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DEMONSTRATION PROJECT ON ALTERNATIVES TO THE USE OF METHYL BROMIDE FOR SOIL FUMIGATION IN SYRIAN ARAB REPUBLIC

Project No: MP/SYR/98/028

Final Report

SECTION THREE: ALTERNATIVES TO THE USE OF MB IN CUT FLOWERS

SECTION ONE

INTRODUCTION

Methyl bromide (MB) is a broad-spectrum chemical commonly used as a soil fumigant for control of soil borne diseases, nematodes, insect pests and weeds. Between 30 and 85 % of the total MB applied to the soil will reach eventually the atmosphere. It is now recognized that MB contributes significantly to ozone depletion and was listed as an ozone-depleting substance (ODS) by the Fourth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer in Copenhagen in 1992. As a consequence many countries are currently required to restrict consumption and production in order to face an eventual phase out of MB usage in agricultural production.

The Methyl Bromide Technical Option Committee (MBTOC) was established by the Parties to the Montreal Protocol to review technical issues concerning MB. MBTOC has produced documents that address the technical availability of chemical and non-chemical alternatives for the current uses of MB.

AVAILABLE ALTERNATIVES TO MB FOR SOIL FUMIGATION

Table 1. Alternatives to MB for soil fumigation (MBTOC)

Non-chemical	Chemical
Cultural practices	Available fumigant chemicals
Artificial and natural substrates	Methyisothiocyanate (MITC)
Crop rotations	MITC generators
Timing of planting	Metam-sodium
Deep plugging	Dazomet
Flooding/water management	Halogenated hydrocarbons
Fallowing	1,3-dicloropropene
Planting date	Chloropicrin
Cover crops	Ethylene dibromide (EDB)
Fertilization and plant nutrition	Combination of fumigants
Living mulches	Non-fumigants
Plant breeding and grafting	Herbicides
Biological control	Fungicides
Organic amendments and biofumigation	Nematicides
Physical methods	Insecticides
Solarization	Chemicals requiring further development
Steam	Formaldehyde
Superheated or hot water	Carbon bisulphide
Wavelength-selective plastic mulches	Sodium tetrathiocarbonate
Other physical methods (microwave...)	Dichloro-isopropyl ether
	Anhydrous ammonia
	Sulfur dioxide
	Bromine containing compounds
	Inorganic acids
	Others

At the present time there is no a single alternative for the use of MB for soil fumigation, and none of the specific alternatives showed in Table 1, used alone, have the broad spectrum of activity, efficacy or consistency of MB. The development of a comparable agricultural system without the use of MB, in many cases, will require the integration of multiple alternative technologies and extensive research to achieve a similar spectrum of efficacy and reliability.

To implement alternatives to MB, an integrated pest management (IPM) strategy will be required. IPM utilizes pest monitoring techniques, establishment of pest injury levels and mix of strategies and tactics to prevent or manage pest problems in an environmentally sound and cost-effective manner.

MONTREAL PROTOCOL ARTICLE 5 COUNTRIES

According to the Parties to the Montreal Protocol, the consumption of MB for soil fumigation in developing countries included in the Article 5 of the Montreal Protocol, will be frozen in year 2002 at the average consumption levels for 1995-1998. In order to determine the direction of action to be taken, further work was needed to demonstrate the efficacy of different alternatives for containment/phasing out. It was considered critical that Article 5 countries receive technical and financial assistance to introduce or adapt alternative materials and methods to manage the pests currently controlled by MB.

On this line, in 1997, The Syrian Arab Republic requested assistance to conduct demonstration trials to decide the efficacy of alternatives for soil fumigation. A comprehensive project was prepared and presented for approval to the 25th Meeting of the Executive Committee in July 1998. Finally, the project was funded by the Multilateral Fund of the Montreal Protocol (MPMF). Since then, the United Nations Industrial Development Organization (UNIDO) is implementing the project. The Ministry of the Environment is the national counterpart and the Professional Unit for Plant Protection (PUPP) from the University of Damascus was subcontracted to deal with the technical aspects of the project.

The varied and special conditions in Article 5 countries require that the alternatives be appropriately adapted to the climatic conditions, particular cropping techniques, resource availability and specific target pests. During our demonstration project, different alternatives

were used for different crops and situations. This involved a significant effort to select the appropriate alternatives, adaptive research, field-testing, technology transfer, user education, institutional capacity building and training.

Most of the present work has been fundamentally based on the alternatives identified by MBTOC with special attention to the concerns relating Article 5 countries where Syria is included.

AGRICULTURE AND METHYL BROMIDE USE IN SYRIA

Approximately 12% of Syria is cultivated. In relation with the irrigated land, by mid 1990's it was estimated that about 80,000 plastic houses existed, which accounted for a total area of 4,000 ha. Most of these plastic houses are located in the coastal area, within the governorates of Tartus and Lattakia, and in the southern regions, in As Swayda and Dar'a governorates. Plastic houses are used for ornamental and vegetable crops, such as tomatoes, cucumber, sweet pepper, strawberries, banana, etc.

In Syria, MB is registered for quarantine measures, commodities and soil fumigation. An increase in the estimated MB consumption in Syria has been observed during the last years. The majority of MB is used for post-harvest treatment of grains stored in public silos and warehouses. There is no record for MB consumption for soil fumigation in Syria, however, there are indications that point to a significant use for this purpose. This MB is used mainly to protect crops grown in plastic tunnels from soil-borne pest and diseases (mainly nematodes and fungi) and weeds.

In the coastal area, tomato and cucumber are the most important cultures. The Mediterranean weather, attenuated by the coastal condition of the area, allow to grow two long cycle vegetable crops like tomato and cucumber in a continuous manner. The cash season is the autumn-winter one, planted from September and harvested till February. The Zabadani area, Located in the head of the valley of the Barada river (1200 m.a.s.l.) is the main area in Syria for ornamental crops. Cut flower cultivation, mainly carnation, chrysanthemum, gerbera and Gypsophyla are grown in 700 tunnels (*c.* 30 ha) in a two-year cycle using oil-heating systems during the winter (Fig 1).

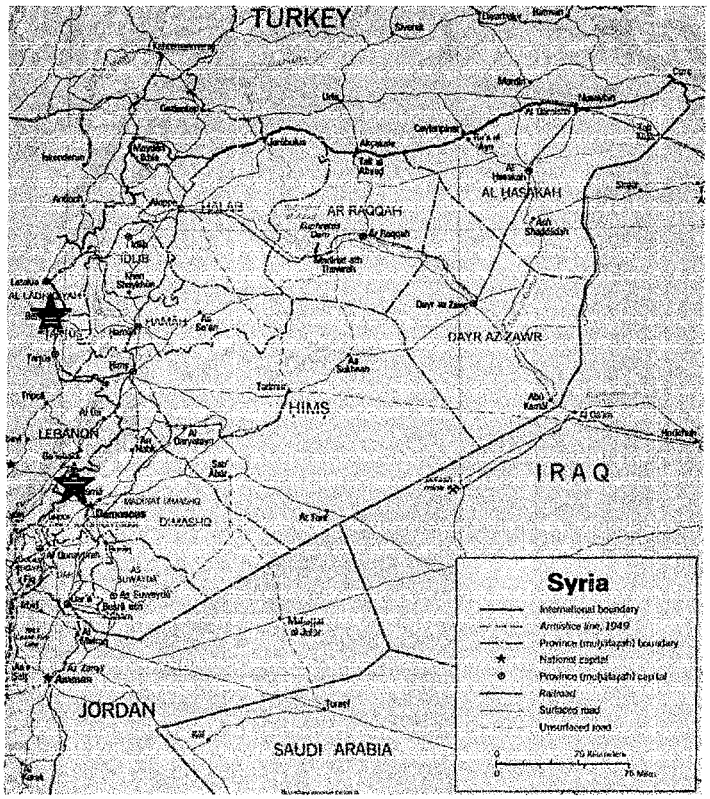


Fig. 1. Location of the demonstration project in Syria

MAIN PHYTOPATOLOGICAL PROBLEMS CONTROLLED BY MB

In the cut flower sector, it was considered that if no soil treatment were applied, up to 40% of plants would die and a significant reduction in quality would be also expected. Main phytopathological problem is *Fusarium oxysporum* f. sp. *dianthi* in carnations followed by vascular diseases affecting chrisanthemum and weeds and underground insects in most other crops.

In the horticultural sector, MB is applied at dosages from 60 to 70 g / m^2 to control weeds and soil borne diseases. Main phytopathological problem for tomato and cucumber is root knot nematodes (*Meloidogyne javanica)* followed by vascular diseases caused by *Fusarium* spp. and *Verticillium* spp. and corky root in tomato caused by *Pyrenochaeta lycopersici.* Also weed incidence is considered as a major cause for using MB in the area.

AVAILABLE ALTERNATIVES TO MB AND INDICATIONS FOR SYRIA

It is widely accepted that there is no a single alternative to the use of MB for soil fumigation. A realistic alternative is a combination of control methods within an integrated pest management (IPM) approach. This imply a careful planing of the crop, based in a well knowledge of the agro system, the correct use of the available cultivars, seedbed sanitation and a continuous monitoring of the crop in order to react quickly to solve problems that may arise and for preventing and ameliorating the techniques for future cropping seasons.

Chemical alternatives

A number of fumigant substances are registered and available in Syria, among others, Dazomet and Metam Na.

Metam Na is a well-known pre-plant disinfectant widely used as soil fumigant for the control of soil nematodes, fungi and weeds. Metam Na is a liquid that decomposed in the soil producing the fumigant methyl isothiocyanate (MIT). It can be applied by injecting into the soil or trough the irrigation system at a dosage ranging from 1000 to 1500 L/ha. After the treatment the soil needs to be covered with plastic for at last 10 days providing also 4 to 5 days without plastic, before planting and the soil will be labor for aeration before planting. Successful use of this chemical requires precise methods of application and conditions of soil temperature and moisture.

Dazomet fumigant principle is similar to that for metam Na. The main difference is that is a solid formulation in micro granules. Solid fumigants have the advantage over of a limited percolation in the soil thereof the risk of underground water contamination is minimized. Successful application requires uniform mechanical distribution in the soil to assure good movement and optimal soil temperature and moisture levels. Doses range from 30 to 50 g/m^2 (Basamid G®) that shall be homogeneously mixed in the first 10 cm of soil, the soil shall be covered with plastic and let for 14 days (preferably exposed to the sun) when will be labor for aeration before planting. Repeated treatment could lead to a microbial degradation by the build up of adapted organisms.

Also a wide variety of plant protection agents are ready available that can be used to control specific problems *i.e.* fungicides (hymexazol, captan, quintozene, metalaxyl), herbicides and insecticides-nematicides (carbofuran, ethoprophos, oxamyl etc).

Non-Chemical alternatives

Solarization: during the summer (July to September) the climatic conditions in Syria are too extreme (mainly in the costal area) for an intensive vegetable production, however are ideal for implementing solarization techniques. During the last decade solarization methods were developed in Syria and the technique is actually adapted as alternative to MB at a commercial scale by a limited number of farms. It has been proved an effective technique for controlling weeds and soil borne pathogens.

Bio-fumigation: It is a technique based in the effect of gases liberated during the decomposition of organic matter for the control of soil borne pests and diseases. The action of microorganisms on the organic matter during its decomposition produce substances such are ammonia, nitrates, hydrogen sulfide and a great number of volatile compounds and organic acids that are effective in controlling soil borne pests and diseases.

To apply biofumigation, normally a partially decomposed organic material, with a C/N >11, is mixed with the soil at a rate ranging from 6 to 10 kg / ha. Then the soil is watered, and mulched with plastic for 15 days. Before planting, the soil is rotovated and let for aeration 2 or 3 days. In order to reduce the amount of organic matter and of plastics, the technique can be also applied in bands that coincide with the planting lines. It is also possible to enhance the effectiveness of the technique by adding BCA's and or materials that produce ammonia after decomposition; also VIF (Virtually impermeable film) plastics can be used.

Steam soil disinfestations: it was used in Syria at small experimental scale only; its application was limited due to the high cost of application. Also there is concern about chemical changes that may occur to the soil due to high temperatures, these include manganese toxicity and nitrogen unbalances due to the reduction of nitrifying microorganisms. For applying this technique, it was recommended to maintain the soil

temperature during the treatment between 65-70 °C, which will produce a soil pasteurization with an effective control of most soil borne diseases whereas avoiding above mentioned problems. Also, although soils may have a high contents in manganese, if the pH is high, the risk for Mn toxicity is lessen due to a quick reversion of reduced Mn forms to the non toxic Mn oxides.

Soilless cultivation: this technique is used at a commercial scale in other countries in the Middle East as Jordan. Ornamental and horticultural crops are grown in benches filled with substrate composed of peat in the bottom of the bench (15 cm) covered by a layer (10 cm) of basaltic pumice (volcanic ash). Water and nutrients are applied by a computerized drip irrigation system on a circulation circuit.

Highly sophisticated system can't be consider as a solution for MB usage in Syria, those are expensive and require an initial high inversion that is not available for the average farmer. However, fertirrigation is a relatively common technique in Syria and this, together with the availability of materials *i.e.* peat, turf, perlite, vermiculite, pumice, etc, provide a good opportunity for developing simple and cheap but effective non-circulating Soilless cultivation techniques.

Biological control agents: In order to ameliorate and reestablish the microbiological characteristics of the soil, biopesticides that were available in Syria, specially with *Trichoderma* spp. Were used to enhance the effectively of the other techniques used.

CROPS, ALTERNATIVES AND LOCATIONS SELECTION, TRIAL DESIGN

The crops chosen were vegetables (tomato in rotation with cucumber) and cut flowers (carnation). Those were selected according to its actual and potential use of MB for soil fumigation.

The areas for the trials ware the Mediterranean coastal area (Baniyas) for vegetables and the irrigated Up-lands (Zabadani) for cut flower cultivation (Fig 1). The areas were selected according to their differential agro ecologic characteristics and by the incidence of soil-borne diseases and pests that necessitate the use of MB.

The alternative treatments to the use of MB in soil fumigation in Syria were selected according to its local availability and considered (by consensus) as appropriate to the crops and the areas under study. This was achieved during discussions and meetings with the institutions, with the personnel from the experimental sites and UNIDO.

The experiments were discussed with the technicians of each site in order to fully fit within their production system. Overall strategy was not to interfere with the production system (planting dates, crops, treatments...) currently used at the site. Some alternatives already available or under experimentation were also chosen.

The different alternatives chosen were compared with MB treated and untreated plots and, at last three replicates were available for each treatment, in a two year, two seasons per year trials. The alternatives chosen were implemented by an IPM strategy that was further improved during the experiments. The IPM strategy was designed and intended in order to produce agricultural systems that are at a time environmentally safe and cost-effective.

SECTION TWO

ALTERNATIVES TO THE USE OF MB IN VEGETABLES

TRIAL DESIGN FOR VEGETABLES

The trial was conducted in four plastic tunnels of 400 m^2 (a total 0f 1.6 Syrian Dunums), each tunnel was divided in five growing plots each one with two rows and 100 plants per row. The design consisted of four completely randomized blocks, With 5 treatments and one replicate per tunnel. Each plot had an area of 60 m^2 (1.2 x 50 m). The tunnels planted with tomato (variety Karam) on the second week of September 1999 (Sept. 9th 1999 for the 1st and 2nd tunnels and Sept. 20th 1999 for the 3ed and 4th tunnels). Before any treatment was applied, soil samples were taken randomly from each of the four tunnels and analyzed to study the physical and chemical properties of the soil.

Treatments

The treatments were applied during the third week of August after the preparation of the soil. Samples were taken on July 7th 1999 for analysis. The treatments were as follows:

O. Control

A- MB (57 g/m^2)
One can of 680g MB for each 12 m^2 of soil surfaces under plastic covers.

B-Dazomet 98% GR + Solarization
Application ratio of 2.4 kg/plot then covered with plastic and solarized.

C-Organic matter + Solarization
5 kg of half decomposed cow manure per m^2

D-Soilless cultivation
Plants were placed in plastic bags (30 cm x 2 m) filled with basaltic volcanic ashes and compost at a ratio 1:1. The nutrients were delivered at appropriated rates by fertirrigation.

Trial layout

The trial layout in the tunnels is shown in figure 2.

Treatments:
O- Control
A-MB
B-Dazomet
C-Solarization
D-Soilless

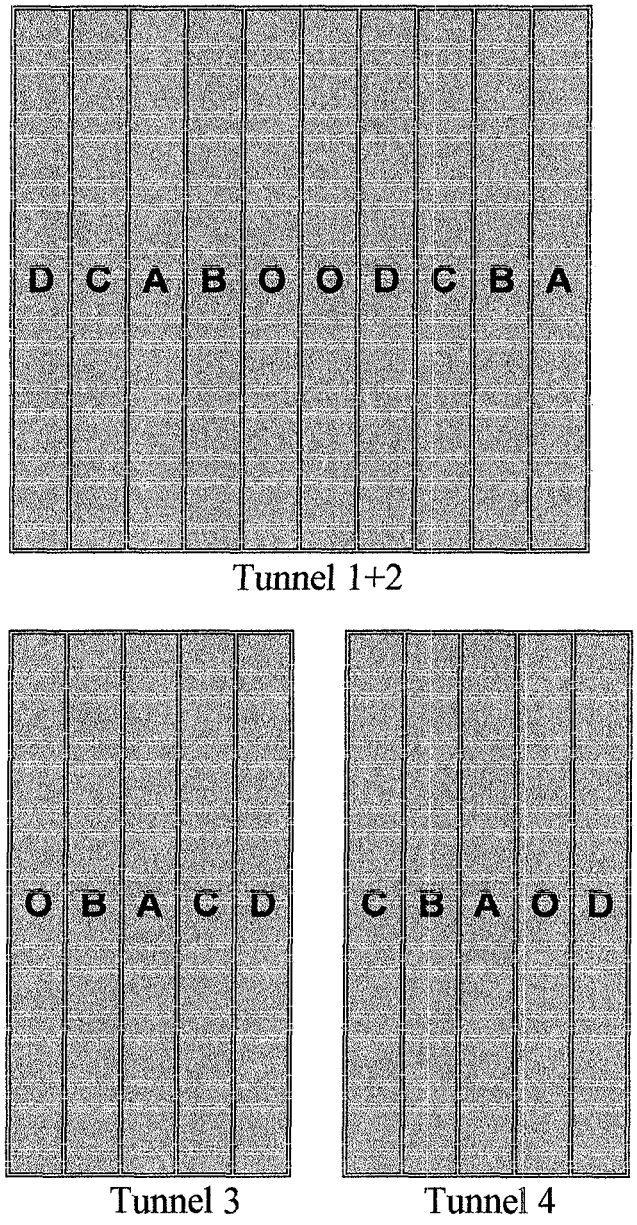


Figure 2- Layout of the vegetable trial

Soil characteristics

On July 19th 1999, soil samples were taken from the four tunnels to determine the main soil characteristics. The soil was collected from 25 randomly selected spots per tunnel from three different depths (0-20 cm, 20-40 cm and 40-60 cm). The soil from each depth was mixed to obtain a representative composite sample from each depth in each tunnel. The samples were then transported to the laboratory where they were air-dried and analyzed. The results showed that the soil characteristics vary with depth. The organic matter is high as compared with other soils from the area (mainly due to the addition of organic matter by the farmer). The percentage of calcium carbonate was low (2-10%). pH of the soil was neutral. Electrical conductivity was normal. The detailed results are listed in table 2.

	pH	EC 1:5 (µmhso/cm)	Active Lime (%)	CaCO3 (%)	O.M. (%)	T.N. (%)	Sand (%)	Silt (%)	Clay (%)
0-20	7,13	305,00	1,14	5,85	4,63	0,17	47,50	22,88	29,63
STD	0,10	50,50	0,68	3,27	0,98	0,04	12,42	10,36	6,76
20-40	7,18	276,25	1,19	5,53	3,90	0,14	44,25	23,63	32,13
STD	0,21	27,50	0,59	2,22	0,85	0,02	5,61	7,93	8,30
40-60	7,23	270,00	1,94	8,13	3,68	0,15	43,13	16,88	40,00
STD	0,15	60,55	0,13	0,65	0,40	0,02	9,66	3,15	7,91

Table 2- Results of soil analysis in the vegetable trial.

EFFECT OF TREATMENTS ON PESTS & DISEASES

In addition to the sample collected in July 19th 1999 for the study of soil characteristics, another two sampling periods were established to determine the effect of treatments on the soil population of Weed, Bacteria, Fungi, Nematodes and Arthropods. In resume, 3 sampling periods were studied:

1. Before the treatments (July 1999)
2. After the treatments (September 1999)
3. At the end of the crop (February 2000).

Weeds

After conducting seed germination trails in the laboratory, four different broad leaf weed and one grass species were found in the soil from the four tunnels (Table 3)

Broad leaves	Grasses
Amaranthus retroflexus L. *Chenopodium album* L. *Oxalis sp.* *Sonchus oleraceus* L.	*Setaria glauca* L.

Table 3. Weed species found in the vegetable soil

In the samples made 17 days after the treatments, the results from the laboratory germination of weed seeds in soil samples showed high weed control in the Dazomet treatment, compared to the control. There were no significant differences between the Dazomet treatment and the MB & Solarization treatments. This indicates that the Dazomet treatment was the best for weed control. Also the total number of weed seeds from the upper layer of soil was significantly higher at the level of significance of 5%.

The results from the laboratory germination of weed seeds in soil samples collected after 5 month period of crop cultivation showed lower weed germination in the MB and Dazomet treatments, as compared to the bio-fumigation. There were no significant differences shown between the bio-fumigation treatment and the control treatment. On the other hand there was no significant difference between the control and the MB & Dazomet treatments. This suggests that the Dazomet and the MB treatments are equally effective and with long lasting effect even after 5 months of application even though there was no differences with the control. The efficacy of bio-fumigation was lower compared to the other treatments after this period, may be indicating the beneficial effect of the treatments on the general vegetation or that uncontrolled seeds were added together with the organic mater added for this treatment. The total number of germinating weed seeds in the three soil layer in the different treatments were not significantly different at the 5% significance level.

Detailed results are shown in Table 4 & Figure 3.

	Germinating weed seeds/m^2	
Before Treatments (Jul 99)		
	68.16	
After treatments (Sept 99)		
O – Control	109.83	a
A – MB	35.25	ab
B- Dazomet + Solarization	23.58	b
C – Bio-fumigation	77.50	ab
Depth		
0-20	137.13	a
20-40	28.75	b
40-60	18.75	b
After treatments (Feb 00)		
O – Control	52.92	ab
A – MB	21.08	b
B – Dazomet + Solarization	23.00	b
C – Bio-fumigation	109.50	a
Depth		
0-20	71.13	a
20-40	50.69	a
40-60	33.06	a

*Numbers followed by the same letter are not significantly different at level of 5% (LSD test).

Table 4. Mean number of germinating weeds/m^2 seeds in the treatments and tree soil depths.

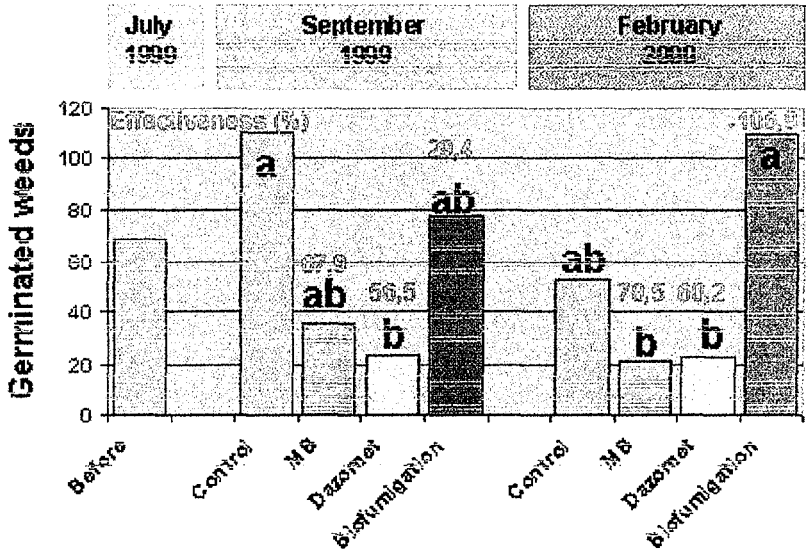


Fig.3. Seed germination trials (weed/m^2), Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, signification level is 5%.

Nematodes

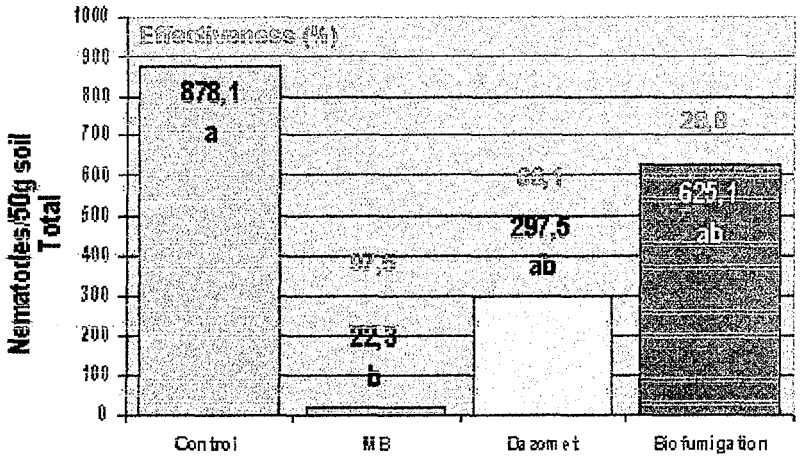
Twenty-one genera of nematodes were found in the soil surrounding the tomato roots. Samples were taken from the field and transported to the lab in a cooler. 50 gram of soil from each composite sample was extracted in a Berman funnel for 24 hours. The nematodes collected were fixed in TAF solution and identified using a light microscope. The nematode genera were divided in three trophic groups according to their feeding habits (Table 5).

Plant Parasitic	Plant & Fungi Feeding	Free Living
Meloidogyne javanica	*Aphelenchus*	*Chiloplacus*
Pratylenchus	*Aphelenchoides*	*Mononchus*
Tylencorhynchus	*Paraseinura*	*Pelodera*
Helicotylenchus		*Panagrolaimus*
Tylenchus		*Eudorylaimus*
Ditylenchus		*Eucephalobus*
		Plectus
		Rhabditis
		Acrobeles
		Cephalobus
		Dorylaimus

Table 5- Nematodes found in the soil associated with tomato crop at the vegetable trial site.

When comparing the means obtained after treatments for the free living nematodes, the results show that there were no significant differences between the treatments at the level of 5%.. The plant parasitic nematodes were significantly higher in the control and the Bio-fumigation treatments compared to the other treatments, but there was no significant difference between the MB and Dazomet treatments. While there were significant differences between the control and the MB treatment for the fungi feeding nematodes, there were no differences between the MB and the other treatments in the total number of nematodes. The means number of free living nematode in all treatments were significantly higher in the top soil layer, while for the total number of nematodes the only significant number was between the top soil layer and the deepest one. These results suggest that the MB treatment performed equal in effectiveness to the Dazomet treatment for the control of plant parasitic nematodes. The Bio-fumigation treatment was less effective in reducing the population of plant parasitic nematodes, however, this treatment did not affect the population of free living nematodes which may be giving a beneficial effect on the soil fauna, maintaining diversity and keeping at low rate the incidence of other diseases.

During the February 2000 sampling period (5 months before treatments), the results showed that there were no significant difference between the control and the solarization treatments in reducing the total population of nematodes. There were significant differences between these two treatments and the other two (Dazomet & MB). The later two treatments reduced the total population of nematodes in the soil. These results suggest that the treatment of soil with MB was equal in effectiveness to the Dazomet treatment in reducing the total nematode numbers, the effect of both treatments lasts until the end of the crop.



The data for this study is shown in Table 6 and graphically in Figs. 4 & 5.

Fig. 4. Total nematode count (50g/soil) after the treatments (19/09/1999). Treatments with the same letter are not significant different according to a Duncan's Multiple Range Test, signification level is 5%.

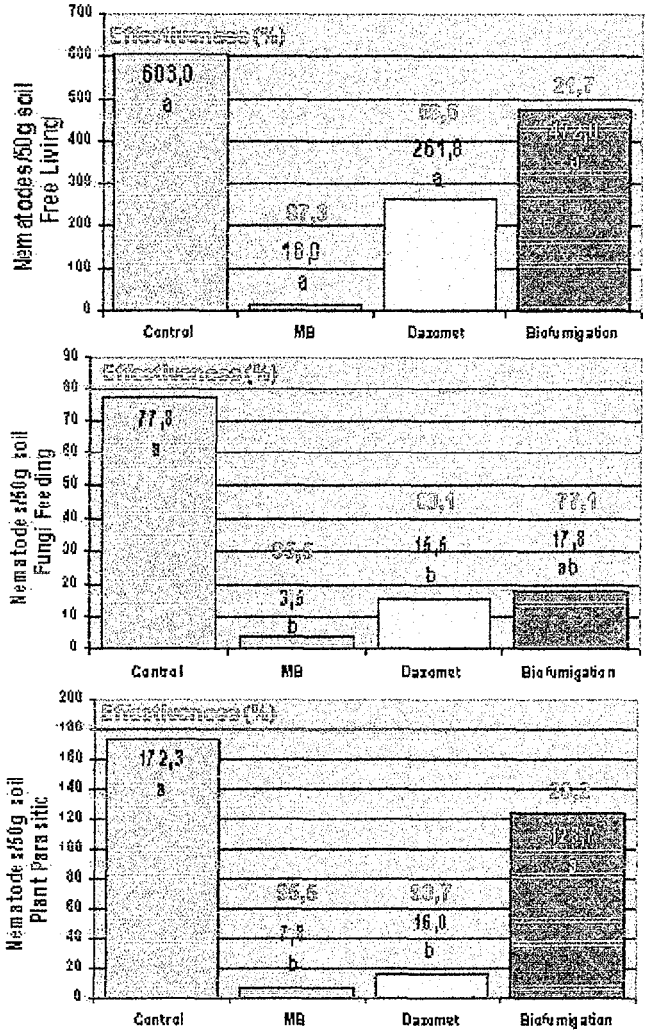


Fig.5. Partial nematode counts (50g/soil) after the treatments (19/09/1999). Treatments with the same letter are not significant different according to a Duncan's Multiple Range Test, signification level is 5%.

Treatments	Fungi Feeding	Plant Parasitic	Free living	Total
Before T. (Jui 99)	3.83	18.91	40.17	72.83
After T. (Sept 99)				
O Control	77.75 a	172.33 a	603.00 a	878.08 a
A – MB	3.50 b	7.75 b	16.00 a	22.25 b
B- Dazomet + Sol.	15.50 b	16.00 b	261.75 a	297.50 ab
C – Bio-fumigation	17.83 ab	123.67 a	472.00 a	625.08 ab
Depth				
0-20	54.06 a	93.44 a	761.75 a	940.63 a
20-40	29.68 a	97.56 a	194.56 b	321.50 ab
40-60	2.18 a	48.81 a	58.25 b	108.81 b
After T. (Feb 00)				
O – Control				1063.25 a
A – MB				152.92 b
B – Dazomet + Sol.				178.08 b
C – Bio-fumigation				950.08 a
Depth				
0-20				1020.00 a
20-40				525.25 ab
40-60				213.00 b

*Numbers followed by the same letter not significantly different at level of 5% (LSD test).

Table 6. Mean number of nematodes in the vegetable trial during three sampling periods.

Tomato Root Knot Index analysis

After the crop, 20 root systems from randomly selected plants were collected from each plot. The root systems were cleaned in water and the root knots produced by the nematode *Meloidogyne javanica* recorded. The root systems were graded according to the following index:

Index 1 = 1-2 root knot.
Index 2 = 3-10 root knot.
Index 3 = 11-30 root knot.
Index 4 = 31-100 root knot.
Index 5 = more than 100 root knot.

The mean index number for each replicate was calculated and statistically analyzed.

The results showed that the plants grown in plots treated with MB had no root knots after 5 months from the treatment. On the other hand, the Dazomet treatment was not significantly different from the MB and thus may be considered equally effective. The effectiveness of the Bio-fumigation treatment was moderate, being not significantly different to any of the other treatments (Fig. 6) .

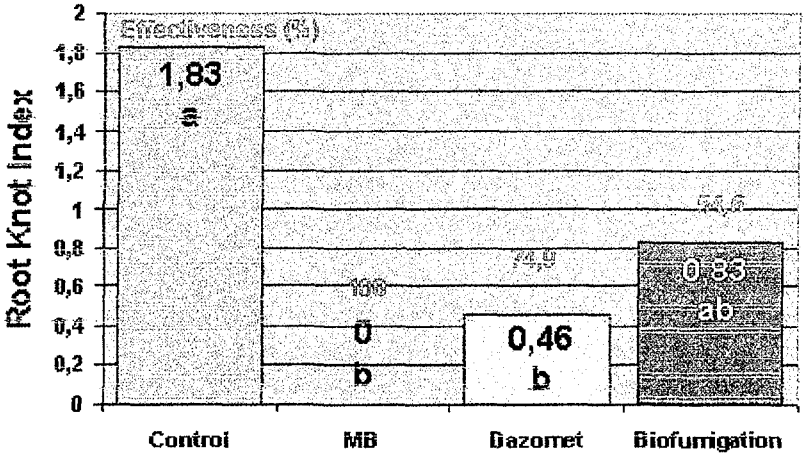


Fig. 6. Root Knot Index (20 tomato plants/plot). Treatments with the same letter are not significant different according to a Duncan's Multiple Range Test, signification level is 5%.

Bacteria

Total bacterial counts were performed using LPGA media. Three Petri dishes were used for each dilution. 31 isolates were chosen from the colonies grown in the total count experiment. The isolates were chosen according to its color, shape, diameter, growth rate, and other characters. These isolate were picked up from the media to perform the following tests:

1-Gram pigment test: 12 of the isolate were gram-positive and 19 were gram-negative.

A-The gram positive isolates belongs to the following genera:

Bacillus
Nocardia
Streptomyces

b- The gram negative isolates belongs to the following genera:

Enterobacterie
Pautoea

2-Respiration test: this test was performed using Heigh & Leifson media, to identify Entrobacter and Non Entrobacter bacterial groups.

3-Oxidation test: Fifteen isolates were found to be positive to this test.

4-Identification of bacteria: The method of API 20 was used utilizing API ZONE test kit, to identify Non Entrobacter bacteria.

The identified bacteria are listed in table 7.

	Bacterial species	Number of isolates
1	*Flavimonas oryzihabitans*	2
2	*Pasteurella haemolytica*	1
3	*Chrysomonas indologens*	2
4	*Aeromonas salmonicida*	1
5	*Pseudomonas alcaligens*	1
6	*Burkholdecia apacia*	2
7	*Chrysomonas luteola*	4
8	Non identified	9

The results of the bacterial count showed that the treatments are affecting the population of bacteria in the soil. There were significant differences between the MB and the Dazomet treatment but no with the control and the Bio-fumigation treatments. More bacteria are colonizing the upper soil layers, the number of bacteria was significantly higher in the first 20 cm of soil, this is the normal situation in agricultural soils.

After 5 month of tomato cultivation, the results of the bacterial count showed no significant differences between all the treatments. The mean bacterial count between the different soil layers also showed no significant differences.

Detailed results are shown in Table 8 & Figure 7.

	Bacteria count / g dry soil
Before Treatments (Jul 99)	31333333.33
After treatments (Sept 99)	
O – Control	23583333.33 ab
A – MB	21000000.00 b
B- Dazomet + Solarization	38666666.67 a
C – Bio-fumigation	29400000.00 ab
Depth	
0-20	45906250.00 a
20-40	24125000.00 b
40-60	14456250.00 b
After treatments (Feb 00)	
O – Control	42666666.67 a
A – MB	66833333.33 a
B – Dazomet + Solarization	40416666.67 a
C – Bio-fumigation	50833333.33 a
Depth	
0-20	54875000.00 a
20-40	56000000.00 a
40-60	39687500.00 a

*Numbers followed by the same letter are not significantly different at level of 5% (LSD test).

Table 8. Bacteria count (nr./g dry soil) during three sampling periods and at three soil depths.

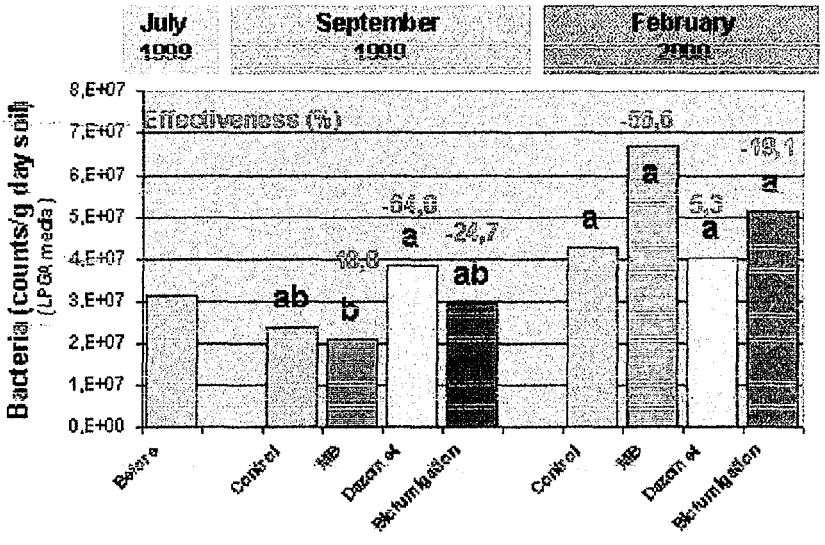


Fig. 7. Bacteria counts in LPGA media (Counts/g dry soil). Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, signification level is 5%.

Fungi

The composite soil samples were air-dried and mixed thoroughly. 5-gram soil sub-sample from each replicate was mixed with 50-ml sterile water. The solution was diluted three times and 5 ml from the original dilution was taken and mixed with 45 ml of sterile water. One ml of the final solution was seeded on a PDA+ antibiotic media in Petri dish. Three replicates were performed for each soil sample. The fungi colonies on the media were counted and identified. All the fungi colonies from the spore count experiment were identified. Five of these fungi were saprophyte (*Rhizopus, Aspergillus, Penicillium, Gliocladium,* and *Cladosporium).* Three of them were found to be plant pathogens (*Rhizoctonia, Alternaria, and Fusarium*).

The results pointed out that the MB and Dazomet treatments were equally effective in reducing the number of fungi spores when compared with the Bio-fumigation and the control treatments. However we have to consider that a significant number of fungi and spores is likely to be introduced to the soil with the organic mater used for the Bio-fumigation treatment (5 kg/m^2), because of this, the Bio-fumigation treatment is not comparable with the other ones. There were no significant differences between the mean number of spores at the three different soil depths.

The results obtained during the sampling period done at the end of the crop (February 2000), pointed out that the MB treatment was the best treatment with an effectiveness lasted for 5 months after treatment. Followed by the Dazomet, Bio-fumigation (with the considerations mentioned before) and the control treatment respectively. There was significant less CFU's at the depth of 40-60 cm than in the other two depths. Detailed results are shown in Table 9 & Figure 8.

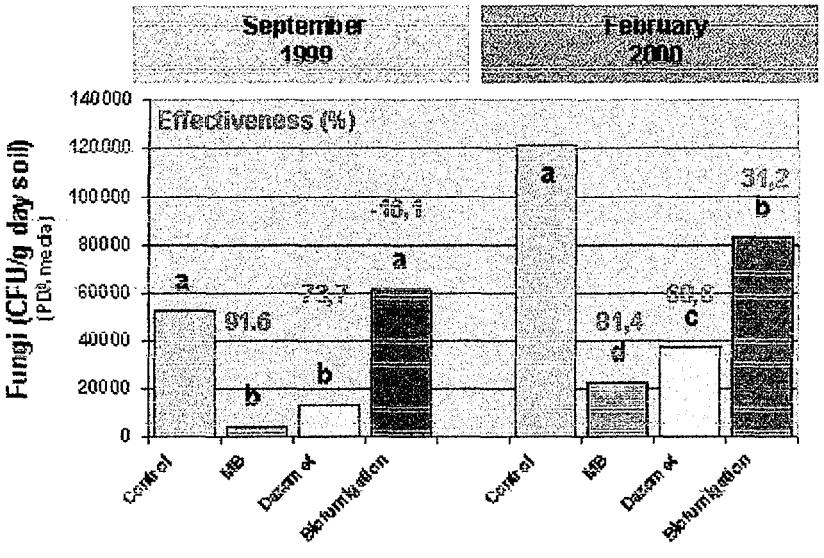


Fig. 8. Fungi counts in PDA media (CFU/g dry soil). Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, signification level is 5%.

	Fungi counts (CFU / g dry soil)
Before Treatments (Jul 99)	
After treatments (Sept 99)	
O – Control	52858.33 a
A – MB	4433.33 b
B- Dazomet + Solarization	13900.00 b
C – Bio-fumigation	61375.00 a
Depth	
0-20	37543.75 a
20-40	33043.75 a
40-60	28837.00 a
After treatments (Feb 00)	
O – Control	121008.33 a
A – MB	22558.33 d
B – Dazomet + Solarization	37941.67 c
C – Bio-fumigation	83308.42 b
Depth	
0-20	83943.81 a
20-40	78175.00 a
40-60	36493.75 b

*Numbers followed by the same letter are not significantly different at level of 5% (LSD test).

Table 9. Fungi counts in PDA media (CFU/g dry soil). Two sampling periods and three depths.

Arthropods

A 500-gram of soil composite sample was obtained from each replicate. The samples were placed in Berlese funnels for 48 hours under 40 watt electrical lamp. The arthropods from the samples were collected in small jars filled with alcohol and a drop of glycerin. The total number of mites and insects in each sample was recorded and the Arthropods were identified to the order taxa. Few insects were found in the soil (Coleoptera, Diptera, Collembola, and Himeptera) and most of the arthropods were found to be mites (Astigmata, Cryptostigmata, and Mesostigmata).

After the treatments, the result shows that there were no significant differences between the treatments in the number of arthropods in the soil, neither between the three depths. This is probably due to the low population of arthropods in the soil.

After the crop (February 2000), that there were not significant differences found between the control and the Bio-fumigation treatments, while the arthropods in the MB treatment was significantly lower than in both of them and not significantly different from the Dazomet treatment. Because it was the end of the crop, there were significantly more arthropods in the top layer of soil.

Detailed results are shown in Table 10 & Figure 9.

	Fungi counts (CFU / g dry soil)
Before Treatments (Jul 99)	0.4
After treatments (Sept 99)	
O – Control	5.250 a
A – MB	1,167 a
B- Dazomet + Solarization	1.167 a
C – Bio-fumigation	3.417 a
Depth	
0-20	6.650 a
20-40	0.810 a
40-60	0.875 a
After treatments (Feb 00)	
O – Control	3.420 a
A – MB	0.080 c
B – Dazomet + Solarization	1.750 bc
C – Bio-fumigation	3.330 ab
Depth	
0-20	3.625 a
20-40	1.560 b
40-60	2.000 b

*Numbers followed by the same letter are not significantly different at level of 5% (LSD test).

Table 10. Arthropods counts (nr./500 g soil). Three sampling periods and three depths.

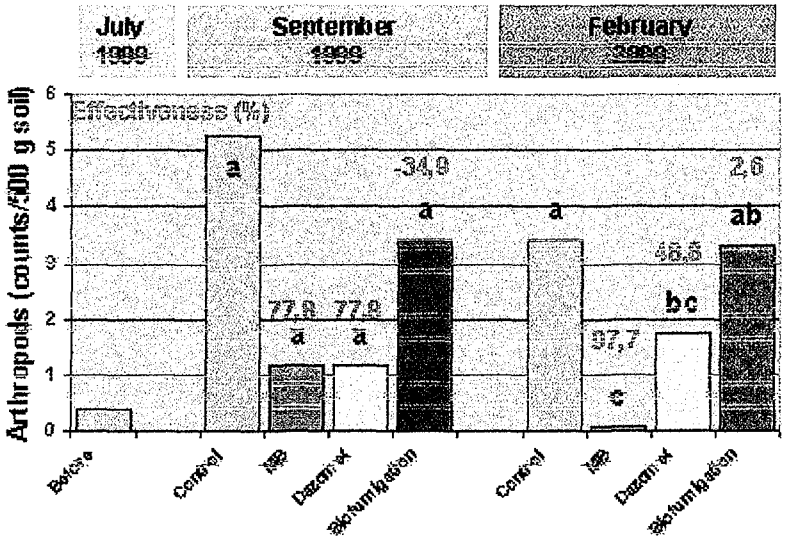


Fig. 9. Arthropod counts (Counts/ 500 g soil). Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, signification level is 5%.

EFFECT OF TREATMENTS ON PLANT VIGOR AND YIELD

Plant vigor

The vigor of the plants in the four different treatments was estimated by recording the tomato plant height and the average number of fruits that each plant was wearing just before the harvest started.

The average height of twenty plants was measured from each replicate and compared among the four treatments. The plants that were grown in the plots treated with Dazomet and MB were found to be significantly higher than those in the control. There were no significant differences between the Bio-fumigation and the other three treatments. There were no significant differences between the alternative treatments and the MB treatment (Fig. 10).

The average number of fruits produced from twenty tomato plants at each replicate was also calculated and compared among treatments; the plants grown in plots treated have significantly more fruits than these grown in the control. There were no significant differences between the alternative treatments and the MB treatment (Fig. 11).

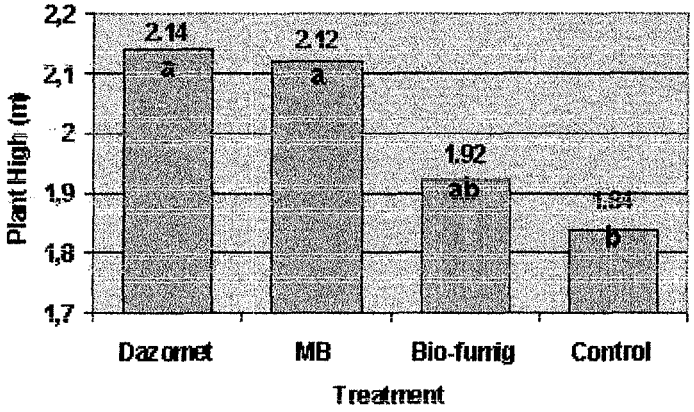


Fig. 10. Plant high before harvest starts. Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, signification level is 5%.

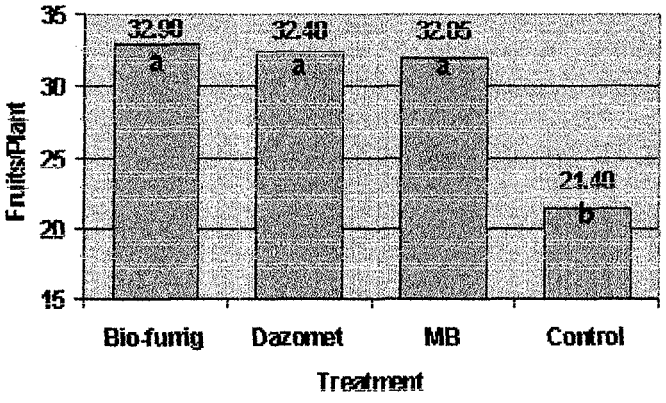


Fig. 11. Number of tomato fruits before harvest starts. Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, signification level is 5%.

Yield

The total production from each plot -measured per kg/plot- was also recorded. The results showed that the highest production was obtained in the MB treated, this was significantly higher than that obtained from the Dazomet and the control plots. There was no significant difference between the yield obtained in the MB treated plots and the Bio-fumigation treatments (Fig. 12). Figure 13 shows the evolution of the harvest along the first 40 days, also included is the data from the soilless plots, this treatment was replanted at middle season (plants dry out due to heat excess) and is not directly comparable with the treatments on soil.

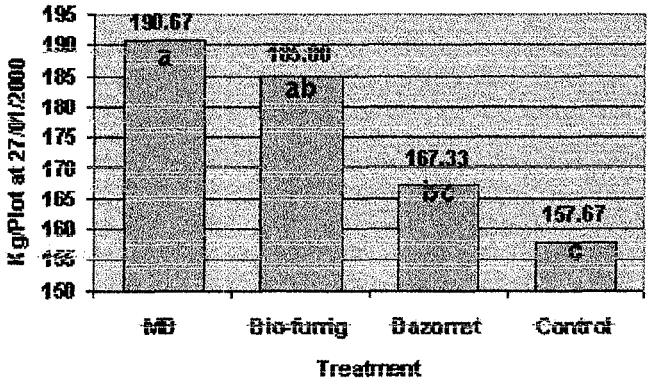


Fig. 12. Tomato yield. Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, signification level is 5%.

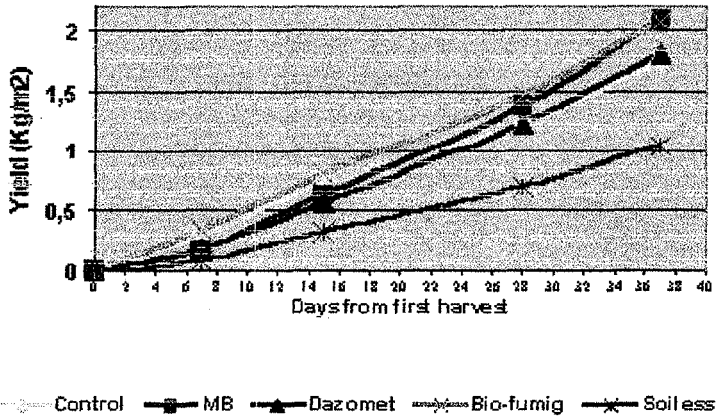


Fig. 13. Tomato yield, temporal series. Treatment is not directly comparable with the other treatments because the soil-less trial was replanted at middle season.

CONCLUSIONS ON ALTERNATIVES TO MB IN VEGETABLES

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

1) Under the conditions of Syria, viable alternatives were found to replace Methyl Bromide in protected vegetable crops.

2) Attending to the effect on soil-borne pathogens and pests, the fumigant Dazomet was found almost as effective as Methyl Bromide.

3) Attending to the vigor and yield of the crop, the Bio-fumigation treatment could represent an alternative method to Methyl Bromide to be used for soil treatment.

4) Bio-fumigation is a treatment method that is friendly to the environment and to the ozone layer and should be recommended to replace Methyl bromide application.

5) Other alternatives to MB that are in use with success in other parts of the world i.e. other fumigants, steam sterilization using negative pressure and soilless cultivation, could be also considered viable alternatives to substitute MB in Syria.

6) It is understood that no a single alternative is valid to replace Methyl Bromide in all uses and situations. The alternatives adopted shall be included and be a part of an Integrated Pest Management program that utilizes pest monitoring techniques, establishment of pest injury levels and mix of strategies and tactics to prevent pest problems in an environmentally sound and cost-effective manner.

SECTION THREE

ALTERNATIVES TO THE USE OF MB IN CUT FLOWERS

TRIAL DESIGN FOR CUT FLOWERS

The trial was conducted in two plastic tunnels of 400 m^2 (a total of 0.8 Syrian Dunums), each tunnel was divided in two sectors with four growing beds per sector. The experimental design consisted of four completely randomized blocks (2 in each tunnel) with 4 treatments and one replicate per block. Each plot had an area of 28 m^2 (1.2 x 23 m) containing *c* 1000 carnation plants. The two tunnels were planted with carnations on the first week of April 1999. Before any treatment was applied, soil samples were taken randomly from each of the four sectors (two tunnels) and analyzed to study the physical and chemical properties of the soil.

Treatments

The treatments were applied during the third week of August after the preparation of the soil. Samples were taken on March 1999 for analysis. The treatments were as follows:

O. Control

A- MB (28 g/m^2)
One can of 680g MB for each 25 m^2 of soil surfaces under plastic covers.

B- Soil Steaming
Using equipment made in Syria

C- Metam Na
750 L/ha (75 cm^3/m^2 in 7 liter of water)

Trichoderma commercial preparation was added to the B and C treatments (7.5 g / plot) before planting.

Trial layout

The trial layout in the tunnels is shown in figure 14.

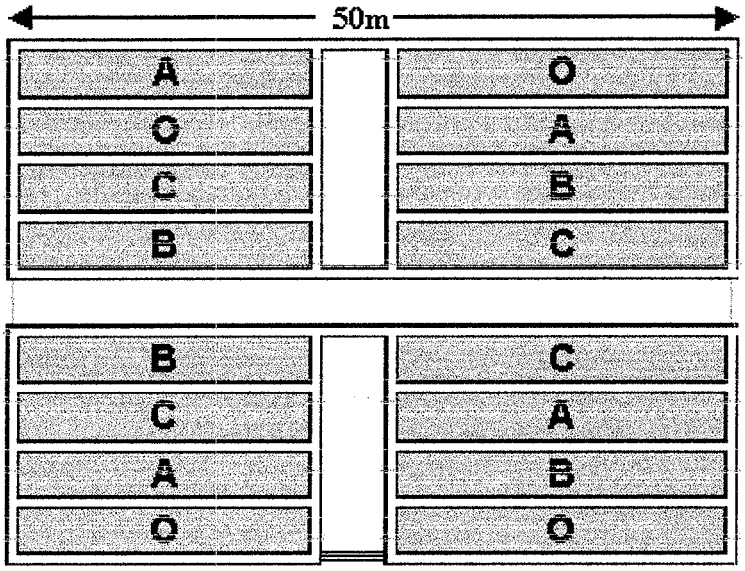


Fig. 14. Layout of the cut flower trial

Soil characteristics

On March 1999, soil samples were taken from the two tunnels to determine the main soil characteristics. The soil was collected from 25 randomly selected spots per tunnel from three different depths (0-20 cm, 20-40 cm and 40-60 cm). The soil from each depth was mixed to obtain a representative composite sample from each depth in each tunnel. The samples were then transported to the laboratory where they were air-dried and analyzed.

The results showed that the soil is a clay loam in texture with high percentage of organic matter as compared with other soils from the area (mainly due to the addition of organic matter by the farmer). The percentage of calcium carbonate is high (30.5%). The soil pH is neutral to weak alkaline. The electrical conductivity is normal except the samples from top layer which was relatively high, probably due to chemical fertilization. The detailed results are listed in Table 11.

Depth	pH	EC 1:5 (dS/cm)	CaCO3 (%)	O.M. (%)	Sand	Silt	Clay
0-20	7,48	0,42	9,00	2,53	54,50	11,50	34,00
STD	0,11	0,00	2,83	0,35	0,71	0,71	1,41
20-40	7,68	0,17	28,75	2,68	40,00	16,25	43,75
STD	0,04	0,01	2,47	0,02	1,77	1,77	0,00
40-60	7,65	0,20	27,50	2,68	39,63	16,50	43,88
STD	0,07	0,06	0,71	0,35	2,30	2,12	0,18

Table 11. Results of soil analysis in the cut flower trial

EFFECT OF TREATMENTS ON PESTS & DISEASES

In addition to the sample collected in March 1999 for the study of soil characteristics, another two sampling periods were established to determine the effect of the treatments on the soil population of Weed, Bacteria, Fungi, Nematodes and Arthropods. In resume, 3 sampling periods were studied:

1. Before the treatments (March 1999)
2. After the treatments (May 1999)
3. At the end of the crop (January 2000).

Weeds

After conducting seed germination trails in the laboratory, seven different broad leaf weed and two grasses species were found in the soil from the four tunnels (Table 12)

Broad leaves	Grasses
Amaranthus retroflexus L.	*Poa annua* L.
Anagalis arvensis L.	*Setaria glauca* L.
Cichorium intybus L.	
Cyperus rotundus L.	
Geranium pratense L.	
Stellaria media L.	
Veronica orvensis L.	

Table 12. Weed species found in the cut flower soil

In the samples made after the treatment, the results from the laboratory germination of weed seeds in soil samples showed high weed control in all the treatments in the upper soil layer (0-20 cm) compared to the control. There were no significant differences between the treatments at the other soil depths but for the Metam Na treatment at the deepest layer (40-60 cm). This indicates that all the alternative treatments were equally effective in controlling weeds at the depth of 0-20 cm and that the only treatment that could be considered as effective bellow this depth was Metam Na..

The results from the germination of weed seeds in soil samples collected at the en d of the trial (January 2000), showed no significant differences between the four different treatments. However, the steam treatment showed the lowest observed number of germinating seeds. There were no differences between the three different depths studied.

Detailed results are shown in Table 13 & Figure 15.

	Germinating weed seeds/m^2		
Depth (cm)	**0-20**	**20-40**	**40-60**
Before T. (March 99)	273.00	1690.50	1192.50
After T. (May 99)			
O – Control	214.50 a	197.00 a	30.25 a
A – MB	43.50 b	122.75 a	39.25 a
B – Steam	30.50 b	118.25 a	30.25 a
C – Metam Na	0.00 b	83.00 a	0.00 b
After T. (January 00)			
O – Control		46.33 a	
A – MB		38.17 a	
B – Steam		16.50 a	
C – Metam Na		31.50 a	
Depth			
0-20		32.44 a	
20-40		32.69 a	
40-60		33.88 a	

*Numbers followed by the same letter are not significantly different at level of 5% (LSD test).

Table 14. Mean number of germinating weeds/m^2 seeds in the treatments and tree soil depths.

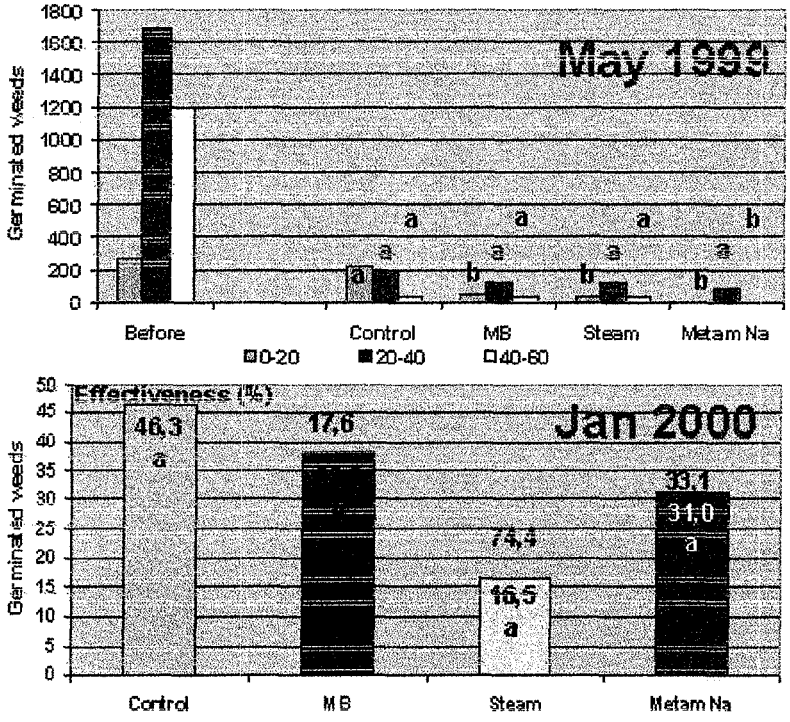


Fig. 15. Seed germination trials, germinated weeds (weed/m^2), Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, at level of 5%.

Nematodes

Twenty-three genera of nematodes were found in the soil surrounding the carnation roots. Samples were taken from the field and transported to the lab in a cooler. 50 gram of soil from each composite sample was extracted in a Berman funnel for 24 hours. The nematodes collected were fixed in TAF solution and identified using a light microscope. The nematode genera were divided in three trophic groups according to their feeding habits (Table 15).

Plant Parasitic	Plant & Fungi Feeding	Free Living
Trichodorus	*Aphelenchus*	*Chiloplacus*
Pratylenchus	*Aphelenchoides*	*Mononchus*
Tylencorhynchus	*Paraseinura*	*Pelodera*
Helinctoylenchus		*Panagrolaimus*
Tylenchus		*Eudorylaimus*
Ditylenchus		*Eucephalobus*
Macroposthonia		*Plectus*
Hemicriconemoides		*Rhabditis*
Xiphinema		*Acrobeles*
		Cephalobus
		Dorylaimus

Table 15- Nematodes found in the soil associated with carnation crop at the cut flower trial site.

When comparing the means obtained after treatments for the Plant parasitic and fungi feeding nematodes, the results show that there were no significant differences between the treatments at the level of 5%. The free-living nematodes were significantly higher in the top soil layer (0-20 cm) in the Steaming treatment. At the depth of 20-40 cm in the soil there were no significant differences between the control and the treatments. The highest reduction occurred in the plots treated with Metham Na. The total number of nematodes was significantly higher in the steam treatment at the depth of 0-30, and all treatments reduced the number of nematodes in the 20-40 cm soil layer as compared with the control. The results suggest that at the depth of 20-40 cm all treatments were equally effective in reducing the total number of nematodes. The Steam treatment promoted the appearance of free living nematodes in the soil which in turn may be giving a beneficial effect by enhancing and maintaining soil biodiversity and preventing the occurrence of diseases in the crop.

After the crop (January 2000), the plots treated with Steam showed the lowest number of plant parasitic nematodes, while those treated with Metam Na had the highest number of free living nematodes. Regarding soil depth, most nematodes are located in the top soil layers but the plant parasitic that are equally distributed through the soil profile.

The data for this study is shown in Tables 16 & 17 and graphically in Fig. 16.

	Plant Parasitic			Fungi Feeding			Free Living			Total		
Depth	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Before	51.76	35.82	41.10	30.24	19.27	29.03	268.79	378.89	219.87	350.79	433.98	290.00
Control	23.18 a	44.32 a	22.32 a	35.40 a	23.79 a	19.72 a	788.90 ab	366.37 a	82.96 a	847.50 b	434.50 a	125.00 a
MB	79.10 a	48.02 a	16.44 a	88.12 a	38.39 a	18.20 a	261.42 a	116.43 b	61.32 a	428.50 b	192.84 b	96.00 a
Steam	104.07 a	55.03 a	53.10 a	220.71 a	24.85 a	8.29 a	1268.4 a	122.61 b	71.77 a	1593.2 a	202.50 b	133.2 a
Metam Na	55.54 a	38.70 a	42.68 a	168.07 a	18.78 a	24.91 a	281.37 b	73.12 c	90.10 a	494.50 b	130.70 b	157.70 a

*Numbers followed by the same letter in the same column are not significantly different at level of 5% (LSD test).

Table 16. Nematodes in the cut flower trial before (March 1999) and after (May 1999).

Treatments	Fungi Feeding	Plant Parasitic	Free living	Total
O – Control	11.42 a	15.92 a	35.83 b	63.17 ab
A – MB	12.33 a	16.75 a	34.83 b	63.92 ab
B – Steam	11.42 a	5.33 b	36.00 b	52.75 b
C – Metam Na	12.42 a	15.58 a	64.08 a	92.25 a
Depth				
0-20	19.56 a	14.25 a	64.50 a	98.31 a
20-40	8.44 b	15.81 a	26.63 b	50.13 b
40-60	7.69 b	10.13 a	36.94 b	55.63 b

*Numbers followed by the same letter not significantly different at level of 5% (LSD test).

Table 17. Nematodes in the cut flower trial after the crop (January 2000).

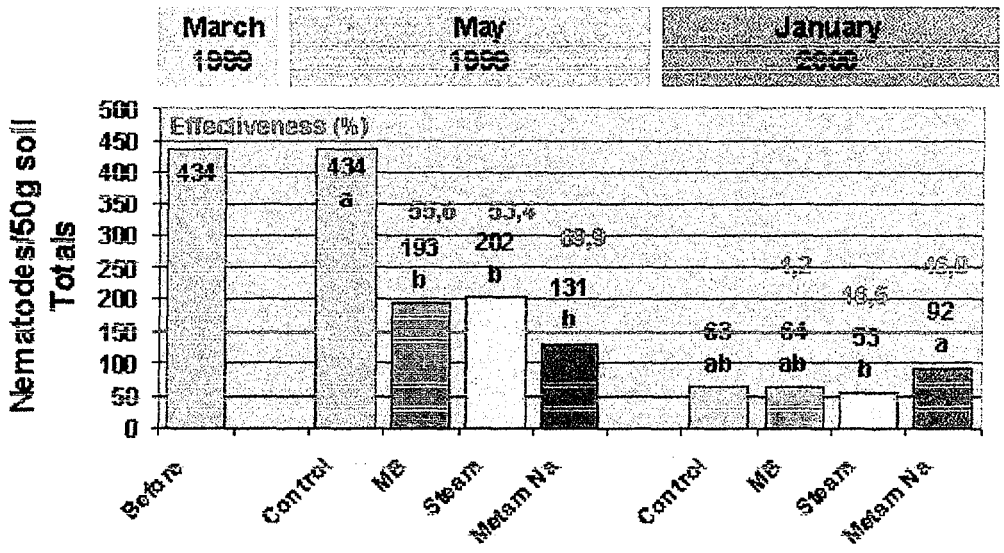


Fig. 16. Nematode counts (50g/soil) during the three sampling periods. Data shown for the sampling periods March and May 1999 corresponds to the nematodes in the middle soil layer.), Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, at level of 5%.

Bacteria

Total bacterial counts were performed using LPGA media. Three Petri dishes were used for each dilution. 130 isolates were chosen from the colonies grown in the total count experiment. The isolates were chosen according to its color, shape, diameter, growth rate, and other characters. These isolate were picked up from the media to perform the following tests:

1-Gram pigment test: 45 of the isolate were gram-positive and 46 were gram-negative.

A-20 gram positive isolates were picked up and identified, belonging to the following genera:

Bacillus
Nocardia
Streptomyces

2-Respiration test: this test was performed using Heigh & Leifson media, to identify Entrobacter and Non Entrobacter bacterial groups.

3-Identification of bacteria: The method of API 20 was used utilizing API ZONE test kit, to identify Non Entrobacter bacteria.

The identified bacteria are listed in table 18.

	Bacterial species	Number of isolates
1	*Flavimonas oryzihabitans*	1
2	*Pseudomonas fluorscens*	4
3	*Pasteurella haemolytica*	1
4	*Agrobactirum rodiobacter*	1
5	*Brenundimonas vesicularis*	2
6	*Chrysomonas indologens*	1
7	*Psychrobacter phenylpur*	1
8	*Aeromonas salmonicida*	2
9	*Pseudomonas alealigens*	1
10	*Raoraxella spp.*	2
11	*Pasteurella spp.*	1
12	*Acinetobacter baumonnii*	1
13	*Burkholdecia apacia*	1
14	*Chrysomonas luteola*	1
15	*Pseudomonas putida*	1
16	Uknown	6

Table 18. Bacteria identified in the cut flower trial

The results of the bacterial count showed no significant differences between the treatments and the control at any of the soil depths studied. that the treatments are affecting the population of bacteria in the soil. However, it is appreciated that there is a certain reduction of bacteria in the upper layer

of the soil in the MB and Metam Na treatments as compared with the control, suggesting that those treatments may be affective in reducing the number of bacteria in the soil. No differences are appreciated between the control and the Steam treated plots, this could be explained by the no residual effect of the steam treatment.

After the crop (January 2000), the MB treated plots showed a significant lower number of bacteria than the control plots, while there were no significant differences with the other treatments. There were no significant differences between the bacteria counts at the three soil depths studied.

Detailed results are shown in Table 19 & Figure 17.

Treatments	0-20	20-40	40-60	Total
Before (03/99)	$147x10^6$	$41x10^6$	$72x10^6$	$260x10^6$
After T. (05/99)				
O – Control	$114.75x10^6$ a	$60.50x10^6$ a	$56.00x10^6$ a	$231.25x10^6$ a
A – MB	$66.25x10^6$ a	$45.00x10^6$ a	$23.25x10^6$ a	$134.50x10^6$ a
B – Steam	$158.00x10^6$ a	$63.00x10^6$ a	$30.00x10^6$ a	$251.00x10^6$ a
C – Metam Na	$67.25x10^6$ a	$41.75x10^6$ a	$32.50x10^6$ a	$141.5x10^6$ a
After T. (01/00)				
O – Control				$51.30x10^6$ a
A – MB				$31.30x10^6$ b
B – Steam				$40.40x10^6$ ab
C – Metam Na				$39.1x10^6$ ab
Depth				
0-20				$41.90x10^6$ a
20-40				$43.10x10^6$ a
40-60				$36.50x10^6$ a

*Numbers followed by the same letter not significantly different at level of 5% (LSD test).

Table 19. Bacteria counts in LPGA media, cut flower trial (Counts/g dry soil).

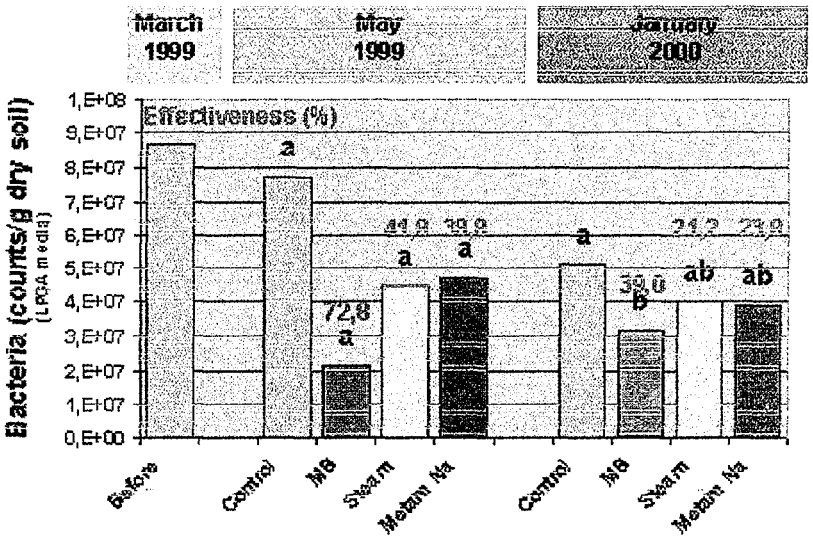


Fig. 17. Total bacteria counts in LPGA media (Counts/g dry soil).), Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, at level of 5%.

Fungi

The composite soil samples were air-dried and mixed thoroughly. 5-gram soil sub-sample from each replicate was mixed with 50-ml sterile water. The solution was diluted three times and 5 ml from the original dilution was taken and mixed with 45 ml of sterile water. One ml of the final solution was seeded on a PDA+ antibiotic media in Petri dish. 3 replicates were done for each sample. The fungi colonies were counted and identified. 7 of these fungi were saprophyte (*Rhizopus, Aspergillus, Penicillium, Hormodendrum, Hoplosporagium, Gliocladium,* and *Cladosporium).* 3 were plant pathogens (*Rhizoctonia, Alternaria, and Fusarium*). 1 (*Trichoderma*) was a BCA added to the soil as part of the IPM program.

After the treatments (May 1999), the results pointed out that the fungal CFU's decrease with the soil depth. The Steam and the Metam Na treatment were equally effective in reducing fungi spores at the top soil layer as compared with the control. The effect on CFU's observed in the MB treatment was not significant different to that in the control and the alternative treatments. There were no a significant difference between the control and the treatments at the other soil depths.

The results obtained during the sampling period done at the end of the crop (January 2000), show that less fungi CFU's were present in the plots treated with MB compared with the control and the steam treatment. There was no significant difference between the effect of MB and that of Metam Na in reducing soil fungi CFU's. There were significantly more fungi propagates in the top layer of the soil. Detailed results are shown in Table 20 & Figure 18.

Treatments	0-20	20-40	40-60	Total
Before (03/99)	61500	73600	62000	65700
After T. (05/99)				
O – Control	78160 a	36880 a	24730 a	46590
A – MB	54830 ab	34000 a	19200 a	36010
B – Steam	34900 b	34000 a	24750 a	31217
C – Metam Na	29180 b	22450 a	18480 a	23370
After T. (01/00)				
O – Control				34413.42 a
A – MB				15103.67 c
B – Steam				25914.92 ab
C – Metam Na				23331.58 bc
Depth				
0-20				36618.38 a
20-40				22497.50 b
40-60				14956.81 b

*Numbers followed by the same letter not significantly different at level of 5% (LSD test).

Table 20. Fungi counts in PDA media, cut flower trial (CFU's/g dry soil).

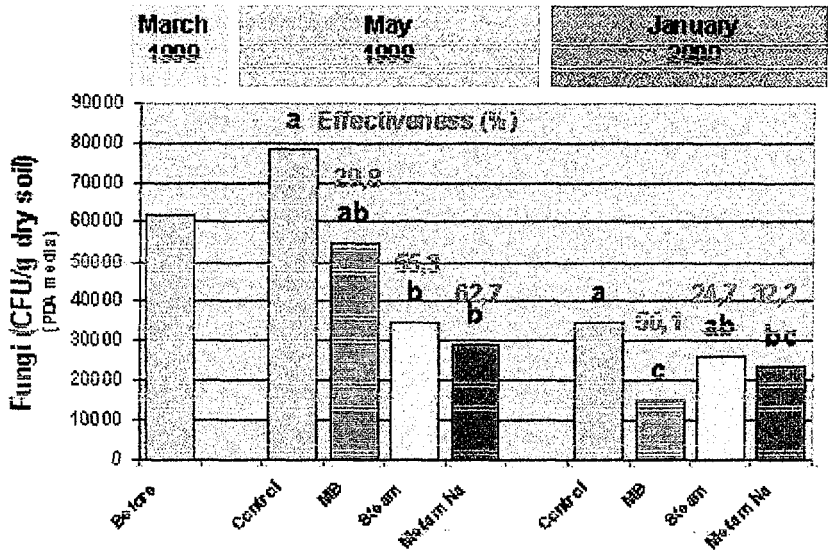


Fig. 18. Fungi counts (CFU's/g dry soil) during the three sampling periods. Data shown for the sampling periods March and May 1999 corresponds to the CFU's in the upper soil layer.), Treatments with the same letter are not significantly different according to a Duncan´s Multiple Range Test, at level of 5%.

Arthropods

A 500-gram of soil composite sample was obtained from each replicate. The samples were placed in Berlese funnels for 48 hours under 40 watt electrical lamp. The arthropods from the samples were collected in small jars filled with alcohol and a drop of glycerin. The total number of mites and insects in each sample was recorded and the Arthropods were identified to the order taxa. Few insects were found in the soil (Coleoptera, Diptera, Collembola, and Himeptera) and most of the arthropods were found to be mites (Astigmata, Cryptostigmata, and Mesostigmata).

After the treatments, the result shows that there were no significant differences between the treatments in the number of arthropods between the control and the treatments in the top soil layer (0-20 cm). In the middle soil layer (20-40 cm), a significant higher number of arthropods were found for the Metam Na treatment as compared with the control and the other treatments. In the deepest soil layer (40-60 cm), significantly less arthropod were found in the plots treated with Metam Na, whereas the MB and the Steam treatment showed a higher number of arthropods.

After the crop (January 2000), no significant differences were found between the treatments or the soil depths studied.

Detailed results are shown in Table 21 & Figure 19.

Treatments	0-20	20-40	40-60	Total
Before (03/99)	17.0	8.5	32.0	19.2
After T. (05/99)				
O – Control	24.0 a	5.0 b	5.0 b	11.3
A – MB	8.8 a	3.0 b	8.5 a	6.8
B – Steam	7.5 a	9.5 b	7.3 ab	8.1
C – Metam Na	2.5 a	27.5 a	2.5 c	10.8
After T. (01/00)				
O – Control				3.17 a
A – MB				1.92 a
B – Steam				1.25 a
C – Metam Na				1.50 a
Depth				
0-20				2.81 a
20-40				1.75 a
40-60				1.31 a

*Numbers followed by the same letter not significantly different at level of 5% (LSD test).

Table 21. Arthropods counts, cut flower trial (Nr./500 g dry soil).

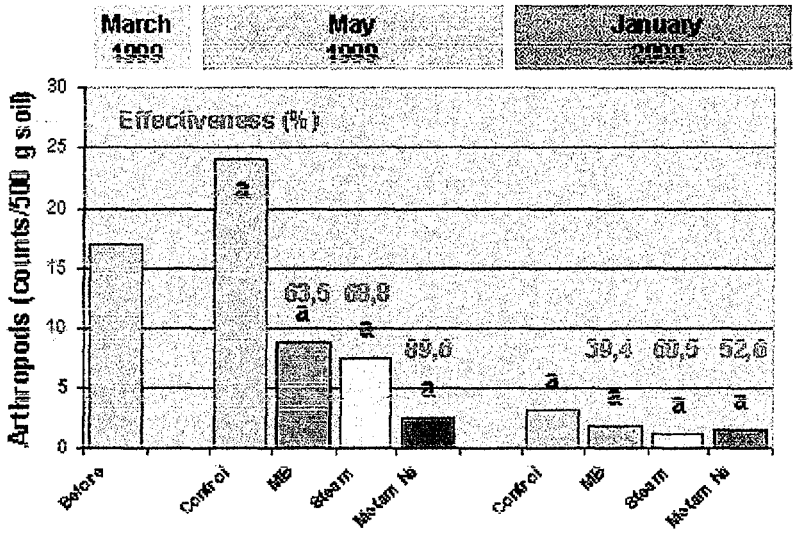


Fig. 19. Arthropod counts (Counts/ 500 g soil). Data shown for the sampling periods March and May 1999 corresponds to the arthropods counted in the upper soil layer), Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test, at level of 5%.

EFFECT OF TREATMENTS ON PLANT VIGOR AND YIELD

Plant vigor and yield

The vigor and yield of the plants in the four different treatments was estimated by recording the carnation plant height and the average number of buds and flowers that each plant was wearing just before the harvest started and every harvest day.

The average height of twenty plants was measured from each replicate and compared among the four treatments. Although there were no significant differences between the control and the treatments, it was clearly observed that the plants grown in all treated plots were higher than in the control plots, with the Steam treatment performing best (Fig. 20). Also it was observed that , at the beginning of the crop, the growth of the plants in the Steam treated plots was faster than in the other treatments and that in these plots harvest start earlier (Fig. 21).

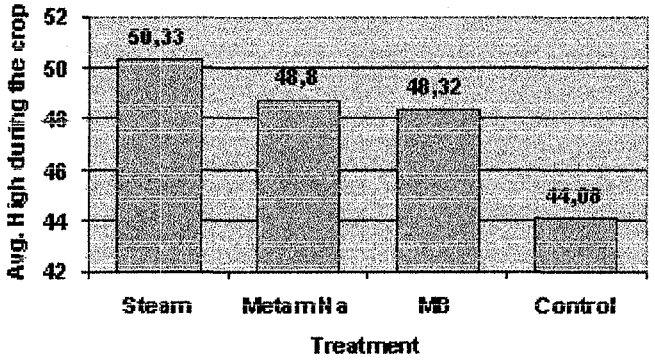


Fig. 20. Carnation average plant high (cm) during the crop at the cut flower site.

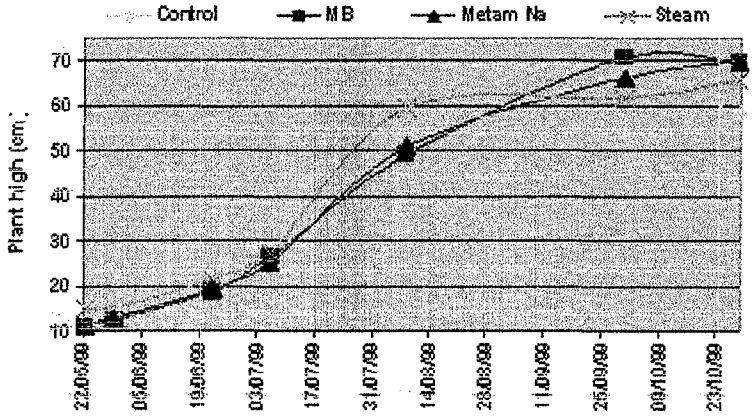


Fig. 21. Carnation average plant high (cm) until harvest started, Time series.

Before harvest started, the plants in the Metam Na treated plots wear the highest number of carnation buds and open flowers, this treatment was followed by MB, Steam and control (Figs. 22 & 23). As an average, during harvest, more flowers were observed in the Metam Na and MB treated plots (Fig. 24).

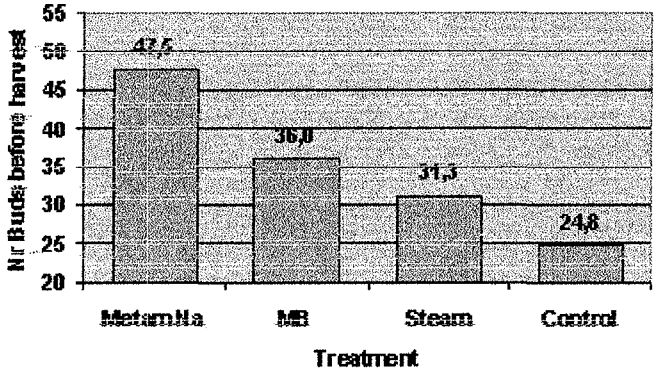


Fig. 22. Maximum number of carnation buds before harvest started (Mean of the four replicates).

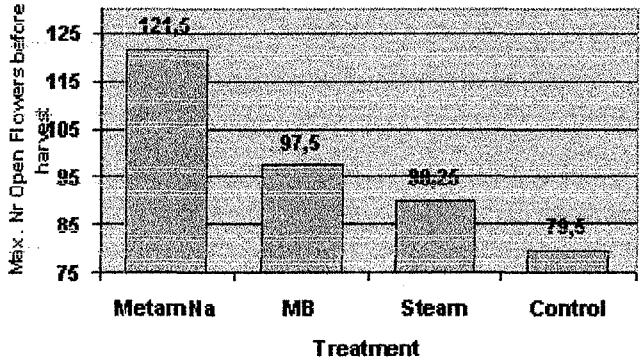


Fig. 23. Maximum number of open flowers before harvest started (Mean of the four replicates).

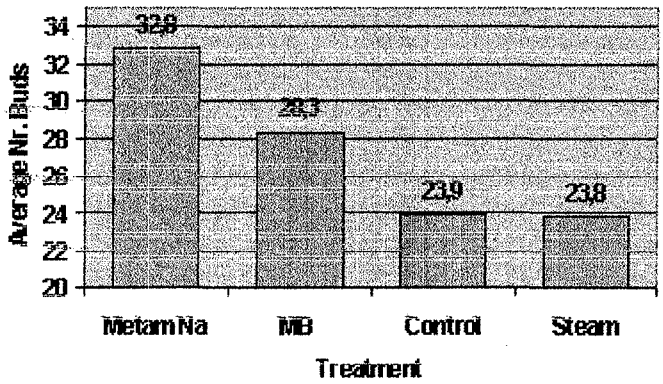


Fig. 24. Average number of carnation buds during each harvest day

CONCLUSIONS ON ALTERNATIVES TO MB 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 The Syrian Arab Republic, we may conclude that:

1) Under the conditions of Syria, viable alternatives were found to replace Methyl Bromide in cut flower crops.

2) Taking into consideration the effect on soil-borne pathogens and pests, and the vigor and yield of the crop, the alternatives tested were found almost as effective as Methyl Bromide.

3) The alternatives tested are friendly to the ozone layer and safer to the environment, in that respect should be recommended for soil treatment and to replace Methyl bromide application.

4) Other alternatives to MB that are in use with success in other parts of the world i.e. other fumigants, steam sterilization using negative pressure and soilless cultivation, could be also considered viable alternatives to substitute MB in Syria.

5) It is understood that no a single alternative is valid to replace Methyl Bromide in all uses and situations. The alternatives adopted shall be included and be a part of an Integrated Pest Management program that utilizes pest monitoring techniques, establishment of pest injury levels and mix of strategies and tactics to prevent pest problems in an environmentally sound and cost-effective manner.