OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

23699

Ministry of Agriculture and Land Reclamation
Agricultural Research Center
Plant Pathology Research Institute

Contract 2005/125
between ARC and UNIDO

Final Report
on Methyl Bromide Phase-out
In Egypt

Dr. Nagi M. Abou-Zeid
Technical Supervisor
Plant Pathology Research Institute

June 2009

Contents

Contractor's Personnel

Names and Project Function of the Contractor's Key Personnel

Name	Project Function
Prof.Dr. Ayman F. Abou-Hadid	Horticulture Expert
Dr. Sami Gaafar	Grafting Expert
Dr. Usama Ahmed El-Behairy	Soilless culture Expert
Dr. Mahmoud Abdallah Medany	Solarization Expert
Dr. Nagi Abou-Zeid	Plant Pathologist
Dr. Magdy El Hariri	Entomologist

List of the Participants companies:

1. Agrotech Company
2. Central Laboratory for Agricultural Climate (CLAC), Agric Res. Center.
3. Egyptian Group for Development Company.
4. Farm Frites Company.
5. Mafa (Magrabi Agriculture Company).
6. Pico (Modern Agriculture Company).
7. Technogreen for Agricultural Investment.
8. Zein El-Din Company.

Introduction

Methyl bromide (MBr) is an essential soil fumigant for a good vegetable production in many private sector's companies in Egypt. It is applied as a pre-planting fumigant for controlling major soil-borne pests including fungal pathogens, root-knot nematodes and weeds in most vegetables such as cantaloupe, cucumber, lettuce, pepper, strawberry and tomato.

Due to the deleterious effects of MBr on the environment and human-being, the Montreal Protocol was issued in 1997 banning MB gradually, with the a complete phase-out by 2005 for the developed nations, and 2015 for the developing nations.

In this regard, the Agricultural Research Center (ARC) at Giza signed the Contract # 2005/125 with the United Nation Industrial Development Organization (UNIDO) in order to introduce alternatives that are safer than MB to the agricultural uses aiming to reduce the amount of MBr by 40:60 metric tons per year. Several alternatives were chosen to replace the reduced amount of MB such as soil solarization, biofungicides (Bioarc and Biozeid), ozone non-depleting fumigants (Basamid and Metam Sodium), and Virtually Impermeable Films (VIF). Such alternatives have been applied on some vegetables produced by certain agricultural companies through this project. These companies are Agrotech, Egyptian Group, Farm Frietz, Mafa, Pico, Technogreen, and Zein El-Din in addition to the Agric Res Center.

The proposed work plan for the season of 2008/2009 includes the following methyl bromide alternatives:

1. Soil Solarization.
2. Soil Solarization + (Bioarc + Biozeid at the rate of 216 kg/ha each).
3. Soil Solarization + Basamid (at the rate of 50 g/m^2).
4. Soil Solarization + Metam Sodium (at the rate of 100 ml/m^2).
5. Methyl Bromide (at the rate of 25 g/m^2) + VIF.

It is noteworthy to mention that selection of the 2009 – season treatments was based on the results of the two previous seasons to maximize the effect of the alternatives. For example the biofungicides (Bioarc& Biozeid) were use in combination (half dose each) to allow their two mechanisms to work together on the phyto–pathogenic soil–borne microorganisms. Also, combining the selected alternatives with the soil solarization was to enhance their efficiency.

Background

1. Soil Solarization:

Solarization is a method in which clear plastic is laid on the soil surface to trap solar radiation and heat the soil. Solarization as a pre-plant soil treatment to control soilborne pathogens and pests can be a viable alternative to methyl bromide for shallow-rooted, short-season crops (Katan and DeVay 1991, Stapleton 1996). Solarization traps solar radiation, and thereby heat, in the soil in order to raise temperatures sufficiently to suppress or eliminate soil-borne pests and pathogens (Katan 1981 and 1991). It can be effective against a broad spectrum of soil diseases, fungi, weeds, nematodes, insect pests and most soilborne bacteria. Solarization also causes complex changes in the biological, physical, and chemical properties of the soil that improve plant development, growth, quality, and yield for up to several years (Stapleton 1994, Katan 1981 and DeVay *et al.* 1990). In areas with a suitable climate, solarization can be used alone, or in combination with lethal or sublethal fumigation or biological control, to provide an effective substitute to methyl bromide (Hartz *et al.* 1993). In addition to disinfecting the soil while reducing or eliminating the need for fumigants, solarization leaves no toxic residues, increases the levels of available mineral nutrients in soils by breaking down soluble organic matter and making it more bio-available, changes the soil microflora to favor beneficial organisms, conserves water, and can serve as a mulch when maintained as a row cover during the growing season (Stapleton 1994, Katan and DeVay 1991). However, solarization appears only to be effective in warm climates and requires that cultivated land be left fallow for short periods of time (Katan and DeVay 1991).

2. Biofungicides:

Effective biological control of soilborne pests has been a challenge to agricultural researchers, for many years. Several studies have been done in the past decade using biological control agents, also known as antagonists, for controlling soilborne diseases (Anonymous, 1997a; Anonymous, 1998b; Bull and Ajwa, 1998; Eayre, 1996; Martin and Bull, 2000; Zehnder *et al.*, 1997). Biofungicides do not fully replace MB but work well in the framework of an integrated pest management strategy (Gianessi, 1998). In the past decade, many biological control agents have been registered with USEPA for use on crops to control disease (Lumsden *et al.*, 1996; Maliekal *et al.*, 1998; Warrior, 1996). These microbial products are categorized as "biopesticides" by pesticide registration agencies. Currently in California, there are twenty-one biopesticides registered for use (CA Department of Pesticide Regulation, Sept 2000). These range from the well-known biocontrol agent *Agrobacterium radiobacter*, a bacterium used in biocontrol of crown gall to *Trichoderma harzianum*, a fungus used to control soilborne diseases of strawberries and other crops. *Trichoderma* spp. are well studied, efficient mycoparasites that perform best in moist, somewhat acidic soil (Cook and Baker, 1989). In a strawberry trial, addition of *Trichoderma* sp. to soil treated with ozone gas decreased *Verticillium* wilt in the first year, but this was not repeated the following year (Pryor, 1999). Only a few microbial-based biological control agents are registered for soil applications and are potential partial alternatives to methyl bromide. None have the broad biocidal spectrum of MB but could be useful as part of an integrated pest management system.

3. Basamid:

Basamid, a chemical soil disinfectants registered in the United States for use on forest tree seedling nurseries, is a technically feasible and cost-effective chemical alternative to methyl bromide. When applied to moist soils, the pesticide's active ingredient (tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione) breaks down into methyl isothiocyanate, and has a broad spectrum of effectiveness against soilborne pests including nematodes, fungi and weeds (McElroy 1985, Pennington 1995). Basamid offers advantages over existing soil sterilizing procedures or chemicals because it is relatively safe, economical, and easy to use. In addition, environmental degradation is rapid with a half life of less than 24 hours under favorable conditions.

In experimental and commercial applications, Basamid has been shown to be an effective preplant soil treatment. In tree seedling nurseries, Basamid can effectively control a number of soil-borne pests that affect tree seedlings including root-knot nematodes (*Meloidogyne incognita*), black root rot caused by *Thielaviopsis basicola*, and black shank (*Phytophthora parasitica* f.sp. *nicotianae*) (Miner and Worsham 1990). In addition, by using Basamid, growers can achieve levels of tree seedling emergence and suppression of *Fusarium oxysporum* that are comparable to levels observed for seedlings treated with methyl bromide (Littke 1994). Basamid was shown to be effective compared to methyl bromide/chloropicrin in controlling several varieties of soil-borne fungi and nematodes in a series of tests conducted in Kingston, Washington. Although both Basamid and methyl bromide/chloropicrin controlled *Pythium* and *Fusarium*, only Basamid was completely effective against *Phytophthora*, reducing populations to 2.3 propagules /g of soil, compared to the control level of 243. In addition, Basamid was shown to significantly reduce seedling mortality, while increasing overall quality (McElroy 1985).

4. Metam Sodium:

Metam sodium is an infinitely water soluble preplant soil fumigant. When combined with water, Metam sodium rapidly decomposes into its bioactive chemical, methylisothiocyanate (MIT). MIT is highly volatile and is found in all three phases of the soil-water-air system . Many researchers have cited metam sodium as a potential alternative to methyl bromide fumigation, and metam sodium's low cost and wide-range of control makes it a strong candidate for fumigation on many crops (Braun and Supkoff 1994, Noling and Becker 1994, Yarkin 1994). Metam sodium is registered for use in controlling a wide array of soil-borne pests, and can be used to control weeds, nematodes (e.g. root knot, lesion, dagger, lance, needle, pin, reniform, stunt, stubby root, sting, spiral), and soil diseases caused by species of *Rhizoctonia*, *Fusarium*, *Pythium*, *Phytopthora*, *Verticillium*, *Sclerotinia*. Metam sodium is also useful in Integrated Pest Management systems, as it can be used in conjunction with resistant varieties, improved sanitation techniques, biological control agents, and soil pasteurization (i.e., solarization, hot water or steam) (Noling and Becker 1994).

In the production of tomatoes in southwest Florida, Fusarium crown and root rot has been the most prevalent soilborne disease. Metam sodium has been demonstrated to significantly reduce crown rot incidence and when combined with solarization, control was equivalent to methyl bromide + chloropicrin (McGovern *et. al.* 1996).

5. Virtually Impermeable Films (VIF Plastic Mulch):

Virtually impermeable films (VIF) or mulches, allow very little methyl bromide and other fumigant gases to pass through it, and as the name implies, are virtually impermeable. These VIF mulches are typically multi-layer films composed of barrier polymers such as ethylene vinyl alcohol (EVOH) or polyamide (nylon) sandwiched between other polymer layers that keep the barrier polymers from swelling. Compared to low-density polyethylene (LDPE) mulches, the most commonly used plastic mulches in agricultural practices (0.6 to 1.4 ml thick); certain VIF's are over 20,000 times less permeable to MB and other fumigant compounds (Noling, 2005). This advantage helps reducing the MB application rates to their halves or less. It is noteworthy that all the used MBr-alternatives are registered and used in Egypt.

Materials and Methods

1. Soil Sampling for Detection of the Phytopathogenic Fungi and Plant Parasitic Nematodes:

Samples were collected from soil before and after the implementation of MBr alternatives. Four sub-samples, 1 kg each, were randomly collected from 4 different spots in each area for each designated treatment. Soil was collected from a depth of 10-20 cm. The collected sub-samples were thoroughly homogenized. A portion (about one kg) of the sub-sample homogenate was put in a plastic bag and carefully labeled on the out side with a permanent marker. Each bag represented one replicate. Four replicates were used for each treatment. The bags were brought to the laboratory. The amount of soil in each bag was divided into 2 portions (500 g each). One portion was sent to the Mycology lab and the other was sent to the Nematology lab for isolation and estimation the number of the phytopathogenic fungi and root-knot nematodes respectively.

1.1. Detection of Phytopathogenic Fungi:

The four soil replicates were thoroughly mixed together, and then 10 g soil were taken, added to 90 ml of sterilized distilled water and mixed well using a vortex mixer. One ml was taken from the resulted soil slurry and diluted to 1:1000. One ml of the previous dilution was spread on Potato Dextrose Agar (PDA) plates' surface. The plates were incubated at 25 ± 2 °C. After 72 hrs, the recovered fungal colonies were identified and counted. The resulted fungi were identified by the staff members of the Mycology Department in the Plant Pathology Research Institute according to their morphological features using the compound light microscope.

1.2. Extraction of Nematodes:

The four soil replicates were thoroughly mixed together; then an amount of 250 g was taken and suspended in 2 volumes of water. The soil suspension was sieved through 60, 350, and 400 mesh sieves respectively. The collected suspension was transferred to Baermann plates and for 48 hr (Southey 1970, Magdy 2006). The resulting suspension of Baermann plates contains the juveniles of root-knot nematodes and other nematodes. The juveniles of root-knot nematodes were counted and identified according to their morphological features using the compound light microscope.

2. Soil Solarization:

Soil solarization was carried out according to the method given by Katan and DeVay (1991). The soil was disked, rototilled, turned over and raked smooth, then be leveled to provide and even surface and to help water penetrate and moistened the soil profile. Soil was moistened by pre-irrigation (surface irrigation) for not only makes microorganisms more sensitive to heat but it also conducts heat faster and deeper into the soil. Clear polyethylene plastic (45 μ thick) mulch was laid (by hand) on the soil surface. Very minimum of space was considered between the plastic mulch and soil surface to prevent air pockets that retard the soil heating process. The plastic mulch was left 6-8 weeks then removed and the soil allowed drying to a workable texture. The period of solarization was differed from company to another upon the companies' desire.

3. Application of biofungicides:

Both Bioarc® (*Bacillus megaterium* 25 x 10^6 cfu/g) and Biozeid® (*Trichoderma album* 10 x 10^6 spores/g) are biofungicides labeled on different crops in Egypt. Both biofungicides were used at the rate of 216 kg/ha each combined with soil previously solarized for 6-8 weeks. The application of biofungicides treatments were as the following:

An amount of 500 g of Bioarc, Biozeid or 250 g each (in case of their combination) was dissolved in 100 liters of water and left for 30-60 minutes. Roots of the proposed seedlings (cantaloupe, pepper, strawberries, and tomato) were sub-immersed in the previous solution for 5-10 minutes, then immediately transplanted. The recommended dose of each biofungicides/ha was divided into 3 equal sub-doses by weight. Each sub-dose was applied to the transplants as soil drench, 20-50 ml / seedling. The first dose was applied 10-15 days after seedlings transplanting and the second and third doses were applied after 30 and 45 days respectively.

4. Solarization + Basamid:

One of the potential alternatives for soil fumigation is Basamid granular (98%). It is a micro-granular formulation of the active ingredient Dazomet (tetrahydro-3, 5-dimethyl-2 H-1, 3, 5 thiadiazine-2-thione).

Soil was solarized for 4 weeks as previously mentioned earlier. Then, the plastic mulch was removed. The Basamid granular was incorporated into the upper layer (20-30 cm) of soil surface at the rate of 50 g/m^2. All the recommended safety precautions were taken into consideration. Drip irrigation lines were installed underneath the plastic mulch. After that, soil was covered properly with plastic mulch and left for 4 weeks. Soil was irrigated during this period if required; then plastic mulch was removed and soil was left for aeration before planting. Aeration periods differed from company to another.

5. Soil Solarization + Metam Sodium:

Metam sodium, (sodium methyl dithiocarbamate), is considered as a potential alternative to methyl bromide fumigation. Soil was solarized for 4 weeks as described earlier. Then the plastic mulch was removed. Metam sodium was applied via shank injection equipment which releases the fumigant at a same depth in the soil. This technique was applied in Mafa, and Farm Frites Companies. However, the soil texture in Farm Frites company was not suitable to perform shank injection technique. Also, another type of application was via drip irrigation system. This technique was applied in Agrotech, Farm Frites, the Egyptian Group, CLAC, ARC, Pico and Zein El-Din companies. Metam sodium in both applications was used at the rate of 100 ml / m^2.

6. Methyl Bromide + VIF:

Methyl bromide at the rate of 25 g/m^2 was combined with VIF. Field plot was prepared for cultivation by removing past crop residues, weeds or large soil clods. Drip irrigation lines were installed underneath the VIF plastic mulch. Then methyl bromide was injected then immediately covered with VIF plastic sheets.

Strawberry Nurseries in Pico and Technogreen Companies

The remaining amounts of basamid, methyl bromide and metam sodium of 2008 season in both Pico and Technogreen companies were applied in strawberry nurseries.

1. Pico:

Basamid and metam sodium were applied at the rate of 50 g/m^2 and 100ml/m^2 respectively then covered with VIF plastic mulch. Both treatments were applied in 0.84 and 1.68 ha respectively. A soil sample was taken from the treated areas before planting, at planting and one month after treatment's application. The percentages of soil borne pathogens (fungi and nematodes) were determined.

2. Technogreen:

Methyl bromide and metam sodium were applied at the rate of 50 g/m^2 and 100 ml/m^2 respectively then covered with VIF plastic mulch. Each treatment was applied in 0.84 ha. The percentage of soil borne fungi and rate of nematode gall index (RGI) on strawberry roots was determined.

THE EXECUTIVE WORK PLAN

For season(2008/2009)

Table 1: The executive work plan of Agrotech Company.

Crop	Cultivar	Treatment	Area/ha	Application Date	Covering period	Planting Date
Cucumber	Jadid	Soil Solarization+Basamid(50g/m^2)	1 green hs	21/8	3 wks	25/9
		Soil Solarization+Metam Sodium (100ml/m^2)**	1 green hs		3 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	1 green hs		3 wks	
		Methyl Bromide (25 g/ m^2) + VIF	1 green hs		3 wks	
		Basamid (50g/m^2)+VIF*	1 green hs		2 wks	
		Metam Sodium (100ml/m^2)+ VIF*	1 green hs		2 wks	
Cherry Tomato	522	Soil Solarization+Basamid(50g/m^2)	1 green hs	10/8	3 wks	15/9
		Soil Solarization+Metam Sodium (100ml/m^2)	1 green hs		3 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	1 green hs		3 wks	
		Methyl Bromide (25 g/ m^2) + VIF	1 green hs		3 wks	
		Basamid (50g/m^2)+VIF*	1 green hs		2 wks	
		Metam Sodium (100ml/m^2)+ VIF*	1 green hs		2 wks	
Bell Pepper	Nelson	Soil Solarization+Basamid(50g/m^2)	1 green hs	10/7	6 wks	1/9
		Soil Solarization+Metam Sodium (100ml/m^2)	1 green hs		6 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	1 green hs		6 wks	
		Methyl Bromide (25 g/ m^2) + VIF	1 green hs		6 wks	
		Basamid (50g/m^2)+VIF*	1 green hs		2 wks	
		Metam Sodium (100ml/m^2)+ VIF*	1 green hs		2 wks	

* Out of program treatment.
** Metam sodium was applied via drip irrigation.

Table 2: The executive work plan of CLAC, ARC.

Crop	Cultivar	Treatment	Area/ha	Application Date	Covering period	Planting Date
Bell Pepper	Reda	Soil Solarization	2 green hs	2/7	6 wks	15/8
		Basamid (50g/m^2)1+Soil Solsrization	3 green hs	10/7	4 wks	
		Soil Solarization +Metam Sodium (100 ml/m^2)*	2 green hs	10/7	4 wks	
		Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	2 green hs	10/7	4 wks	
		Methyl Bromide (25 g/ m^2) + VIF	1 green hs	10/7	2 wks	

Soil solarization treatment was lasted for 35 days then plots left fallow for planting date.
* Metam sodium was applied via drip irrigation.

Table 3: The executive work plan of The Egyptian Group Company.

Crop	Cultivar	Treatment	Area/ha	Application Date	Covering period	Planting Date
Cherry Tomato	Nasia	Soil Solarization+ Basamid (50g/m^2)	8 green hs	27/7	6 wks	20/10
		Soil Solarization+Metam Sodium (100ml/m^2)*	2 green hs		6 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	5 green hs		6 wks	
		Methyl Bromide (25 g/ m^2) + VIF	2 green hs		2 wks	

* Metam sodium was applied via drip irrigation.

Table 4: The executive work plan of Farm Frites Company.

Crop	Cultivar	Treatment	Area/ha	Application Date	Covering period	Planting Date
Strawberry	Festival	Soil Solarization	1.00	25/6	8 wks	23/9
		Soil Solarization+Basamid (50g/m^2)	0.68	15/7	4 wks	24/9
		Soil Solarization+Metam Sodium (100ml/m^2) *	0.68	15/7	4 wks	10/9
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	1.00	25/6	6 wks	24/9
		Methyl Bromide (25 g/ m^2) + VIF**	0.68	08/6	3 days	08/10

* Metam sodium was applied via drip irrigation

** VIF was removed 3 days after application of Methyl Bromide.

Table 5: The executive work plan of Mafa Company.

Crop	Cultivar	Treatment	Area/ha	Application Date	Covering period	Planting Date
Strawberry	Yael	Soil Solarization	2.08	23/5	8 wks	27/9
		Soil Solarization+Basamid (50g/m^2)	1.67	21/7	6 wks	5/10
		Soil Solarization+Metam Sodium (100ml/m^2)*	2.30	21/7	6 wks	6/10
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	5.42	23/7	6 wks	27/9
		Methyl Bromide (25 g/ m^2) + VIF	3.33	23/7	1 wk	29/9
Lettuce	Iceberg	Soil Solarization	0.42	23/5	8 wks	24/10
		Soil Solarization+Basamid (50g/m^2)	0.42	21/7	6 wks	
		Soil Solarization+Metam Sodium (100ml/m^2)*	0.42	21/7	6 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	0.42	23/7	6 wks	
		Methyl Bromide (25 g/ m^2) + VIF	0.42	23/7	1 wk	
Herbs		Soil Solarization	1.00	23/5	8 wks	3/8-12/9
		Soil Solarization+Basamid (50g/m^2)	1.04	21/7	6 wks	10/8-7/9
		Soil Solarization+Metam Sodium (100ml/m^2)*	4.17	21/7	6 wks	26/6-14/9
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	0.42	23/7	6 wks	23/7

- Metam sodium was applied via shank machine

- Table 6: The executive work plan of Pico Company.

Crop	Cultivar	Treatment	Area/ha	Application Date	Covering period	Planting Date
Strawberry	K-13	Soil Solarization+Basamid (50g/m^2)	1.67	13/7	6 wks	15/9
		Soil Solarization+Metam Sodium (100ml/m^2)**	1.04	13/7	6 wks	15/9
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	1.25	10/6	7 wks	15/9
		Soil Solarization+Bioarc at the rate of 432 kg/ha*	0.83	10/6	7 wks	15/9
		Soil Solarization+Biozeid at the rate of 432 kg/ha*	0.60	10/6	7 wks	15/9
		Methyl Bromide (25 g/ m^2) + VIF	0.83	01/8	2 wks	15/9

* Out of program treatment. **Metam sodium was applied via shank machine.

Table 7: The executive work plan of Technogreen Company.

Crop	Cultivar	Treatment	Area/ha	Applic. Date	Covering period	Planting Date
Strawberry (Tabark Farm)	Sweet Charlie	Soil Solarization	3.33	01/7	8 wks	12/9
		Basamid (50g/m^2) + PE plastic mulch (1 month)	0.20	11/7	4 wks	
		M.Sodium (100ml/m^2)+ PE plastic mulch (1 month)*	0.42	11/7	4 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	1.25	12/9	8 wks	
Cherry Tomato (Tabark Farm)	522	Basamid (50g/m^2) + PE plastic mulch (1 month)	0.20	11/7	4 wks	5/9
		M. Sodium (100ml/m^2)+ PE plastic mulch (1 month)*	0.42	11/7	4 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	1.25	5/9	8 wks	
Strawberry (Berkash Farm)	Sweet Charlie	Soil Solarization	1.25	1/7	8 wks	22/9
		Basamid (50g/m^2) + VIF (1 month)	0.10	9/7	4 wks	
		Basamid (50g/m^2) + PE plastic mulch (1 month)	0.73	9/7	4 wks	
		M. Sodium (100ml/m^2) + Soil Solarization	0.83	9/7	4 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	0.83	1/9	8 wks	
Cherry Tomato (Berkash Farm)	522	Soil Solarization	0.83	1/7	8 wks	2/9
		Basamid (50g/m^2)+VIF (1 month)	0.03	9/7	4 wks	
		Basamid (50g/m^2) + PE plastic mulch (1 month)	0.80	9/7	4 wks	
		Metam Sodium (100ml/m^2) + VIF (1 month)*	0.03	9/7	4 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	0.83	5/9	8 wks	

* Metam sodium was applied via drip irrigation.

Table 8: The executive work plan of Zein El-Din Company.

Crop	Cultivar	Treatment	Area/ha	Application Date	Covering period	Planting Date
Strawberry	Tamar	Soil Solarization	0.21	6/7	8 wks	26/9
		Soil Solarization+ Basamid (50g/m^2)	0.63	12/8	5 wks	
		Soil Solarization+Metam Sodium (100ml/m^2)*	0.63	5/9	8 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	0.63	18/9	8 wks	
		Methyl Bromide (25 g/ m^2) + VIF	0.42	15/8	2 wks	
	Festival	Soil Solarization	0.54	6/7	8 wks	27/9
		Soil Solarization+ Basamid (50g/m^2)	0.63	12/8	5 wks	
		Soil Solarization+Metam Sodium (100ml/m^2)	0.50	5/9	8 wks	
		Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	0.84	18/9	8 wks	
		Methyl Bromide (25 g/ m^2) + VIF	0.42	15/8	2 wks	

* Metam sodium was applied via drip irrigation.

Results

1. Effect of Methyl Bromide Alternatives on Occurrence of Soilborne Phytopathogenic Fungi:

Results of the effect of MBr alternatives on controlling of soil inhabitant phytopathogenic fungi the cause of root diseases of the selected vegetable crops were tested in farms of the participated companies.

The efficiency of MBr alternatives on controlling of soil inhabitant phytopathogenic fungi was calculated using the following equation:

$$\% \text{ Efficiency} = \frac{\text{Mean of pathogens No. in non-treated plot} - \text{Mean of pathogens in treated plot}}{\text{Mean of pathogens No. in non-treated control}} \times 100$$

The tested alternatives showed a considerable effect on controlling soil phytopathogenic fungi that cause root diseases on the tested crops. Results were varied from company to another as follows:

Agrotech:

Results of the efficiency of the used MBr-alternatives on controlling such pathogens in cherry tomato, strawberry and cucumber are presented in Tables (9-11). The combination of methyl bromide (25 g/m^2) and VIF plastic mulch significantly showed the highest effect compared to the other treatments on controlling soil-borne pathogens on cherry tomato followed by basamid (50 g/m^2) with VIF and soil solarization combined with basamid (50 g/m^2) (Table 9). Also, the combination of methyl bromide (25 g/m^2) and VIF plastic mulch showed the highest effect in controlling soilborne pathogens in bell pepper followed by soil treated with metam sodium (100 ml/m^2) combined with VIF, then solarized soil combined with basamid (50 g/m^2) (Table 10). In addition, both methyl bromide (25g/m^2) and metam sodium (100 ml/m^2) when combined with VIF were superior to the other treatment in controlling soil-borne pathogens in cucumber (Table 11).

Table 9: Efficiency of methyl bromide alternatives in controlling fungal pathogens of cherry tomato (cv. 522) grown in greenhouse at Agrotech farm (2008-2009)

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization+Basamid(50g/m^2)	**4.4**	**85.7^{ab}**
Soil Solarization+Metam Sodium (100ml/m^2)	**7.7**	**75.00^{c}**
Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	**7.3**	**76.30^{c}**
Methyl Bromide (25 g/ m^2) + VIF	**2.7**	**91.20^{a}**
Basamid (50g/m^2)+VIF*	**3.0**	**90.3^{ab}**
Metam Sodium (100ml/m^2)+ VIF*	**4.4**	**84.10^{b}**
Non-treated Control	**30.8**	

Standard deviation= 6.85
*** Out of program treatment.**

Table 10: Efficiency of methyl bromide alternatives in controlling fungal pathogens of bell pepper (cv. Nelson) grown in greenhouse at Agrotech farm **(2008-2009).**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization+Basamid(50g/m^2)	**4.9**	**80.3^{bc}**
Soil Solarization+Metam Sodium (100ml/m^2)	**5.2**	**79.1^{c}**
Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	**5.2**	**79.1^{c}**
Methyl Bromide (25 g/ m^2) + VIF	**3.3**	**86.7^{a}**
Basamid (50g/m^2)+VIF*	**3.7**	**85.1^{ab}**
Metam Sodium (100ml/m^2)+ VIF*	**4.4**	**82.3^{b}**
Non-treated Control	**24.9**	

Standard deviation= 3.2
*** Out of program treatment.**

Table 11: Efficiency of methyl bromide alternatives in controlling fungal pathogens of cucumber (cv. Jadid) grown in greenhouse **(2008-2009).**at Agrotech farm.

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization+Basamid(50g/m^2)	**7.7**	**70.5^{b}**
Soil Solarization+Metam Sodium (100ml/m^2)	**8.0**	**69.3^{b}**
Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	**8.4**	**67.8^{b}**
Methyl Bromide (25 g/ m^2) + VIF	**2.4**	**90.8^{a}**
Basamid (50g/m^2)+VIF*	**1.7**	**93.5^{a}**
Metam Sodium (100ml/m^2)+ VIF*	**7.1**	**72.8^{b}**
Non-treated Control	**26.1**	

Standard deviation= 11.54
*** Out of program treatment.**

Central Lab for Agricultural Climate (CLAC), Agric Res. Center:

Methyl bromide (25g/m^2) soil treatment combined with VIF was significantly more efficient than the other applied alternatives, followed by solarized soil combined with basamid (50g/m^2). However, solarized soil alone was the least efficient soil treatment in controlling soilborne pathogens (Table 12).

Table 12: Efficiency of Methyl Bromide alternatives in controlling fungal pathogens of bell pepper (cv. Reda) grown at CLAC farm **(2008-2009).**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	8.8	75.0^{c}
Soil Solarization +Basamid (50g/m^2)	3.2	90.9^{ab}
Soil Solarization +Metam Sodium (100 ml/m^2)	5.3	84.9^{b}
Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	6.0	83.0^{b}
Methyl Bromide (25 g/ m^2) + VIF	2.5	92.9^{a}
Non-treated Control	35.2	

Standard deviation= 7.08

The Egyptian Group:

Table 13 showed the effect of methyl bromide alternatives, in the Egyptian Group farm, on controlling soilborne fungal pathogens of cherry tomato grown in the greenhouse. The obtained results indicated that soil treated with either methyl bromide (25g/m^2) or basamid (50g/m^2) combined with VIF were highly efficient treatments in controlling soilborne pathogens of cherry tomato. However, there was no significant difference between the rests of treatments.

Table 13: Efficiency of Methyl Bromide alternatives in controlling fungal pathogens of cherry tomato (cv. Nasia) grown in greenhouse at the Egyptian Group farm **(2008-2009).**

Treatment	Pathogen's Meam	Efficiency (%)
Soil Solarization+ Basamid (50g/m^2)	**2.6**	**89.1^{a}**
Soil Solarization+Metam Sodium (100ml/m^2)	**4.7**	**80.3^{b}**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**4.3**	**81.9^{b}**
Methyl Bromide (25 g/ m^2) + VIF	**1.8**	**92.4^{a}**
Non-treated Control	**23.8**	

Standard deviation= 5.9

Farm Frites:

Table 14 showed the effect of MBr-alternatives tested on the soil-borne fungal pathogens on root diseases in strawberry. The efficiency of methyl bromide (25g/m^2) combined with VIF was as equal as the efficiency of solarized soil combined with either basamid (50g/m^2), metam sodium (100 ml/m^2), or the tested biofungicides (216kg/ha each). Solarized soil treatment alone was less efficient than the above mentioned treatments.

Table 14: Efficiency of Methyl Bromide alternatives in controlling fungal pathogens of strawberry (cv. Festival) grown at Farm Frites farm **(2008-2009).**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**7.2**	**77.4^b**
Soil Solarization+Basamid (50g/m^2)	**2.5**	**92.1^a**
Soil Solarization+Metam Sodium (100ml/m^2)	**3.1**	**90.3^a**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**3.3**	**89.6^a**
Methyl Bromide (25 g/ m^2) + VIF	**1.9**	**94.0^a**
Non-treated Control	**31.8**	

Standard deviation= 6.53

Mafa:

Methyl bromide alternatives were tested in Mafa farm for controlling soil phytopathogenic fungi that cause root diseases on lettuce and strawberry and different kind of herbs grown in the field. Results of the efficiency of the alternatives on controlling such pathogens were presented in Tables (15-17). Methyl bromide (25g/m^2) soil treatment combined with VIF, and solarized soil combined with basamid (50g/m^2) were the highly efficient treatments in controlling soilborne pathogens of lettuce. Solarized soil combined with the tested biofungicides (216 kg/ha each) had higher efficiency than solarized soil alone (Table 15). Also, methyl bromide (25g/m^2) soil treatment combined with VIF showed the highest efficiency in controlling soilborne pathogens of strawberry followed by solarized soil combined with either basamid (50g/m^2) or metam sodium (100 ml/m^2) (Table 16). In addition, solarized soil combined with either basamid (50g/m^2), metam sodium (100 ml/m^2), or the tested biofungicides

(216kg/ha each) were more efficient in controlling soil-borne pathogens in herbs fields than solarized soil alone (Table 17).

Table 15: Efficiency of Methyl Bromide alternatives in controlling fungal pathogens of lettuce (cv. Iceberg) grown at Mafa farm **(2008-2009).**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**10.4**	**55.2^{c}**
Soil Solarization+Basamid (50g/m^2)	**2.7**	**88.4^{a}**
Soil Solarization+Metam Sodium (100ml/m^2)	**7.2**	**69.0^{bc}**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**6.6**	**71.6^{b}**
Methyl Bromide (25 g/ m^2) + VIF	**2.2**	**90.5^{a}**
Non-treated Control	**23.2**	

Standard deviation= 14.65

Table 16: Efficiency of Methyl Bromide alternatives in controlling fungal pathogens of strawberry (cv. Yael) grown at Mafa farm**(2008-2009).**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**9.1**	**66.8^{c}**
Soil Solarization+Basamid (50g/m^2)	**2.2**	**92.0^{ab}**
Soil Solarization+Metam Sodium (100ml/m^2)	**3.7**	**86.5^{ab}**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**5.0**	**81.8^{b}**
Methyl Bromide (25 g/ m^2) + VIF	**2.1**	**92.3^{a}**
Non-treated Control	**27.4**	

Standard deviation= 10.48

Table 17: Efficiency of Methyl Bromide alternatives in controlling fungal pathogens of herbs grown at Mafa farm **(2008-2009).**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**7.7**	**59.3^{b}**
Soil Solarization+Basamid (50g/m^2)	**2.1**	**88.9^{a}**
Soil Solarization+Metam Sodium (100ml/m^2)	**3.3**	**82.5^{a}**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**3.6**	**81.0^{a}**
Non-treated Control	**18.9**	

Standard deviation= 12.88

Pico:

Data presented in Table 18 showed that methyl bromide (25g/m^2) combined with VIF was significantly the highst efficient treatment followed by solarized soil combined with basamid (50g/m^2) in controlling strawberry grown in Pico farm. There was no significant difference between the efficiency of solarized soil either combined with metam sodium (100 ml/m^2) or the mixture of the tested biofungicides (216 kg/ha each).

Table 18: Efficiency of methyl bromide alternatives in controlling fungal pathogens of Strawberry (cv. K-13) grown at Pico farm **(2008-2009)**..

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization+Basamid (50g/m^2)	**3.1**	**89.20^{ab}**
Soil Solarization+Metam Sodium (100ml/m^2)	**3.6**	**87.50^{b}**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**3.4**	**88.20^{b}**
Soil Solarization+Bioarc at the rate of 432 kg/ha*	**4.3**	**85.10^{c}**
Soil Solarization+Biozeid at the rate of 432 kg/ha*	**4.4**	**83.70^{c}**
Methyl Bromide (25 g/ m^2) + VIF	**2.6**	**90.99^{a}**
Non-treated control	**28.8**	-

Standard deviation = 2.67
*** Out of program treatment.**

Technogreen:

The tested soil treatments except soil solarization alone showed highly efficient effect without a significant difference between them in controlling soilborne pathogens of cherry tomato grown in Berkash farm (Table 19). Basamid (50g/m^2) soil treatment combined with VIF was highly efficient soil treatment followed by soil treated with basamid (50g/m^2) combined with polyethylene plastic mulch and solarized soil combined with a mixture of the tested biofungicides (216 kg/ha each) in controlling soilborne pathogens of strawberry grown in Brekash farm (Table 20). The tested soil treatments but soil solarization alone showed highly efficient effect without a significant difference between them in controlling soilborne pathogens of cherry tomato and strawberry grown in Tabark farm (Tables 21&22).

Table 19: Efficiency of methyl bromide alternatives in controlling fungal pathogens of cherry tomato (cv. 522) grown at Berkash farm of Technogreen Company **(2008-2009)**..

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**11.8**	**57.9^{b}**
Basamid (50g/m^2)+VIF (1 month)*	**1.2**	**95.7^{a}**
Basamid (50g/m^2) + PE plastic mulch (1 month)	**1.6**	**94.2^{a}**
Metam Sodium (100ml/m^2) + VIF (1 month)*	**2.4**	**91.4^{a}**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**2.9**	**89.6^{a}**
Non-treated Control	**28.0**	

Standard deviation= 15.70
***Out of program treatment.**

Table 20: Efficiency of methyl bromide alternatives in controlling fungal pathogens of strawberry (cv. Sweet Charlie) grown at Berkash farm of Technogreen Company **(2008-2009)..**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**5.1**	**79.3[c]**
Basamid (50g/m^2) + VIF (1 month)*	**1.8**	**92.7[a]**
Basamid (50g/m^2) + PE plastic mulch (1 month)	**2.3**	**90.7[ab]**
Soil Solarization +Metam Sodium (100ml/m^2)	**3.4**	**86.2[b]**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**3.0**	**87.8[ab]**
Non-treated Control	**24.6**	

Standard deviation= 5.15

***Out of program treatment.**

Table 21: Efficiency of methyl bromide alternatives in controlling fungal pathogens of cherry tomato (cv. 522) grown at Tabark farm of Technogreen Company **(2008-2009)..**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**4.3**	**72.8[b]**
Basamid (50g/m^2) + PE plastic mulch (1 month)	**1.6**	**89.9[a]**
Metam Sodium (100ml/m^2)+ PE plastic mulch (1 month)	**1.3**	**85.4[a]**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**2.5**	**84.2[a]**
Non-treated Control	**15.8**	

Standard deviation= 7.28

Table 22: Efficiency of methyl bromide alternatives in controlling fungal pathogens of Strawberry (cv. Sweet Charlie) grown at Tabark farm of Technogreen Company **(2008-2009)..**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**4.90**	**75.30[b]**
Basamid (50g/m^2) + PE plastic mulch (1 month)	**1.65**	**91.70[a]**
Metam Sodium (100ml/m^2)+ PE plastic mulch (1 month)	**1.84**	**90.60[a]**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**2.00**	**89.90[a]**
Non-treated control	**19.80**	**-**

Standard deviation = 7.75

Zein El-Din:

The tested soil treatments but soil solarization alone showed highly efficient effect without a significant difference between them in controlling soilborne pathogens of two cultivars of strawberry grown in Zein El-Din farm (Tables 23&24).

Table 23: Efficiency of methyl bromide alternatives in controlling fungal pathogens of strawberry (cv. Festival) grown at farm Zein El-Din farm **(2008-2009)..**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**6.90**	**75.2[b]**
Soil Solarization+ Basamid (50g/m^2)	**2.00**	**92.8[a]**
Soil Solarization+Metam Sodium (100ml/m^2)	**2.94**	**89.4[a]**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**3.10**	**88.8[a]**
Methyl Bromide (25 g/ m^2) + VIF	**1.60**	**94.2[a]**
Non-treated Control	**27.8**	

Standard deviation=7.55

Table 24: Efficiency of methyl bromide alternatives in controlling fungal pathogens of strawberry (cv. Tamar) grown at farm Zein El-Din farm **(2008-2009)..**

Treatment	Pathogen's Mean	Efficiency (%)
Soil Solarization	**6.7**	**74.0[b]**
Soil Solarization+ Basamid (50g/m^2)	**1.6**	**93.8[a]**
Soil Solarization+Metam Sodium (100ml/m^2)	**2.9**	**88.8[a]**
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	**3.3**	**87.2[a]**
Methyl Bromide (25 g/ m^2) + VIF	**1.6**	**93.8[a]**
Non-treated Control	**25.8**	

Standard deviation= 8.11

2. Effect of Methyl Bromide Alternatives on Controlling Root-Knot Nematodes of Vegetable Crops:

The efficiency of the tested methyl bromide alternatives on controlling root-knot nematodes was calculated using the following formula:

$$\% \text{ Effeiciency} = \frac{\text{RB for control treatment} - \text{RB for treatment}}{\text{RB for control treatment}} \times 100$$

Where RB = rate of nematode population build up =

$$\frac{\text{Mean of nematode No. during season}}{\text{Initial population of nematode}}$$

Results of the effect of MB alternatives on controlling root-knot nematodes were varied from company to another as the following:

Agrotech:

The tested soil treatments showed that soil treated with basamid (50g/m^2) and metam sodium (100ml/m^2) when combined with VIF were highly efficient than the other treatment on controlling root-knot nematode (Meloidogyne spp.) of cucumber grown in the greenhouse (Table 25). In addition, methyl bromide (25 g/ m^2) combined with VIF was the highest efficient treatment on controlling root-knot nematode of cherry tomato grown in the greenhouse (Table 26). On the other hand, all the tested methyl bromide alternatives have suppressed root-knot nematode in the greenhouses planted with bell pepper.

Table 25: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on cucmber (cv. Jadid) in the greenhouse at Agrotech farm **(2008-2009).**

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Soil Solarization+Basamid(50g/m^2)	6	7	1.2	69^b
Soil Solarization+Metam Sodium (100ml/m^2)	5	7	1.3	67^b
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	6	7	1.2	69^b
Methyl Bromide (25 g/ m^2) + VIF	6	7	1.2	70^b
Basamid (50g/m^2)+VIF*	4	3	0.8	78^a
Metam Sodium (100ml/m^2)+ VIF*	5	4	0.8	79^a
Non-treated control	4	15	3.8	

Standard deviation = 5.14
***Out of program treatment.**

Table 26: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on cherry tomato (cv. 522) in the greenhouse at Agrotech farm **(2008-2009)..**

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Soil Solarization+Basamid(50g/m^2)	13	17	1.3	67^c
Soil Solarization+Metam Sodium (100ml/m^2)	17	20	1.2	70^b
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	17	20	1.2	71^b
Methyl Bromide (25 g/ m^2) + VIF	16	13	0.8	76^a
Basamid (50g/m^2)+VIF*	13	16	1.2	71^b
Metam Sodium (100 ml/m^2)+ VIF*	14	17	1.2	71^b
Non-treated control	15	60	4.0	

Standard deviation = 2.9
***Out of program treatment.**

Central Lab for Agricultural Climate (CLAC), Agric Res. Center:

The tested methyl bromide alternatives except soil solarization alone showed 64-70% efficiency in controlling root-knot nematode in bell pepper grown in greenhouse without any significant difference between them (Table 27).

Table 27: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on bell pepper (cv. Reda) at CLAC farm **(2008-2009)**..

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Soil Solarization	18	36	2.0	51[b]
Soil Solarization + Basamid (50 g/m^2).	21	32	1.5	64[a]
Soil Solarization + Metam sodium (100 ml/m^2).	17	24	1.4	65[a]
Soil Solarization + (Bioarc+Biozeid, 216 kg/ha each).	17	22	1.3	68[a]
Methyl Bromide (25 g/m^2) + VIF.	20	24	1.2	70[a]
Non-treated control	20	80	4.0	

Standard deviation = 7.43

The Egyptian Group:

Data presented in Table 28 showed that soil treated with methyl bromide (25 g/m^2) combined with VIF was the highly efficient soil treatment in controlling root-knot nematode than the rest of other treatments in cherry tomato grown in greenhouse of the Egyptian Group farm.

Table 28: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on cherry tomato (cv. Nasia) at the Egyptian Group farm **(2008-2009)**..

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Soil Solarization + Basamid (50 g/m^2).	11	15	1.4	68[b]
Soil Solarization + Metam sodium (100 ml/m^2).	13	18	1.4	68[b]
Soil Solarization + (Bioarc+Biozeid, 216 kg/ha each).	15	21	1.4	68[b]
Methyl Bromide (25 g/m^2) + VIF.	15	20	1.3	70[a]
Non-treated control	10	44	4.4	

Standard deviation = 1.00

Farm Frites:

Data in Table 29 indicated that methyl bromide (25 g/m^2) combined with VIF was as equal as solarized soil combined with either basamid (50 g/m^2), metam sodium (100 ml/m^2) or the biofungicides (216 kg/ha each) were highly efficient in controlling root-knot nematodes of strawberry grown in Farm Frites farm. Solarized soil treatment alone was less efficient than the above mentioned treatments.

Table 29: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on strawberry (cv. Festival) at Farm Frites farm**(2008-2009)**..

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Solarization	30	66	2.20	43[b]
Solarization + Basamid (50 g/m^2).	30	27	0.97	75[a]
Solarization + Metam sodium (100 ml/m^2).	28	31	1.09	72[a]
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	32	31	0.97	75[a]
Methyl Bromide (25 g/m^2) + VIF.	32	25	0.78	80[a]
Non-treated control	32	133	3.90	

Standard deviation = 14.82

Mafa:

The efficiency of methyl bromide alternatives on controlling root-knot nematode (*Meloidogyne* spp.) in lettuce and strawberry and herbs were tested at Mafa farm. The results obtained from lettuce and strawberry fields were presented in Tables 30 and 31 respectively. The data showed that soil treated with the tested bromide alternatives except soil solarization alone were highly efficient in controlling root-knot nematodes in both crops.

(Nematode extraction trial did not reveal any parasitic nematodes from soil of herbs fields).

Table 30: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on lettuce (cv. Iceberg) at Mafa farm**(2008-2009)**..

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Soil Solarization	13	28	2.1	43[b]
Soil Solarization + Basamid (50 g/m^2).	18	14	0.8	79[a]
Soil Solarization + Metam sodium (100 ml/m^2).	15	13	0.9	75[a]
Soil Solarization + (Bioarc+Biozeid, 216 kg/ha each).	16	14	0.9	76[a]
Methyl Bromide (25 g/m^2) + VIF.	15	9	0.6	83[a]
Non-treated control	13	48	3.7	

Standard deviation = 16.06

Table 31: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on strawberry (cv. Yael) at Mafa farm **(2008-2009).**.

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Soil Solarization	19	48	2.5	38[b]
Soil Solarization + Basamid (50 g/m^2).	17	16	0.9	78[a]
Soil Solarization + Metam sodium (100 ml/m^2).	20	20	1.0	75[a]
Soil Solarization + (Bioarc+Biozeid, 216 kg/ha each).	17	17	1.0	75[a]
Methyl Bromide (25 g/m^2) + VIF.	16	2	0.1	85[a]
Non-treated control	16	64	4.0	

Standard deviation = 18.46

Pico:

Results presented in Table 32 illustrated the effect of MB alternatives on controlling root-knot nematodes on strawberry at Pico farm. Methy bromide (25 g/m^2) soil treatment combined with VIF was the highly efficient treatment, followed by solarized soil combined with either basamid (50 g/m^2), metam sodium (100 ml/m^2), or the mixture of the tested biofungicides (Bioarc+Biozeid, 216 kg/ha each).

Table 32: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on strawberry (cv. K-13) at Pico farm **(2008-2009).**

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Solarization + Basamid (50 g/m^2).	14	14	1.0	75[ab]
Solarization + Metam sodium (100 ml/m^2).	14	15	1.1	73[b]
Solarization + Bioarc (432 kg/ha)*.	16	18	1.1	73[b]
Solarization + Biozeid (432 kg/ha)*.	15	21	1.4	65[c]
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	12	17	1.4	66[c]
Methyl Bromide (25 g/m^2) + VIF.	15	12	0.8	76[a]
Non-treated control	15	60	4.0	

Standard deviation = 5.38
***Out of program treatment.**

Technogreen:

The efficiency of methyl bromide alternatives in controlling root-knot nematodes were implemented on cherry tomato and strawberry in two farms (Berkash and Tabark farms) of Technogreen Company. Data of Berkash and Tabark farms were presented in Tables (33-34) and (35-36) for cherry tomato and strawberry respectively. Results showed that the tested methyl bromide alternatives except soil solarization alone were efficient in controlling rood-knot nematodes of cherry tomato and strawberry respectively.

Table 33: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on cherry tomato (cv. 522) at Berkash farm of Technogreen Company **(2008-2009).**

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Solarization.	**13**	**34**	**2.60**	**38[b]**
Basamid (50 g/m^2) + VIF*.	**15**	**26**	**1.70**	**84[a]**
Basamid (50 g/m^2) + PE plastic mulch (1 month).	**14**	**15**	**1.05**	**75[a]**
Metam sodium (100 ml/m^2) +VIF (1 month)*.	**15**	**17**	**1.13**	**73[a]**
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	**13**	**12**	**0.90**	**78[a]**
Non-treated control	**12**	**50**	**4.20**	

Standard deviation = 18.15
***Out of program treatment.**

Table 34: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on cherry tomato (cv. 522) grown at Tabark farm of Technogreen Company **(2008-2009)**..

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Solarization	**15**	**32**	**2.1**	**49[b]**
Basamid (50g/m^2) + PE plastic mulch (1 month)	**16**	**16**	**1.0**	**76[a]**
Metam Sodium (100ml/m^2)+ PE plastic mulch (1 month)	**20**	**20**	**1.0**	**76[a]**
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	**21**	**21**	**1.0**	**76[a]**
Non-treated control	**20**	**82**	**4.1**	

Standard deviation = 13.5

Table 35: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on strawberry (cv. Sweet Charlie) at Berkash farm of Technogreen Company **(2008-2009).**

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Solarization.	**8**	**19**	**2.4**	**40[b]**
Basamid (50 g/m^2) + VIF (1 month)*.	**11**	**8**	**0.7**	**83[a]**
Basamid (50g/m^2) + PE plastic mulch (1 month)	**12**	**11**	**0.9**	**77[a]**
Solarization + Metam sodium (100 ml/m^2).	**12**	**12**	**1.0**	**75[a]**
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	**12**	**11**	**0.9**	**77[a]**
Non-treated control	**11**	**84**	**4.0**	

Standard deviation = 17.26
***Out of program treatment.**

Table 36: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on strawberry (cv. Sweet Charlie) grwon at Tabarak farm of Technogreen Company (2008-2009).

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Soil Solarization	16	34	2.1	51[b]
Basamid (50g/m^2) + PE plastic mulch (1 month)	16	22	1.4	67[a]
Metam Sodium (100 ml/m^2)+ PE plastic mulch (1 month)	16	22	1.4	68[a]
Soil Solarization + (Bioarc+Biozeid, 216 kg/ha each).	18	21	1.2	72[a]
Non-treated control	20	84	4.2	

Standard deviation = 9.26

Zein El-Din:

Results in Table 37-38 showed the effect of the tested MB alternatives on controlling root-knot nematodes of strawberry in Zein El-Din farm. Results showed that the tested MB alternatives except soil solarization alone were highly efficient in controlling root-knot nematodes in strawberry fields.

Table 37: Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on strawberry (cv. Tamar) at Zein El-Din farm (2008-2009).

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Soil Solarization	17	43	205	45[b]
Soil Solarization + Basamid (50 g/m^2).	18	14	0.8	81[a]
Soil Solarization + Metam sodium (100 ml/m^2).	16	15	0.9	79[a]
Soil Solarization + (Bioarc+Biozeid, 216 kg/ha each).	18	20	1.1	76[a]
Methyl Bromide (25 g/m^2) + VIF.	19	17	0.9	80[a]
Non-treated control	19	84	4.4	

Standard deviation = 15.32

Table 38:Efficiency of methyl bromide alternatives in controlling root-knot nematode, *Meloidogyne* spp. on strawberry (cv. Festival) at Zein El-Din farm (2008-2009).

Treatment	Initial population	Mean of juveniles	RB	Efficiency (%)
Soil Solarization	18	44	206	46[b]
Soil Solarization + Basamid (50 g/m^2).	19	15	0.9	82[a]
Soil Solarization + Metam sodium (100 ml/m^2).	17	16	1.0	80[a]
Soil Solarization + (Bioarc+Biozeid, 216 kg/ha each).	19	21	1.2	77[a]
Methyl Bromide (25 g/m^2) + VIF.	20	18	1.0	81[a]
Non-treated control	20	85	4.5	

Standard deviation = 16.32

3. Economic Evaluation of Yield of Some Vegetable Crops Treated with Methyl Bromide Alternatives:

To elucidate the economical feasibility of the used Methyl Bromide alternatives, their Influence on the productivity of the selected vegetable crops and the cost of each alternative were determined. The incremental cost for each alternative was calculated by subtracting the cost value of such a treatment from the cost value of MBr at the rate of 25 g/m^2 combined with VIF. Results were presented in Tables 38-45.

Agrotech:

Methyl bromide soil treatments at 25 g/m^2 combined with VIF was superior to the used alternative regarding to yield. The incremental cost of alternative ranged from less to slightly higher except for treatments where VIF was used in combination with the used alternative. Results from the selected crops, cherry tomato, cucumber and bell pepper, showed similar or slightly different trend (Tables 39-41).

Table 39: The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in Cherry tomato(cv. 522) grown in greenhouse at Agrotech farm **(2008/2009).**

Treatment	Yield (Kg/m^2)	Costs (LE/Kg)	Incremental Costs (LE/Kg)
Soil Solarization	6.6a	0.098	**- 0.098**
Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	6.6a	0.344	- 0.344
Soil Solarization+Basamid(50g/m^2)	6.8c	0.404	**0.041**
Basamid (50g/m^2)+VIF*	6.8c	0.536	0.173
Soil Solarization+Metam Sodium (100ml/m^2)	6.76bc	0.334	- 0.029
Metam Sodium (100ml/m^2)+ VIF*	6.8c	0.462	0.099
Methyl Bromide (25 g/ m^2) + VIF	7d	0.363	

Standard deviation= 0.08

Figures followed by the same letters are not significantly different at 0.08 of probability.

(Remark: no nematode results were obtained the bell pepper experiment in Agrotech Company)

Table 40: The yield and incremental-costs of MBr alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in cucumber (cv. Jadid) grown in greenhouse at Agrotech farm **(2008/2009).**

Treatment	Yield (Kg/m^2)	Costs (LE/Kg)	Incremental Costs (LE/Kg)
Soil Solarization	8.6a	0.070	- 0.02
Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	8.6a	0.264	- 0.02
Soil Solarization+Basamid(50g/m^2)	8.8b	0.312	0.028
Basamid (50g/m^2)+VIF*	8.8b	0.409	0.125
Soil Solarization+Metam Sodium (100ml/m^2)	8.8b	0.258	- 0.026
Metam Sodium (100ml/m^2)+ VIF*	8.8b	0.355	0.071
Methyl Bromide (25 g/ m^2) + VIF	8.96c	0.284	

Standard deviation= 0.02

Figures followed by the same letters are not significantly different at 0.02of probability.

Table 41: The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in bell pepper (cv. Nelson)grown in greenhouse at Agrotech farm **(2008-2009).**

Treatment	Yield (Kg/m^2)	Costs (LE/Kg)	Incremental Costs (LE/Kg)
Soil Solarization	5.32a	0.122	- 0.238
Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	5.32a	0.426	- 0.032
Soil Solarization+Basamid(50g/m^2)	5.4b	0.509	0.051
Basamid (50g/m^2)+VIF*	5.4b	0.666	0.208
Soil Solarization+Metam Sodium (100ml/m^2)	5.32a	0.428	- 0.03
Metam Sodium (100ml/m^2)+ VIF*	5.32a	0.587	0.129
Methyl Bromide (25 g/ m^2) + VIF	5.55c	0.458	

Standard deviation: 0.02

Figures followed by the same letters are not significantly different at 0.02 of probability.

Central Lab for Agricultural Climate (CLAC), Agric Res. Center:

Data indicate that yield of bell pepper differed significantly among the used alternatives. The bio-fungicides (Biozeid and Bioarc) was gave the second highest bell pepper yield (6.11 kg/ m^2) after MBr treatment (6.5 kg/ m2) with little higher incremental cost (0.059 L.E/ kg) than using the MBr at 50g/ m^2 (Table 42).

Table (42): The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in bell pepper (cv. Reda) grown at CLAC farm **(2008-2009.**

Treatment	**Yield (Kg/m2)**	**Costs (LE/Kg)**	**Incremental Costs (LE/Kg)**
Soil Solarization	3.64a	0.178	- 0.213
Soil Solarization +Basamid (50g/m^2)	4.13b	0.551	0.16
Soil Solarization +Metam Sodium (100 ml/m^2)	5.85c	0.388	- 0.003
Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	6.11d	0.450	0.059
Methyl Bromide (25 g/ m^2) + VIF	6.5e	0.391	

Standard deviation= 0.06

Figures followed by the same letters are not significantly different at 0.06 of probability.

The Egyptian Group:

It is noteworthy that yield of cherry tomato (cv. Nasia) from any of the used alternatives was higher than that from MBr (50 gm/ m^2). Metam sodium (100 ml/ m^2) combined with soil solarization gave the highest yield (6. 03 kg/ m^2) while the lowest (5.12 kg/ m^2) was from MBr (25 g/ m^2) combined with VIF. The incremental cost of MBr (25 gm/ m^2) was higher than that of any of the used alternatives (Table 43).

Table 43: The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + cherry tomato (cv. Nasia) grown in greenhouse at the Egyptian Group farm **(2008-2009).**

Treatment	**Yield (Kg/m^2)**	**Costs (LE/Kg)**	**Incremental Costs (LE/Kg)**
Soil Solarization+ Basamid (50g/m^2)	5.82 b	0.472	- 0.025
Soil Solarization+Metam Sodium (100ml/m^2)	6.03 c	0.377	- 0.12
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	5.90 d	0.384	- 0.113
Methyl Bromide (25 g/ m^2) + VIF	5.12 a	0.497	

Standard deviation= 0.03
Figures followed by the same letters are not significantly different at 0.03of probability.

Mafa:

The yield data of strawberry, lettuce and the herb cilantro (Cospara) are indicated in Tables 44-46. Except for that of the only soil solarization treatment, the yield of strawberry did not, significantly differed than that of MBr (25 g/m^2). Than incremental cost of the used alternatives was less than that of MBr (25 g/m2) except that of Metam sodium which was higher (Table 44).

The yield of lettuce from different treatments varied significantly recording the highest from MBr (4.1 kg/ m2) and the lowest (3.62 kg/ m^2) from the basamid treatment (Table 44). The incremental cost of the used alternatives varied from lower (Biozeid - Bioarc and soil solarization treatments) to higher (Basamid and Metam sodium treatments) than the cost of using MBr. (Table 44).

The yield of the herb cilantro (Cospara) from the bio-fungicides (Biozeid + Bioarc) was sam of that from MBr (6 kg/ m^2), also, the yield from Basamid and Metam sodium was the same (4.75 kg/ m^2) (Table 46). Regarding to the incremental cost, it ranged from higher (Basamid and Metam sodium treatments) to lower (Biozeid-Bioarc and soil solarizatio treatments) than the cost of using MBr (25 g/m^2) (Table 46).

Table 44: The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in strawberry grown in the Mafa farm **(2008/2009).**

Treatment	**Yield (k/m2)**	**Costs (LE/Kg)**	**Incremental Costs (LE/Kg)**
Solarization	1.25b	0.52	**- 1.480**
Soil Solarization+Basamid (50g/m^2)	1.27a	2.165	**0.1650**
Soil Solarization+Metam Sodium (100ml/m^2)	1.27a	0.79	**- 0.210**
Solarization + (*Bioarc+Biozeid, 216 kg/ha each*).	1.26a	0.80	**- 0.200**
Methyl Bromide (25 g/m^2) + VIF.	1.27a	2.00	

Standard deviation = 0.02
Figures followed by the same letters are not significantly different at 0.02 of probability.

Table 45:The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in lettuce grown in the Mafa farm **(2008/2009).**

Treatment	**Yield (k/m2)**	**Costs (LE/Kg)**	**Incremental Costs (LE/Kg)**
Solarization	3.83b	0.169	**- 0.452**
Soil Solarization+Basamid (50g/m^2)	3.62e	0.760	**0.139**
Soil Solarization+Metam Sodium (100ml/m^2)	3.96c	0.574	**0.074**
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	4.07d	0.557	**- 0.064**
Methyl Bromide (25 g/m^2) + VIF.	4.1a	0.621	

Standard deviation = 0.04
Figures followed by the same letters are not significantly different at 0.04of probability.

Table 46: The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in the herb cilantro (Cospara) grown in the Mafa farm **(2008/2009).**

Treatment	**Yield (k/m2)**	**Costs (LE/Kg)**	**Incremental Costs (LE/Kg)**
Solarization	5.00b	0.13	**- 0.294**
Soil Solarization+Basamid (50g/m^2)	4.75c	0.579	**0.550**
Soil Solarization+Metam Sodium (100ml/m^2)	4.75c	0.479	**- 0.055**
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	6.00a	0.378	**- 0.046**
Methyl Bromide (25 g/m^2) + VIF.	6.00a	0.424	

Standard deviation = 0.02
Figures followed by the same letters are not significantly different at 0.02 of probability.

<u>Pico:</u>

Yield of strawberry at Pico farm was the same (4 kg/ m^2) from MBr (25 g/ m^2) and basamid treatments. The highest yield (4.5 kg/ m^2) was from plants treated with Bioarc (432 kg/ ha) or Biozeid (432 kg/ ha) while the lowest was from plants treated with Metam sodium (100 ml/m^2). The incremental cost ranged from slightly higher (Metam and Basamid treatments) to slightly lower (Biofungicidal treatments) (Table 47)

Table 47: The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in strawberry grown in the Pico farm **(2008/2009).**

Treatment	Yield (k/m^2)	Costs (LE/Kg)	Incremental Costs (LE/Kg)
Soil Solarization+Metam Sodium (100ml/m^2)	3.81d	0.597	0.005
Soil Solarization+Basamid (50g/m^2)	4.00c	0.687	0.095
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	4.30b	0.527	- 0.065
Soil Solarization+Bioarc at the rate of 432 kg/ha*	4.5a	0.504	- 0.088
Soil Solarization+Biozeid at the rate of 432 kg/ha*	4.5a	0.504	- 0.088
Methyl Bromide (25 g/m^2) + VIF.	4.0c	0.592	

Standard deviation = 0.04
Figures followed by the same letters are not significantly different at 0.04 of probability.

Technogreen:

The highest strawberry yield was obtained from plants treated with MBr (50 g/m2) in both locations followed by the yield of plants from different alternatives with lowest yield from plants of the only solarization treatment (Table 48). Regarding the incremental cost, most treatments showed higher incremental cost at the technogreen farm (Table 48). In the Tabarak location, the incremental cost of the used alternatives ranged from slightly lower to slightly higher compared to the cost of using MBr (Table 49)

Table 48: The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in strawberry grown in the Technogreen farm **(2008/2009).**

Treatment	Yield (k/m2)	Costs (LE/Kg)	Incremental Costs (LE/Kg)
Solarization	2.98 a	0.218	- 0.418
Soil Solarization+Basamid (50g/m^2)	3.57 b	0.770	0.134
Basamid (50 g/m^2)+ VIF	3.6 b	0.955	0.319
Soil Solarization+Metam Sodium (100ml/m^2)	3.2 a	0.711	0.075
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	3.33 a	0.681	0.045
Methyl Bromide (25 g/m^2) + VIF.	4 c	0.636	

Standard deviation = 0.24
Figures followed by the same letters are not significantly different at 0.24 of probability.

Table (49): The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in strawberry grown in the Technogreen Tabarak farm **(2008/2009).**

Treatment	Yield (k/m2)	Costs (LE/Kg)	Incremental Costs (LE/Kg)
Solarization	2.44 a	0.266	- 0.447
Soil Solarization+Basamid (50g/m^2)	3.51 d	0.783	0.070
Soil Solarization+Metam Sodium (100ml/m^2)	3.23 c	0.709	- 0.004
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	3.15 b	0.720	0.007
Methyl Bromide (25 g/m^2) + VIF.	3.57 e	0.713	

Standard deviation = 0.03
Figures followed by the same letters are not significantly different at 0.03 of probability.

Table 50 : The incremental costs of MB alternatives compared to the costs of MB at the rate of 25 g/m^2 + VIF in Tomato grown in the Technogreen, Tabarak farm **(2008/2009).**

Treatment	Yield (k/m2)	Costs (LE/Kg)	Incremental Costs (LE/Kg)
Soil Solarization+Basamid (50g/m^2)	5.95 c	0.462	0.055
Soil Solarization+Metam Sodium (100ml/m^2)	5.9 b	0.386	- 0.021
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	5.8 a	0.391	- 0.016
Methyl Bromide (25 g/m^2) + VIF.	6.25 d	0.407	

Standard deviation = 0.02
Figures followed by the same letters are not significantly different at 0.02 of probability.

Table 51: The incremental costs of MB alternatives compared to the costs of MB at the rate of 25 g/m^2 + VIF in Tomato grown in the Technogreen, Berkash farm **(2008/2008).**

Treatment	k/m2	Costs (LE/Kg)	Incremental Costs (LE/Kg)
Soil Solarization	6.0a	0.108	**- 0.231**
Soil Solarization+(Biozeid+Bioarc, 216 kg/ha each)	6.4b	0.354	0.015
Soil Solarization+Basamid(50g/m^2)	6.8d	0.404	**0.0.065**
Basamid (50g/m^2)+VIF*	6.8d	0.530	0.191
Metam Sodium (100ml/m^2)+ VIF*	6.5c	0.481	0.142
Methyl Bromide (25 g/ m^2) + VIF	7.5e	0.339	

Standard deviation= 0.04
Figures followed by the same letters are not significantly different at 0.04 of probability.

Zein El-Din:

The methyl bromide treatment (25 g/m^2) gave the highest strawberry yield while the bio-fungicidal (Bioarc and Biozeid 216 kg/ha each) was the superior MBr-alternative giving 2.612 kg/ m^2. The cost of using either solarization only or the Bioarc-Biozeid was less than that of using MBr while using either Metam sodium or Basamid was higher (Tables 52-53).

Table 52: The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in strawberry(Tamara) grown in the Zein El-Din farm **(2008/2009).**

Treatment	**Yield (kg/m^2)**	**Costs (LE/Kg)**	**Incremental Costs (LE/Kg)**
Soil Solarization	1.19a	0.546	**- 0.347**
Soil Solarization+ Basamid (50g/m^2)	1.90c	1.545	0.262
Soil Solarization+Metam Sodium (100ml/m^2)	1.40b	1.370	0.477
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	2.14d	1.194	- 0.024
Methyl Bromide (25 g/ m^2) + VIF	2.38e	0.889	

Standard deviation= 6.12

Figures followed by the same letters are not significantly different at 6.12 of probability.

Table 53: The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in strawberry(Festeval) grown in the Zein El-Din farm **(2008/2009).**

Treatment	**Yield (kg/m^2)**	**Costs (LE/Kg)**	**Incremental Costs (LE/Kg)**
Soil Solarization	1.19a	0.546	- 0.523
Soil Solarization+ Basamid (50g/m^2)	2.38c	1.545	0.378
Soil Solarization+Metam Sodium (100ml/m^2)	1.66b	1.370	0.556
Soil Solarization+(Biozeid+Bioarc, 216kg/ha each)	2.61d	1.194	0.305
Methyl Bromide (25 g/ m^2) + VIF	2.85e	0.889	

Standard deviation: 0.025

Figures followed by the same letters are not significantly different at 0.05 of probability

Farm Frites Company:

The yield of the used treatments differed significantly with 2.9 kg/ m2 from Basamid (50 g/ m^2) treatment followed by MBr (25 g/ m^2). While the cost of using most alternatives was lower that of using the MBr (Table 54).

Table (54). The yield and incremental costs of MBr-alternatives compared to the costs of MBr at the rate of 25 g/m^2 + VIF in strawberry Farm Frites company**(2008/2009).**

Treatment	**Yield (k/m2)**	**Costs (LE/Kg)**	**Incremental Costs (LE/Kg)**
Solarization	2.61a	0.249	-0.647
Soil Solarization+Basamid (50g/m^2)	2.90d	0.948	0.052
Soil Solarization+Metam Sodium (100ml/m^2)	2.72b	0.836	-0.600
Solarization + (Bioarc+Biozeid, 216 kg/ha each).	2.81c	0.807	-0.890
Methyl Bromide (25 g/m^2) + VIF.	2.84c	0.896	

Standard deviation = 0.03

Figures followed by the same letters are not significantly different at 0.03 of probability

3. Results of Strawberry Nurseries in Pico and Technogreen Companies

1. Pico:

Results of the effect of basamid and metam sodium on the percentage of the phytopathogenic fungi in strawberry nursery of Pico Company are presented in Table (55). Basamid was superior to metam sodium in controlling soil borne pathogenic fungi. The tested soil samples of both treatments did not reveal pathogenic nematodes.

Table 55: The effect of Basamid and Metam Sodium on the soil borne phytopathogenic fungi in strawberry nursery of Pico Company **(200/2009)**.

Treatment	% Mean*	No of plants/m^2
Basamid (at the rate of 10 g/m^2)+VIF	**8.8^a**	**39**
Metam Sodium (at the rate of 100 ml/m^2	**7.65^b**	**37**

*** The prevalent soil borne fungi: *Fusarium solani, Rhizoctonia solani.***
Standard deviation = 0.81

2. Technogreen:

Results of the effect of methyl bromide and metam sodium on the percentage of phytopathogenic fungi and rate of nematode gall index (RGI) on strawberry roots of Technogreen Company are presented in Table (52). Data show that methyl bromide was better than metam sodium in controlling the soil borne pathogens (fungi and nematodes).

Table 52: The effect of Methyl Bromide and Metam Sodium on the soil-borne phytopathogen (fungi and nematodes) in strawberry nursery of Technogreen Company **(2008/2009)**.

Treatment	% Fungi Mean*	RGI/100 Plants	No of plants/m^2
Methyl Bromide (50 g/m^2)	**2.3^a**	**0.10^A**	**60**
Metam Sodium (100 ml/m^2)	**3.1^b**	**0.13^B**	**59**

*** The prevalent soil borne fungi: *F. solani, Macrophomina phaseolina, R. solani***
Standard deviation between fungi means = 0.56
Standard deviation between RGI means = 0.02

Conclusion

Some alternatives to soil fumigant Methyl Bromide i.e. soil solarization (Physical), Biofungicides (Biological), and Ozone-nondepleting fumigants (Basamid and Metam Sodium) were evaluated on different vegetable crops as alternatives to Methyl Bromide (MBr) under greenhouse and field conditions. The aforementioned MBr alternatives were in combination with soil solarization. The efficiency of each of the used MBr alternatives on controlling of soil-borne phytopathogenic fungi and root-knot nematode (*Meloidogyne* spp) that affect the tested horticultural commodities varied from company to another and from crop to another.

Methyl bromide alternatives were tested in Agrotech farm for controlling soil phytopathogenic fungi that cause root diseases on cherry tomato, bell pepper, and cucumber grown in greenhouses. Results indicated that the combination of methyl bromide (25 g/m^2) soil treatment and VIF plastic mulch significantly the highest effect in reducing the soil-borne diseases compared to the other treatments on cherry tomato followed by basamid (50 g/m^2) soil treatment combined with VIF and soil solarization combined with basamid (50 g/m^2) Also, the combination of methyl bromide (25 g/m^2) and VIF plastic mulch significantly showed the highest effect in controlling soilborne pathogens in bell pepper followed by soil treated with metam sodium (100 ml/m^2) combined with VIF, then solarized soil combined with basamid (50 g/m^2). Additionally, both methyl bromide (25g/m^2) and metam sodium (100 ml/m^2) when combined with VIF were superior to the other treatment in controlling soil-borne pathogens in cucumber. The Bioarc and Biozeid (216 kg/ ha. each) efficiency in suppressing the soil-borne fungal pathogens ranged from 76.3 to 79.1% on tomato cherry, bell pepper and cucumber in the Agrotech experiments. The reproduction of *Meloidogyne* spp. was also suppressed by 67 to 79%. The used MBr alternatives showed similar trends in all the tested vegetable crops at the different locations of experimentation. The efficiency of suppressing the fungal soil-borne pathogens 75-90.9% in CLAC, 81.9-89.1 % in the Egyptian Group, 77.4-92.1% in Farm Frites, 55.2-91% in Mafa farm, 83.7-89.2 in Pico, 57.9-95.7 in Technogreen and from 75.2-92.8% in Zein El-Din company.

Similar trend was observed with suppressing the reproduction of root-knot nematodes as most of the used MBr-alternatives were as efficient as the MBr with some variation that could be due to the tested host and the difference in the ambient environmental conditions. For example the used alternatives, except for the only solarization treatment, suppressed the nematode reproduction by 75-84% compared to 75% for MBr (25 g/m2) when they were used on the cherry tomato experiments. Similar trend was observed in strawberry experiments with nematode reproduction of 67-79% for the used alternatives compared to 80-85% when MBr (25 g/m2) was used. Bell pepper and cucumber experiments showed the same trend and similar efficiency value ranges.

The yield and economical evaluation of the used MBr-alternatives was evaluated to determine the feasibility of using those alternatives at the large scale. Results showed that slightly lower to same yield was obtained with most of the used MBr-alternatives compared to that of MBr (50g/ m2). No differences in yield quality were observed in any of the tested MBr-alternatives treated vegetable crops compared to that from the MBr treatment. Regarding to economical evaluation, the cost of the used MBr-alternatives fluctuated between slightly higher to lower and in general it was acceptable.

Since some of the used MBr-alternative ,especially, basamid and metam sodium and sometimes the biofungicides (Bioarc& Biozeid) were highly efficient in suppressing the soil –borne phytopathogens (fungi and nematodes) they could be substitute the out-phasing methyl bromide. The positive results over more than one season of the used alternatives is a confirmation to stability of their efficacy in controlling the soil-borne plant diseases under nursery, greenhouse and field conditions. The suitability of any of those alternatives will be determined based on nature and production conditions of the target crop. Also, the reasonable crop yield and cost of using those MBr-alternatives is a supporting factor to the feasibility and success of those alternatives as a feasible substitute to MBr. in controlling the phytopathogenic soil-borne fungi and nematodes.

For all the previous reasons, it is recommended to use any of the tested MBr.-alternatives, Metam sodium, Basamide or the bio-fungicides (Bioarc& Biozeid) combined with soil soalrization on the certain tested crop(s) that it was tested on in the next phase of the project.

References

Braun, A. and Supkoff, D. 1994. "Options to Methyl Bromide for the Control of Soil-Borne Diseases and Pests in California with Reference to the Netherlands". Adolf Braun and David Supkoff, Pest Management Analysis and Planning Program, California Environmental Protection Agency, Department of Pesticide Regulation, Sacramento, CA, July 1994.

Bull, C.T. and Ajwa, H. 1998. Yield of Strawberries inoculated with biological control agents and planted in fumigated or non-fumigated soil. From: 1998 Proceedings of Annual Research C onference on Methyl Bromide Alternatives and Emissions Reductions p.94.

Cohen, R., Horev, C., Burger, Y., Shriber, S., and Hershenhorn, J. 2002. Horticultural and pathological aspects of Fusarium wilt management using grafted melons. Hort Science 37:1069-1073.

Cohen, R., Pivonia, S., Burger, Y., Edelstein, M., Gamliel, A., Katan, J. 2000. Various approaches toward controlling sudden wilt of melons in Israel. Acta Hortic. 510:143-147.

Cook, R.J., and Baker, K.F. 1989. The Nature and Practice of Biological Control of Plant Pathogens. APS Press. St. Paul, MN.

DeVay, J.E., Stapleton, J.J. and Elmore, C.L. 1990. Soil Solarization. Food and Agricultural Organization, United Nations. FAO Report #109. Rome, Italy.

Eayre, C.G. 1996. A new research program on biological control of soil-borne diseases of peaches and strawberries. From: 1996 Proceedings of Annual Research Conference on Methyl Bromide Alternatives and Emissions Reductions, p. 88.

Edelstein, M., Cohen, R., Burger, Y., Shriber, S. Pivonia, S., Shtienberg, D. 1999. Integrated management of sudden wilt in melons, caused by *Monosporascus cannonballus*, using grafting and reduced rates of methyl bromide. Plant Dis. 84:1177-1179.

Gianessi, L. 1998. Changing the Mindset Regarding Use of Biocontrol Products. National Center for Food and Agricultural Policy, presented at Rutgers University Workshop on Alternative Paradigms for Commercializing Biological Control. New Brunswick, N.J.
http://www.ncfap.org/RUTGRS01.html

Hartz, T., J.J. Stapleton, and Elmore, C.L. 1993. "Solarization is an effective soil disinfestation technique for strawberry production. HortScience 28: 104-106.

Katan, J. 1981. Solar heating (solarization) of soil for control of soilborne pests. Annu. Rev. Phytopathol. 19: 211-36.

Katan, J. and DeVay, J.E. 1991. Soil Solarization. CRC Press Inc. Boca Raton-Ann. Arbor-Boston-London. 267pp.

Littke, W. 1994. Meeting resource management goals through sustainable forest seedling production using alternative treatment strategies. In Proceedings of the 1994 Annual International Conference on Methyl Bromide Alternatives and Emissions Reductions. Kissimmee, FL.

Lopez-Escudero, F. J., and Blanco-Lopez, M. A. 2001. Effect of a single or double soil solarization on control Verticillium wilt in established olive orchards in Spain. Plant Dis. 85:489-496.

Lumsden, R.D. et al. 1996. Soil Gard ™. In: USDA-ARS Methyl Bromide Alternatives Newsletter, January 1996. http://www.ars.gov/is/np/mba/jan96/lumsden.htm

Maliekal, J., Beach, M., and Warrior, P. 1998. DiTera Nematicide. From: 1998 Proceedings of Annual Research Conference on Methyl Bromide Alternatives and Emissions Reductions, p. 102-1.

Martin, F.N. and Bull, C.T. 2000. Biological approaches for control of some root pathogens of strawberry. Phytopathology 90:S102.

McElroy, F.D. 1985. A newly registered sterilant shows strength in field tests. American Nursery man.

McGovern, R.J., Vavrina, C.S., Obreza, T.A., and Capece, J.C. 1996. Reduction of Fusarium Crown and Root Rot of Tomato by Combining Soil Solarization and Metam Sodium. Methyl Bromide Alternatives 2: 8, January, 1995 U.S. Department of Agriculture Agricultural Research Service, Beltsville, Maryland.

Miner, G. S., and Worsham, A.D. 1990. Fumigation of tobacco plant beds with dazomet. Tobacco Sci. 43:82-87.

Magdy, Neveen G. 2006. Integrated control of root-knot nematodes on strawberry. Ph. D. thesis. Fac. of Agric. Minufiya University, Egypt, 200pp.

Noling, J. W. 2005. Reducing methyl bromide field application rates with plastic mulch technology. http://edis.ifas.ufl.edu/

Noling, J. W. and Becker 1994. "The Challenge of Research and Extension to Define and Implement Alternatives to Methyl Bromide". Supplement to the Journal of Nematology, Vol. 26, No. 4s, pp.573-586.

Pavlou, G. C., Vakalounakis, D.J., Ligoxigakis, E.K. 2002. Control of root and stem rot of cucumber, caused by *Fusarium oxysporum* f.sp. *radicis-cucumerinum*, by grafting onto resistant rootstocks. Plant Dis. 86:379-82.

Pennington, W. 1995. Basamid. BASF Corp. Research Park, North Carolina.

Pryor, A. 1999. Results of 2 years of field trials using ozone gas as a soil treatment. From: 1999 Proceedings of Annual Research Conference on Methyl Bromide Alternatives and Emissions Reductions, p.32-1.

Southey, J. F. 1990. Laboratory methods for work with plant and soil nematodes. Ministry of Agriculture, fisher and food. Technical bulletin 2. London, 148 pp.

Stapleton, J.J. 1994. Solarization as a framework for alternative soil disinfestation strategies in the interior valleys of California. In Proceedings of the 1994 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. Kissimmee, FL.

Stapleton, J.J. 1996. Fumigation and solarization practice in plastic culture systems. HortTechnology 6: 189-192.

Warrior, P. 1996. DiTera – A Biological Alternative for Suppression of Plant Nematodes. From: 1996 Proceedings of Annual Research Conference on Methyl Bromide Alternatives and Emissions Reductions, p. 3-1.

Yarkin, C. 1994. Methyl Bromide Regulation: All crops should not be treated equally. Cherisa Yarkin, David Sundling, David Silberman, and Jerry Siebert, University of California, Davis. California Agriculture, Volume 48, Number 3. May-June 1994.