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ALTERNATIVES TO THE USE OF THE METHYL BROMIDE
FINAL RESULTS

Republic of Turkey
Demonstration Projects
MP/TUR/98/060

ALTERNATIVES TO THE USE OF METHYL BROMIDE AS SOIL FUMIGANT IN PROTECTED HORTICULTURE (Tomatoes, Cucumbers) AND ORNAMENTAL CROPS (Carnations)

UNITED NATIONS INDUSTRY DEVELOPMENT ORGANIZATION
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CITRUS AND GREENHOUSE CROPS RESEARCH INSTITUTE
CGCRI

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PRESENTATION

Turkey lies between 36 and 42° North and 26° and 45° East. The total area is about 78 million hectares of which 36% (27 575 000 ha) is agricultural land. 68% and 13% of the cultivated land is used for field and horticultural crops respectively and 19% is follow.

One of the main activity in the Turkey is agricultural production. The contribution of the agriculture to Gross Domestic Products (GDP) is about 14% in 1999. Agricultural population in Turkey is decreasing due to economic development and urbanization, but it is still very high particularly comparing to developed countries. About 40% of the total population of the country, which is 64.4 million according to 1999 census, is engaged in agriculture, farm holdings of 4 million population. Agriculture also plays a key role in supplying raw materials to industry. Agricultural export represent 18 % of the total export. The horticultural is one of the most dynamic subsector in agriculture and represents 48% of the agricultural export.

Methyl Bromide is widely used to control soil fumigation, protect plant development and quarantine measures. In 1994, the Turkish Government tried to reduce the use of Methyl Bromide in agriculture. However, this drastic measure was not well accepted by the farmers due to the usefulness of this broad spectrum, biologically active and cost effective fumigant. In fact, over the last 4 years, the consumption of Methyl Bromide has increased, from 841 tons in 1997. More than 50 % of the estimated quantity of Methyl Bromide used in Turkey in 1997 was consumed in the province of Antalya, in Mediterranean Region of Turkey. Antalya province, with a total of 179.103 decars of covered land is the most important protected cultivation area in Turkey and high value crops such tomatoes, cucumbers, peppers, eggplants etc. Cut flower (carnations gerberas etc.) are grown.

Two research sites were selected, in the experimental stations of the Directorate of Citrus and Greenhouse Crops Research Institute in Aksu and Kocayatak.

Three greenhouse crops were selected as a materials which are tomato, cucumber and carnation.

In the second year, the most promising technologies were tested in full commercial scale with leader growers in Antalya province.

1. ALTERNATIVES TO THE USE OF METHYL BROMIDE IN VEGETABLES

1.1. Experimental Site

Trials of tomato and cucumber on the "Alternatives Use of Methyl Bromide as soil Fumigant" were conducted in glasshouse which are in Aksu and Kocayatak section of Citrus and Greenhouse Crops Research Institute in Antalya. (Figure 1).

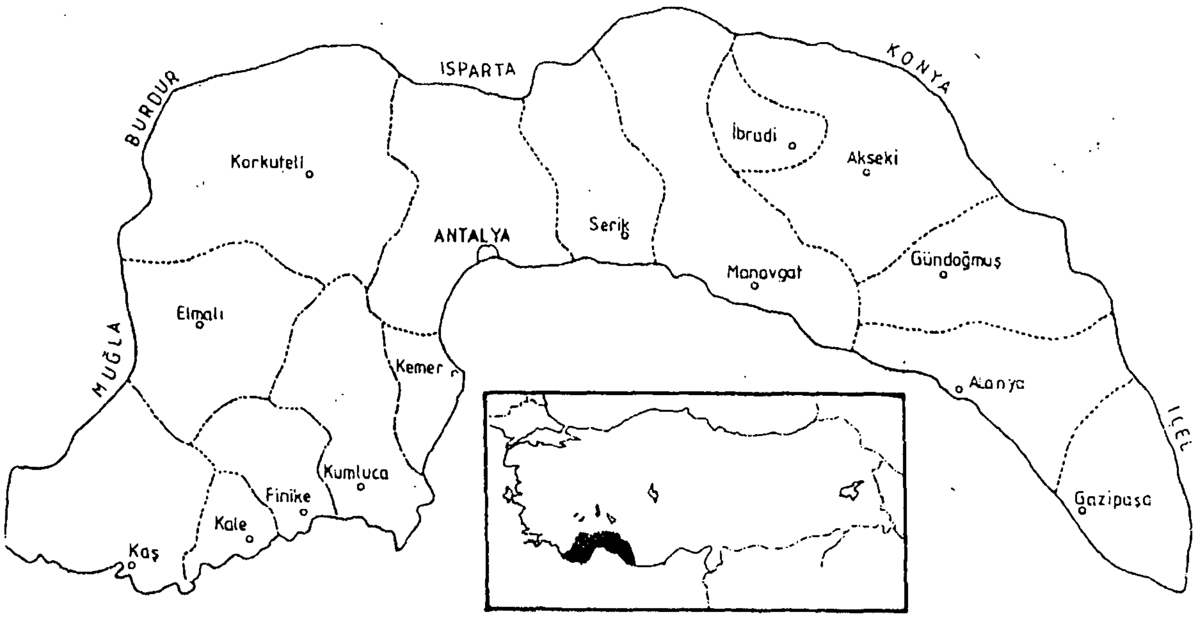


Figure 1. Location of Demonstration Project in Turkey

1.2. Objectives

1. To comply with Montreal Protocol regarding the use of MeBr.
2. To scientifically evaluate the use of alternative treatments to the use of MeBr.
3. To establish treatments effectiveness for nematodes control (*Meloidogyne* sp.)
4. To determine costs for each of the alternative treatments.

1.3. Experimental Design

All treatments (five MeBr alternative techniques, two Methyl Bromide and one blank control) were applied for tomatoes and cucumbers using a randomized block design.

All treatment were implemented according to the detailed procedures provided by the international experts and they were compared against two Methyl Bromide tests and a blank control.

Each plot has a surface of 40 m^2 with at least 1.0 meter space between plots. The experimental site were divided into plots.

Soil preparation, planting time and number of plants per square meter (For tomato 1.0 m x0.45 m and for cucumber 1.0 m x 0.60 m) were carried out using the same methodology applied by growers.

The application of soil fumigation method with Methyl Bromide was also same as growers applied two weeks before planting time using irrigation system.

All the selected alternative technologies were applied in combination with an Integrated Pest Management-IPM System (use of resistant variety of tomatoes, appropriate cultural practies, etc.)

Treatments which are soil solarization, bio fumigant, low dose of alternative chemicals were applied on 26-28 July in Aksu (tomatoes) and 2-6 August in Kocayatak (cucumber).

The trial were fumigated with fresh chicken manure (5 ton/decar) and mulched, The glasshouse was closed during the solarization.

The temperature in the soil was recorded with soil thermograph from 06 August 1999 to 31 August 1999 (Figure 2). Soil temperature was recorded in solarization, bio-fumigant+ solarization and control (unmulched) plots in the depth 10 cm and 20 cm. The maximum temperature was 53 °C in the depp 10 cm depth (18 August 1999).

In the dept of 10 cm of control plots the temperature was not higher the 46°C

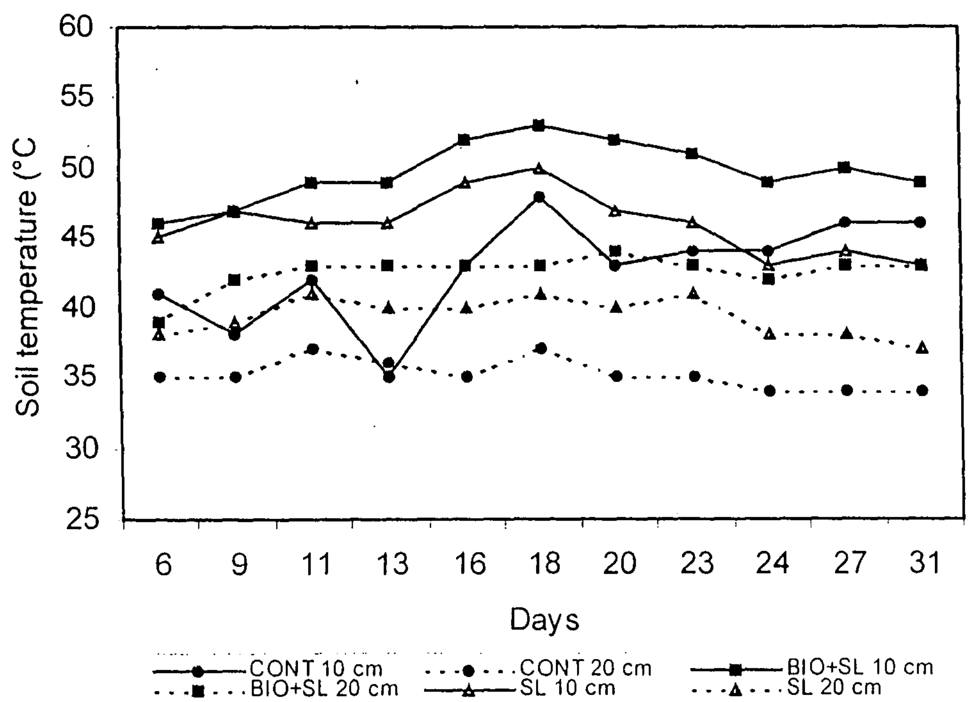


Figure 2. Temperature (°C) recorded in Solarization (SL), Bio Fumigant (BIO) and in control plots.

The soil which this trial was conducted on was the characteristics of Mediterranean Terra Rosse soil. Greenhouses were heated from frost damage by LPG.

The amount of water to be applied was calculated using according to Class A pan (FAO). The plants were irrigated two or three times a week. Amount of irrigation water was controlled periodically so that plants did not suffer under moisture stress. Fertigation was started with the first irrigation.

The following treatments were applied on the vegetable

1- Soil solarization (SL)
2- Soil solarization in combination with low doses of alternative chemicals.
    a. Metham Sodium (MS) : 40 ml/ m^2
    b. Basamid (DZ) : 25 gr/ m^2
    c. 1.3 Dichloropropene (DD) : 6 ml/ m^2
3- Soil solarization in combination with biocontrol (BC) agent : *Trichoderma harzianum* (with the irrigation system after planting)
4- Soil solarization in combination with bio-fumigant (BIO) : 5 ton/da (fresh chicken organic manure)
5- Soilless cultivation (NSC)
    a. Sand (river sand) and organic materyal
    b. Mixing volcanic tuff : peat : (1:1)
    c. Volcanic Tuff

1. Soil Solarization (SL)

Soil solarization is a technique which heats the soil by covered plastic sheets. This technique is most effective during the period of maximum sun radiation (July-August in Antalya) and also the greenhouse are not used for cultivation at this time.

The glasshouse soil was carefully cultivated leveled and watered until the cultivated soil layer (25-30 cm) was completely moistened. Soil was covered with transparent 0.20 mm thick polyethylene film. Additional irrigation were applied during the solarization period by drip irrigation. The soil was covered with the plastics films for 8 weeks for tomatoes (from July 26 to September 21) and for 9 weeks for cucumbers (from August 2 to November 8). During this period the greenhouse were closed to provided a confined a atmosphere (Figure 3).

Figure 3. Soil solarization.

2. Soil solarization in combination with low doses of alternative chemicals.

a. Metham Sodium (MS)

The glasshouse soil was carefully cultivated leveled and divided as a pools. Metham Sodium was applied manually as a drench, diluted in tap water at the rate of 40 ml/ m^2. After applying Metham Sodium, the soil was covered with plastic film during a long period in summer (July-August) (Figure 4).

Figure 4. Metham Sodium (MS)

b. Basamid (DZ)

The basamid granular was spread on the soil surface and incorporated into the soil. With a small rotavator. Basamid was applied half dosage (25 gr/ m^2) and combined with soil solarization. Half doses of basamid (25 gr/ m^2) plus soil solarization were applied as treatments.

c. 1.3 Dichloropropene (DD)

After deep ploughing and rotavating, half dosage (6 ml/ m^2) of fumigant chemical, 1.3-DD, was manually injected in to the soil in depp of 15-17 cm with 30-40 cm spaces using a gun. (Figure 5).

Figure 5. 1.3 Dichloropropene (DD)

3. Soil solarization in combination with Biocontrol (BC)

Two types of biocontrol agent were used in tomatoes and cucumbers. One of the biocontrol agent was Promot which could multiply in the soil and colonize on the roots and protect plants from certain soil pathogenic fungi. Promot contains *Trichoderma koningii* and *Trichoderma harzianum* as biological agents.

Promot was used the transplanting time. Promot powder was diluted in rate of 10 grams per litre of water and dipped the roots of plants in the solution. Than every month promat was applied to the plants in the biocontrol plots.

The other biocontrol agent was Mycormax Plus. Which was Mycormax Plus of versicular mycorrhizal fungi (*Glosmous intraradices*). It contained spores which were clonized on the root fragments and other propaqules which were in clay-based carriers.
These biocontrol agent were used the same as Promot and diluted in the rate of 35-40 gr per litre of water and dipped the roots of plants in the solution at transplanting than every month, it was poured to the plants in to the biocontrol parcels plots.

4. Soil solarization Bio-fumigant (BIO)

This old technique has been recently improved with the use of plastic sheets. Covering the soil with organic waste results in fermentation and produces gases which are toxic to many soil-borne pathogens. This method is cost effective and easy. Fresh chicken manure was used 5 tons per decor (1000 m^2) as a biofumigant. The soil was covered with fresh chicken manure and watered by flooding. Than, the soil was covered with plastic film for solarization (Figure 6).

Figure 6. Soil solarization (SL) + Bio-fumigant (BIO)

5. Open circuit non-soil cultivation (NSC)

Three different growing media were used in soilless cultivation as treatments.
a) Sand (0–1 mm Ø) from river plus organic material b) Volcanic tuff (6-8 mm Ø) from Isparta and c) mixing volcanic tuff with peat (1:1) from Yeniçağ Bolu. 3mm thick of hard dark plastic were used for growing beds constracted on the soil were 24 cm in depth and 22 cm in whith. (Figure 7 and 8).
Plants were feeded with a complete nutrient solution given by drip irrigation system.

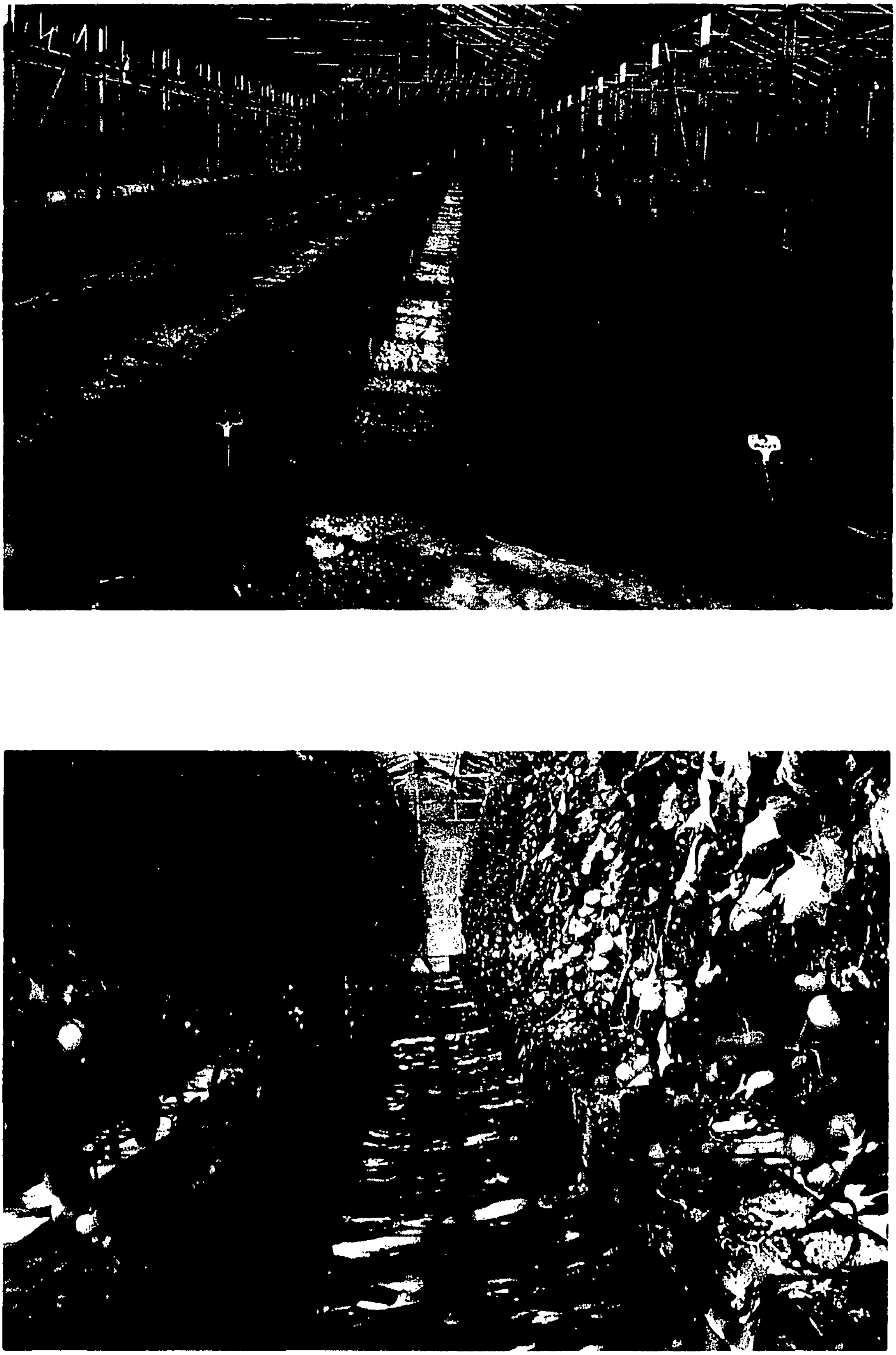


Figure 7. Soilless culture

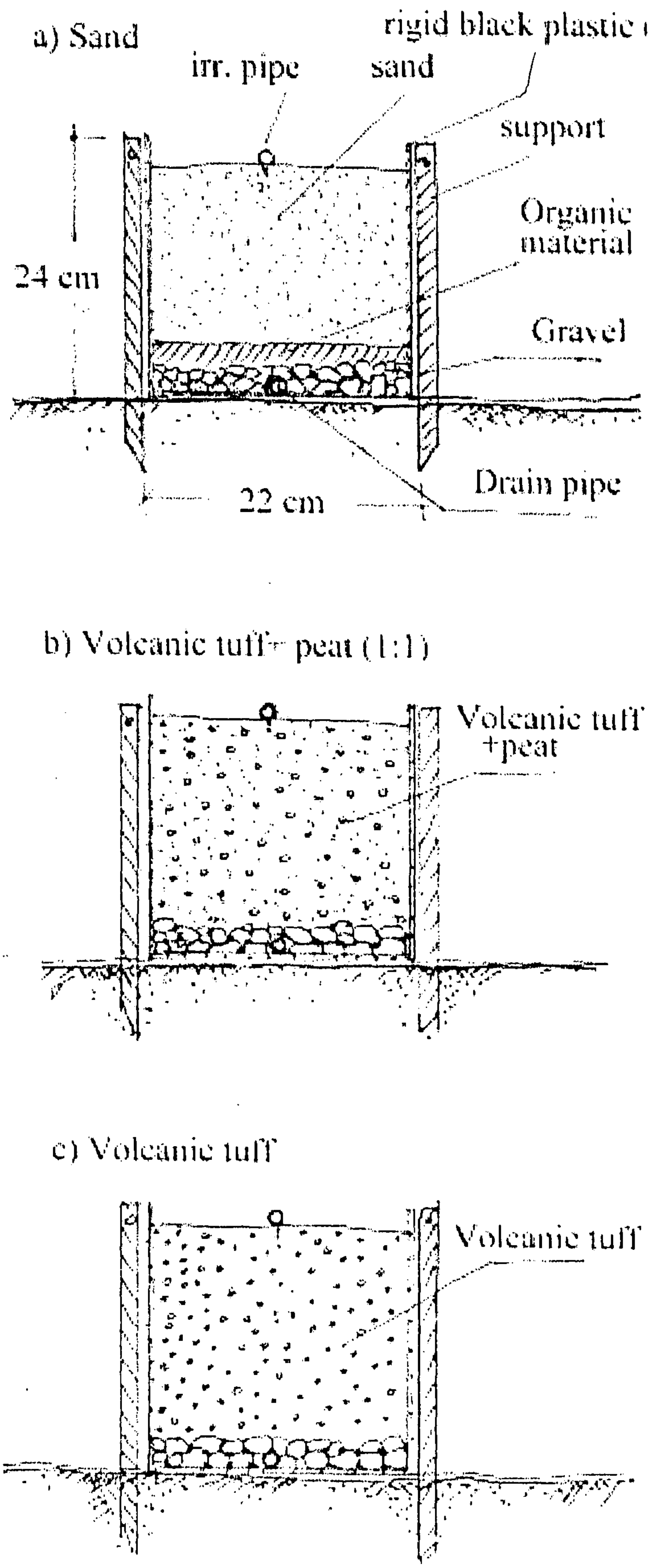


Figure 2. Cross section of soilless culture beds.

A. TOMATO

1. Experimental Design and Layout

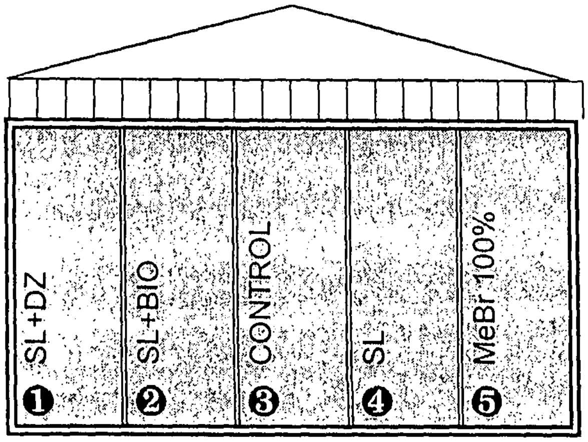
The tomatoes trials were carried out in 3628 m^2 land of 10 glasshouses, each glasshouse was divided into application and plots each one had a control (untreatment) plot.
One-month-old tomato seedlings (*Lycopersicon esculentum* Mill.) of a indeterminate hybrid "Fantastic F144 and Fantastic F144 RV (Resistant Variety) were grown in peat compost on the seedling company were planted on 1 October 1999 at 45 cm in the row and 1 m between rows (1.00 m-1.00 m=2.2 plants/ m^2). The trial layout in the glasshouses are shown in figure 9.
Followed planting, all kinds of care procedures (twisting, take out of second branches, fertilizing etc.) have been fulfilled.
Pollination : Plants were pollinated every other day. Pollinating was done between 10:00 a.m. and 2:00 p.m. under sunny conditions with electric vibrator. This was done by tapping the flowers.

The following treatments were applied on the tomatoes

Alternative Techniques		Number of Plots
•Solarization (SL)		2
•Low doses of alternative chemicals.		12
Solarization+1.3 Dichloropropene(SL+DD)	: 4	
Solarization+ Metham sodium (SL+MS)	: 4	
Solarization+Dazomet (SL+DZ)	: 4	
•Solarization+Biocontrol (SL+BC)		6
Solarization +Mycormax plus (SL+BC/m)	: 3	
Solarization +Promot (SL+BC/p)	: 3	
•Solarization+bio-fumigant (SL+BIO)		6
* •Non-Soil cultivation (NSC)		9
- Sand	: 3	
- Volcanic tuff (VT)	: 3	
- Volcanic tuff + Peat (VT+Peat)	: 3	
•Resistans Variety (RV)		
Solarization+Resistant variety (SL+RV)	: 2	2
Low doses of alternative chemicals.		3
1.3 Dichloropropene+ Resistant variety (DD+RV)	: 1	
Metham soidyum+resistant variety (MS+RV)	: 1	
Basamid + Resistant variety (DZ+RV)	: 1	
Resistant variety+Solarization+Biocontrol (RV+SL+BC)		2
Resistant variety + Solarization + Bio-fumigant (RV+SL+BIO)		2
•Methyl Bromide (MB 100%) (Normal Dose: 70 g/m^2)		2
•Methyl Bromide (MB 50%) (Reduced Dose: 35 g/m^2)		2
•Control (CONT)		8
•Control + Resistant variety (CONT+RV)		3
Total Number of Plots		59

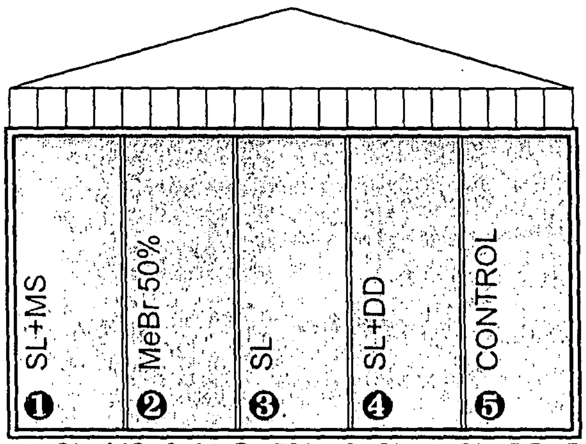
Figures 9. The experiment of tomatoes layout in Aksu

Glasshouse No : 51



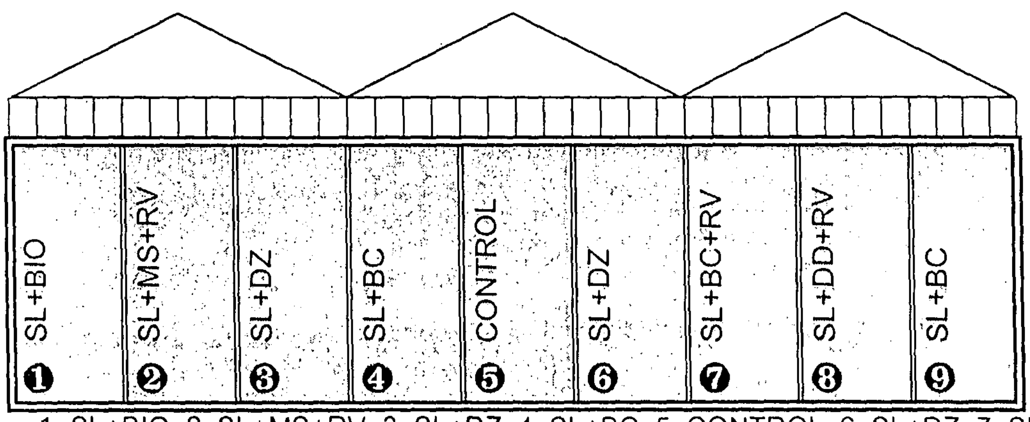
1. SL+DZ, 2. SL+BIO, 3. CONTROL, 4. SL, 5.MeBr 100%
(7 rows/plot= 56 m^2/plot, 56 m^2x5=280 m^2)

Glasshouse No : 54



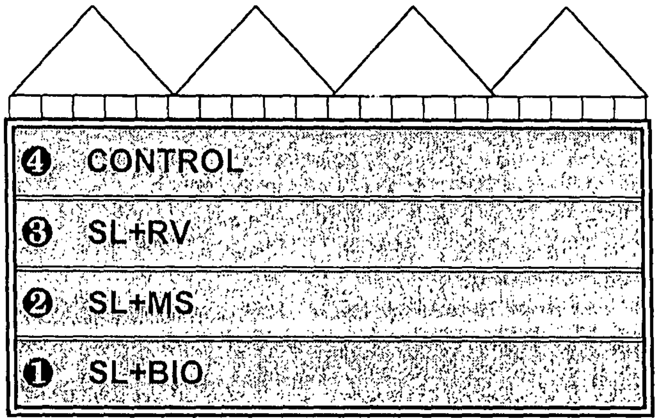
1. SL+MS, 2. MeBr 50%, 3. SL, 4. SL+DD, 5. CONTROL (7 rows/plot)
(7 rows/plot= 56 m^2/plot, 56 m^2x5=280 m^2)

Glasshouse No : 55



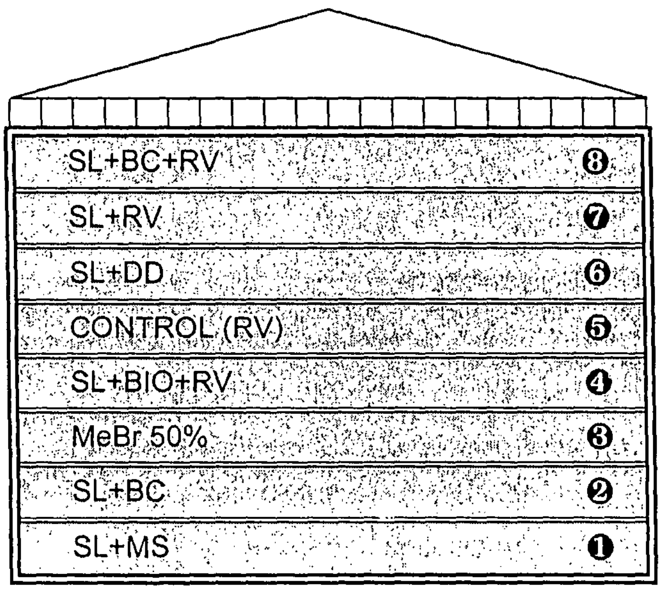
1. SL+BIO, 2. SL+MS+RV, 3. SL+DZ, 4. SL+BC, 5. CONTROL, 6. SL+DZ, 7. SL+BC+RV, 8. SL+DD+RV, 9. SL+BC
(4 rows/plot, 56 m^2/plot = 56 m^2x9=504 m^2)

Glasshouse No: 68



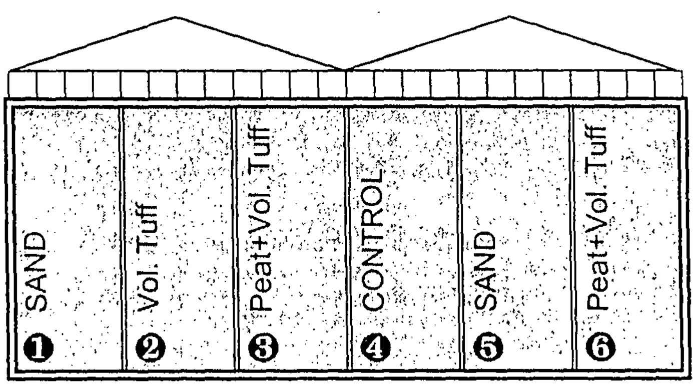
1. SL+BIO, 2. SL+MS, 3. SL+RV, 4. CONTROL
(6 rows/plot, 72 m^2/plot = 72 m^2x4=288 m^2)

Glasshouse No: 69



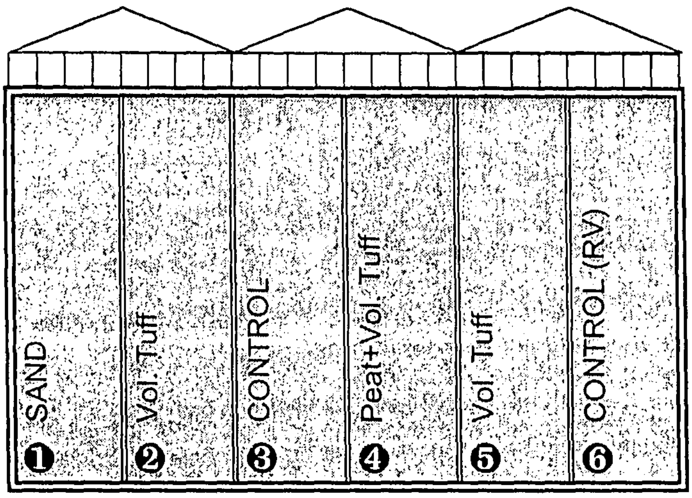
1. SL+MS, 2. SL+BC, 3. MeBr 50%, 4. SL+BIO+RV, 5. CONTROL, 6. SL+DD, 7. SL+RV, 8. SL+BC+RV
(6 rows/plot, 54 m^2/plot = 54 m^2x8=432 m^2)

Glasshouse No : 65 (Soilles culture)



1. SAND, 2. Vol. Tuff, 3. Peat+Vol. Tuff, 4. CONTROL, 5. SAND, 6. Peat+Vol. Tuff
(2 rows/plot, 50 m^2/plot = 50 m^2x6=300 m^2)

Glasshouse No: 66 (Soilles culture)



1. SAND , 2. Vol. Tuff, 3. CONTROL, 4. Peat+Vol. Tuff, 5. Vol. Tuff, 6. CONTROL (RV)
(2 rows/plot, 60 m^2/plot = 60 m^2x6=360 m^2)

2. Diseases

Before the treatment soil samples were taken from three different crops (carnation, tomato and cucumber).

Table 1. Number of Soil Pathogens in Tomato.

	Before Treatments			After Treatments		
	10^5 (Fungi)	10^6 (Actinomycetes)	10^7 (Bacteria)	10^5 (Fungi)	10^6 (Actinomycetes)	10^7 (Bacteria)
SL	36.3	72.2	58.6	13.8	27.6	16.4
SL+DD	38.6	63.5	62.4	13.0	17.3	9.5
SL+MS	31.2	69.6	55.6	11.7	18.8	8.5
SL+DZ	29.9	64.9	54.6	16.4	31.5	20.9
SL+BC (Promot)	35.3	66.7	57.8	25.3	53.2	49.3
SL+BC (Mycormax)	37.2	64.2	62.9	33.4	56.3	52.8
SL+BIO	32.8	63.2	50.5	18.8	32.0	26.7
MeBr 50%	34.0	70.6	56.5	2.5	27.4	2.0
MeBr 100%	34.2	68.9	57.9	1.2	24.2	0.0
Control	39.2	71.6	56.2	41.0	64.2	58.8

In Table 1, in the fungi number the most effective treatments were MeBr 100% and 50%. But, also low dose of chemicals were effective according to control (Figure 10). The most effective of low dose of chemicals was solarization plus MS. Solarization plus biofumigation and solarization plus biocontrol agents (promot) were also effective.

In the bacteria most effective treatments according to control were MeBr 100%, MeBr 50%, SL+MS, SL+DD, SL, SL+DZ, SL+BIO, respectively.

In the actinomycetes the most effective treatments were SL+DD and SL+MS.

Figure 10. Disease in control plots.

Table 2. Number of Fungi Counted in Tomato

Fungi (10^5)	December	February	April	June
SL	13.3	13.5	14.0	21.0
SL+DD	12.7	12.8	13.5	20.6
SL+MS	12.1	12.0	12.2	19.5
SL+DZ	17.0	16.8	17.0	21.0
SL+BC (Promot)	25.1	24.8	25.6	25.9
SL+BC (Mycomax)	32.5	33.0	34.0	34.0
SL+BIO	17.6	17.9	19.1	20.1
MeBr 50%	2.2	2.4	3.0	6.4
MeBr 100%	1.0	1.0	1.4	3.2
Control	39.8	41.3	39.9	41.0

In tomato application the alternatives were changed according to the carnation. In tomato and cucumber we used 9 different alternatives. In Table 2 the most effective applications were MeBr 100%, MeBr 50%, SL+MS, SL+DD, SL and SL+BIO, respectively. Also biocontrol agents were effective but not so much. We used two kinds of biocontrol agents one of them was, PROMOT the other one was MYCORMAX. These biocontrol agents were effective only fungi in the soil. It was no effect against actinomycetes and bacteria. According to the biocontrol agents, PROMOT was better than MYCORMAX in the soil. PROMOT consisted *T. horzianum* in it. But MYCORMAX was a kind of mycorrhiza which effected phosphorus nutrition in the soil.

Table 3. Number of Actinomycetes Counted in Tomato

Actinomycetes (10^6)	December	February	April	June
SL	28.0	27.8	28.0	33.0
SL+DD	19.2	19.0	19.1	22.4
SL+MS	19.1	18.9	19.0	22.1
SL+DZ	32.3	32.0	32.5	33.0
SL+BC (Promot)	54.3	54.0	54.0	54.5
SL+BC (Mycomax)	56.2	55.3	56.5	58.9
SL+BIO	33.2	32.5	32.3	37.8
MeBr 50%	27.6	27.8	27.9	31.7
MeBr 100%	25.6	24.6	24.4	28.8
Control	66.7	65.8	68.7	69.0

In Table 3 the most effective applications were SL+DD and SL+MS we didn't consider enough pathogens caused by actinomycetes.

Table 4. Number of Bacteria Counted in Tomato

Bacteria (10^7)	December	February	April	June
SL	17.1	17.0	17.0	21.3
SL+DD	10.1	10.0	10.1	16.4
SL+MS	9.0	9.5	9.5	16.5
SL+DZ	21.2	21.3	21.5	21.9
SL+BC(Promot)	48.7	49.0	49.5	51.5
SL+BC (Mycomax)	52.5	52.7	53.0	53.2
SL+BIO	27.1	27.2	27.2	27.9
MeBr 50%	4.1	4.0	3.5	8.5
MeBr 100%	0.0	0.0	0.0	4.2
Control	57.1	56.8	57.5	59.0

In Table 4 the most applications were MeBr 100%, MeBr 50%, SL+MS and SL+DD, respectively.

3. Nematodes

To determine the nematod level (*Meloidogyne* spp.) in the soil, five samples were taken randomly per plot before treatments (Figure 11). These samples were taken from 0-30 cm depth and mixed together. Then we took 100 cc soil from this mixture to determine the nematod level as to its II. larval stages (J_2). Than the same sampling procedure is repeated after the treatment.

During vegetation stage root gall levels were checked once a month at each plot as to 0–4 root gall index.

Index 0: Healthy root system, no infestation.

Index 1: Very few small galls can only be detected upon close examination.

Index 2: Numerous small galls, some big galls, majority of roots still functioning.

Index 3: 25-50 % of root system severally galled and not functioning

Index 4: Root system completely deformed by large galls, not functioning.

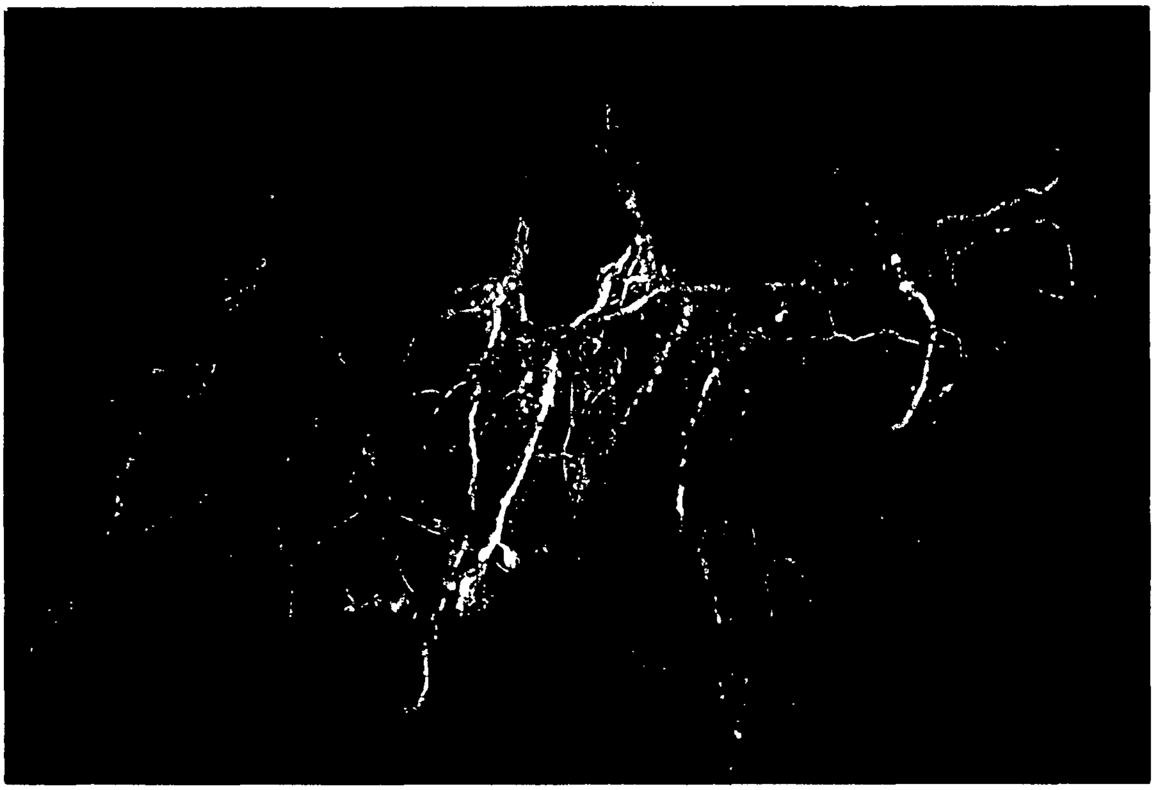


Figure 11. Nematode in the soil before treatments(it was taken from glasshouse no : 69).

To asses the different treatments against nematodes several tests were carried out on tomato plots namely Solarization, solarization plus several low doses of chemical (1,3 Dichloropropene, Dazomet, Metam sodium) and Methyl bromid. Methyl bromid 100% application was most effective in controlling *Meloidogyne* spp. Methyl bromid 50 %, Solarization plus 1,3 Dichloropropene and Solarization plus biofumigation were also effective then other applications (Table 5).

Table 5. Effect of different treatments to *Meloidogyne* spp. on tomato (J_2 / 100 cc soil)

Treatments	Before Treatments	After Treatments	% Effect	At the end of vegetation
Control	321.1	266.0	-	520.0
Methyl Bromid 100%	273.3	3.6	98.7 A	8.5
Methyl Bromid 50%	276.0	11.0	96.0 AB	30.0
Solarization	224.0	35.0	84.4 D	70.0
Solarization + Bio fumigation	292.5	18.5	93.7 BC	48.5
Solarization + Bio control	308.5	48.8	84.2 D	85.5
Solarization + 1,3 Dichloroproene	284.0	11.5	96.0 AB	40.0
Solarization + Dazomet	255.8	22.8	91.1 C	56.0
Solarization + Metam sodium	290.3	30,3	89.6 C	70.5

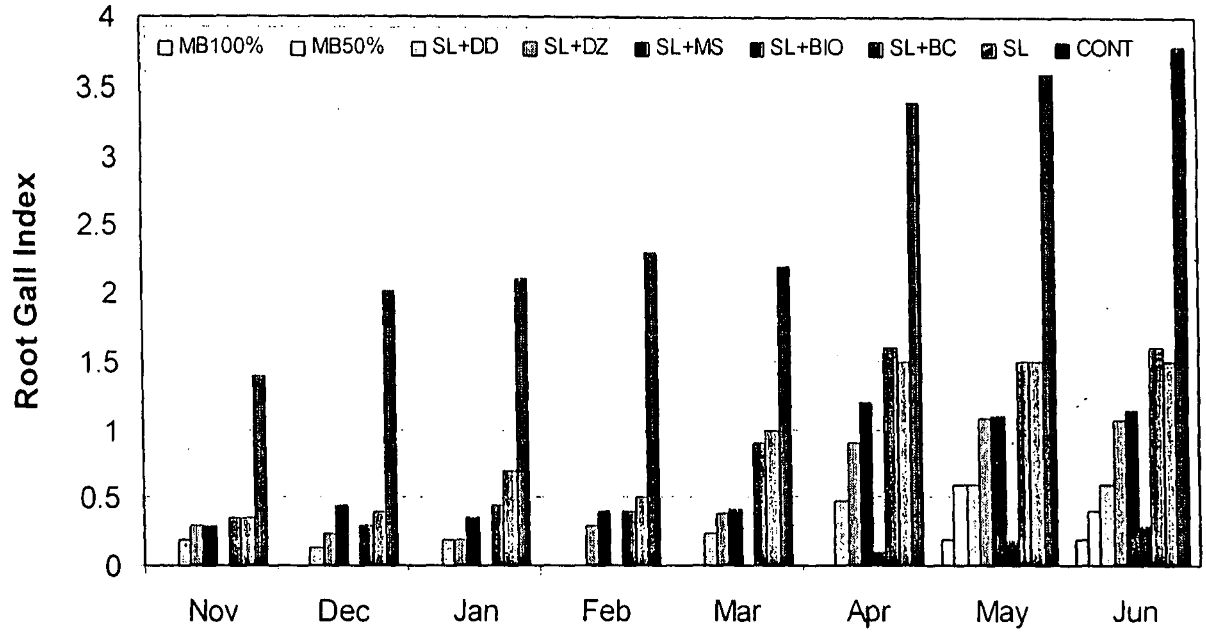


Figure 12. Seasonal dispersion of root galls during the vegetation period in tomato.

In the control blocks there were a little root-knots determined in November. It has seen any root-knots in the Me Br 100%, Me Br 50%, Solarization plus 1,3 Dichloropropene and Solarization plus biofumigation since April. In April some of the plants has been died by means of root-knots in control blocks. At the end of vegetation period all of the plants which in some control blocks had been died. It hasn't seen died plants but in solarization and solarization plus biocontrol blocks but big nodules shown (Figure 12 and 13).

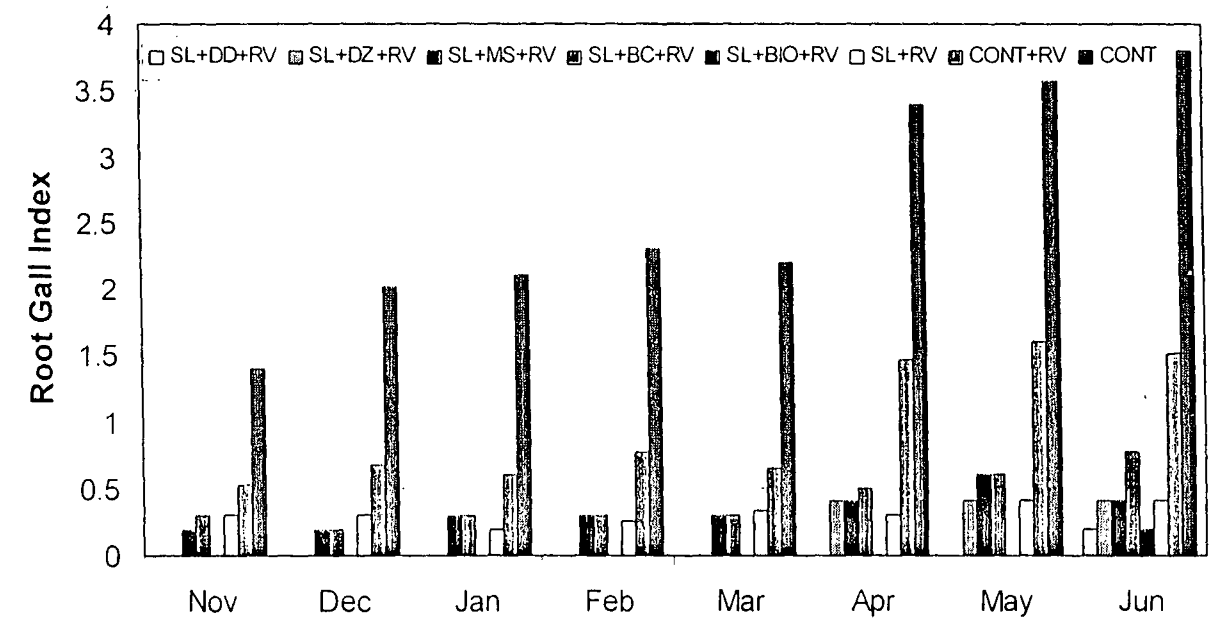


Figure 13. Seasonal dispersion of root galls during the vegetation period in tomato.

As it shown in Table 6 at the end of vegetation period in the control blocks all the plants were completely deformed by large galls. Root gall index was highest on plants grown in Contorl plots (3.8), moderate in Solarization plus Dazomet (1.06), Solarization plus Metam sodium (1.14), Solarization (1.5), Solarization plus Bio control (1.6) and lowest in Methyl Bromid 100% (0.2), Methyl Bromid 50% (0.4), Solarization plus Bio fumigation (0.3) and Solarization plud 1,3 Dichloropropene (0.8).

Table 6. Effectiveness of different treatments to *Meloidogyne* spp. galls on tomato at the en of vegetation

Treatments	Root-Gall Index	
	Maximum	Average
Control	4	3.8
Methyl Bromid 100%	1	0.2
Methyl Bromid 50%	1	0.4
Solarization	3	1.5
Solarization + Bio fumigation	1	0.3
Solarization + Bio control	3	1.6
Solarization + 1,3 Dichloroproene	2	0.8
Solarization + Dazomet	2	1.06
Solarization + Metam sodium	2	1.14

To see the effect of different treatments on Root-Knot nematodes we carried out another tests, this time by using resistant variety. In this case Solarization plus 1,3 Dichloropropene and Solarization plus biofumigation found to be more effective. One other result is that no dead plants are seen in Control plus Resistant variety where as in Control plots there are many dead plants (Table 7).

Table 7. Effectiveness of different treatments to *Meloidogyne* spp. galls when resistant tomato variety used at the end of vegetation.

Treatments	Root-Gall Index	
	Maximum	Average
Control	4	3.8
Control+ RV	2	1.5
Solarization+ RV	1	0.4
Solarization + Bio fumigation+ RV	1	0.2
Solarization + Bio control+ RV	1	0.8
Solarization + 1,3 Dichloroproene+ RV	1	0.2
Solarization + Dazomet+ RV	1	0.4
Solarization + Metam sodium+ RV	1	0.4

4. Weeds

Table 8. Number of weeds counted in tomato after the treatments.

	SL	DD	MS	DZ	BC	BIO	MeBr 50%	MeBr 100%	Control
Portuloca oleracea	18	24	15	29	40	11	4	-	156
Chenopodium sp.	23	20	11	18	46	10	-	-	135
Cyperus sp.	4	2	3	4	5	5	-	-	35
Malva sp.	1	-	2	3	7	-	1	-	30
	46	46	31	54	26	98	5	-	356

According to the number of weeds counted in 1 m^2 in tomato, the most effective treatments were found MeBr%100, MeBr5%0, BIO and MS, respectively.

5. Yield

The total production from each plot (per kg/plot) was recorded. The tomatoes fruit was harvested once a week over a 23 week period beginning 21 January 2000 to 27 June 2000. All reaming fruit of tomatoes was harvested and weighed. The yield was classified due to the size of fruit, according to standard marketable size. Extra over 55 mm, class I 55-35 mm, and Class II less than 35 mm.

And the Data were statistically analysed and mean values compared by Duncan multiple range test.

All of the alternatives gave substantial and significant yield increases over untreated control. The highest total and marketable yields of tomatoes were optioned from bio-fumigant.

Table 9. Yield and quality of tomato and effective by Alternative techniques. SL, SL+DD, SL+MS, SL+DZ, SL+BIO, SL+BC/m, SL+BC/p, MeBr100%, MeBr50%

	Alternatives	Extra ($kg.da^{-1}$)	Class I ($kg.da^{-1}$)	Class II ($kg.da^{-1}$)	TOTAL YIELD ($kg.da^{-1}$)	
1	CONTROL	7989.0	4913.6	2038.3	14940.9	**D**
2	SL	8815.5	5744.0	2797.1	17356.5	**C**
3	SL+DD	9921.4	6860.0	2785.3	19566.8	**A B**
4	SL+MS	8907.5	6578.3	2671.6	18157.4	**B C**
5	SL+DZ	11657.7	5933.2	1930.5	19521.3	**A B**
6	SL+BIO	11726.8	6556.0	2314.7	20597.5	**A**
7	SL+BC/m	10401.1	5882.0	1723.6	18006.7	**B C**
8	SL+BC/p	9607.1	6541.7	2488.0	18636.7	**B C**
9	MeBr100%	10959.8	5826.9	2376.3	19163.1	**A B**
10	MeBr50%	9986.1	6669.6	2483.2	19138.9	**A B**

Treatments with the same letter one not significant different according to a Duncan Multiple Range Test, signification level is 5%.

Da : 1000 m^2
P : Promot
M : Mycormax Plus

The yield of tomato classified due to the size of fruit was the highest in the bio-fumigant (fresh chicken manure, 5 ton/da) treatments the yield in low doses of chemical (DD) and BZ was the same as a MeBr (Low doses 35 gr/ m^2, and full dose 70 gr/ m^2) and on the second place, the lowest in the control (Table 9).

Table 10. Effects of soil treatments with resistant variety on yield of tomatoes - SL+RV, DD+RV, MS+RV, BC+RV, BIO+RV

	Alternatives	Extra (kg.da^{-1})	Class I (kg.da^{-1})	Class II (kg.da^{-1})	TOTAL YIELD (kg.da^{-1})
1	CONTROL+RV	9079.3	6410.5	2750.4	18240.2 C
2	SL+RV	9112.3	6356.4	2861.7	18330.3 C
3	SL+DD+RV	10539.2	6065.1	2414.7	19018.9 B C
4	SL+MS+RV	10010.3	7698.5	2441.7	20150.4 A B
5	SL+DZ+RV	9655.2	6716.2	3911.9	20283.3 A B
6	SL+BC+RV/m	10410.7	6964.6	2417.1	19792.4 A B
7	SL+BC+RV/p	9121.8	5825.2	3389.4	18336.4 C
8	SL+BIO+RV	10121.2	7267.9	3273.3	20662.4 A
9	MeBr100%	10789.7	5739.2	2349.5	19163.1 B C
10	MeBr50%	10871.9	6896.0	2676.5	19138.9 B C

Treatments with the same letter one not significant different according to a Duncan Multiple Range Test, signification level is 5%.

Yield and classify was given in Table 10. The highest yield per da (kg. da-1) was harvested from plants grown on the BIO+RV parcel (20 662.4 kg.da-1) as a MeBr50%. Which were followed by Dazomet (DZ+RV). The lowest yield was obtained from plants grown on the control (CONT), (18 240.2) parcel.

Table 11. Effect of the soilless culture on yield of tomatoes. Sand (S), Volcaniff Tuff (VT) and mixing volcaniff tuff + peat (VT+P), MeBr.

	Alternatives	Extra (kg.da^{-1})	Class I (kg.da^{-1})	Class II (kg.da^{-1})	TOTAL YIELD (kg.da^{-1})
1	CONTROL	7989.0	4913.6	2038.3	14940.9 D
2	CONTROL+RV	8947.1	6153.5	2742.2	17842.8 C
3	MeBr100%	10959.8	5826.9	2376.3	19163.1 B C
4	MeBr50%	9986.1	6669.6	2483.2	19138.9 B C
5	SAND	12191.3	7367.2	1505.6	21064.1 A
6	VT	10708.4	7339.2	1372.9	19420.4 A B C
7	PEAT+VT	11565.1	7416.1	1455.0	20436.2 A B

Treatments with the same letter one not significant different according to a Duncan Multiple Range Test, signification level is 5%.

The yield and classify of tomatoes given in Table 11. The highest yield was harvest from plants grown on Sand (S) parcel. Which were followed by mixing Volcaniff Tuff + Peat (VT+P) parcel. The result of the study was showed that soilless culture could be used successfully for alternatives of MeBr.

6. Economic Evaluation

In this research alternatives application methods for methyl bromide was studied and nineteen production systems were compared for differences in production cost, yield, gross income and net income. Information shown on Table 12 is based on cost figures provided by the tomato plots.

Table 12. Treatment costs per 1000 m² under greenhouse for tomato (US $)*

Alternatives	CONT.	1	2	3	4	5	6	7	8	9
Control	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
SL+DD	0	0	28.3	0	0	0	0	0	0	0
SL+MS	0	0	0	71.1	0	0	0	0	0	0
SL+DZ	0	0	0	0	99.6	0	0	0	0	0
SL+BIO	0	0	0	0	0	105.0	0	0	0	0
SL+BC/m	0	0	0	0	0	0	652.2	0	0	0
SL+BC/p	0	0	0	0	0	0	0	363.3	0	0
MeBr 100%	0	0	0	0	0	0	0	0	284.1	0
MeBr 50%	0	0	0	0	0	0	0	0	0	142.0
Plastic	0	58.7	58.7	58.7	58.7	58.7	58.7	58.7	79.1	79.1
Labour	43.5	27.0	31.3	35.6	31.3	28.7	27.0	27.0	26.1	26.6
Total	43.5	85.7	118.3	165.4	189.6	192.4	737.9	449.0	389.3	247.7

(*): 690 000 Turkish Liras = 1 US $

Table 12 Continued.

Alternatives	CON.+RV	10	11	12	13	14	15	16	17	18	19
Control+RV	12.8	0	0	0	0	0	0	0	0	0	0
SL+RV	0	12.8	0	0	0	0	0	0	0	0	0
SL+DD+RV	0	0	41.1	0	0	0	0	0	0	0	0
SL+MS+RV	0	0	0	83.9	0	0	0	0	0	0	0
SL+DZ+RV	0	0	0	0	112.4	0	0	0	0	0	0
SL+BC/m+RV	0	0	0	0	0	665.0	0	0	0	0	0
SL+BC/p+RV	0	0	0	0	0	0	376.1	0	0	0	0
SL+BIO+RV	0	0	0	0	0	0	0	117.8	0	0	0
Sand	0	0	0	0	0	0	0	0	89.3	0	0
V. tuff	0	0	0	0	0	0	0	0	0	149.7	0
V. tuff+Peat	0	0	0	0	0	0	0	0	0	0	404.3
Plastic	0	58.7	58.7	58.7	58.7	58.7	58.7	58.7	0	0	0
Mat.&Equipment	0	0	0	0	0	0	0	0	72.5	72.5	72.5
Labour	43.5	27.0	27.0	31.3	35.6	27.0	27.0	28.7	54.5	54.5	54.5
Total	56.3	98.5	126.8	173.9	206.7	750.7	461.8	205.2	216.3	276.7	531.3

Table 12 Comments: The results indicated that the control plot had the lowest cost. The costs of solarization, low doses of chemicals, soilless culture (sand) lower than MeBr 100% and 50%.

7. Plant Nutrition

Some chemical and physical properties of soil that grown tomatoes was given in Table 16. pH were alkaline or weakly alkaline, no salinity problem, textures were Loam and Sandy Loam. Organic matter were between 2.23 - 5.20 percentage. Carbonate values changed 21.3-31.8%. Amounts of some plant nutrient elements changed 0.11-0.28% N, 160-397 ppm P, 318-645 ppm K, 1512-2545 ppm Ca, 321-500 ppm Mg. C/N were between 8-12. CEC were between 18-37 meq/100 g. Soil samples were taken twice at before planting and after cultivation. Soil properties are same as other soils that grown vegetables in Antalya region.

Also some properties of substrates used as growing medium for soilless culture are shown in Table 18. pH of sand and volcanic tuf were alkaline but pH of peat was weakly alkaline. Amount of carbonate were 31.30% for sand, 1.30% for volcanic tuff and 1.80% for peat. Organic matter of peat was 57.13%.

Some properties of water used at trials were given in Table 19.

Fertilization plan was adjusted according to soil, water and plant analysis results. Amount of elements in nutrient solution prepared for plant grown in soil were changed between 80-120 ppm N, 30-70 ppm P_2O_5 , 150-250 ppm K_2O for tomatoes.

Nutrient solutions used in soilless culture for tomatoes were given in Table 20. Nutrient solution used in soilless culture for tomatoes were 14 mmol/lt NO_3, 1mmol/lt H_2PO_4, 3.75 mmol/lt SO_4, 1.25 mmol/lt NH_4, 8.75 mmol/lt K, 4.25 mmol/lt Ca, 2 mmol/lt Mg, 15 µmol/lt Fe, 10 µmol/lt Mn, 5 µmol/lt Zn, 30 µmol/lt B, 0.75 µmol/lt Cu, 0.75 µmol/lt Mo. Amount of nutrient elements were adjusted according to properties of water.

Some nutrient elements concentration in leaf tissue of tomatoes grown in soil and substrates were %4.0-4.98 N, %0.29-0.69 P, %2.71-4.92 K, %1.38-2.40 Ca, %0.36-0.83 Mg, 67-161 ppm Fe, 44-98 ppm Mn, 32-209 ppm Zn (Table 17). As a result of that fertilization program, average values of some plant nutrient elements in leaf tissue of tomatoes grown in soil and substrates were generally sufficient or high So that any nutritional problems at tomatoes during growing period weren't determined. Leaf samples were taken twice during growing period.

Table 16. Some physical and chemical properties of soil grown tomatoes.

	PH	%CaCO$_3$	EC Micromhos / cm	TEXTURE %SAND	TEXTURE % CLAY	TEXTURE % SILT	% Organic Matter	C/N	CEC meq/100 g	%N	P ppm	K ppm	Ca ppm	Mg ppm
BEFORE PLANTING	7.4-8.0	21.3-28.0	512-1000	44	22	34	2.23-5.10	8-12	22-35	0.11-0.26	172-385	318-605	1512-2490	321-499
				Loam										
				63	18	19								
				Sandy Loam										
AFTER CULTIVATION	7.7-8.0	22.8-31.8	518-1100				2.98-5.20	10-11	18-37	0.20-0.28	160-397	354-645	1820-2545	340-500

Table 17. Some plant nutrient elements concentration in leaf tissue of tomatoes.

MONTH		N %	P %	K %	Ca %	Mg %	Fe ppm	Mn ppm	Zn ppm
DECEMBER	SOIL	4.60-4.98	0.40-0.69	3.86-4.92	1.96-2.40	0.47-0.55	70-83	55-98	88-209
	SOILLESS CULTURE	4.5-4.6	0.29-0.52	4.18-4.57	2.04-2.36	0.36-0.45	67-76	48-76	104-167
APRIL	SOIL	4.0-4.7	0.32-0.48	2.71-3.45	1.38-1.89	0.66-0.83	75-161	44-71	32-74
	SOILLESS CULTURE	4.63-480	0.38-0.52	3.37-3.63	1.40-1.52	0.56-0.61	90-107	48-65	37-45

Table 18. Properties of substrates

	PH	EC micromhos/cm	Carbonates %	Organik Matter %
SAND	8.73	84	31.30	-
VOLCANIC TUF	8.80	270	1.30	-
PEAT	7.54	1200	1.80	57.13

Table 19 Some properties of water

	Kocayatak	Aksu (Channel)
EC (Micromhos/cm)	750	370
PH	7.15	7.92
SAR	0.40	0.15
ESP	10.08	6.9
Na ppm	16	8
Ca ppm	110	72.18
Mg ppm	9.30	13.2
K ppm	2	2
Cl ppm	53.25	53.25
SO_4 ppm	17.28	27.84
HCO_3 ppm	353.80	183

Table 20. Nutrient solutions for vegetables and flowers grown in substrates.

	Tomatoes	Cucumbers	Carnation
NO_3 mmol/lt	14	16	13
H_2PO_4 mmol/lt	1	1.25	1.25
SO_4 mmol/lt	3.75	1.375	1.25
NH_4 mmol/lt	1.25	1.25	1
K mmol/lt	8.75	8	6.25
Ca mmol/lt	4.25	4	3.75
Mg mmol/lt	2	1.375	1
Fe μmol/lt	15	15	25
Mn μmol/lt	10	10	10
Zn μmol/lt	5	5	4
B μmol/lt	30	25	30
Cu μmol/lt	0.75	0.75	0.75
Mo μmol/lt	0.75	0.5	0.75

B. CUCUMBER

1. Experimental Design and Layout

The cucumber trials were carried out in 2956 m^2 land of for glasshouse, each glasshouse was divided in to application and growing plots each one had a control (untreatment) plot. Tree-weeks-old cucumber seedlings (*Cucumis sativus* L.) of a indeterminate hybrid "Quamar" were growing in peat compost on the seedling company were planted on 19 October 1999 in Aksu and 22 October in Kocayatak at 60 cm in the row and 1 mm between rows (060 m-1.00 m=1.67 plants/ m^2). The trial layout in the glasshouse is shown in figure 1.

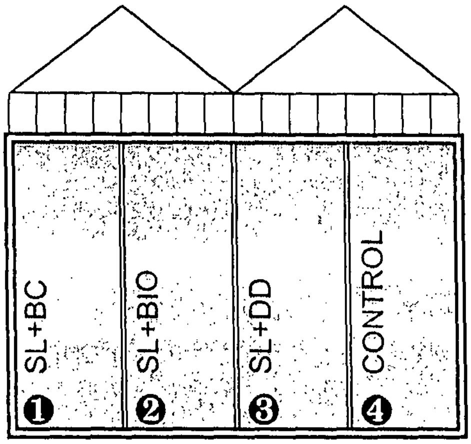
Followed planting, all kinds of care procedures (twisting, take out of second branches, fertilizing etc.) have been fulfilled.

Fruits were counted and graded according to standard marketable size.

The following treatments were applied on the cucumber.

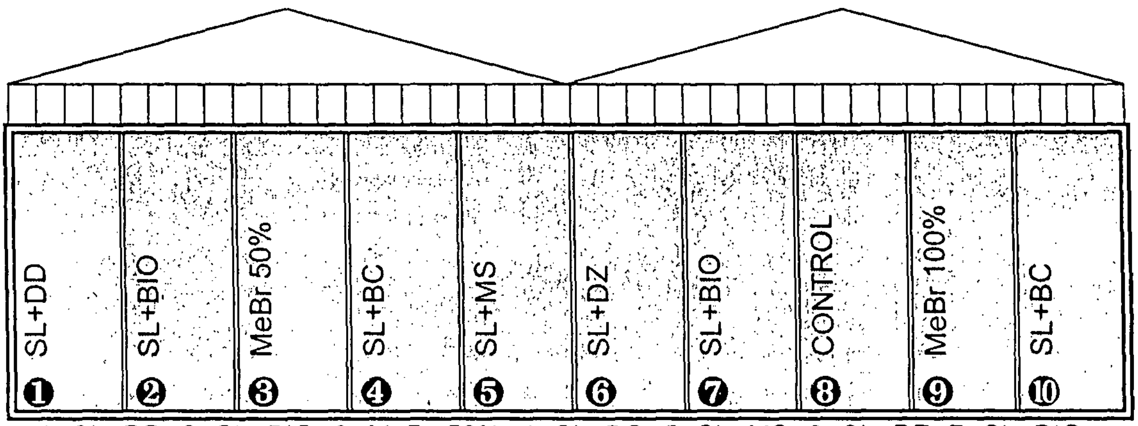
Treatments		Number of Plots
• Solarization (SL)		2
• Low doses of alternative chemicals		12
Solarization +1.3 Dichloropropere (SL+DD)	: 4	
Solarization +Metham Sodium (SL+MS)	: 4	
Solarization +Dazomed (SL+DZ)	: 4	
• Solarization +Bio-fumigant (SL+BIO)		6
• Solarization +Bio-control (SL+BC)		6
Solarization +Mycormax plus (SL+BC/m)	:3	
Solarization +Promot (SL+BC/p)	:3	
• Non-Soil cultivation (NSC)		9
- Sand	:3	
- Volcanic tuff (VT)	:3	
- Volcanic tuff + Peat (VT+Peat)	:3	
• Methyl Bromide (MB 100%) (Normal Dose: 70 g/m^2)	:	2
• Methyl Bromide (MB 50%) (Reduced Dose: 35 g/m^2)	:	2
• Control	:	7
Total Number of Plots		46

Figure 1. The experiment of cucumbers layout Cucumbers in Aksu and Kocayatak.
Glasshouse No : 63



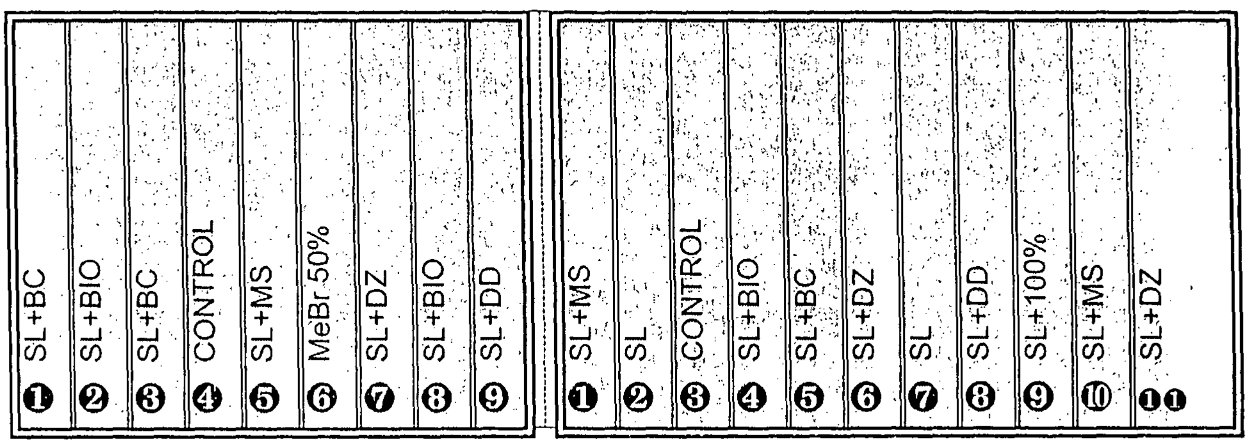
1. SL+BC, 2. SL+BIO, 3. SL+DD, 4. CONTROL
(2 rows/plot, 80 m^2/plot=90 m^2x4=360 m^2)

Glasshouse No : 23



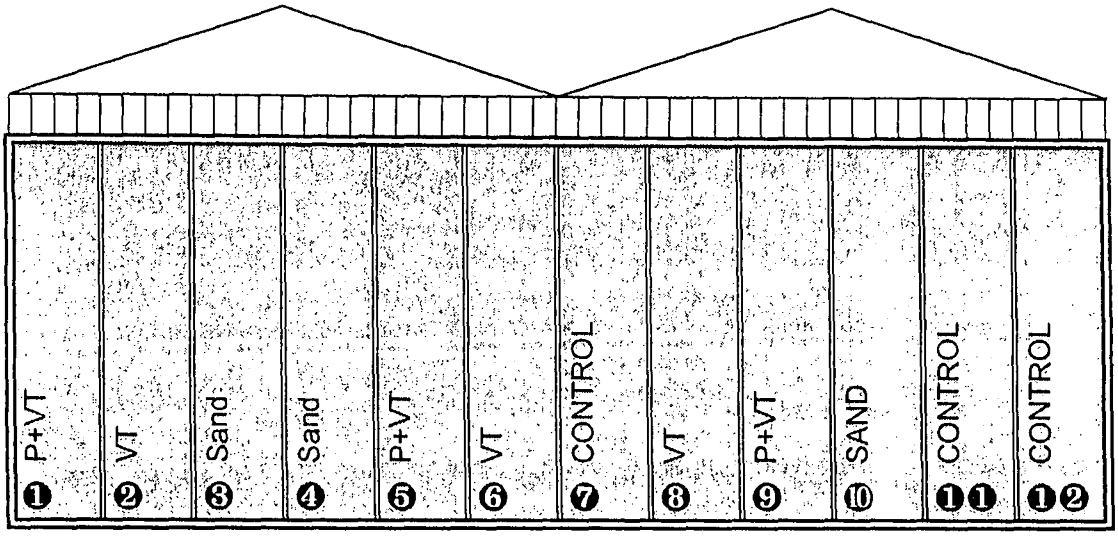
1. SL+DD, 2. SL+BIO, 3. MeBr 50%, 4. SL+BC, 5. SL+MS, 6. SL+DZ, 7. SL+BIO, 8. CONTROL, 9. MeBr 100%, 10. SL+BC
(2 rows/plot, 90 m^2/plot=90 m^2x10=900 m^2)

Glasshouse No : 16 (in Kocayatak)



1. SL+BC, 2. SL+BIO, 3. SL+BC, 4. CONTROL, 5. SL+MS, 6. MeBr 50%, 7. SL+DZ, 8. SL+BIO, 9. SL+DD,
(5 rows/plot, 56 m^2/plot=56 m^2x9=504 m^2)
1. SL+MS, 2. SL, 3. CONTROL, 4. SL+BIO, 5. SL+BC, 6. SL+DZ, 7. SL, 8. SL+DD, 9. SL+100%, 10. SL+MS, 11. SL+DZ (5 rows/plot)
(5 rows/plot, 56 m^2/plot=56 m^2x11=616 m^2)

Glasshouse No : 57 (Soiless Culture)



- Volcanic tuff (VT) = 2, 6, 8
- Sand (S) = 3, 4, 10
- Peat : Volcanic tuff (P : VT) (1:1) = 1, 5, 9
- Control = 7, 11, 12 (2 rows/plot)

(2 rows/plot, 90 m^2/plot=90 m^2x12 =1080 m^2)

2. Diseases

Table 1. Number of Soil Pathogens in Cucumber

	Before Treatments			After Treatments		
	10^5 (Fungi)	10^6 (Actinomycetes)	10^7 (Bacteria)	10^5 (Fungi)	10^6 (Actinomycetes)	10^7 (Bacteria)
SL	35.7	60.5	53.1	14.9	28.5	17.9
SL+DD	34.7	62.6	64.6	14.0	27.8	14.6
SL+MS	38.9	55.7	51.7	14.2	26.9	14.1
SL+DZ	36.4	64.2	55.6	15.6	33.1	16.2
SL+BC (Promot)	38.2	61.1	57.1	19.7	41.4	48.3
SL+BC (Mycormax)	33.3	62.8	55.4	24.5	46.9	50.2
SL+BIO	34.8	61.1	60.3	26.1	44.3	22.0
MeBr 100%	38.0	65.2	58.6	0.9	24.2	0.7
MeBr 50%	37.1	64.8	56.1	1.8	30.4	2.9
Control	38.1	66.5	61.8	38.4	62.9	57.4

In Table 1 in the fungi number the most effective treatments were MeBr 100%, MeBr 50%, SL+DD, SL+MS, SL and SL+DZ respectively.

In the actinomycetes MeBr 100%, MeBr 50%, SL+MS and SL+DD have got same effectively (Table 1).

In the bacteria the most effective were MeBr 100 % and MeBr 50%. But low dose of chemicals and solarization plus biofumigation were effective according to the control.

Table 2. Number of Fungi Counted in Cucumber

Fungi (10^5)	December	February	April	June
SL	15.1	15.0	15.0	20.9
SL+DD	14.3	14.2	14.0	19.5
SL+MS	14.5	14.6	14.5	18.7
SL+DZ	15.0	15.2	15.4	20.1
SL+BC (Promot)	19.9	19.6	19.8	29.6
SL+BC (Mycomax)	25.9	25.3	25.0	33.6
SL+BIO	25.8	26.0	26.1	28.2
MeBr 50%	1.5	1.6	1.8	5.8
MeBr 100%	0.7	0.8	1.0	2.7
Control	37.5	39.0	38.7	39.1

The alternatives were same as in tomato. According to the Table 2, the most effective applications were MeBr 100%, MeBr 50%, SL+DD, SL+MS, SL+DZ, SL and SL+BC (Promot), respectively.

Table 3. Number of Actinomycetes Counted in Cucumber

Actinomycetes (10^6)	December	February	April	June
SL	28.9	28.7	28.5	29.8
SL+DD	28.3	28.0	28.0	29.0
SL+MS	27.5	27.0	27.1	29.2
SL+DZ	35.1	33.0	33.3	38.6
SL+BC (Promot)	40.7	40.5	40.8	44.9
SL+BC (Mycomax)	45.9	46.5	46.8	49.5
SL+BIO	44.8	44.9	44.4	48.6
MeBr 50%	29.5	30.0	31.0	33.4
MeBr 100%	22.8	25.5	24.8	28.0
Control	64.1	63.2	63.0	64.5

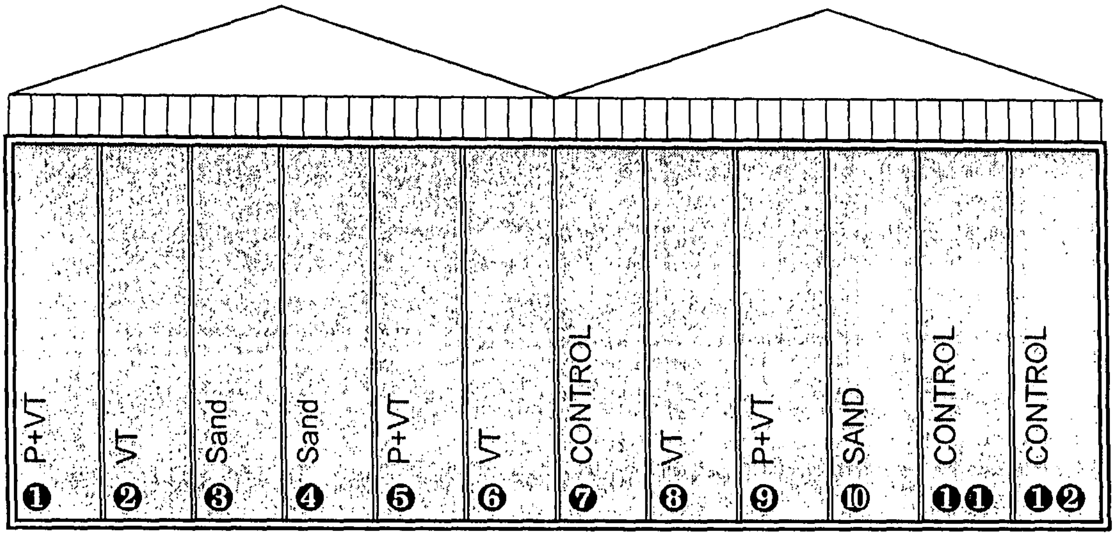
In Table 3 the most effective applications were MeBr 100%, SL+MS, SL+DD, and MeBr 50% respectively.

Table 4. Number of Bacteria Counted in Cucumber

Fungi (10^{-6})	December	February	April	June
SL	16.8	17.0	17.4	21.9
SL+DD	14.0	14.5	15.0	18.7
SL+MS	13.2	14.0	14.2	18.4
SL+DZ	16.5	16.4	16.7	20.3
SL+BC (Promot)	46.5	47.0	48.0	52.3
SL+BC (Mycomax)	51.1	51.0	50.8	55.7
SL+BIO	23.1	23.4	22.8	30.1
MeBr 50%	3.2	3.0	2.9	9.0
MeBr 100%	0.5	0.8	1.0	4.8
Control	58.9	58.7	58.9	60.7

In Table 4, the most effective applications were MeBr 100%, MeBr 50%, SL+MS, SL+DD, SL+DZ and SL, respectively.

Glasshouse No : 57 (Soiless Culture)



- Volcanic tuff (VT) = 2, 6, 8
- Sand (S) = 3, 4, 10
- Peat : Volcanic tuff (P : VT) (1:1) = 1, 5, 9
- Control = 7, 11, 12 (2 rows/plot)

(2 rows/plot, 90 m^2/plot=90 m^2x12 =1080 m^2)

2. Diseases

Table 1. Number of Soil Pathogens in Cucumber

	Before Treatments			After Treatments		
	10^5 (Fungi)	10^6 (Actinomycetes)	10^7 (Bacteria)	10^5 (Fungi)	10^6 (Actinomycetes)	10^7 (Bacteria)
SL	35.7	60.5	53.1	14.9	28.5	17.9
SL+DD	34.7	62.6	64.6	14.0	27.8	14.6
SL+MS	38.9	55.7	51.7	14.2	26.9	14.1
SL+DZ	36.4	64.2	55.6	15.6	33.1	16.2
SL+BC (Promot)	38.2	61.1	57.1	19.7	41.4	48.3
SL+BC (Mycormax)	33.3	62.8	55.4	24.5	46.9	50.2
SL+BIO	34.8	61.1	60.3	26.1	44.3	22.0
MeBr 100%	38.0	65.2	58.6	0.9	24.2	0.7
MeBr 50%	37.1	64.8	56.1	1.8	30.4	2.9
Control	38.1	66.5	61.8	38.4	62.9	57.4

In Table 1 in the fungi number the most effective treatments were MeBr 100%, MeBr 50%, SL+DD, SL+MS, SL and SL+DZ respectively.

In the actinomycetes MeBr 100%, MeBr 50%, SL+MS and SL+DD have got same effectively (Table 1).

In the bacteria the most effective were MeBr 100 % and MeBr 50%. But low dose of chemicals and solarization plus biofumigation were effective according to the control.

Table 2. Number of Fungi Counted in Cucumber

Fungi (10^5)	December	February	April	June
SL	15.1	15.0	15.0	20.9
SL+DD	14.3	14.2	14.0	19.5
SL+MS	14.5	14.6	14.5	18.7
SL+DZ	15.0	15.2	15.4	20.1
SL+BC (Promot)	19.9	19.6	19.8	29.6
SL+BC (Mycomax)	25.9	25.3	25.0	33.6
SL+BIO	25.8	26.0	26.1	28.2
MeBr 50%	1.5	1.6	1.8	5.8
MeBr 100%	0.7	0.8	1.0	2.7
Control	37.5	39.0	38.7	39.1

The alternatives were same as in tomato. According to the Table 2, the most effective applications were MeBr 100%, MeBr 50%, SL+DD, SL+MS, SL+DZ, SL and SL+BC (Promot), respectively.

Table 3. Number of Actinomycetes Counted in Cucumber

Actinomycetes (10^6)	December	February	April	June
SL	28.9	28.7	28.5	29.8
SL+DD	28.3	28.0	28.0	29.0
SL+MS	27.5	27.0	27.1	29.2
SL+DZ	35.1	33.0	33.3	38.6
SL+BC (Promot)	40.7	40.5	40.8	44.9
SL+BC (Mycomax)	45.9	46.5	46.8	49.5
SL+BIO	44.8	44.9	44.4	48.6
MeBr 50%	29.5	30.0	31.0	33.4
MeBr 100%	22.8	25.5	24.8	28.0
Control	64.1	63.2	63.0	64.5

In Table 3 the most effective applications were MeBr 100%, SL+MS, SL+DD, and MeBr 50% respectively.

Table 4. Number of Bacteria Counted in Cucumber

Fungi (10^{-6})	December	February	April	June
SL	16.8	17.0	17.4	21.9
SL+DD	14.0	14.5	15.0	18.7
SL+MS	13.2	14.0	14.2	18.4
SL+DZ	16.5	16.4	16.7	20.3
SL+BC (Promot)	46.5	47.0	48.0	52.3
SL+BC (Mycomax)	51.1	51.0	50.8	55.7
SL+BIO	23.1	23.4	22.8	30.1
MeBr 50%	3.2	3.0	2.9	9.0
MeBr 100%	0.5	0.8	1.0	4.8
Control	58.9	58.7	58.9	60.7

In Table 4, the most effective applications were MeBr 100%, MeBr 50%, SL+MS, SL+DD, SL+DZ and SL, respectively.

3. Nematodes

Solarization, solarization plus several low doses of chemical (1,3 Dichloropropene, Dazomet, Metam sodium) and Methyl bromid were tested in cucumber. Methyl bromid 100% application was most effective in controlling *Meloidogyne* spp. Solarization plus 1,3 Dichloropropene and Methyl bromid 50 % were also effective then other applications (Table 5).

Table 5. Effect of different treatments to *Meloidogyne* spp. on cucumber (J_2 / 100 cc soil)

Treatments	Before Treatments	After Treatments	% Effect	At the end of vegetation
Control	177.0	130.0	-	375.0
Methyl Bromid 100%	175.3	3.3	98.1 A	5.0
Methyl Bromid 50%	181.5	11.8	93.5 AB	26.0
Solarization	130.0	19.1	85.3 C	58.5
Solarization + Bio fumigation	171.0	12.5	92.7 B	40.0
Solarization + Bio control	166.0	25.4	84.7 C	60.5
Solarization + 1,3 Dichloroproene	182.5	10.7	94.1 AB	20.0
Solarization + Dazomet	155.0	13.2	91.5 B	42.0
Solarization + Metam sodium	150.3	14.8	90.2 B	50.0

In the Control Blocks there were a little root-knots determined in November. In the first months of vegetation in Solarization, Solarization plus Bio control, Solarization plus Dazomet and Solarization plus Metam sodium blocks seen small galls, but the nematod population didn't increase according to the decreasing of the soil temperature. At the end of vegetation periodthere were seen died plants in the Control blocks (Figure 2).

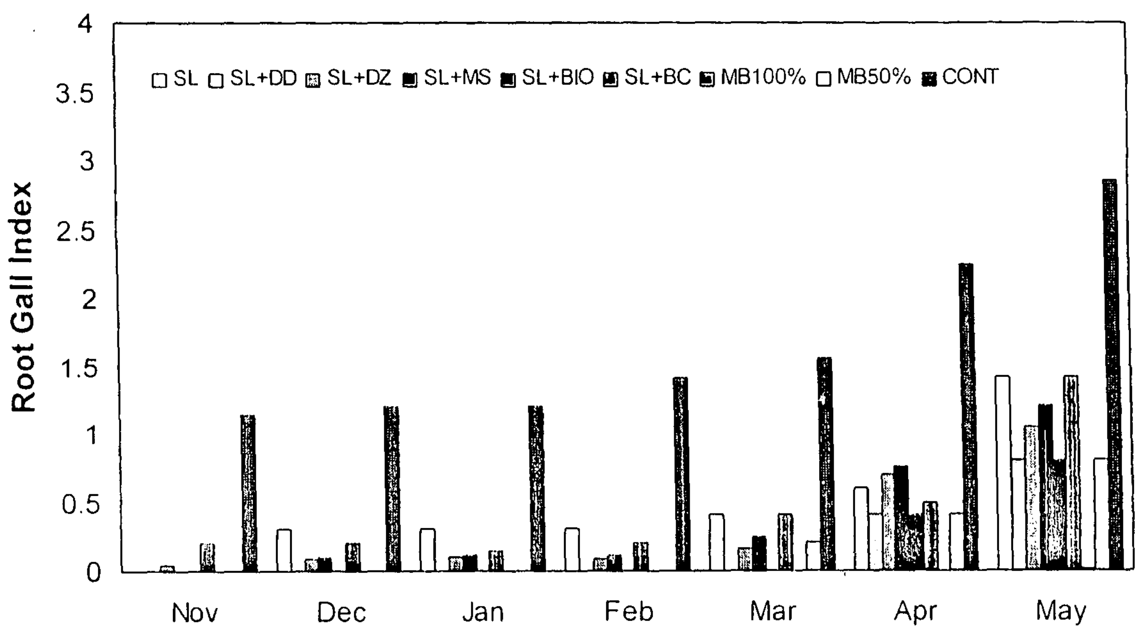


Figure 2. Seasonal dispersion of root galls during the vegetation period in cucumber.

Table 6. Effectiveness of different treatments to *Meloidogyne* spp. galls on cucumber at the end of vegetation.

Treatments	Root-Gall Index	
	Maximum	Average
Control	4	2.3
Methyl Bromid %100	1	0.02
Methyl Bromid 5%0	2	0.08
Solarization	3	1.4
Solarization + Bio fumigation	2	0.8
Solarization + Bio control	3	1.4
Solarization + 1,3 Dichloroproene	2	0.8
Solarization + Dazomet	2	1.0
Solarization + Metam sodium	3	1.2

Root gall index was highest on plants grown in Contorl plots (2.3), moderate in Solarization plus Dazomet (1.0), Solarization plus Metam sodium (1.2), Solarization (1.4), Solarization plus Bio control (1.4) and lowest in Methyl Bromid 100% (0.02), Methyl Bromid 50% (0.08), Solarization plus Bio fumigation (0.8) and Solarization plud 1,3 Dichloropropene (0.8) (Table 6).

4. Weeds

Table 7. Number of weeds counted in cucumber after the treatments.

	SL	DD	MS	DZ	BC	BIO	MeBr %50	MeBr %100	Cont
Portuloca oleracea	22	21	10	31	44	9	6	-	174
Chenopodium sp.	13	18	9	24	79	6	-	1	140
Cyperus sp.	-	-	1	6	4	4	1	-	24
Malva sp.	-	-	1	3	4	1	-	1	21

According to the number of weeds counted in 1 m^2 in cucumber.
The most effective treatments were Me Br %100, Me Br 5%0, BIO and MS, respectively.

5. Yields

The cucumber fruit was harvest two or three time a week over a 24 weeks period beginning 22 November 1999 to 26 May 2000. All cucumber fruit was harvested and weighed. The yield was classified due to the size of fruit, according to standard marketable size. Extra and class one.

And the Data were statistically analyzed and mean values compared by Duncan multiple range test.

All of the alternatives gave substantial and significant yield increases over untreated control.

Table 8. Effect of soil treatment on yield and quality of cucumber by Alternative techniques. SL, SL+DD, SL+MS, SL+DZ, SL+BIO, SL+BC/m, SL+BC/p, MeBr100%, MeBr50%

	Alternatives	Class I ($kg.da^{-1}$)	Class II ($kg.da^{-1}$)	TOTAL YIELD ($kg.da^{-1}$)
1	CONTROL	4351.029	2123.068	6474.097 **B C**
2	SL	4847.062	2395.031	7242.093 **B C**
3	SL+DD	5903.669	1970.612	7874.282 **A B**
4	SL+MS	5231.412	2613.479	7844.891 **A B**
5	SL+DZ	4578.735	2262.994	6841.729 **B C**
6	SL+BIO	5354.814	2291.673	7646.487 **A B C**
7	SL+BC/m	4480.806	2340.716	6337.047 **C**
8	SL+BC/p	4681.248	2036.727	6717.975 **C**
9	MeBr100%	5838.619	2228.051	8066.671 **A B**
10	MeBr50%	6339.831	2909.32	9249.151 **A**

Treatments with the same letter one not significant different according to a Duncan Multiple Range Test, signification level is 5%.

The yield of cucumber was given in Table 8. The highest yield per da (kg.da-1) was harvested from plants grown on the solarization + 1.3 Dichloroppene parcel (7 874.282 kg.da-1). Which was followed by Solarization + Metham Sodium. The larwest yield was obtained from plants grown on Control (CONT) (6474.097 kg.da-1).

Table 9. Yield and quality of cucumber and effective by MeBr and soilles culture.

	Alternatives	Class I ($kg.da^{-1}$)	Class II ($kg.da^{-1}$)	TOTAL YIELD ($kg.da^{-1}$)
1	CONTROL	4351.029	2123.068	6474.097 **C**
2	MeBr100%	5838.619	2228.051	8066.671 **A B**
3	MeBr50%	6339.831	2909.32	9249.151 **A**
4	SAND	5799.475	1964.12	7763.595 **B C**
5	VT	5920.1	1909.588	7829.688 **B**
6	PEAT+VT	6524.066	1977.656	8501.722 **A B**

Treatments with the same letter one not significant different according to a Duncan Multiple Range Test, signification level is 5%.

The yield and classify of cucumber given in Table 9. The highest yield was harvest from plants grown on Sand (S) parcel. Which were followed by mixing Volcaniff Tuff + Peat (VT+P) parcel. The result of the study was showed that soilless culture could be used successfully for alternatives of MeBr.

6. Economic Evaluation

Alternatives Treatments;1. Solarization, 2. Solarization +1.3 Dichloropropere (SL+DD), 3. Solarization +Metham Sodium (SL+MS), 4. Solarization + Basomed (SL+DZ), 5. Solarization +Bio-fumigant (SL+BIO), 6. Solarization +Mycormax plus (SL+BC/m), 7. Solarization +Promot (SL+BC/p), 8. Methyl Bromide 70 gr/ m^2 (MeBr %100), 9. Methyl Bromide 35 gr/ m^2 (MeBr 50%), 10. Soilless Cultivation - Sand, 11. Soilless Cultivation - Volcanic tuff (VT), 12. Soilless Cultivation - Volcanic tuff + peat

In the cucumber greenhouse, input of soil solarisation, biofumigation, low doses of alternatives chemicals and labour costs were considered according to the methyl bromide (Table 10).

Table 10. Treatment costs Per 1000 m^2 under greenhouse for cucumber (US $)

Alternatives	CONT.	1	2	3	4	5	6	7	8	9	10	11	12
Control	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0
SL+DD	0	0	28.3	0	0	0	0	0	0	0	0	0	0
SL+MS	0	0	0	71.1	0	0	0	0	0	0	0	0	0
SL+DZ	0	0	0	0	99.6	0	0	0	0	0	0	0	0
SL+BIO	0	0	0	0	0	104.0	0	0	0	0	0	0	0
SL+BC/m	0	0	0	0	0	0	652.2	0	0	0	0	0	0
SL+BC/p	0	0	0	0	0	0	0	363.3	0	0	0	0	0
MeBr 100%	0	0	0	0	0	0	0	0	284.1	0	0	0	0
MeBr 50%	0	0	0	0	0	0	0	0	0	142.0	0	0	0
Sand	0	0	0	0	0	0	0	0	0	0	88.4	0	0
V. tuff	0	0	0	0	0	0	0	0	0	0	0	147.3	0
V. tuff+Peat	0	0	0	0	0	0	0	0	0	0	0	0	404.3
Plastic	0	58.7	58.7	58.7	58.7	58.7	58.7	58.7	79.1	79.1	0	0	0
Mat.&Equipment	0	0	0	0	0	0	0	0	0		72.5	72.5	72.5
Labour	43.5	27.0	31.3	35.6	31.3	28.7	27.0	27.0	26.1	26.6	54.5	54.5	54.5
Total	**43.5**	**85.7**	**118.3**	**165.4**	**189.6**	**191.4**	**737.9**	**449.0**	**389.3**	**247.7**	**215.4**	**274.3**	**531.3**

Table 10 comments: The cheaper cost of this experiment had control plot followed by Solarization and SL+DD, SL+MS, SL+DZ and SL+BIO.

Low doses of chemical costs were found lower then the MeBr 100% and 50%.

The cost of biocontrol agents and soilless culture (pumice+peat) were higher than the others.

There was no labour cost of weed control in the Methyl Bromide 100% plot. All other treatments had labour cost of weed control.

The labour cost of weed control in the control plot was higher than the others.

The cost of production, yields, gross income and net income showed in Table 11.

Table 11. Yield, gross income, variable cost and net income for cucumber

Alternatives	Yield (kg/1000m²)	Gross income ($/1000m²)	Variable cost ($/1000m²)	Net income ($/1000m²)
Control	6474.1	1502.0	43.5	1458.5
SL	7242.1	1680.2	85.7	1594.5
SL+DD	7874.3	1826.8	118.3	1708.5
SL+MS	7844.9	1820.0	165.4	1654.6
SL+DZ	6841.7	1587.3	189.6	1397.7
SL+BIO	7646.5	1774.0	191.4	1582.6
SL+BC/m	6337.0	1470.2	737.9	732.3
SL+BC/p	6718.0	1558.6	449.0	1109.6
MeBr 100%	8066.7	1871.5	389.3	1482.2
MeBr 50%	9249.2	2145.8	247.7	1898.1
Sand	7763.6	1801.2	215.4	1585.8
V. tuff	7829.7	1816.5	274.3	1542.2
V. tuff+Peat	8501.7	1972.4	531.3	1441.1

Table 11 Comments; Maximum yields were obtained using MeBr 50% application followed by the soilless cultivation (VT+peat), SL+BC/m Plot had the lowest yield and the lowest net income than the other treatments.

Gross income and net income of MeBr 50% was the highest in the experiment.

Table 12. Doninans analysis by treatments for cucumber

Alternatives	Variable cost ($/1000m²)	Net income ($/1000m²)	Dominance
Control	43.5	1458.5	--
SL	85.7	1594.5	--
SL+DD	118.3	1708.5	--
SL+MS	165.4	1654.6	D
SL+DZ	189.6	1397.7	D
SL+BIO	191.4	1582.6	D
Sand	215.4	1585.8	D
MeBr 50%	247.7	1898.1	--
V. tuff	274.3	1542.2	D
MeBr 100%	389.3	1482.2	D
SL+BC/p	449.0	1109.6	D
V. tuff+Peat	531.3	1441.1	D
SL+BC/m	737.9	732.3	D

Table 12 Comments; Control, SL, SL+DD and MeBr 50% show the best economic benefits.

Table 13. Marginal rate of return by treatments for cucumber

Alternatives	Variable cost ($/1000m²)	Net income ($/1000m²)	Incremental variable cost	Incremental net income	MR of Return (%)
Control	43.5	1458.5	--	--	--
SL	85.7	1594.5	42.2	136	322
SL+DD	118.3	1708.5	32.6	114	350
MeBr 50%	247.7	1898.1	129.4	189.6	147

Table 13 Comments; Control as compared to SL shows a 322%MRT.
SL as compared to SL+DD show a 350%MRT.
SL+DD as compared to MeBr 50% show a 147%MRT.
SL+DD as shows first best MRT followed by SL and MeBr 50%.

7. Plant Nutrition

Some chemical and physical properties of soil that grown cucumber were given in Table 14. pH were alkaline and weakly alkaline, no salinity problem, textures were Loam and Sandy Loam. Organic matter were between 1.7 - 3.5 percentage. Carbonate values changed 1.35-24.6 %. Amounts of some plant nutrient elements changed 0.1-0.22% N, 54-232 ppm P, 201-414 ppm K, 1985-2775 ppm Ca, 163-328 ppm Mg. C/N were between 7.6-11. CEC were between 19-32 meq/100 g. Soil samples were taken twice at before planting and after cultivation. Soil properties are same as other soils that grown vegetables in Antalya region.

Also some properties of substrates used as growing medium for soilless culture are shown in Tomatoes Section. pH of sand and volcanic tuff were alkaline but pH of peat was weakly alkaline. Amount of carbonate were 31.30% for sand, 1.30% for volcanic tuff and 1.80% for peat. Organic matter of peat was 57.13%.

Some properties of water used at trials were given in Tomatoes Section.

Fertilization plan was adjusted according to soil, water and plant analysis results. Amount of elements in nutrient solution prepared for cucumber grown in soil were changed between 80-120 ppm N, 30-70 ppm P_2O_5, 150-200 ppm K_2O for cucumber.

Nutrient solutions used in soilless culture for cucumber was given in Tomatoes Section. Nutrient solution used in soilless culture for cucumber were 16 mmol/lt NO_3, 1.25 mmol/lt H_2PO_4, 1.375 mmol/lt SO_4, 1.25 mmol/lt NH_4, 8 mmol/lt K, 4 mmol/lt Ca, 1.375 mmol/lt Mg, 15 µmol/lt Fe, 10 µmol/lt Mn, 5 µmol/lt Zn, 25 µmol/lt B, 0.75 µmol/lt Cu, 0.5 µmol/lt Mo. Amount of nutrient elements were adjusted according to properties of water.

Some nutrient elements concentration in leaf tissue of cucumber grown in soil and substrates were %3.39-4.94 N, %0.44-1.09 P, %3.08-4.81 K, %1.51-4.28 Ca, %0.45-0.95 Mg, 65-117 ppm Fe, 21-362 ppm Mn, 32-82 ppm Zn. As a result of that fertilization program, average values of some plant nutrient elements in leaf tissue of cucumber grown in soil and substrates were generally sufficient or high Table 15). So that any nutritional problems at cucumber during growing period wasn't determined. Leaf samples were taken twice during growing period.

Table 14. Some physical and chemical properties of soil grown cucumber.

	PH	% $CaCO_3$	EC Micromhos/cm	TEXTURE % SAND	% CLAY	% SILT	% Organic Matter	C/N	CEC meq/100 g	%N	P ppm	K ppm	Ca ppm	Mg ppm
BEFORE PLANTING	7.7-7.9	1.35-23.5	271-785	47	30	23	3.32-2.7	7.6-11	19-28	0.1-0.18	54-164	201-344	1985-2390	163-306
				Loam										
				54	27	19								
				Sandy Loam										
AFTER CULTIVATION	7.6-7.8	3.54-24.6	3.57-848				1.7-3.5	7.6-9.2	22-32	0.13-0.22	84-232	243-414	2132-2775	182-328

Table 15. Some plant nutrient elements concentration in leaf tissue of cucumber.

MONTH		N %	P %	K %	Ca %	Mg %	Fe ppm	Mn ppm	Zn ppm
NOWEMBER	SOIL	4.50-4.94	0.68-1.05	3.95-4.58	2.54-3.84	0.55-095	65-88	100-362	52-82
	SOILLESS CULTURE	4.2-4.33	0.63-0.73	3.62-3.76	1.51-1.70	0.53-0.70	90-107	21-29	34-38
MARCH	SOIL	4.13-4.8	0.44-0.67	3.08-3.36	1.9-2.9	0.45-0.91	93-117	25-222	32-50
	SOILLESS CULTURE	3.39-4.79	0.73-1.09	4.68-4.81	3.54-4.26	0.71-0.83	80-90	73-88	40-54

C. CONCLUSIONS ON ALTERNATIVES TO MeBr IN VEGETABLES

On the light of the results from this demonstration project on Alternatives to the Use of Methyl Bromide for Soil Fumigation in Republic of Turkey, we may conclude that.

1. Under the conditions of Turkey, alternative treatments to Methyl Bromide were found. These can be used in protected vegetable crops.
2. In this research, alternative application methods for Methyl Bromide was investigated in the tomato and cucumber experiments. For this purpose nineteen tomato and twelve cucumber production systems were analysed in terms of production cost yield gross income, net income.
3. According to the number of soil-borne pathogens, solarization plus metham sodium was found as effective as MeBr in tomato, but in cucumber SL+DD and SL+MS were found as effective as MeBr.
4. According to the number of nematodes Solarization+DD and Solarization+Bio-fumigation were found as effective as MeBr in tomato as effective as MeBr.
   While the nematode problems so much, we will advice SL+DD application and also SL+Bio-fumigation while the nematode problems so low in tomato.
5. We should recommend SL+Bio-fumigation treatment, is friendly to the environment.
6. We understand that no a single alternative was used to replace Methyl Bromide. The alternatives should be included and be a part of on IPM program. The other alternatives should be used with resistant variety soilless cultivation and etc.
7. Bio fumigation treatment was showed superior performance for plant growth than the other treatments including Methyl Bromide.
8. Tomato experiment analysis showed that the yield of control plot was lower then the other treatments and maximum yield was obtained from using soilless culture. It was found that soilless culture gave the highest net income. The analysis of marginal rate of return (MRT) showed that Control+RV applications was the best one in terms of economic evaluation.
9. For cucumber it was found that maximum yield was obtained from Methyl Bromide %50 application and the highest net income was obtained from the same treatment. The analysis of MRT showed that SL+DD have the highest MRT.
10. In conclusion the results of alternatives to the use of Methyl Bromide was better than the methyl bromide application in term of both technical and economic aspect.

2. ALTERNATIVES TO THE USE OF METHYL BROMIDE IN ORNAMENTAL CROPS PRODUCTIONS.

A. CARNATION

1. Experimental Site

Trials of carnation on the "Alternatives Use of Methyl Bromide as soil Fumigant" were conducted in five plastic greenhouses which have 2850 m^2 total in Kocayatak section of Citrus and Greenhouse Crops Research Institute.

2. Objectives

1. To comply with Montreal Protocol regarding the use of MeBr.
2. To scientifically evaluate the use of alternative treatments to the use of MeBr.
3. To determine costs for each of the alternative treatments.

3. Experimental Design

In this study; was compared to the 3 alternative treatments with to applications of Methyl Bromide and one control (Figure 1 and 2). Each application plots had 60 m2 that measured 1.5 m wide and 40 m long. Seven treatments (control, two Methyl Bromide, three low doses of alternative chemicals and Steam pasteurization) were applied in a randomized plots design with 4 replications (Figure 3).

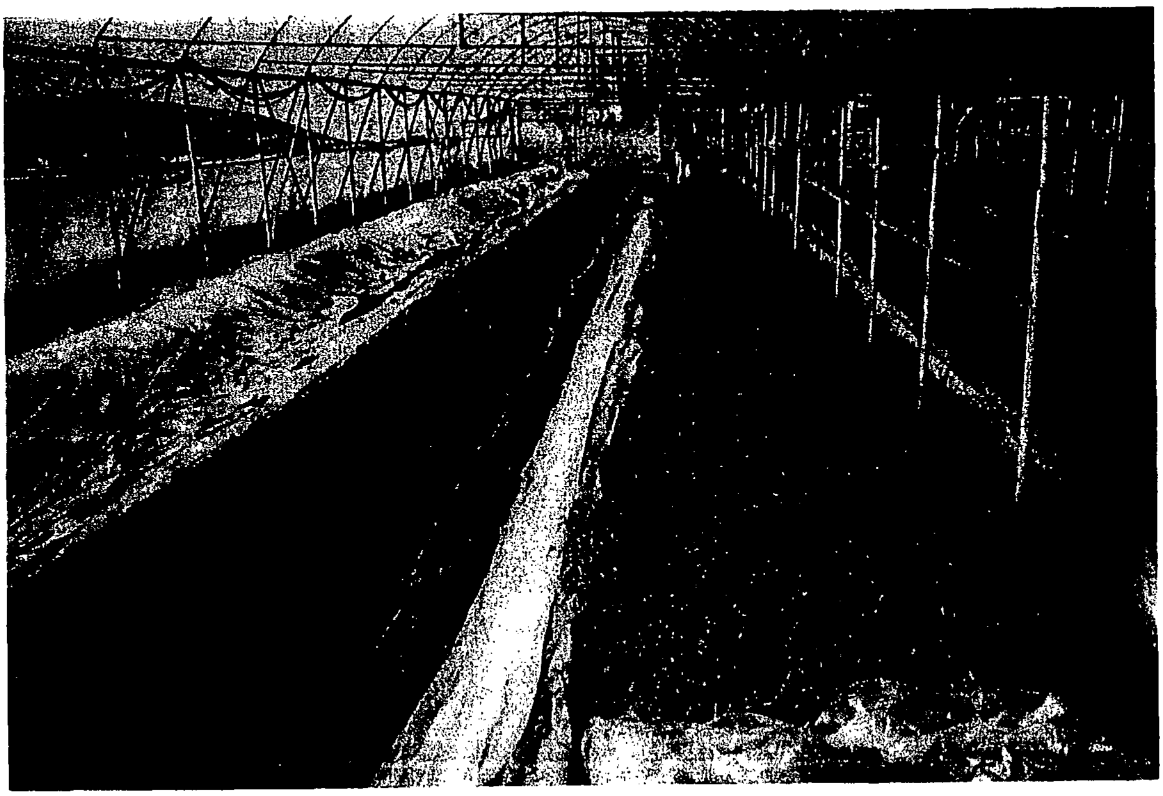


Figure 1. Alternative treatments with the control.

In soilless treatments were used 3 different growing media [sand (0-1 mm ∅), V. tuff (0-5mm ∅) and (Peat 5%0+V. tuff 5%0)] and their controls with 3 replications for each one. Growing beds were made from thickness 3 mm of hard dark plastic which unit measured 35 m long and 1.2 m wide.

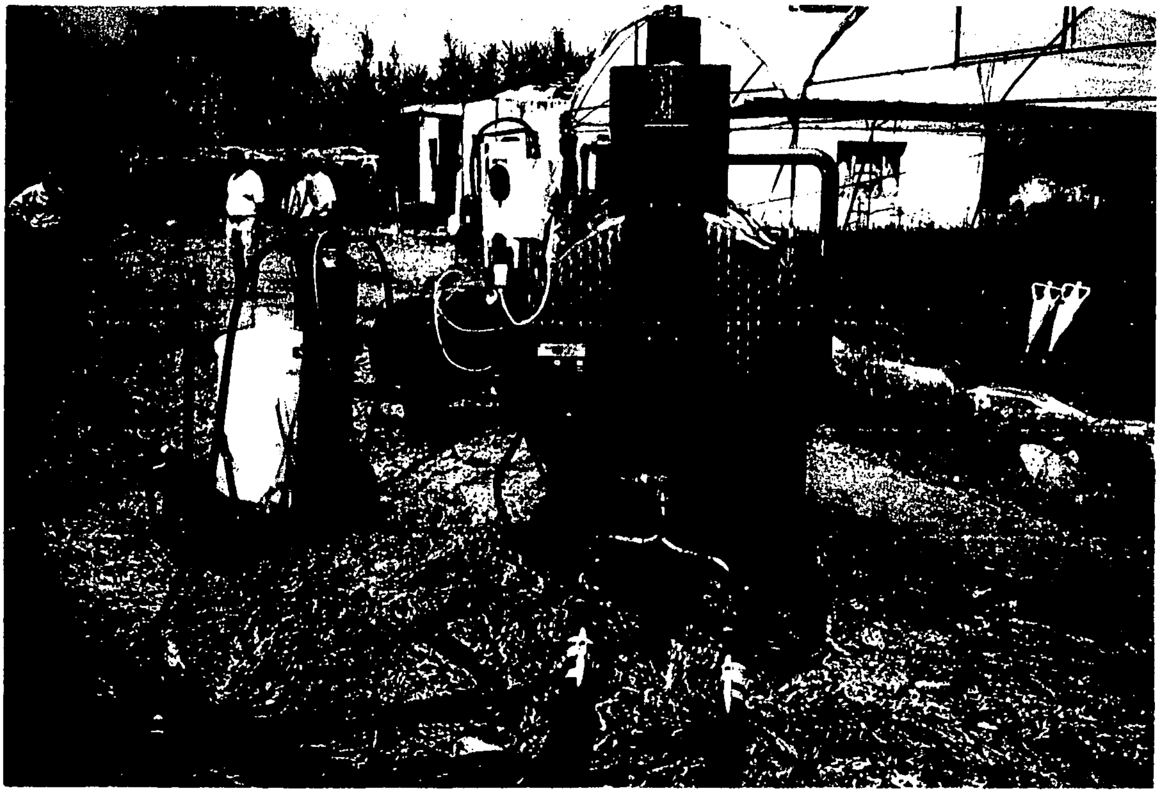
In soil treatments was planted variety of Darling as 16x16 row-distance, in soilless variety of Darling with together variety of Batu as 20 x 20 row distance at 14.06.1999.

After the planting; irrigation was made with roof irrigation system for 20 days.

Before applications soil was applied organic manure (3 tons/da).

Program of nutrient applications were changed according to soil and water analyses and growing period.

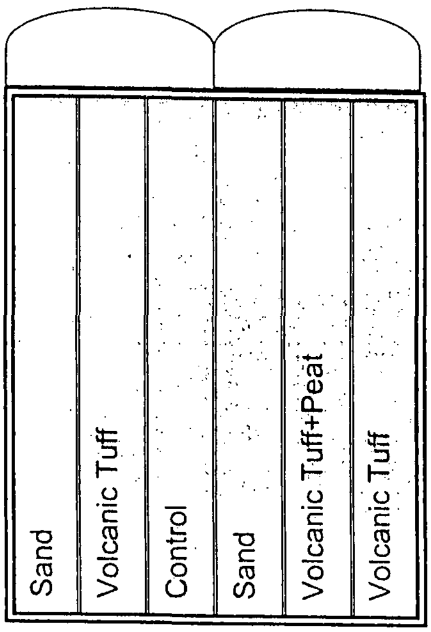
Alternative Techniques for Carnation			Number of Plots
• Opencircut non-soil cultivation			: 12
- Sand	: 3		
- Volcanic tuff	: 3		
- Volcanic tuff : Peat (1:1)	: 3		
- Control	: 3		
• Steam pasteurization			: 2
• Low doses of alternative chemicals			: 12
- Metham sodium (MS)	: 4	(2/3 dose)	
- Basamid (DZ)	: 4	(2/3 dose)	
- 1,3 - Dichloropropene (DD)	: 4	(2/3 dose)	
• Methyl Bromide (MB 100%) (Normal Dose	: 70 g/m^2)		: 4
• Methyl Bromide (MB 50%) (Reduced Dose	: 35 g/m^2)		: 4
• Control			: 4
Total number of plots			: 38



Figures 2. Steam boiler.

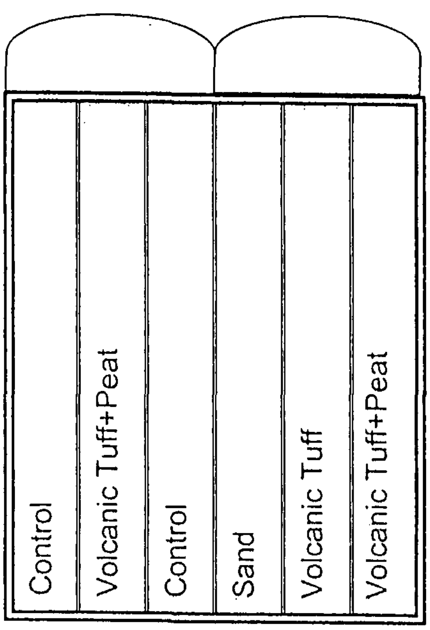
Figures 3. Steam pasteurization

Greenhouse No : 17
Area : 480 m^2



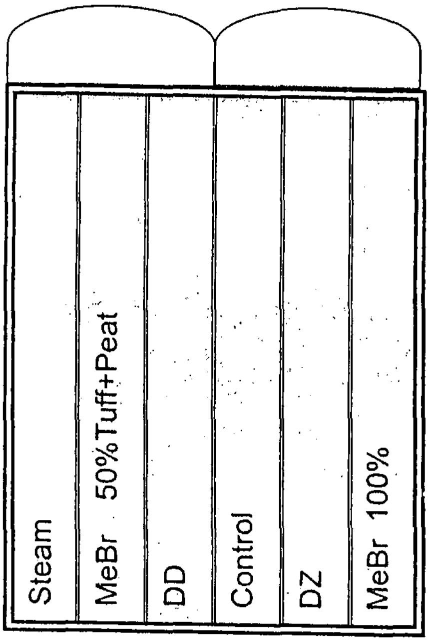
Alternatives	number of plots
Sand	2
Control	1
Volcanic tuff	2
V. tuff + peat	1

Greenhouse No : 18
Area : 480 m^2



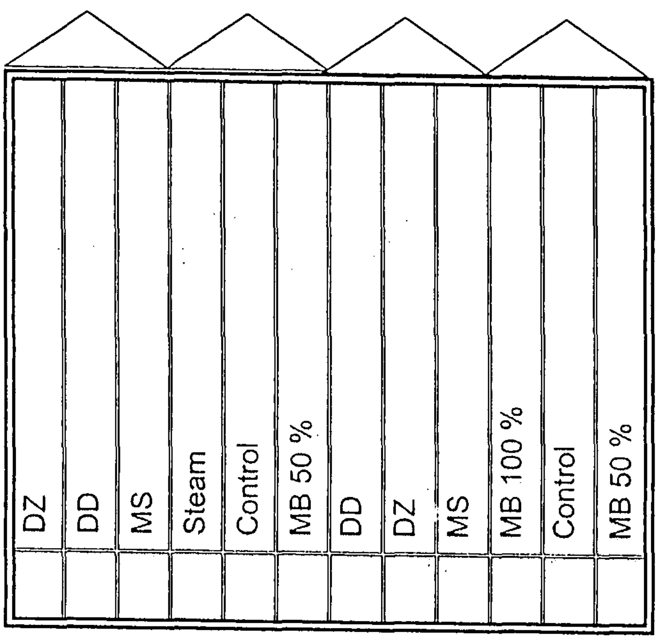
Alternatives	Number of plots
Sand	1
Control	2
Volcanic tuff	1
V. tuff + peat	2

Greenhouse No : 19
Area : 480 m²



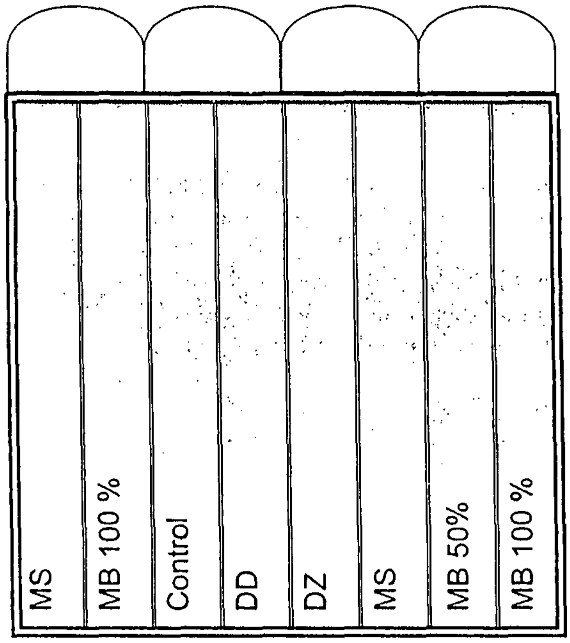
Alternatives	Number of plots
Steam	1
Methyl Bromide 50%	1
Methyl Bromide 100%	1
Dazomed	1
1,3-dichloropene	1
Control	1

Greenhouse No : 25
Area : 880 m²



Alternatives	Number of plots
Dazomed	2
1,3-dichloropene	2
Metham Sodium	2
Methy bromide 50 %	2
Control	2
Steam	1
Methy bromide 100%	1

Greenhouse No : 26
Area : 720 m^2



Alternatives	Number of plots
Metham Sodium	2
Methy bromide 100%	2
Control	1
Methy bromide 50 %	1
1,3-dichloropene	1
Dazomed	1

In the control plots, was not made any application, but other cultural works were made as same as during growing period.

Normal (75 gr/ m^2) and low (35 g/ m^2) dose of Methyl Bromide applications and Dazomed (30 g/ m^2), metham Sodium (50 ml/ m^2) and 1.3 Dichloropropene (7 ml/ m^2) applications of alternative chemicals were made at the 5-7/5/1999 and plastics of over the soil taken out 10 days ago from planting and airing.

- Steam pasterization is generated by a steam boiler. The pipes which have got hole on it was put 30-35 cm deep in the soil and than boiler was begin to give water vapour into soil. When the soil temperature of 20 cm deep were 60-70 °C the application were finished reached to.

- In the experiment average yield, flower stem length and flower stem weight were investigated and compared with control and Methyl Bromide applications.

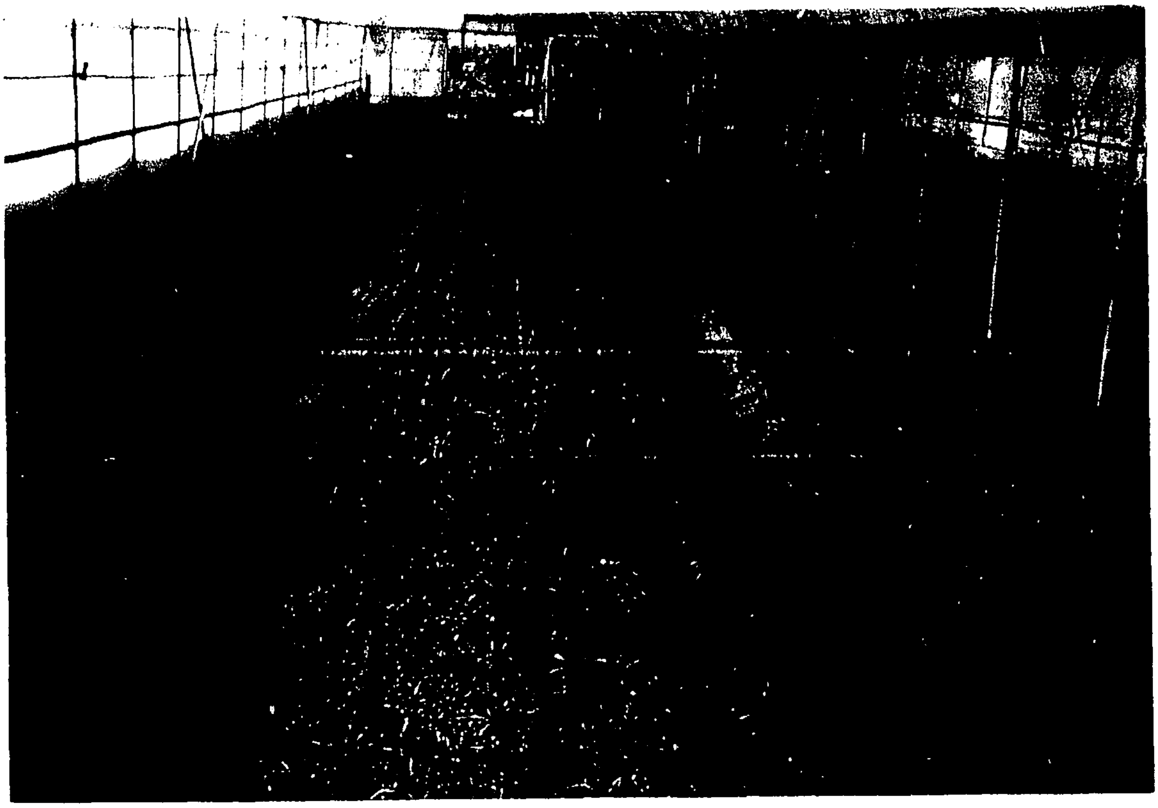


Figure 4. Alternative treatments (soilles culture and control parcels).

Figure 5. Carnations

4. Disease

After the treatments plastic were taken off and then another soil samples were taken. During the plantation time every two months soil samples were taken and looked for the soil pathogens (fungi, actinomycetes and bacteria).

Table 1. Number of Soil Pathogens in Carnation

	Before Treatments			After Treatments		
	10^5 (Fungi)	10^6 (Actinomycetes)	10^7 (Bacteria)	10^5 (Fungi)	10^6 (Actinomycetes)	10^7 (Bacteria)
SL+DD	32.4	70.2	58.0	14.3	22.9	3.0
SL+MS	32.6	64.8	53.2	14.9	19.1	3.9
SL+DZ	35.4	65.1	51.1	15.7	27.4	30.1
Steam	29.2	60.4	44.8	10.3	20.0	0
MeBr 50%	29.6	66.0	51.4	2.0	18.9	2.1
MeBr 100%	35.6	69.6	52.6	0.0	15.2	0
Control	33.8	67.7	51.7	34.1	56.5	48.2

According to Table 1 the number of fungi in the soil approximately 33.8 x 10^4=338000. After the treatments the most effective of them MeBr 50% and 100 %. But also steam application was also effective. Low dose of chemicals effects were very near to each other. In the actinomycetes, the most effective treatments were MeBr 100%, MeBr 50%, Steam, respectively. According to low dose of chemicals the most effective was SL+MS application. (Solarization plus metham sodium).

In the bacteria steam and MeBr 100% were the most effective applications.

Table 2. Number of Fungi Counted in Carnation

Fungi (105)	August	November	December	February	May
SL+DD	15.0	14.5	14.8	17.6	19.1
SL+MS	14.8	14.9	14.5	17.0	18.5
SL+DZ	16.0	15.9	15.8	18.8	20.2
Steam	9.7	10.1	10.0	13.2	14.2
MeBr 50%	1.5	1.4	1.7	4.5	9.2
MeBr 100%	0.0	0.0	0.0	2.0	4.3
Control	33.0	33.6	33.8	34.0	34.6

According to the Table 2, the most effective applications were MeBr 100%, MeBr 50% and steam, respectively. The low doses of chemicals effectiveness were approximately same in the vegetation period. We could advice steam as on alternative to MeBr in fungi application.

Table 3. Number of Actinomycetes Counted in Carnation

Actinomycetes (10^6)	August	November	December	February	May
SL+DD	22.2	23.0	22.8	26.3	46.3
SL+MS	19.9	20.0	20.5	24.5	44.2
SL+DZ	28.0	27.5	27.8	31.7	48.6
Steam	21.3	21.0	21.4	24.2	44.1
MeBr 50%	18.0	19.1	19.8	22.1	41.3
MeBr 100%	14.9	15.0	14.7	21.0	40.2
Control	55.8	57.0	56.7	58.9	60.1

According to the Table 3, steam also was effective against actinomycetes after MeBr. But there wasn't so much pathogens coursed by actinomycetes.

Table 4. Number of Bacteria Counted in Carnation

Bacteria (10^7)	August	November	December	February	May
SL+DD	6.5	7.0	7.1	15.2	15.8
SL+MS	5.7	6.0	5.9	14.3	15.3
SL+DZ	28.6	30.0	28.3	33.4	33.6
Steam	0.0	0.0	0.0	4.1	8.5
MeBr 50%	1.8	2.0	2.1	5.6	11.2
MeBr 100%	0.0	0.0	0.0	3.0	6.1
Control	49.9	48.7	49.1	50.1	51.2

In the Table 4, also steam was the most effective applications against bacteria. We saw in Table 4 from August to February there weren't enough bacteria in the soil. After February the number of bacteria increase but not so much.

5. Nematodes

Steam, several low doses of fumigants (1,3 Dichloropropene, Dazomet, Metam sodium) and Methyl bromid were tested in carnation. Methyl bromid 100%, Methyl bromid 50%, 1,3 Dichoropropene and steam applications were most effective than other applications (Table 5).

Table 5. Effect of different treatments to *Meloidogyne* spp. on carnation (J_2 / 100 cc soil).

Treatments	Before Treatments	After Treatments	% Effect	At the end of vegetation
Control	153.5	125.0	-	350.0
Methyl Bromid 100%	164.8	5.1	96.9 A	20.0
Methyl Bromid 50%	160.3	15.5	90.3 B	27.5
Steam	136.5	18.7	86.3 B	54.0
1,3 Dichloroproene	140.0	15.7	88.8 B	40.0
Dazomet	165.0	32.5	80.3 C	62.0
Metam sodium	145.0	38.5	73.4 D	70.0

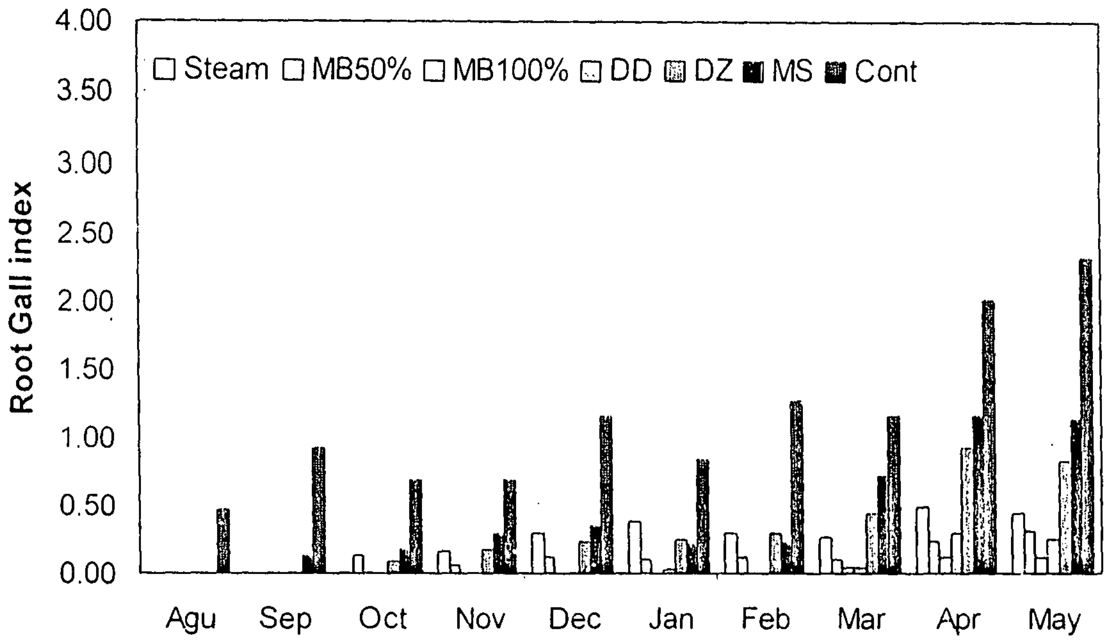


Figure 6. Seasonal dispersion of root galls during the vegetation period in carnation.

In the beginning of vegetation there were seen root-konots in the Control blocks , also the Metham sodium blocks the root-knots has seen in September. In November root-knots has seen in the Steam blocks but the population of nematodes hasn't increased during the winter season and plants didn't injured so much (Figure 6).

Table 6. Effect of different treatments to *Meloidogyne* spp. galls on carnation at the en of vegetation.

Treatments	Root-Galls Index	
	Maximum	Average
Control	4	2.32
Methyl Bromid 100%	1	0.12
Methyl Bromid 50%	2	0.31
Steam	2	0.43
1,3 Dichloroproene	2	0.25
Dazomet	3	0.82
Metam sodium	3	1.13

Root gall index was highest on plants grown in Control plots (2.32), moderate in Dazomet (0.82), Metam sodium (1.13), and lowest in Methyl Bromid 100% (0.12), Methyl Bromid 50% (0.31), Steam (0.43) and 1,3 Dichloropropene (0.25) (Table 6).

6. Weeds

After the treatments we counted the number of weeds in our greenhouses. In the greenhouses mostly these kinds of weeds were found as in follows:

1- *Portulaca oleracea*
2- *Chenopodium* sp.
3- *Cyperus* sp.
4- *Malva* sp.

Table 7. Number of weeds counted in carnation after the treatment.

	DD	MS	DZ	Steam	MeBr 50%	MeBr 100%	Control
Portulaca oleracea	19	35	43	1	-	-	117
Chenopodium sp.	21	46	52	1	3	-	180
Cyperus sp.	15	13	21	-	-	-	63
Malva sp.	14	12	16	-	3	-	70

We also saw that the effectiveness of the treatments in the weed counting. In carnation most effective of them was MeBr 100%, MeBr 50% and Steam, respectively.

7. Yield, Flower Stem Length, Flower Stem Weight

The effects of alternatives which were compared with MeBr applications and control on the yield, stem length and on the flower stem weight were investigated in table 8.

Table 8. The effects of low doses chemicals compared with MeBr and control on the yield, flower stem length and flower stem weight

ALTERNATIVES	YIELD flowers / plant	FLOWER STEM LENGTH (cm)	FLOWER STEM WEIGTH (gr)
Blank Control	11.50 C	62.20	66.00
MeBr 100 %	14.20 A	68.98	71.50
MeBr 50 %	14.23 A	63.00	53.50
Dazomet	13.45 AB	66.30	62.75
Metham Sodium	11.73 C	68.55	81.00
1.3 Dichloropropene	13.00 B	65.50	67.75
LSD %0.05	1.004	n.s	n.s

The effects of low doses chemicals compared with two MeBr doses and control on the yield, flower steam weight. Applications were not significantly affected on the flower stem legth and flower stem weight. But, applications were found to be statically significant on the yield from Dazomed (13.45 flowers/plant). The highest yield, after applications of MeBr was obtained.

The effects of steam compared with MeBr 50%, MeBr 100% and control applications on the flower yield, flower stem length and flower stem weight (Table 9).

The highest number of flower harvested from MeBr applications.

Table 9. The effects of steam compared with MeBr and control on the yield, flower stem length and flower stem weight

ALTERNATİVES	YIELD flowers / plant	FLOWER STEM LENGTH (cm)	FLOWER STEM WEIGTH (gr)
Blank Control	11.50 C	62.20	66.00
MeBr 100 %	14.20 A	68.98	71.50
MeBr 50 %	14.23 A	63.00	53.50
Steam Pasteurization	13.21 B	66.30	62.75
LSD %0.05	0.951	n.s	n.s

In soilless culture working; there different growing media (sand, V. tuff and peat 50%: V. tuff 50%) were compared with MeBr 50%, MeBr 100% and control applications. Average values of flower yield and measurements of flower stem length (cm) and flower-stem weight (gr) were given Table 10.

Table 10. The effects of soilless cultivation compared with MeBr and control on the yield, flower stem length and flower stem weight

ALTERNATİVES	YIELD flowers / plant		FLOWER STEM LENGTH (cm)		FLOWER STEM WEIGTH (gr)	
	Darling	Batu	Darling	Batu	Darling	Batu
Blank Control	10.50	9.11	62.12	60.57	61.83	41.67
MeBr 100 %	14.20	-	68.98	-	71.50	-
MeBr 50 %	14.23	-	63.00	-	53.50	-
Sand (0-1 mm ∅)	14.54	12.46	64.41	64.00	61.00	38.50
V. tuff (0-5 mm ∅)	11.93	11.11	56.94	62.57	56.00	44.83
Peat: V. tuff (1:1)	15.32	15.08	64.27	63.63	46.50	40.83
LSD %0.05	1.062		n.s		n.s	

The highest number of flower per plant (15.32 flowers/plant) was harvested from plants grown on the mixture of peat:V. tuff (1:1). The lowest yield was obtained from plants grown on the control parsels (10.50 flowers/plant). The results showed that flower yield was significant affected by applications. There was no statically significant effect of the flower stem length and flower stem weight.

8. Economic Evaluation

Alternatives Treatments; 1. Steam, 2. 1.3 Dichloropropere (DD), 3. Metham Sodium (MS), 4. Dazomed (DZ), 5. Methyl Bromide 70 gr/ m^2 (MeBr %100), 6. Methyl Bromide 35 gr/ m^2 (MeBr 50%), 7. Soilless Cultivation - Sand, 8. Soilless Cultivation - Volcanic tuff (VT), 9. Soilless Cultivation - Volcanic tuff (VT) + peat.

In this research alternatives application methods for methyl bromide was studied and nine production systems were compared for differences in production cost, yield, gross return and net returns. Treatment costs per 1000 m² were shown in Table 11.

Table 11. Treatment costs per 1000 m² under greenhouse for carnation (US $)

Alternatives	CONT.	1	2	3	4	5	6	7	8	9
Control	0	0	0	0	0	0	0	0	0	0
Steam	0	0	0	0	0	0	0	0	0	0
DD	0	0	33.0	0	0	0	0	0	0	0
MS	0	0	0	71.1	0	0	0	0	0	0
DZ	0	0	0	0	119.6	0	0	0	0	0
MeBr 100%	0	0	0	0	0	284.1	0	0	0.0	0
MeBr 50%	0	0	0	0	0	0	142.0	0	0	0.0
Sand	0	0	0	0	0	0	0	31.9	0	0
V. tuff	0	0	0	0	0	0	0	0	53.1	0
V. tuff+Peat	0	0	0	0	0	0	0	0	0	143 5
Plastic	0	0	58.7	58.7	38.3	79.1	79.1	0	0	0
Mat.&Equipment	0	595.1	0	0	0	0	0	105.8	105.8	105.8
Labour	43.5	38.3	41.7	49.6	31.3	26.1	26.7	48.8	48.8	48.8
Total	**43.5**	**633.4**	**133.4**	**179.4**	**189.2**	**389.3**	**247.8**	**186.5**	**207.7**	**298.1**

Table 11 Comments : The results indicated that the highest cost was in the application of steam sterilisation. The reason of high cost results from the cost of steam machine. If the steam machine is used for larger areas it can be more efficient and economical and may be an alternative method for methyl bromide.

When we compared the low doses of chemicals (1.3 Dichloropropere, Metham Sodium, Dazomed) to methyl bromide the cost of all these chemicals were lower than the methyl bromide.

Among the cost of soilless cultures, the cost of sand, pumice, pumice+peat were lower than the MeBr 100% although peat + pumice were the soilless culture their cost was higher then MeBr 50%.

Cost of treatments, yield, gross income and net income were shown table 12.

Table12. Cost of treatments, out put (yield), gross income, net income for carnation

Alternatives	Yield (steam/1000m²)	Gross income ($/1000m²)	Variable cost ($/1000m²)	Net income ($/1000m²)
Control	225216	4887.2	43.5	4843.7
Steam	258705	5613.9	633.4	4980.5
DD	254592	5524.6	133.4	5391.2
MS	229720	4984.9	179.4	4805.5
DZ	263405	5715.9	189.2	5526.7
MeBr 100%	278093	6034.6	389.3	5645.3
MeBr 50%	278680	6047.4	247.8	5799.6
Sand	284751	6179.1	186.5	5992.6
V. tuff	233637	5069.9	207.7	4862.2
V. tuff+Peat	300027	6510.6	298.1	6212.5

Table 12 Comments; Maximum yield was obtained using soilless culture (pumice+peat and sand) followed by MeBr 50% and MeBr 100%.

Pumice+peat plot had maximum net income followed by sand and MeBr 50%.

Net return for the steam was lower than the other alternatives. Therefore it would appear that steam application would allow the farmers to take into account consumer concerns about pesticide safety and reduce damage to the environment.

Table 13. Doninans analysis by treatment for carnation

Alternatives	Variable cost ($/1000m²)	Net income ($/1000m²)	Dominance
Control	43.5	4843.7	--
DD	133.4	5391.2	--
MS	179.4	4805.5	D
Sand	186.5	5992.6	--
DZ	189.2	5526.7	D
V. tuff	207.7	4862.2	D
MeBr 50%	247.8	5799.6	D
V. tuff+Peat	298.1	6212.5	--
MeBr 100%	389.3	5645.3	D
Steam	633.4	4980.5	D

Table 13 Comments; Control, DD, soilless culture (sand) and pumice+peat applications show the best economic benefits.

Table 14. Marginal rate of return by treatment for carnation

Alternatives	Variable cost ($/1000m²)	Net income ($/1000m²)	Incremental variable cost	Incremental net income	MR of return (%)
Control	43.5	4843.7	--	--	--
DD	133.4	5391.2	89.9	547.6	609
Sand	186.5	5992.6	53.1	601.4	1133
V. tuff+Peat	298.1	6212.5	111.6	219.9	197

Table 14 Comments; Control as compared to DD shows 152.2% MRT. DD as compared to soilless culture (sand) shows 1906% MRT. Sand compared to Pumice+peat shows 197% MRT. Sand shows the best marginal rate of return in all treatments followed by pumice+peat and DD.

9. Plant Nutrition

Some chemical and physical properties of soil that grown carnation were given in Table 15. pH were alkaline and weakly alkaline, no salinity problem, texture was Sandy Clay Loam. Organic matter were between 2.00 - 3.32 percentage. Carbonate values changed 2.5-4.1 Amounts of some plant nutrient elements changed 0.15-0.20%N, 58-110 ppm P, 322-408 ppm K, 2760-3659 ppm Ca, 196-261 ppm Mg. C/N were between 7.6-9.6. CEC were between 20-35 meq/100 g. Soil samples were taken twice at before planting and after cultivation. Soil properties are same as other soils that grown flowers in Antalya region.

Also some properties of substrates used as growing medium for soilless culture are shown in tomatoes section. pH of sand and volcanic tuff were alkaline but pH of peat was weakly alkaline. Amount of carbonate were 31.30% for sand, 1.30% for volcanic tuff and 1.80% for peat. Organic matter of peat was 57.13%.

Some properties of water used at trials were given in Tomatoes Section.

Fertilization plan was adjusted according to soil, water and plant analysis results. Amount of elements in nutrient solution prepared for plant grown in soil were changed between 80-125 ppm N, 30-90 ppm P_2O_5, 150-180 ppm K_2O for carnation.

Nutrient solutions used in soilless culture for carnation were given in Tomatoes Section. Nutrient solution used in soilless culture for carnation were 13 mmol/lt NO_3, 1.25 mmol/lt H_2PO_4, 1.25 mmol/lt SO_4, 1 mmol/lt NH_4, 6.25 mmol/lt K, 3.75 mmol/lt Ca, 1 mmol/lt Mg, 25 µmol/lt Fe, 10 µmol/lt Mn, 4 µmol/lt Zn, 30 µmol/lt B, 0.75 µmol/lt Cu, 0.75 µmol/lt Mo. Amount of nutrient elements were adjusted according to properties of water.

Some nutrient elements concentration in leaf tissue of carnation grown in soil and substrates were 3.20-3.75 %N, 0.30-0.46 % P, %2.57-3.75 K, %1.55-2.22 Ca, %0.33-0.40 Mg, 45-109 ppm Fe, 77-221 ppm Mn, 15-30 ppm Zn. As a result of that fertilization program, average values of some plant nutrient elements in leaf tissue of carnation grown in soil and substrates were generally sufficient or high (Table 16). So that any nutritional problems at carnation during growing period weren't determined. Leaf samples were taken twice during growing period.

Table 15. Some physical and chemical properties of soil grown carnation.

				TEXTURE										
	Ph	%$CaCO_3$	EC Micromhos/cm	% SAND	% CLAY	% SILT	% Organic Matter	C/N	CEC meq/100 g	%N	P ppm	K ppm	Ca ppm	Mg ppm
BEFORE PLANTING	7.75-8.05	2.5-3.1	340-403	58	30	12	2.0-2.55	8.1-8.7	25-35	0.15-0.17	58-93	330-408	2920-3659	210-228
				Sandy Clay Loam										
				56	28	16								
				Sandy clay Loam										
AFTER CULTIVATION														
	7.5-7.7	3.5-4.1	421-480				2.1-3.32	7.6-9.6	20-30	0.16-0.20	82-110	322-405	2760-3438	196-261

Table 16. Some plant nutrient elements concentration in leaf tissue of carnation.

MONTH		N %	P %	K %	Ca %	Mg %	Fe ppm	Mn ppm	Zn ppm
NOWEMBER	SOIL	3.48-3.75	0.38-0.46	3.09-3.75	2.06-2.22	0.37-0.40	45-101	160-193	15-21
	SOILLESS CULTURE	3.20-3.46	0.38-0.40	3.29-3.67	1.81-2.04	0.36-0.39	80-109	77-79	28-30
MARCH	SOIL	3.33-3.43	0.30-0.38	2.76-3.13	2.13-2.15	0.34-0.35	65-88	181-221	19-23
	SOILLESS CULTURE	3.33-3.56	0.37-0.38	2.57-2.88	1.55-1.78	0.33-0.34	68-71	83-102	19-30

C. CONCLUSIONS ON ALTERNATIVES TO MeBr IN CUT FLOWERS

On the light of the results from this demonstration project on Alternatives to the Use of Methyl Bromide for Soil Fumigation in Republic of Turkey, we may conclude that.

1. Under the conditions of Turkey, alternative treatments to Methyl Bromide were found. These can be used in cut flowers protected crops.

2. According to the number of soil-borne pathogens, steam pasteurisation was found as effective as MeBr in carnation.

3. According to the number of nematodes, steam pasteurisation and SL+DD were found as effective as MeBr.

4. In this research, alternative application methods for Methyl Bromide was investigated in the carnation experiments. For this purpose nine carnation production systems were analysed in terms of production cost yield gross income, net income.

5. Regarding carnation, maximum yield was obtained from soilless culture. The application of pumice+peat treatment have the highest net income. The result of MRT analysis showed that the treatments of the sand gave the highest MRT.

6. .The results of alternatives to the use of Methyl Bromide was better than the methyl bromide application in term of both technical and economic aspect

7. In conclusion, we would like to continue most promising alternatives at full – scale commercial basis, in leader companies of the Antalya province producing horticultural crops (tomatoes and cucumber) and cut flowers (carnation) in next year. This cost of trial will be provide by Citrus and Greenhouse Crops Research Institute.