty day old "special back" tomato transplants were set in 18 x 20 cm plastic pots on December 14, 1986. Each pot was inoculated with 9000 eggs of the nematode M. javanica at time of planting. Cultural practices were similr for all treatments.

Fresh weight of shoots and roots were measured. Representative samples were oven dried to a constant weight at 75°C and dry weights determined.

Nematode assessment - Galling indices and rotting (Taylor, 1967), number of eggs (Barker, 1985) and second stage juvenile in the soil (Flegg and Hooper, 1970) were determined. Samples for perineal pattern determination were prepared as described by Hooper (1970).

Statistical analysis - All data obtained were either analyzed as for the randomized complete block design (plastic house experiment) or completely randomized design (glasshouse experiment) as outlined by Little and Hills (1977). Correlation coefficients were also determined.

RESULTS AND DISCUSSION

Yield - Yield data (Fig. 1) were obtained for the plastic house experiment only. The 1986 marketable tomato yields of the 4 and 8 mM STS MS were significantly higher than the SD tretment combinations, but the 4 mM treatment only proved to be significatnly superior to the other MS treatments in the 1987 season. Marketable tomato yields in both seasons were almost similar in the control and the SD treatments; however considerable yield reductions were observed in the other treatments, especially at the higher concentrations of STS MS. The unmarketable yields were consistantly higher for the 1986 than the 1987 season and were similar for all treatment combinations of either season (Fig. 1). Such seasonal descrepencies in yield responses could be partially attributed to differences in temperture and the variable adverse effects of the STS treatments. The minimum, maximum and average weekly air and soil temperatures under plastic house conditions were consistantly higher in the 1986 season (Fig. 2). Higher temperatures are usually associated with higher transpiration rates leading to more absorption of STS from the soil (Reid et al, 1980). It is therefore possible that the STS SD treatments adversely affected growth of tomato plants in the first season; however, the STS spray treatments, were more detrimental during the second season, especially for the 12 mM treatment.

Though soil temperatures of the 1986 season were more favourable for nematode reproduction and development, the elivated air temperatures seemingly led to more favourable balance between the vegetative and reproductive phases of tomatoes with concomitant increase in marketable yields.

The present yield results are reported for the first time in literature as STS effects were investigated only under laboratory conditions and were usually terminated before fruiting (Glazer et al., 1984; Glazer et al., 1985).

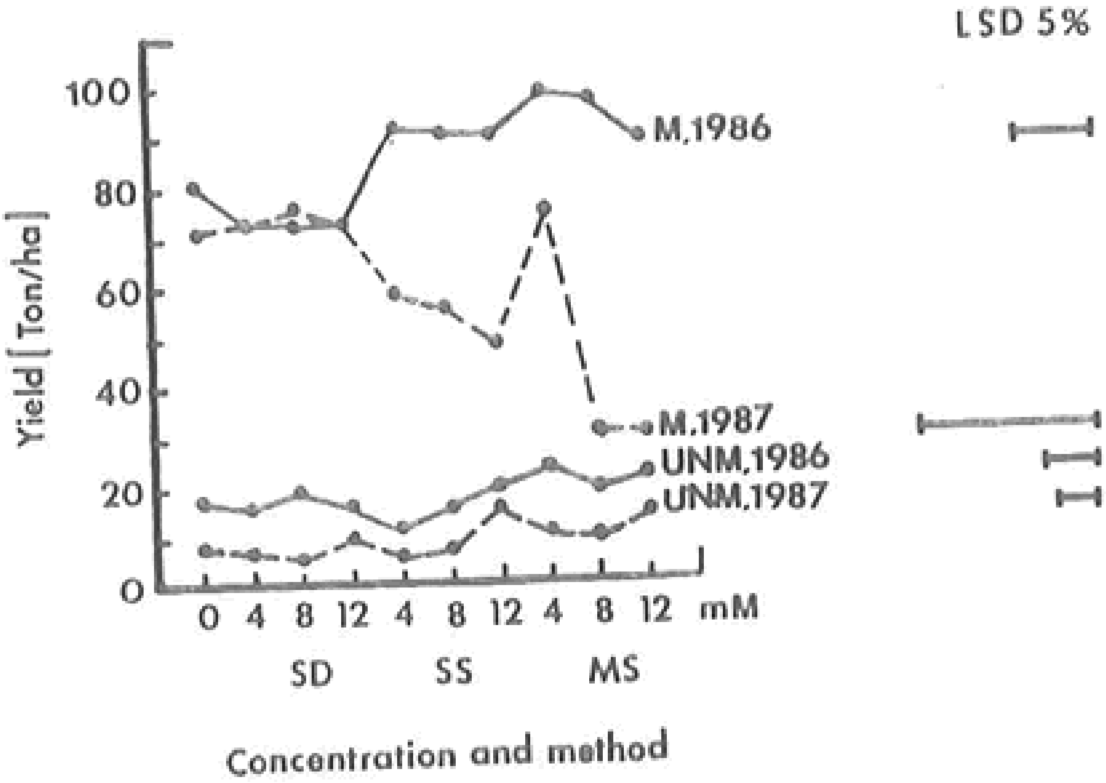

Fig. 1 : Influence of STS on marketable (M) and unmarketable (UNM) yields of late plastic house tomato.

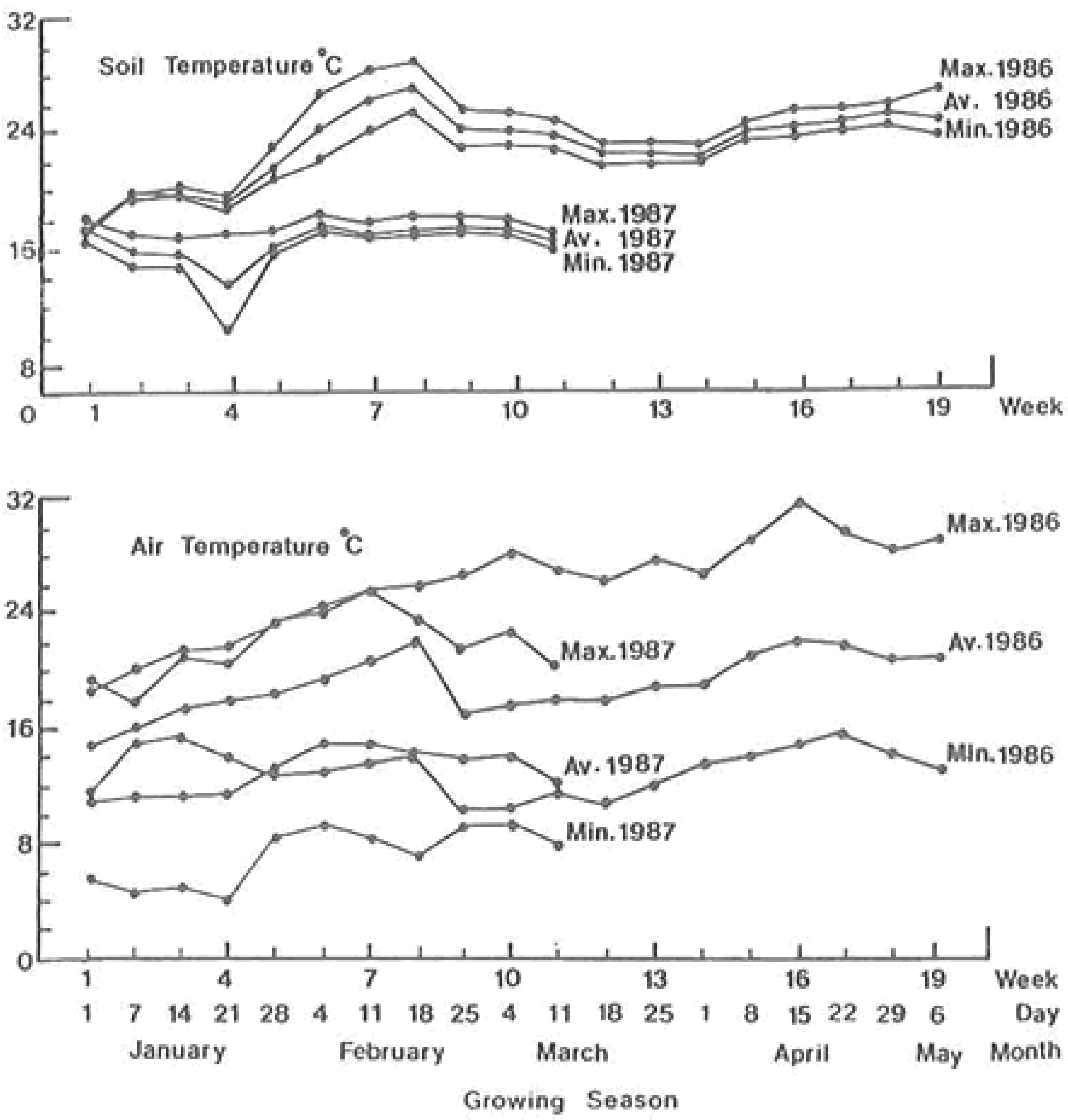

Fig. 2 : Air and soil tempertures (oC) under plastic houses in the Jordan Valley (1986 and 1987 seasons).

Fruit number – Marketable fruit numbers obtained for both seasons (Fig. 3) followed patterns similar to those of marketable yields (Fig. 1). Responses in terms of unmarketable fruit number's, however, were inconsistant and somewhat slightly different in pattern (Fig. 3). These variations (Fig. 3) resulted in no significant differences in unmarketable yields (Fig. 1) and consequently marketable yields were not affected.

The general agreement in the patterns of marketable and unmarketable fruit numbers obtained with those of their corresponding yields along with the highly positive and significant correlation coefficient in both seasons (r = 0.833–0.952) indicate the importance of fruit number as a major yield component. Similar results were reported earlier on tomato growth under open field (Mahrakani and Suwwan, 1987) and plastic house (Al-Maslamani and Suwwan, 1987) conditions.

Average weight per fruit – While no significant differences were detected (1986), consistantly lower values for weight per fruit were obtained in the 1987 season (Fig. 4) with only significantly reduced weight for the 12 mM as SS or MS. Correlation between the average weight per marketable fruit and marketable yields were positive and significant in both seasons (r=0.436–0.662) indicating that average weight per fruit contributed favourably to marketable yields obtained under the conditions of this investigation.

Plant growth – At the end of both seasons (Fig. 5), shoot dry weight was significantly highest at the 4 mM STS MS; the higher concentrations of STS resulted in lower shoot dry weights mainly under the MS treatments. After 3 months, however, the 4 mM STS SD significantly increased shoot dry weight over the other treatments.

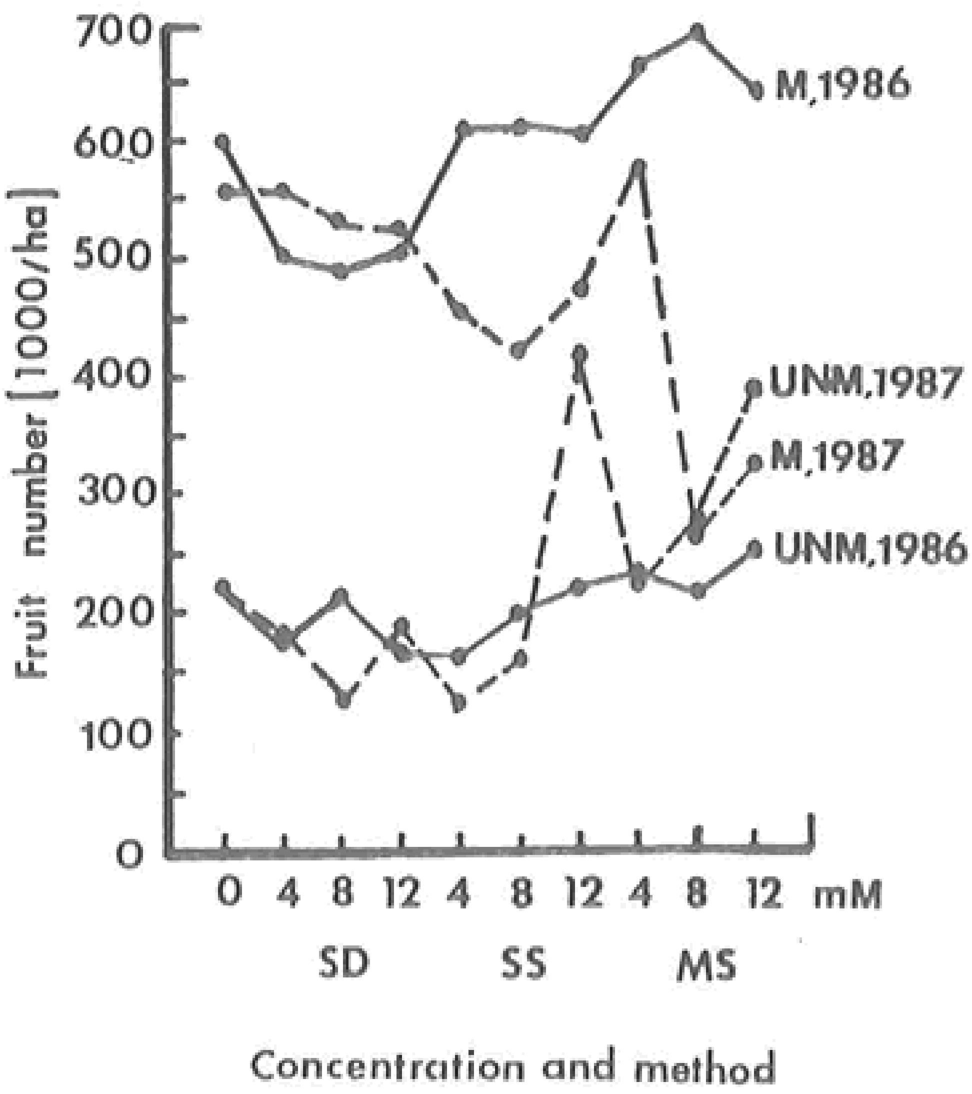

Fig. 3 : Influence of STS on marketable (M) and unmarketable (UNM) fruit numbers of late plastic house tomato.

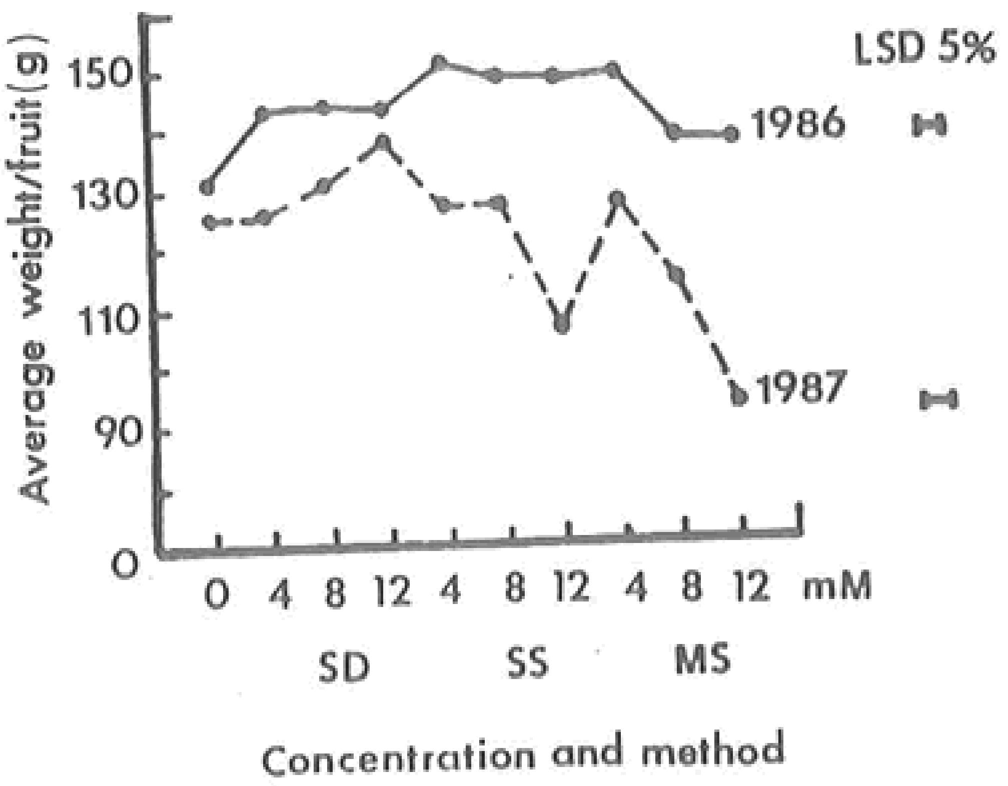

Fig. 4 : Influence of STS on average weight per fruit of late plastic house tomato.

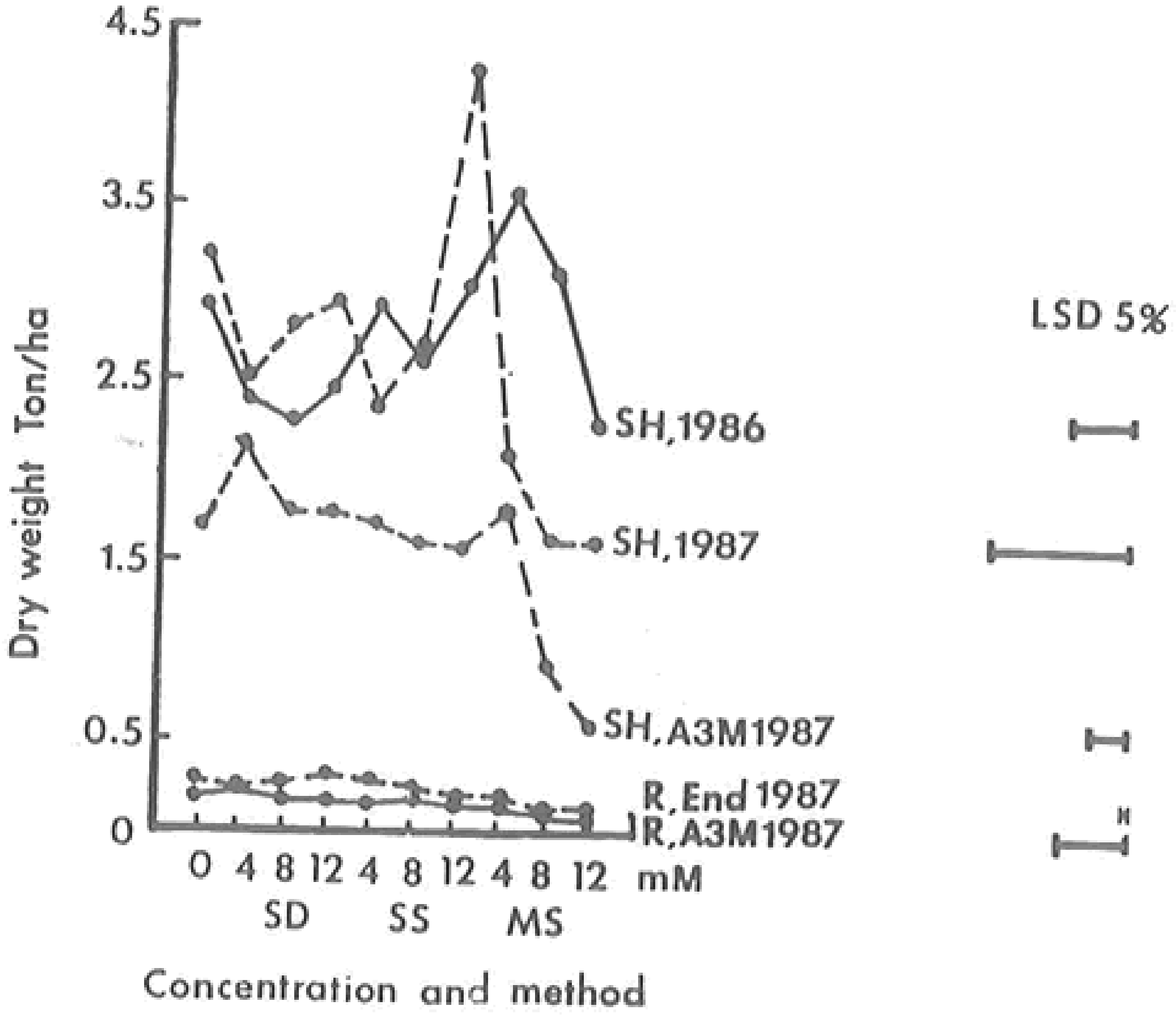

Fig. 5 : Influence of STS on dry weight of shoot (SH) and root (R) of late plastic house tomato after three months (A3M) and at the end of both seasons.

Twenty one days after planting, shoot fresh weight was significantly reduced by the 8 and 12 mM STS SD compared with the noninfected control and the 8 mM STS SS (Fig. 6-B). Shoot fresh weight, 42 days after planting, was only significantly increased by the 8 mM STS MS compared with 12 mM STS SD treatment; the 4 and 12 mM STS MS and 12 mM SD significantly have the lowest shoot fresh weight after 63 days from planting.

Root dry weight, after 3 months from planting and at the end of 1987 season, was significantly reduced by the 8 and 12 mM STS MS (Fig. 5). Twenty one days after planting root fresh weight was significantly reduced by the 12 mM STS SD (Fig. 6-A); forty two days and 63 days after planting root fresh weight was significantly lowest at the 12 mM, either as SD or as MS.

Plant fresh weight (Fig. 6-C) followed trends similar to those described for shoot fresh weights (Fig. 6-B).

That concentration of STS higher than 4 mM showed a higher tendency to decrease plant growth agrees with earlier findings with tomato (Glazer et al., 1985), where high STS concentrations adversely affected plant growth. This was attributed to accumulation and precipitation of STS as sulphides, bound to SH-groups or deposited as metalic silver in the plant tissue (Veen and Van de Geijn, 1978). In the present study, toxic effects of silver were exhibited as brownish spots observed on tomato leaves subjected to MS of higher STS concentrations.

In both seasons correlation coefficients between shoot growth and either yield or fruit number (r = 0.61 and 0.63) were generally positive and highly significant (o.01 level)

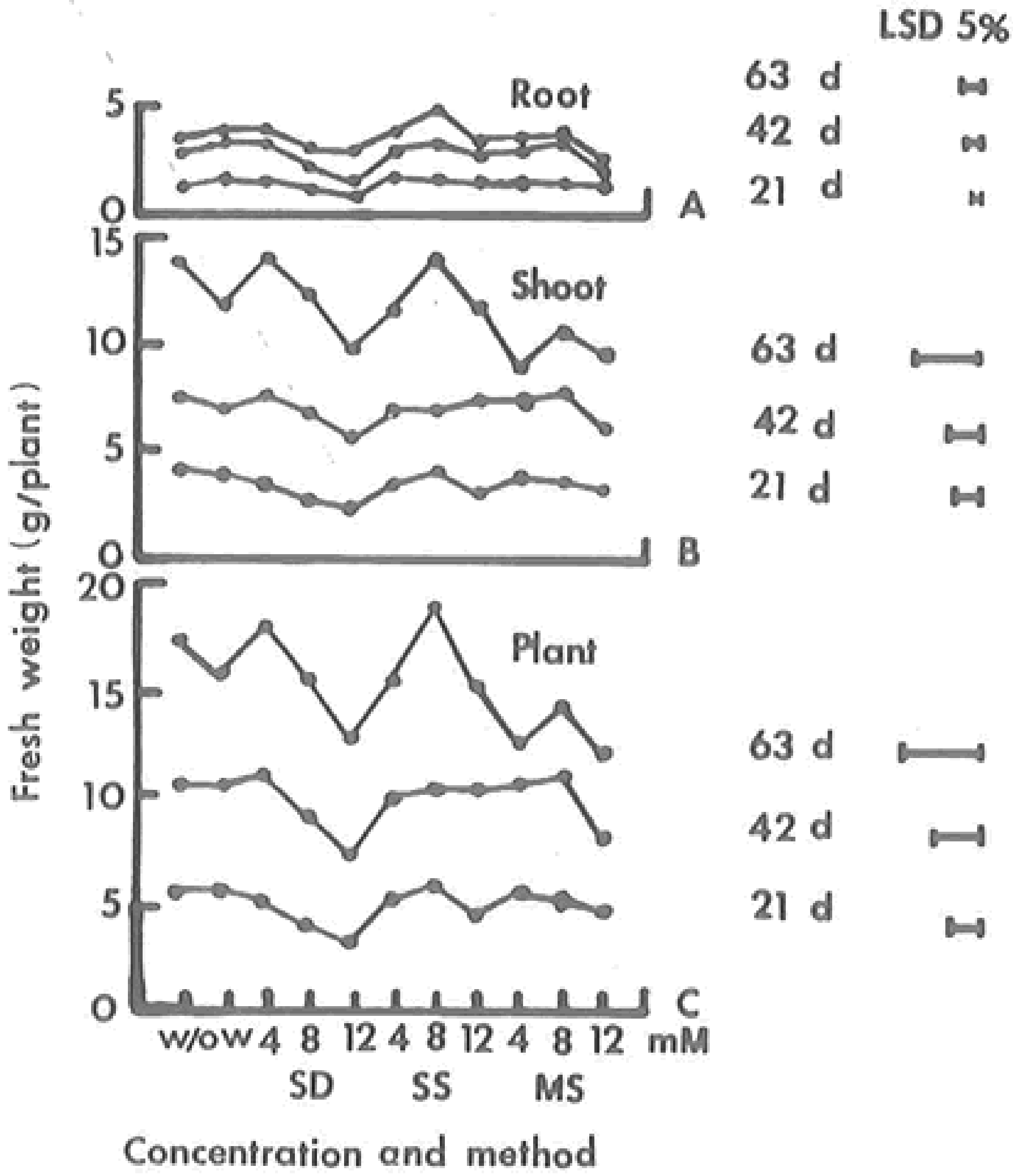

Fig. 6 : Influence of STS on tomato root (R), shoot (SH) and plant fresh weight 21-d, 42-d and 63-d after planting (d = day).

indicating that better shoot growth supported more fruits and higher marketable yields; average weight per fruit was not consistantly affected by the vegetative growth of the different STS treatments (r= 0.29 and 0.45 for the respectie seasons) where competition for photosynthates was least likely to occur (r for fruit number and average weight per fruit = -0.05 and 0.36 for the respective seasons).

Gall formation and nematode reproduction - The nematode identification using perineal pattern method show that Meloidogyne javanica was the species found in the plastic house.

Gall formation and rotting were significantly decreased by the 4 and 12 mM MS of STS compared with most of the other treatments (Fig. 7). In the glasshouse experiment, however, the lowest gall formation was observed at 8 and 12 mM SD after 21 days and 42 days after planting (Fig. 8-A,B); MS showed the lowest gall formation, mainly 63 days after planting (Fig. 8-C); possibly due to a build up of high STS concentrations in plant tissues following repeated applications of nematicide. In agreement with the plastic house experiment, MS effects persisted while those of the SD and SS diminished gradually as the season advanced. Accoding to Glazer (1985) application of STS, an inhibitor of ethylene action, caused inhibitions of growth on tomato roots in culture.

Number of eggs (Fig. 9-A, B, C) and L2 (Fig. 9-D, E) were significantly decreased by repeated sprays of STS in both seasons. In the glasshouse, no eggs were found in all the treatments up to 42 days. Sixty three days after planting, number of eggs was significantly decreased in the 8 and 12 mM STS, SS or MS treatments, compared with the nematode infected control plants and 4 mM MS (Fig. 8-D). The 4 and 8 mM SD, 12 mM SS and all MS treatments gave significantly

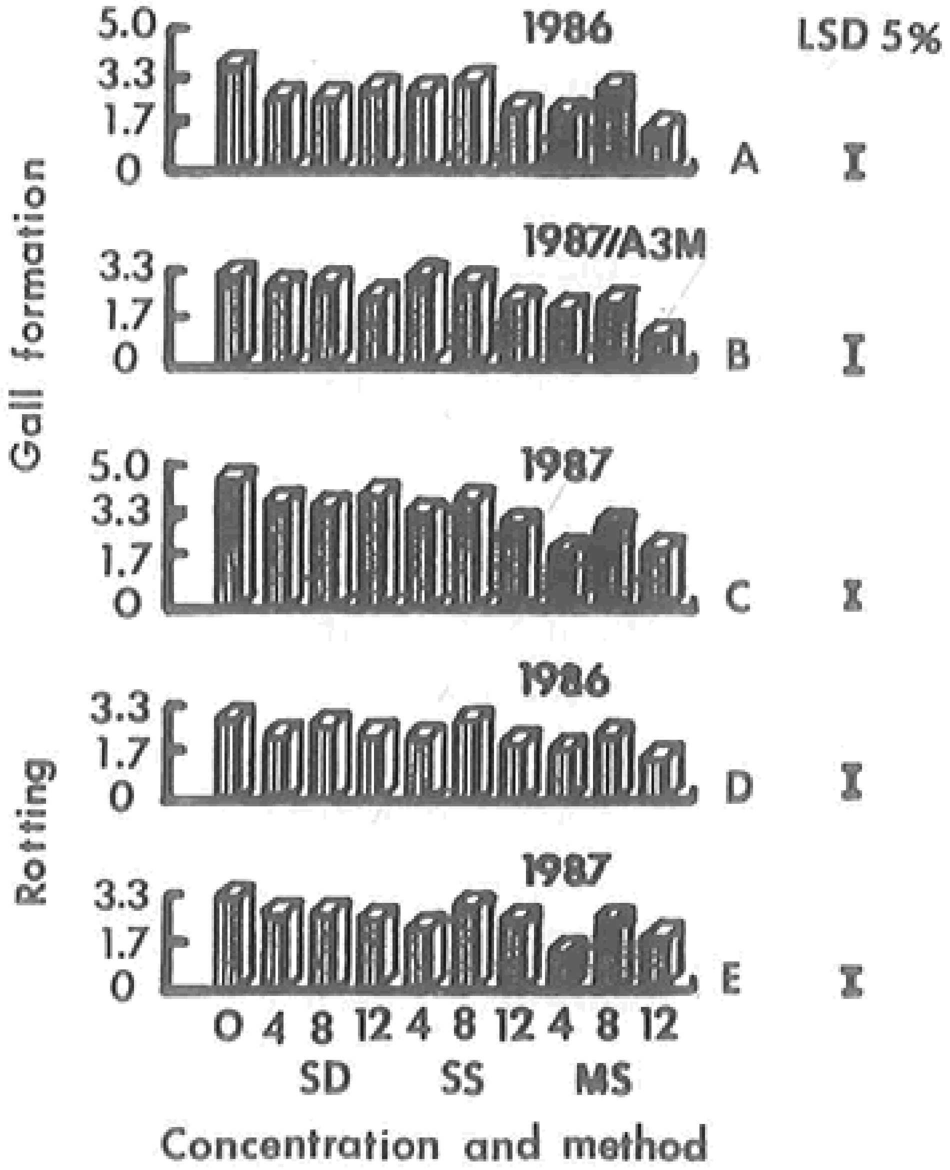

Fig. 7 : Influence of STS on gall formation and rotting of late plastic house tomato after three months (A3M) and at the end of both seasons.

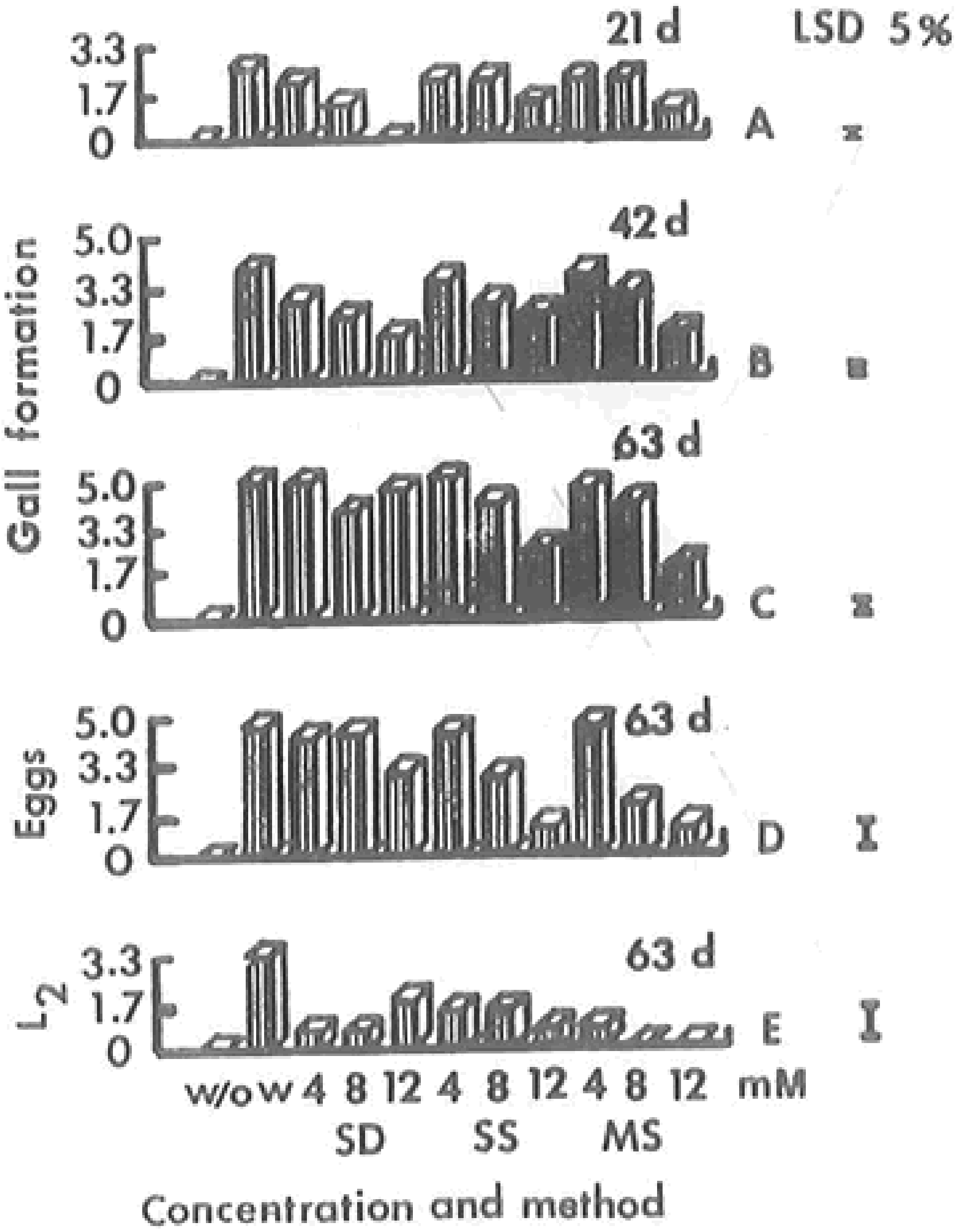

Fig. 8 : Influence of SIS on gall formation, number of eggs and second stage larvae (L2) on tomato plants 21-d, 42-d and 63-d after planting in the glasshouse (d= day).

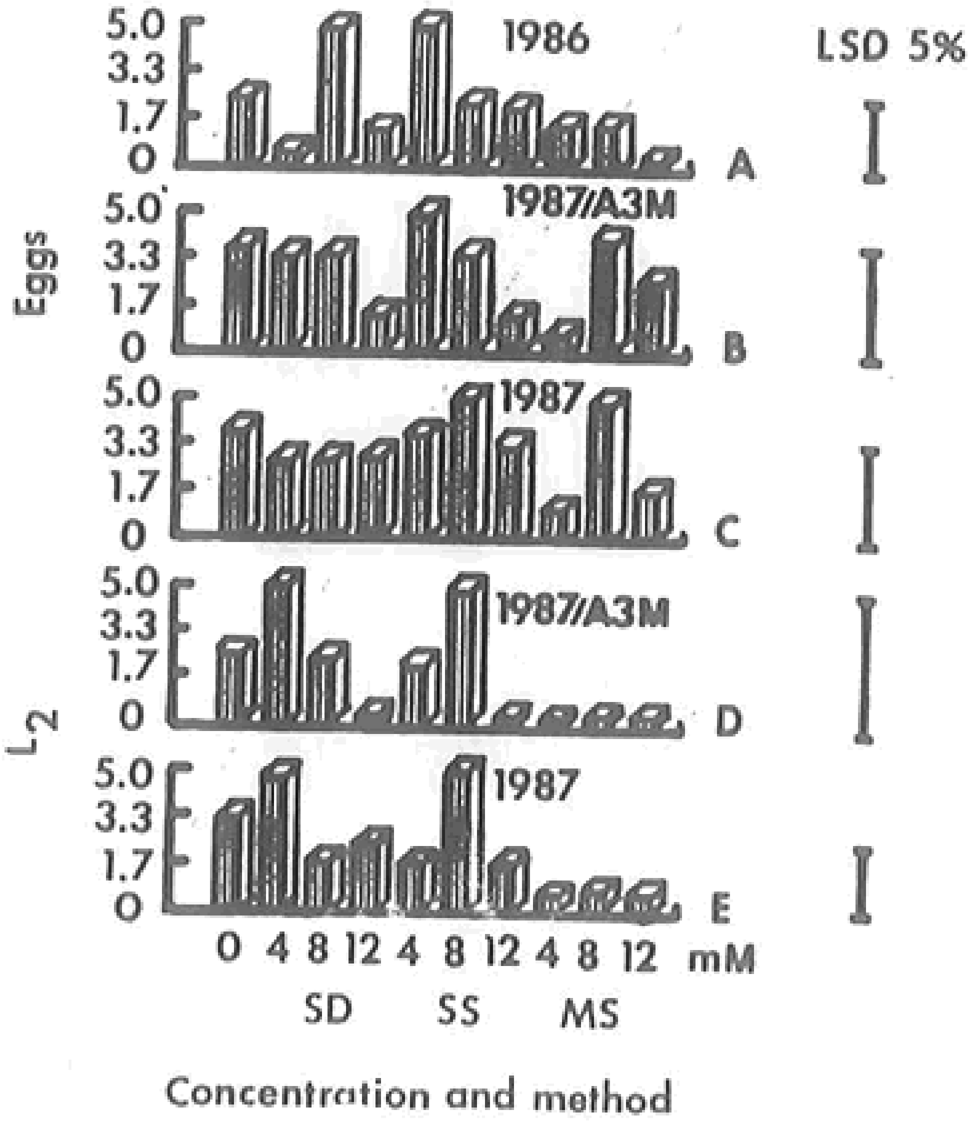

Fig. 9 : Influence of STS on number of eggs and second stage larvae (L2) of late plastic house tomato after three months (A3M) and at the end of both seasons.

lower number of L2 compared with the nematode-infected control plants but were significantly similar to the other treatments (Fig. 8-E and Fig. 9-D, E).

Under the conditions of the present investigation it has been observed that gall size was generally larger in the control than in the STS treated plants. The STS SS treatments were less effective than the MS, as the SS were reported effective for only 26 days after application (Glazer et al., 1984). Upon root entry by L2, mechanical injuries occur, giant cells form, increase in size (Christie, 1936), and become multinucleate as a result of repeated mitosis, but without cytokinesis (Endo, 1987). Gall formation is attributed to intense cell multiplication (hyperplasia) around the larval head (Taylor and Sasser, 1978). This activity is associated with ethylene production (Glazer et al., 1984; Glazer et al., 1985); other authors (Glazer et al., 1985; Veen and Van de Geijn, 1978) reported on counter action of ethylene through use of silver treatments with consequent reductions in both gall formation and size.

Nematodes predispose plant root to entry of fungi and bacteria and root rotting occurs (Abu Gharbieh, 1977; Sidhy and Webster, 1974). Root rotting, however, is not likely to have affected tomato growth and production in this experiment as it occured only at the conclusion of both harvest seasons.

CONCLUSIONS AND RECOMMENDATIONS

The best treatment combination is the 4 mM STS MS, as the general adverse effects on growth, yield and fruit quality of late plastic house tomato, were minimal compared with the other treatments.

- For future research, concentrations lower than 4mM STS should be investigated under field conditions.

- Effects of STS should be also considered on early plastic house tomato, where conditions are more favourable for nematode reproduction.

- Residue analysis in the fruit should precede any recommendation on use of STS under field conditions.

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LIST OF FIGURES

مجلة الأمارات للعلوم الزراعية (١٩٩١) ٢ : ٤١ - ٦٥

تاثير ثيوكبيرتات الفضة على نمو وانتاج البندورة تحت البيوت البلاستيكية عند زراعتها في تربة موبوءة طبيعيا بنيماتود تعقد الجذور .

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الخلاصـــــة :

تمت دراسة تاثير ثلاثة تراكيز (٤ ، ٨ ، ١٢ مليمول) من مركب ثيوكبريتات الفضة (STS) اضيفت حقنا في التربة او رشا على النباتات (رشه واحدة او اربع رشات) ومقارنتها مع الشاهد . على نمو وانتاج البندورة المزروعة في تربة موبوءة طبيعيا بنيماتود تعقد الجـــذور (Meloidogyne Javanica) تحت البيوت البلاستيكية في غور الاردن للموسمين ١٩٨٦ ، ١٩٨٧ . وقد اجريت تجربة اخرى في البيوت الزجاجية في اصص لدراسة تاثير هذه المعاملات على المراحل الاولى من نمو نباتات البندورة بعد ان تمت عدوى تربتها بنيماتود تعقد الجذور .

نتج عن الرش المتكرر بـ ٤ مليمول STS زيادة طفيفة في الانتاج وعدد الثمار المسوقة في الموسمين . وعند تكرار الرش بتركيز ١٢ مليمول STS نقص معدل وزن الثمرة بدرجة معنوية في موسم ١٩٨٧ فقط . وعند نهاية الموسمين زاد الوزن الجاف للمجموع الخضرى نتيجة للرش المتكرر بـ ٤ مليمول STS .

اما في تجربة البيت الزجاجي فقد ادت اضافة المركب STS الى التربة بتركيز ٨ر١٢ مليمول الى نقصان في نمو النبات بعد ٢١ يوما من الزراعة . اما بعد ٤٢ و ٦٣ يوما من الزارعة فقد نتج عن اضافة STS الى التربة بتركيز ١٢ مليمول وتكرار الرش بالتركيزات المختلفة الى نقصان في نمو النبات .

وفي جميع المعاملات ادت التركيزات المختلفة من STS عند استعمالها بالطرق المختلفة الى تدني واضح في تدرن الجذور وفي تكاثر نيماتود تعقد الجذور.

هذا ولابد من دراسة اثر هذه المادة على الزراعةالمبكرة لمحصول البندورة تحت البيوت البلاستيكية، حيث الظروف اكثر ملاءمة لنمو وتطور النيماتود والكشف عن الاثار المتبقية لـ STS في ثمار البندورة وذلك قبل الخروج بتوصيات عملية تطبيقية في حقول المزارعين .

كلمات مفتاحية : البندورة ، تعقد الجذور ، ثيوكبريتات الفضه ، نيماتودا .