22251

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

DEMONSTRATION PROJECT ON ALTERNATIVES TO THE USE OF METHYL BROMIDE IN SOIL FUMIGATION

(THE FINAL REPORT)

INSTITUTE FOR PLANT PROTECTION

CHINESE ACADEMY OF AGRICULTURAL SCIENCES

THE PEOPLE'S REPUBLIC OF CHINA

CONTENTS

SECTION ONE
MB AND ALTERNATIVES FOR SOIL FUMIGATION IN CHINA

SECTION TWO
DESCRIPTION OF THE TRIALS

TRIAL 1: BEIJING(TOMATO AND CUCUMBER)

TRIAL 2: HEBEI (STRAWBERRY)

TRIAL 3: SHANDONG(TOMATO AND PEPPER)

TRIAL 4: HUBEI(TOBACCO SEEDBEDS)

TRIAL 5: JILIN(GINSENG)

EXECUTIVE SUMMARY

It is now recognized that MB contributes significantly to ozone depletion. As a consequence many countries are currently restricting consumption and production in order to face an eventual phase out of MB for use in agriculture. The reduction of MB is an essential step that the countries can take towards overcoming one of the most serious problems contributing to environmental degradation. The People's Republic of China was among the first countries in requesting International assistant to conduct demonstration trials of alternatives for soil fumigation.

This paper is a compilation of the results of the project "Alternatives to the Use of Methyl Bromide for Soil Fumigation in the People's Republic of China" (MP/CPR/97/125). The project was funded by the MFMP and implemented by UNIDO.

The work presented here is based on the idea that the development of a comparable agricultural system without the use of MB requires the integration of multiple alternative technologies and extensive researches 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, the 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.

Alternatives to the use of methyl bromide for soil fumigation that are at a time environmentally acceptable and cost effective were effectively identified and demonstrated in China.

Floating tray is a suitable alternative to MB for tobacco. It has been the best among the tested techniques. It can be used in phasing out MB used in tobacco seedbeds once further large-scale trials in all different areas are conducted. However, considering the high cost of the technique, the support from Multilateral Fund under Montreal Protocol will be requested for phasing-out.

Among the identified techniques, the use of substrate is a promising technique for strawberries and vegetables. However, larger-scale experiment and tests to optimize the problems existed will be necessary. The other alternatives showed possibility in phasing out MB are dazomet, resistance cultivar, solarization/biofumigation and avermectin. Further large-scale test will be required to ensure that the alternatives work in all conditions.

No available alternative techniques were identified for ginseng yet.

The use of products from natural origin like the antibiotic avermectin and bio-fumigation, a novel technique for soil treatment using organic materials, are among the most promising alternatives to methyl bromide. The fumigant dazomet is also envisaged as a viable alternative in the production of strawberry, vegetables and in tobacco seedbeds.

If the related industries are developed then, the use of substrates and soil-less cultivation are the best alternatives to replace methyl bromide in certain crops, mainly in strawberry and tobacco seedbeds. Plant breeding and the introduction of new and resistant cultivars of strawberry and vegetables will also help to solve the problem if technical and industrial assistance is provided.

FOREWORD

The earth's protective ozone layer has been damaged by ozone-depleting substances (ODS), such as CFCs, methyl bromide and halons (WMO, 1994). Methyl bromide (MB) is a broad-spectrum chemical commonly used as a soil fumigant for the control of soil-borne diseases, nematodes, insect pests and weeds. Between 30 and 85 % of the total MB applied to the soil (*c.* 50730 t in 1996) will reach eventually the atmosphere (UNEP, 1998). It is now recognized that MB contributes significantly to ozone depletion and was listed as an 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 restricting consumption and production in order to face an eventual phase out of MB for use in agriculture. The reduction of MB use in agriculture is an essential step that the countries can take towards overcoming one of the most serious problems contributing to environmental degradation.

The Vienna Convention for the Protection of the Ozone Layer (1985) and the subsequent Montreal Protocol (1990) have formed the basis for global, multilateral cooperation to deal with the problem. The Multilateral Fund for the Implementation of the Montreal Protocol (MFMP) has been set up to help developing countries, which have fewer resources (Article 5 Countries), to cover the costs for phasing-out ODS.

UNIDO is one of the implementing agencies for the Montreal Protocol agreements. UNIDO has an active presence in 86 Article 5 countries where it is currently implementing demonstration and phase-out projects.

The Parties to the Montreal Protocol in the 9th Meeting held in Montreal in 1997 (Montreal Amendment), for countries operating under Article 5, agreed that:

- From 1st January 2002, the production and consumption of MB will be frozen at the average consumption levels for 1995-1998 (Base-line).
- From 1st January 2005, the production and consumption of MB will be reduced in 20%, based on the average levels for 1995-1998 (Base-line).
- In 2003, decisions would be taken on further reductions on MB for the period 2005 and beyond.
- From 1st January 2015, complete MB phase-out.
- MB used for quarantine and pre-shipment (QPS) purposes is exempted from the agreements.

In order to determine the direction of action to be taken, further work was needed to be done to demonstrate the efficacy of different alternatives for containment/phasing out MB. In 1997, The People's Republic of China was among the first countries in requesting International assistant to conduct demonstration trials of alternatives for soil fumigation.

The present project on "Alternatives to the Use of Methyl Bromide for Soil Fumigation in The People's Republic of China" (MP/CPR/97/125) was designed and started in 1997. The project was funded by the MFMP and implemented by UNIDO. The Ministry of Agriculture of China (MOA) and the National Environment Protection Agency (NEPA) were the counterpart institutions. A long term contract was established with the Institute for Plant Protection of the Chinese Academy of Agricultural Sciences (IPP-CAAS), that were responsible for the national expertise and the following up of the laboratory and field trials on a day to day basis.

SECTION ONE

MB AND ALTERNATIVES FOR SOIL FUMIGATION IN CHINA

ALTERNATIVES TO THE USE OF MB FOR SOIL FUMIGATION

The Methyl Bromide Technical Options Committee (MBTOC) was established by the Parties to the Montreal Protocol to identify existing and potential alternatives to MB. Up to date, MBTOC has identified viable alternatives for more than 95% of the current tonage of MB, excluding QPS. Replant problems in areas with limited land availability and some certified pest-free propagation materials are difficult to solve without MB. These two cases are estimated to use less than 2500 t/year (UNEP, 1998).

An alternative to MB is defined as:

- Those non-chemical or chemical treatments and/or procedures that are technically feasible for controlling pests, thus avoiding or replacing the use of MB. "Existing alternatives" are those in present or past use in some regions. "Potential alternatives" are those in the process of investigation or development. Alternatives demonstrated in one region of the world would be applicable in another, unless there was obvious constraints to the contrary e.g. a very different climate or pest complex (UNEP, 1998).

The varied and special conditions in Article 5 countries require that the alternatives chosen be appropriately adapted to the climatic conditions, particular cropping techniques, and specific target pests. However, local availability of an alternative due to materials availability and/or registration problems may be specific to the country or local region. Therefore, it is not consider appropriate to omit alternatives based on such considerations.

The reduction of MB use by dosage and emission reduction can't be considered as an alternative for obvious reasons.

Different alternatives will have to be used for different crops and situations. This is likely to involve significant effort to select appropriate alternatives, adaptive research, field testing, technology transfer, user education, institutional capacity building and training, among other factors. It is critical that those article 5 countries which utilize MB receive technical and financial assistance to introduce or adapt alternative materials and methods to manage the pests currently controlled by MB.

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.

Table 1. Available alternatives to MB for soil fumigation (MBTOC, 1998)

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 azides
	Others

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.

AVAILABLE ALTERNATIVES TO MB FOR SOIL FUMIGATION IN CHINA

CHEMICAL ALTERNATIVES

Fumigants. A number of fumigant substances that could be used as alternatives to MB are currently available in China:

- Chloropicrin is commercialized since the 1950's, the current capacity is 6400 t/year and the current production is 2850 t. Chloropicrin is difficult to apply, is highly poisonous and produces chronic odour and eye irritation, its efficacy is limited due to high boiling point and poor permeability. Currently, China is in short of the application equipment for chloropicrin.

- Dazomet is produced in China since 1982, the current capacity is *c.* 100 t/year (95% technical product), the production is 50 t. Dazomet has been used for soil fumigation in the Xinjiang region.

- Metam-Sodium is produced in China since 1997, the current capacity is 2000t/year(35%SL). Metam sodium has been registered since October 1999.

- 1,3 Dichloropropene is produced in small quantities as a by-product from the production of Chloropropene.

Non-fumigants. A variety of non-fumigant phytosanitary compounds (nematicides, fungicides, herbicides, insecticides...) are produced or are available in China. A natural origen molecule, Avermectin, is actually showing excellent control of soil nematodes, mainly root knot (*Meloidogyne* spp.).

NON-CHEMICAL ALTERNATIVES

- Steam has been used in some areas to disinfect mushroom substrates before inoculation. Also it has been used on an experimental basis in the treatment of tobacco seedbeds and nurseries.

- Crop rotation is a traditional practice in China, the technique is able to avoid soil infections and guarantee the output and quality of crops.

- Organic amendments are widely available and its application to the soil also constitutes a major traditional practice to control soil-borne diseases.

- Solarization and bio-fumigation, when applied in the traditional manner, solarization alone necessitates long exposure time (aprox 2 months) which is limiting the usefulness of the technique. It is believed that when combined with other practices like the application of organic amendments its efficacy could be improved whereas decreasing exposition time.

- Substrate use in agriculture is very limited in China, this is due to the lack of companies manufacturing and offering this product. Locally formulated substrates that included vermiculite and turf have been used with success in protected strawberry crops in the Hebei province. Mixture of coconut powders, peat blocks and manure as strawberry substrate is used on Beijing-Mitsubishi Friendship Demonstration Farm.

- Resistant cultivars and varieties are scarce in China, no root-knot nematodes resistant tomatoes are commercially available and many cultivars used are obsolete e.g. the most popular strawberry cultivar, "All Star", has been grown for more than 15 years.

- Biological control agents are available in china, mainly based in *Trichoderma* spp. And *Pseudomonas* spp.

- Grafting has been used in China for the control of soil-borne diseases, mainly fusarium and verticillium wilts and root knot nematodes in cucumber, watermelon and eggplant.

MB IN CHINA. PRESENT AND FUTURE PROSPECTS

MB PRODUCTION AND CONSUMPTION IN CHINA

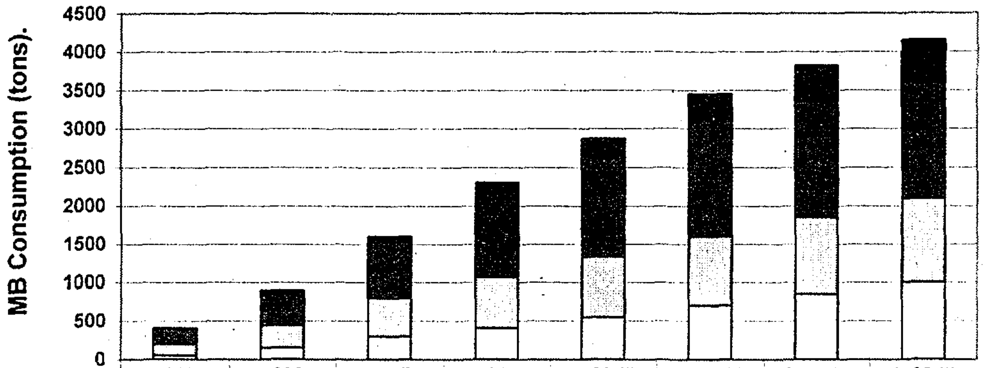
China is both, a consumer and producer of MB that has been used and produced for more than 45 years. The first commercial production started in 1954. Five plants, i.e., Linhai Jianxin Chemical Industrial Factory, Zhejiang Province, Lianyungang Guanxi Yanchang Chemical Industrial Factory, Lianyungang Sea-Water Chemical Industrial Factory 1st Plant, and Nanjing Zhongshan Chemical Industrial Factory, Jiangsu Province, Changyi Chemical Industrial Factory, Shandong Province, were built to produce the chemical. Two plants are actually operative with a total capacity of 3300 t/year.

Initially MB was used only for the fumigation of cotton seed, perishables and for quarantine purposes. With the reform and the development of installation agriculture, the growers found that the soil-borne diseases and nematodes became more and more serious than ever. Qingzhou Institute for Tobacco, Chinese Tobacco Corporation, Lianyungang Sea-Water Chemical Industry 1st Plant, Israel Dead Sea Bromide Group and American Great Lake Chemical Corporation started to conduct soil fumigation experiments on tobacco seedbeds in 1987. IPP-CAAS conducted experiment on tomato and cucumber in plastic tunnels in 1990. Lianyungang Sea-Water Chemical Industry 1st Plant and Mancheng Strawberry Extension Centre, Hebei Province, carried out experiment on strawberry. All the experiments gained good results and significant profit, especially with the release of tinned MB (681g) to market in 1995. The farmers mastered the technique very quickly. The consumption of MB has been increased significantly since then.

It was not till late 1980' when expansion for soil fumigation occurred. There were four factories with a total capacity of 2300 t in 1996. Two of them ceased production in 1997 and the total capacity decreased to 1800 t. In 1998, Lianyungang Sea-Water Chemical Industry 1st Plant (Jiangsu) expanded its capacity to 3000 t/year and the capacity of Changyi Chemical Plant (Shandong) is 300 t/year (Ni Jiasheng, 1999).

China's agriculture is largely based on small holders for whom the use of tins to apply MB is more convenient. The average area cultivated per rural farmer for 1994 was 2100 m^2, and this figure is smaller (between 660 and 1000 m^2) for farmers producing tobacco and protected crops like vegetables and strawberries. One of the reasons for the late use of MB for soil fumigation in China was that no small containers were available. The traditional packages in China were 40 or 70 Kg cylinders, but recently the imports and production of small package MB (1 ¼ pounds, 681g) increased greatly.

In October 1995, the largest plant for MB production in China (Lianyungang Sea-Water Chemical Industry in Jiangsu Province) started a joint venture with Dead-sea Bromine Compounds Ltd of Israel, to build a 1000 t/year equipment of small packed MB that was expected to enter in production during 1997 (Zhejiang Chemical Industry Research Institute, 1996). This certainly facilitated the use of MB for soil fumigation being one of the main reasons for the increased actual MB consumption and trends (Fig. 1).



Year	1995	1996	1997	1998	1999 (*)	2000 (*)	2001 (*)	2002 (*)
■ Others (**)	10	50	80	130	240	350	470	550
■ Tobacco seedbeds	200	400	720	1100	1300	1500	1500	1500
□ Strawberry	150	300	500	660	780	900	1000	1100
□ Vegetables	50	150	300	410	550	700	850	1000

Fig. 1. Use of MB for soil fumigation in China (1995-2000).
(*): Predict data; (**): include herbs, flowers and turf.

In 1996, China consumed 2%, of the global MB used for pre-plant soil fumigation, being ranked as the 13th highest consumer in the world. However China is one of the areas in the world with a highest potential for increasing MB consumption for agricultural purposes. As seen from Fig. 1, a 5.6 fold increase of MB consumption for soil fumigation has occurred in China in the period between 1995 and 1998, and more than a 10 fold increase is predicted in the period between 1995 and 2002.

MAJOR CROPS AND AREAS FOR MB CONSUMPTION

In China more than 95 % of the MB used for soil fumigation is dedicated to four crops: tobacco seedlings, strawberries, vegetables (mainly tomato, cucumber and pepper) and medical herbs (mainly ginseng).

There are more than 2,352,810 ha (1987) land planted with tobacco in China. The main regions are Yunnan Province (570,600 ha), Guizhou Province (436,600 ha), Henan Province (215,560 ha), Hunan Province (138,300 ha), Helongjiang Province (107.70 ha), Hubei Province (102,17 ha) and Sichang Province (100,200 ha). It has been estimated that more than 6000 t of MB could be used to fumigate all the tobacco seedbeds needed for one year's plantation. In 1995 the consumption was 200 t but an increasing interest exists to further promote the use of MB in areas of tobacco production in Hubei, Yunnan, Guizhou and Shandong provinces. It was estimated that the consumption of MB would rise to 1100 t for this commodity only if 20 % of tobacco seedbeds were fumigated with MB by 1998.

There are more than 20,000 ha strawberries in China. Among them, 5,000 ha are in the plastic tunnels. Main planting strawberry regions are Hebei Province (5,500 ha), Liaoning Province (3,000 ha), Shandong Province (2,600 ha), and Jilin Province (2,000 ha). More than 4000 ha of strawberry were planted in Mancheng. Main problems of crop protection are: Fungal diseases verticillium wilt (*Verticillium albo-atrum* Reinke et Berthold), Fusarium wilt (*Fusarium oxysporum* Schlechtendahl f.sp. *tragariae* Winks et Willians), *Phytophthora fragariae* Hickman, *Phytophthora cactorum* spp., *Colletotrichum fragarae & C. acutatum*, *Thanatephorus cucumeris* (Frank) Donk **Rhizoconia solani* Kuhn,and *Alternaria fragariae*; Bacterial disease *Pseudomonas solanacerum* E.F. Smith and nematodes.

The strawberry grows in land corresponding to 1/4 of protected crops in Hebei Province in 1997. In 1995 20 t of MB were used to fumigate *c* 45 ha. This figure increased greatly and the estimations for MB usage in 1997 for this commodity was 550-600 t in Mancheng only. In 1996 it was planned to expand the use of MB to the strawberry growing areas in Liaoning, Jiangsu and Zhejiang provinces. MB is expected to increase rapidly in this sector, especially in regions with high disease incidence such are Mancheng (Hebei) and Dandong (Lianning).

The total growing area for vegetables was 11,288,190 ha in China according to the consesus in 1997 because all the provinces grow vegetables. The protected land was about 1,300,000 ha. The main growing areas were in Shandong (1,267,600 ha), Guangdong (944,100 ha), Henan (760,37 ha), Hubei (721,700 ha), Guangxi (682,682 ha), Sichang (627,900 ha), Jiangsu (619,300 ha), Hebei (599,300 ha). The area of tomato and cucumber in protected land is over 1,000,000 ha. According to the surveys conducted in Hebei, Henan, Liaoning, Jiangxi, Heilongjiang and Tianjin in 1995, the areas for protected vegetables were:

Cucumber	123,380 ha
Tomato	102,880 ha
Hot pepper	63,387 ha
Green beans	51,213 ha
Egg plant	37,786 ha

The main plant protection problems in vegetables are: fungal diseases *Fusasium* spp., *Verticillium* spp., *Phytophthora* spp., *Collectotirum* spp., *Sclerotinia selerotiorum*, bacterial diseases, and nematodes. The efficacy of applying MB is very good in vegetables but not yet extensively used. The main reason is that the cost is too high. The use of MB in vegetables will increase sharply due to the increased domestic production of MB, the reduced price and more and more serious soil-borne diseases in protected lands.

Fumigation trials conducted in tomato and cucumber protected crops give satisfactory results, but MB application is not yet extended mainly because the costs of application is too high for this crop. At the present moment research is being conducted in order to lowering the costs. This sector is one with a major potential to increase MB consumption. Estimates made by technicians from Lianyungang Chemical Industrial 1st Plant situated the potential consumption of MB in protected vegetable crops in more than 10,000 t / year.

The cultivation area of ginseng is more than 10,000 ha per annum. The biggest problem in ginseng is that the incidence of diseases. The main diseases are *Cylindrocarpon* spp., *Rhizoctonia solani* Kuhn, *Pythium debaryanum* Hesse, *Alternaria panax* Whetz, *Phytophthora cactorum* (Leb. et Cohn) Schrot, and *Sclerotinia selerotiorum* (Lib.) de Bary and root knot nematode (*Meloidogyne hapla*) . Ginseng can not been cultivated continiously due to the heave incidence of soil-borne disease especially *Cylindrocarpon* spp.. It needs over 30 years' rotation. The main measure to avoid this disease was to deforest to get new land. The heavy erosion of soil and flood caused by deforest caught the attention of the Government. It was forbidden to deforest naturally grown forests including for the purpose of growing ginseng since 1988. MB has become the only pesticide to control *Cylindrocarpon* spp. The dose is 60-90 g/m2 . It can reach the efficacy of newly deforested land. If the use of MB in ginseng is not forbidden, the amount of application will increase sharply.

Ginseng is grown in many regions of China. They are used at a large scale for local consumption, but also a significant part of the production (60 %) is exported. The limited area available for new plantations and the incidence of soil borne diseases, mainly *Cylindrocarpon* spp. and insect pests are considered as limiting factors for the production of ginseng and MB is seen as an alternative in controlling these problems, so the consumption is expected to be extended rapidly.

WORKPLAN

SELECTION OF CROPS AND LOCATION

The crops and locations (sites) for the trials to test alternatives to the use of MB in China, were initially proposed by the Ministry of Agriculture (MOA) and The Institute for Plant Protection of the Chinese Academy of Agricultural Sciences (IPP-CAAS). MOA and IPP-CAAS selected the crops according to its actual and potential use of MB for soil fumigation (Fig. 1). The sites (Fig. 2) were selected attending to the relevance of the crop for the area, the reliability of the local personnel for the follow-up of the trials and by the presence of a qualified technical team from the Regional Environmental Monitoring Stations able to provide adequate support.

Fig. 2. Location of the demonstration trials in China

SELECTION OF ALTERNATIVES

A minimum of four different alternatives were chosen for each site and crop. These were compared with MB treated and untreated plots and, at last three replicates were available for each treatment, in a one or two-year trial.

The alternative treatments to the use of MB in soil fumigation in China 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 personnel from the Regional Environmental Monitoring Stations, from the trial locations and UNIDO.

The trials were largely 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 site. Some alternatives already available or under experimentation were also chosen. This introduced in acquired local knowledge in the demonstration trials and also a major commitment of the local personnel.

Fourteen different alternatives were chosen (Table 2), these were implemented into an IPM system, that was further improved during the trials. The IPM strategy was designed and intended in order to produce agricultural systems that are at a time environmentally safe and cost-effective.

TABLE 2.- ALTERNATIVES TO MB TESTED IN CHINA

Jilin	**Beijing**	**Hebei**	**Shandong**	**Hubei**
Ginseng	Tomato & cucumber	Strawberry	Tomato & pepper	Tobacco seedbeds
Dazomet	Dazomet	Biofumigation	Dazomet	Dzomet
Metam Na	Biofumigation	Soilless	Biofumigation	Suspended tray
Chloropicrin	Local substrate	New soil or ratation	Local substrate	Floating trays
BCA's	Avermectin	Steam pasteurization	New cultivars	Soil burn
	New cultivars	Dazomet		
		New cultivars		

PROGRAM MANAGEMENT

There was a responsible person allocated for each location (Local Agricultural Bureau), which was in charge of all the work to be conducted directly in the fields and had direct contact with the Provincial Agro-Environmental Monitoring Stations.

There was a responsible person allocated in provincial agro-environmental monitoring stations, who was in charge of all the work conducted in relation to soil and water analyses (according to the Chinese standards for environmental analysis), sample organization and technical advice and the backup to activities that were conducted in the site in general.

The personnel from the Institute for Plant Protection of the Chinese Academy of Agricultural Sciences (CAAS-IPP), was the key institution and responsible for the following of the project on a day to day basis. They were the contact and link between sites and Stations and MOA-SEPA and UNIDO. They were in direct contact with the responsible persons in the Stations, being in charge of organizing and briefing the activities and collection of data. CAAS-IPP also assisted the international experts and informed regularly to the Ministry of Agriculture (MOA), State Environmental Protection Agency (SEPA) and United Nations Industrial Development Organization (UNIDO). Also CAAS-IPP provided substantial national expertise and laboratories to conduct the soil biology analysis.

In close co-operation with the project manager at UNIDO and the national experts and institutions, an International expert in integrated pest management systems and soil fumigation was responsible for the management and co-ordination of all project activities as well as setting up the detailed work-plan. International experts also participated and assisted in specific aspects of the project.

Project management chart is shown in Fig. 3.

MANAGEMENT CHART OF ALTERNATIVES TO THE USE OF MB IN SOIL FUMIGATION IN CHINA

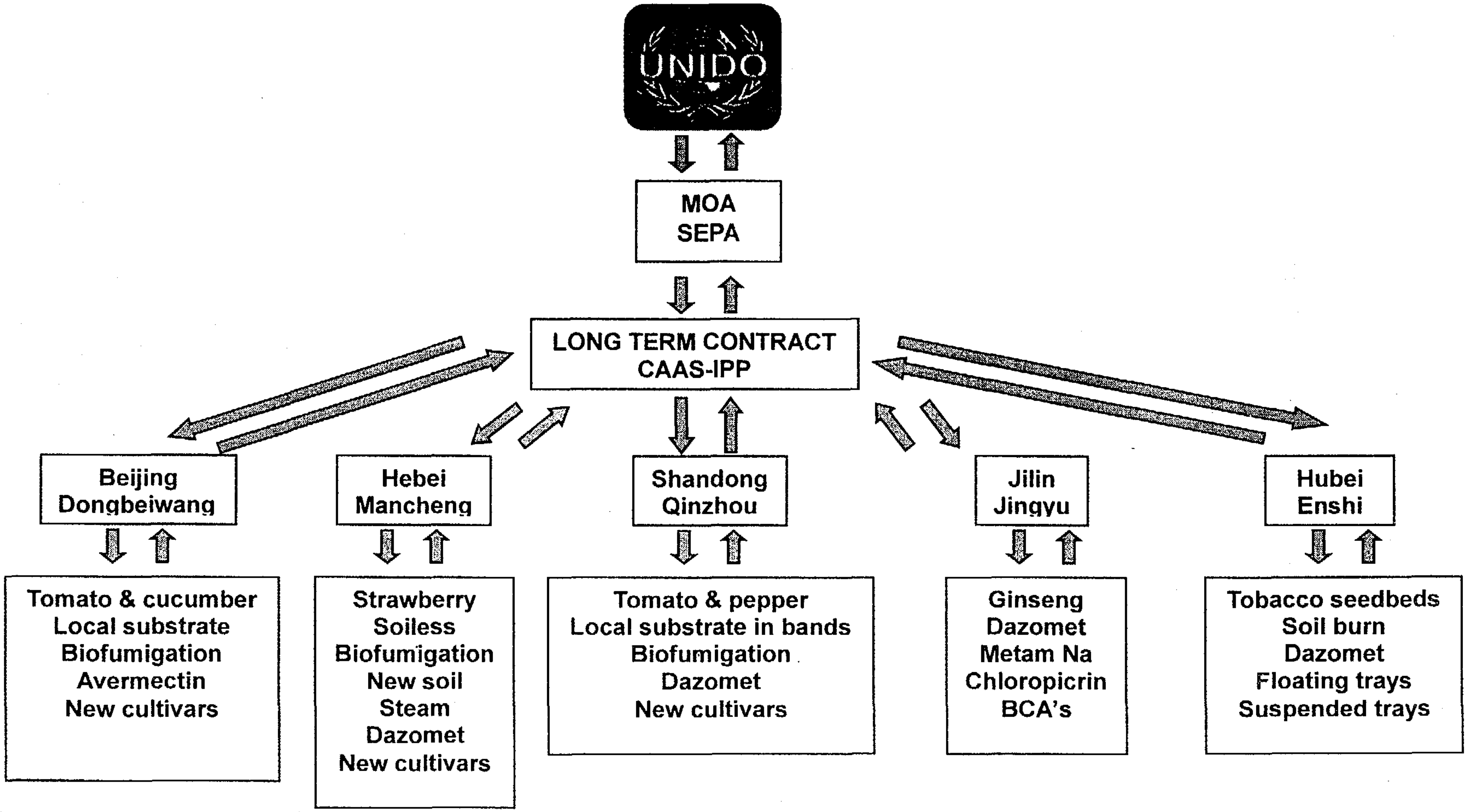


Fig.3. Project management chart.

REFERENCES

CITED LITERATURE

WMO, 1994. Scientific Assessment of Ozone Depletion. The World Meteorological Organization, Report No. 37, UNEP.

UNEP, 1998. MBTOC 1998 Assessment of Alternatives to Methyl Bromide. United Nations Environment Programme. Nairobi.

Zhejiang Chemical Industry Research Institute, 1996. Survey on the production and consumption of methyl bromide in China. Repport to UNDP.

Ni Jiasheng, 1999. Workshop on Developing a strategic framework to control MB in China, Beijing, China, 27-29 July 1999.

TO KNOW MORE

Bell, A., J. Böye, O. Nück, 1998. Methyl Bromide Substitution in Agriculture. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH. English version (Chinese edition available). 159p.

Australian Methyl Bromide Consultative Group, 1998. National Methyl Bromide Response Strategy. 75p.

Marcotte, M. 1998. Improving Food and Agriculture Productivity - and the Environment. Canadian Iniciatives in Methyl Bromide Alternatives and Emission Control Technologies. 46p.

UNEP IE, 1998. Methyl Bromide. Getting Ready for the Phase Out. 31 p.

Bello A., J.A. González, M. Arias y R. Rodríguez-Kábana (Eds), 1998. Alternatives to Methyl Bromide for the Southern European Countries. EU-DG XI, CSIC, 404 pp

Bello A., J.A. González, J. Pérez-Parra. J. C. Tello, (Eds), 1998. Alternativas al Bromuro de Metilo en Agricultura. Comunicación I+D Agroalimentaria. Junta de Andalucía, Dir. Gral. de la Producción Agraria, 192p.

ON-LINE RESOURCES

www.unepie.org/ozonaction.html
www.ars.usda.gov/is/mb/mebrweb.htm
www.epa.gov/spdpublc/mbr/mbrqa.html
www.teap.org/html/methyl_bromide.html
www.ccma.csic.es/agroecol/mebr/mebr1.htm
www.environment.gov.au/epg/pubs/mb_strategy.html
www.ec.gc.ca/ozone/mbrfact.htm
www.gtz.de/proklima/methyl1.htm

SECTION TWO

DESCRIPTION OF THE TRIALS

TRIAL 1: BEIJING

(TOMATO AND CUCUMBER)

GENERAL INFORMATION AND RESPONSIBLE PERSONS

TRIAL CROP: VEGETABLES

SYSTEM: AUTUMN TOMATO AND SPRING CUCUMBER

ODS USE IN VEGETABLE (1998): 410.0 t (246 t ODP)
SUB-SECTOR BASELINE (1995-1998): 227.5 t (136.5 t ODP)

Crop history:	10-28 July 1998:	Treatments
	July-November 1998:	Tomato
	November 1998-March 1999:	Edible rape
	April 1999-June 1999:	Cucumber
Site Location:	Dong Bei Wang Township, Hai Dian District, Beijing.	
Contact at site:	Ms. Wang Shuzhi	
Tel:	+86-10-62893227	
Joined institution:	Beijing Agro-Environmental Monitoring Station:	
Chief:	Ms. Zhao Yingrong (Senior Engineer)	
Tel:	+86-10-62057660	
Technique backup:	IPP-CAAS	
Advisors:	Ms. Qi Shuhua and Dr. Duan Xiayu	
Tel:	+86-10- 62815941/62815946	
Fax:	+86-10-62894863	
E-mail:	sygs@public.east.cn.net/xiayud@public.east.cn.net	

THE SITE

The site is located in Ma Lian Wa Villege, Dong Bei Wang Town, Hai Dian District, northwest Beijing and not far from IPP-CAAS headquarters. The area is being used for vegetable production for more than 30 years. The fertilization is organic manure.

Traditional irrigation system is by flooding. This system was considered inadequate for the planned trial design. A drip irrigation system supplied by UNIDO was installed in order to avoid soil-borne disease spread (mainly root knot nematodes and fusarium wilt) in June 1998. MB was previously used in the field during the 1995 campaign.

Average temperature and rainfall in the area for the period 1996-97 are shown in Fig. 1.1. In general, maximum temperatures are higher than 35 °C, and the average annual temperature is between 10 to 13.0 °C. The minimum temperature can reach –15 °C in January. Frost occurs during the night in November and all the day throughout since late November to February. The precipitation occurs mainly in summer (June to August). Evaporation (1500 mm) is higher than precipitation so there is shortage of water and the climate is dry.

The type of soil in the trial is an hygro-cinamom. Soil physical and chemical characteristics determined from 6 composite samples that were taken before the treatments can be found in Table 1.1. The irrigation water variables are in Table 1.2.

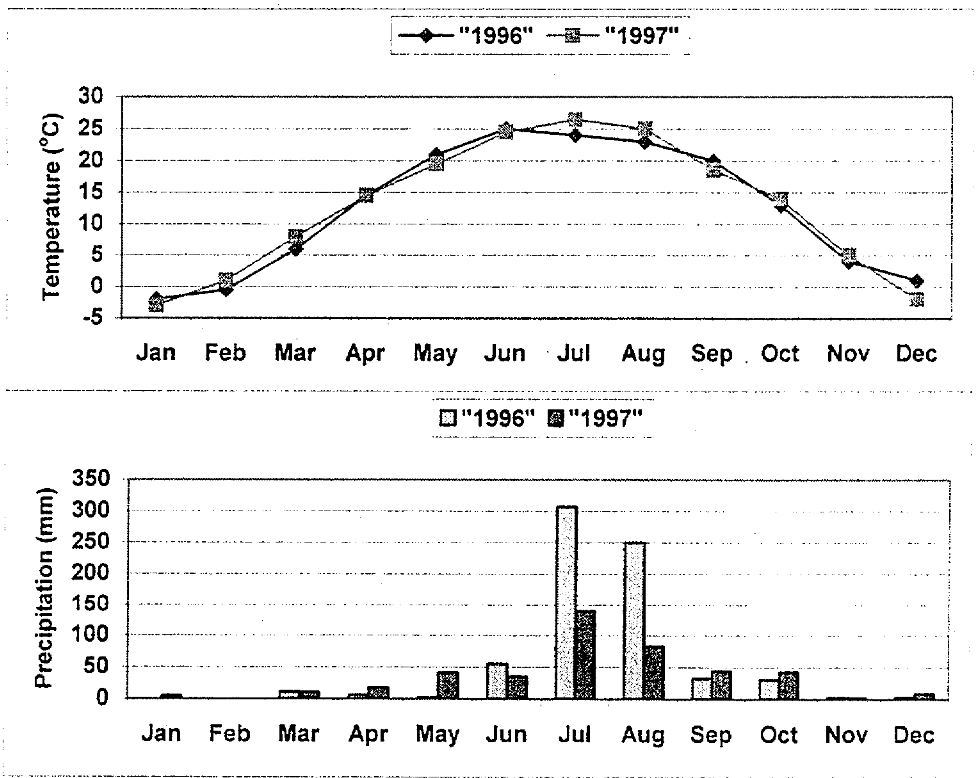


Figure 1.1. -Average monthly temperatures and rainfall in the Dong Bei Wang area.

Table 1.1. -Soil characteristics in the experimental field in Dong Bei Wang

Variable	Mean	STD	Granulometry		
pH	7.05	0.013	Size (mm)	(%)	STD
Field Water Capacity (%)	28.83	0.513	1-0.25	9.35	1.017
Organic Matter (%)	3.81	0.123	0.25-0.05	43.38	1.629
CEC (cmol/kg)	15.96	0.772	0.05-0.01	30.83	1.472
C/N	8.61	1.361	0.01-0.005	5.50	0.837
EC (ms/cm)	0.56	0.081	0.005-0.001	7.33	1.033
Total N (%)	0.26	0.055	< 0.001	3.6	1.095
Total P (%)	0.42	0.029			
Total K (%)	2.21	0.096			
Effective N (mg/kg)	230.65	16.967			
Effective P (mg/kg)	216.03	16.115			
Effective K (mg/kg)	530.00	168.522			
		n=6			n=6

Table 1.2. -Irrigation water characteristics in Dong Bei Wang

Variable	
pH	7.92
EC (μs/cm)	1840
Hardness (mg/L $CaCO_3$)	752

THE TRIAL

The design of the experiment was three completely randomized blocks, each with one replicate from one treatment. The area of the plot was 27.5 m^2 (5.5 x 5 m). Following the usual management in the area, only one treatment per year was applied in July 1998, before the cash crop, tomato (200 plants/plot) that was harvested in November 1998. After the tomato crop, a fast crop, edible rape (Yu Chai, *Brassica napus*, Cruciferae), was planted and was harvested in March 1999. Then a spring crop of cucumber (170 plants/plot) was planted and harvested in June 1999. Along the year, care was taken during tillage in not to displace the treatments and in maintaining the original plots. The following up of the trial was done in the winter tomato crop and the spring cucumber.

THE TREATMENTS

O Control: The land was prepared in the usual way in the area and remained untreated.

A MB: This treatment was done in the usual way. The land was plugged and worked correctly, then was covered with plastic sheet. MB was then applied and the land sealed for 3 days with plastic mulch till 13th July 1998 when it was opened for aeration. Final dosage was 49.5 g/m^2.

B Local bio-fumigation: The land was prepared for treatment and the 10th July. A previously prepared amendment for bio-fumigation (cabbage, wheat straw and fresh cattle manure at 2:2:3 ratio) was mixed and applied evenly in the soil at a rate of 7 kg m^{-2}. The soil was watered and covered with plastic mulch. The soil remained covered with plastic for 15 days till July 25th. Soil temperature was recorded during the treatment using a Data-Logger.

C Local substrate in bands, soilless cultivation: A substrate made of a mixture of composed cattle manure, local turf or peat and wheat straw was used (1:6:2 ratio). The land was opened by deep plugging and the substrate deposited. The plants grew in soilless culture on the band of substrate (Fig. 1.3).

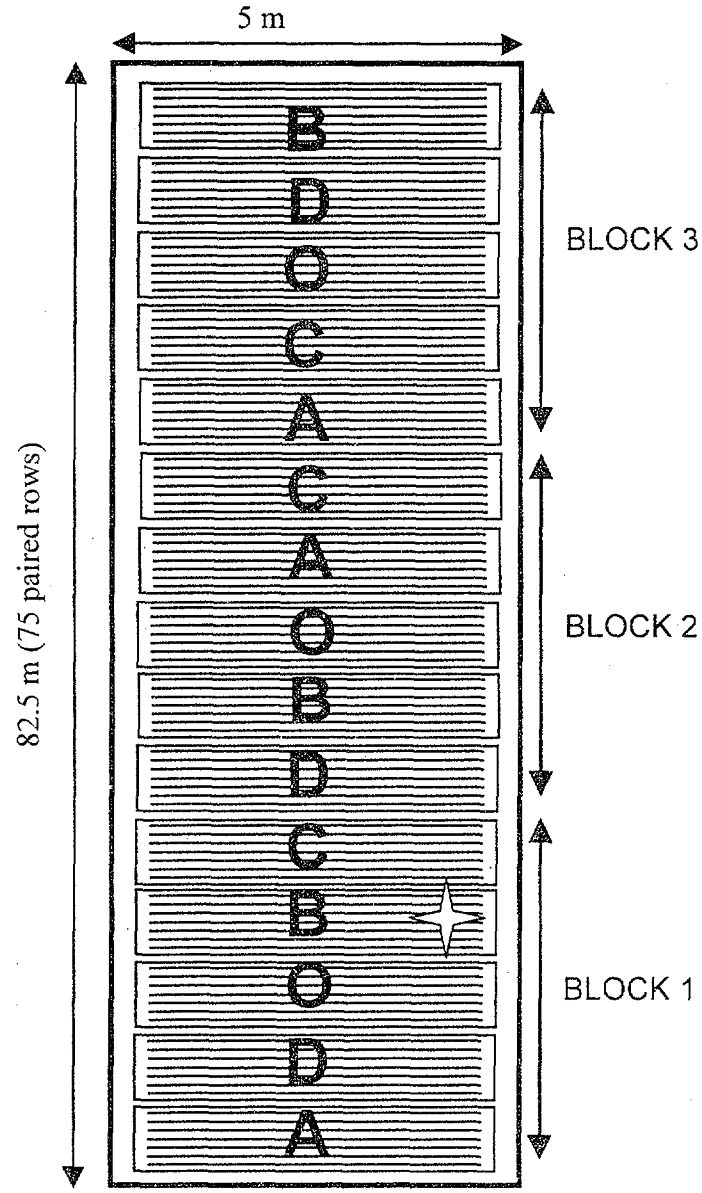


Fig. 1.2. -Trial layout for Dong Bei Wang Farm. " Indicates temperature recorders

D Avermectin: Before planting, a solution of avermectin (Aifuding 1.8 EC + synergist) was made with 1 ml product / 3 L water, sprayed over the soil and incorporated deeply in the soil by a labor. Final dose was 0.018 g of technical product 95% purity / m^2 (1ml Aifuding/m^2). The avermectin used is locally manufactured by The Beijing Agricultural University Newtech Development Corporation under trade name of "Aifuding" agricultural pesticide and miticide, it is also available in other formulations: 0.9 and 0.2 % EC + synergist.

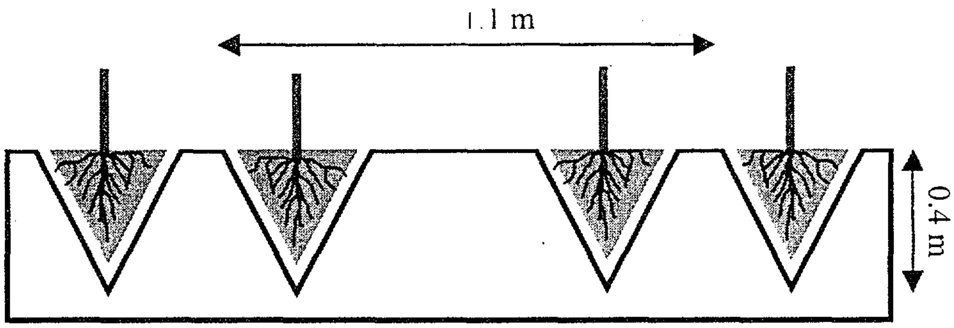


Fig. 1.3 -Scheme of soilless cultivation in Dong Bei Wang Farm.

THE PLANTS

Autumn tomato crop: Three tomato cultivars were used:

a) Chinese MaoFen 802 with resistance to TMV. Planted in Blocks 1 & 2.
b) Chinese JiaFen 15 with resistance to TMV. Planted in Block 3.
c) AR-35200 a long life, determined growth cultivar, with multiple resistance to TMV, root knot nematodes, Verticilosis, Fusariosis (Race 2) and *Stemphylium*. Planted in a paired row in the control plots (**O**) along side with the local cultivars.

Winter fast crop: A local cultivar of edible rape, Yu Chai (*Brassica napus*, Cruciferae) was planted in all the field.

Spring Cucumber:

a) 170 plants of cucumber cultivar 887 in each plot.

EFFECT OF TREATMENTS ON PATHOGENS AND WEEDS

EFFECT OF THE TREATMENTS ON SOIL FUNGI

Komada selective method was used. The method was done in a quantitative manner during the trial: before and after the treatments and after the crop. Three to four dishes per sample were analyzed and the results are summarized in Table 1.3.

Table 1.3. -Evolution of soil fungi during the trial (c.f.u/g soil)

	Fo	Fs	Fr	Cy	TOTAL
TREATMENT	Before treatments (27 May 1998)				
All the field (24 samples)	991.7	216.7	8.3		1217
	After treatments (15 September 1998)				
CONTROL (O)	867 **a**	400 **a**			1267 **a**
MB (A)	133 **c**	200 **a**			333 **c**
BIOFUMIG. (B)	667 **ab**	333 **a**			1000 **ab**
SUBSTRATE (C)	467 **b**	333 **a**			800 **b**
AVERMECTIN (D)	533 **b**	200 **a**			733 **b**
	After the autumn tomato crop (26 November 1998)				
CONTROL (O)	450 **ab**	333 **a**	167 **ab**	133 **ab**	1083 **a**
MB (A)	167 **c**	400 **a**	67 **ab**	33.3 **b**	667 **b**
BIOFUMIG. (B)	233 **bc**	233 **ab**	267 **a**	117 **ab**	850 **ab**
SUBSTRATE (C)	533 **a**	117 **b**	17 **b**	333 **a**	1000 **ab**
AVERMECTIN (D)	500 **a**	333 **a**	100 **ab**	150 **ab**	1083 **a**
	After the spring cucumber (2 July 1999)				
CONTROL (O)	717 **a**	1433 **a**	100 **a**	17 **a**	2267 **a**
MB (A)	233 **b**	1350 **a**	0 **a**	50 **a**	1633 **a**
BIOFUMIG. (B)	200 **b**	600 **b**	0 **a**	0 **a**	800 **b**
SUBSTRATE (C)	917 **a**	0 **c**	17 **a**	0 **a**	933 **b**
AVERMECTIN (D)	250 **b**	1283 **a**	683 **a**	17 **a**	2233 **a**

Fo: *Fusarium oxisporum*; Fs: *Fusarium solani*; Fr: *Fusarium roseum*; Cy: *Cylindrocarpon* spp. Treatments with the same letter are not significant different according to a Duncan's Multiple Range Test. signification level is 5%.

The treatment with MB was effective in reducing the fungal soil population. However, this effect only lasted for one season. There were not significant differences between the treatments MB, bio-fumigation and substrate before the spring cucumber crop. The total populations of soil fungi were reduced in the bio-fumigation and substrate treatments after the cucumber crop.

EFFECT OF THE TREATMENTS ON SOIL NEMATODES

Nematodes were extracted eliminating fine particles (silt and sand) from 200 cc rhyzospheric soil by sieving (0.5 cm) and nematodes separated by centrifugation. The nematodes recovered were stored in vials with formol for further study. Nematode population was studied at four periods: before treatments, after treatments, middle crop season and after the autumn tomato crop. The data is shown in Table 1.4.

Table 1.4.- Population reduction (%)* at different stages during the autumn tomato crop.

TREATMENT	***Meloidogyne* spp.**	Other Parasitic nematodes	**Free living nematodes**	Dorylaimids	**TOTAL**
AT PLANTING TIME (28 July 1998)					
CONTROL (O)	32.61	-627.27	11.69	35.26	11.31
MB (A)	100	100	89.34	100	90.53
BIOFUMIG. (B)	81.52	100	84.85	-18.46	79.82
SUBSTRATE (C)	81.52	100	0.07	53.17	7.92
AVERMECTIN (D)	84.78	100	74.71	32.51	73.42
AT MIDLE SEASON (13 October 1998)					
CONTROL (O)	7.27 **a**	-553.53 **a**	32.07 **a**	100 **a**	31.23 **a**
MB (A)	76.09 **ab**	100 **b**	88.33 **a**	100 **a**	88.23 **b**
BIOFUMIG. (B) **	65.20 **ab**	-6.07 **ab**	76.53 **a**	72.47 **a**	75.30 **ab**
SUBSTRATE (C)	75.37 **ab**	9.1 **ab**	52.07 **a**	68.80 **a**	54.07 **ab**
AVERMECTIN (D)	100 **b**	100 **b**	77.17 **a**	65.10 **a**	78.03 **ab**
AFTER THE AUTUMN TOMATO CROP (24 November 1998)					
CONTROL (O)	15.87 **a**	-81.82 **a**	32.69 **a**		34.39 **a**
MB (A)	68.04 **a**	9.09 **a**	81.18 **b**		80.97 **b**
BIOFUMIG. (B) **	55.43 **a**	-36.36 **a**	91.84 **b**		89.49 **b**
SUBSTRATE (C) **	82.61 **a**	100 **a**	80.07 **b**		81.26 **b**
AVERMECTIN (D)	75.43 **a**	69.70 **a**	64.96 **b**		67.25 **b**

* 100-((Pf/Pi)x100). ** Only two replicates were considered. The third was an average of the other two. Treatments with the same letter are not significantly different according to a Duncan's Multiple Range Test. Signification level is 5%.

Avermectin was the only treatment effective in reducing the presence of *Meloidogine* juveniles in the soil. This treatment and MB was also effective in reducing the populations of other soil plant parasitic nematodes. After the second crop (cucumber), all the treatments showed a significant reduction of the total number of nematodes in the soil.

Because the only nematode causing problems in Dong Bei Wang area is root knot nematodes, the root knot index was also recorded periodically along the cropping season: early, middle and after the crops. Data is shown in Table 1.5 and Fig. 1.4 and Fig.1.5.

Table 1.5. - Incidence and index of root knot and the control efficacy at different crop stages

TREATMENT	n	Root knot incidence (*)	Root knot index (**)	Control efficacy
Early stage of the autumn tomato crop				
CONTROL	15	93.3 **a**	35.0 **a**	-
MB	15	46.7 **bc**	13.3 **bc**	59.3
BIO-FUMIGATION	15	60.0 **ab**	16.7 **b**	60.6
SUBSTRATE	15	80.0 **ab**	23.3 **ab**	31.0
AVERMECTIN	15	6.7 **c**	1.7 **c**	95.8
RESISTANT CUL.***	15	13.3	3.3	87.5
Middle stage of the autumn tomato crop				
CONTROL	30	96.7 **a**	88.3 **a**	-
MB	30	56.7 **c**	23.3 **b**	73.6
BIO-FUMIGATION	30	93.3 **a**	71.7 **a**	20.1
SUBSTRATE	30	83.3 **ab**	42.5 **b**	52.7
AVERMECTIN	30	70.0 **bc**	26.7 **b**	70.0
AR 35200***	6	33.3	16.7	90.4
After the autumn tomato crop				
CONTROL	161	100.0 **a**	92.4 **a**	-
MB	161	47.1 **bc**	47.8 **bc**	57.9
BIO-FUMIGATION	184	78.8 **ab**	65.1 **ab**	17.6
SUBSTRATE	163	71.5 **abc**	55.0 **abc**	26.7
AVERMECTIN	120	31.6 **c**	19.7 **c**	88.2
AR 35200***	30	25.6	6.7	92.8
After the spring cucumber crop				
CONTROL	150	100 **a**	75.4 **a**	-
MB	150	100 **a**	63.2 **ab**	16.6
BIO-FUMIGATION	150	99.3 **a**	78.8 **a**	-5.1
SUBSTRATE	150	98.7 **a**	57.0 **ab**	25.2
AVERMECTIN	150	97.3 **a**	47.3 **b**	35.3

*) % Of plants showing symptoms of root knot nematodes. **) Index is based on a 0-4 scale. ***) No statistical analysis was performed for this treatment. Treatments with the same letter are not significant different according to a Duncan's Multiple Range Test. signification level is 5%.

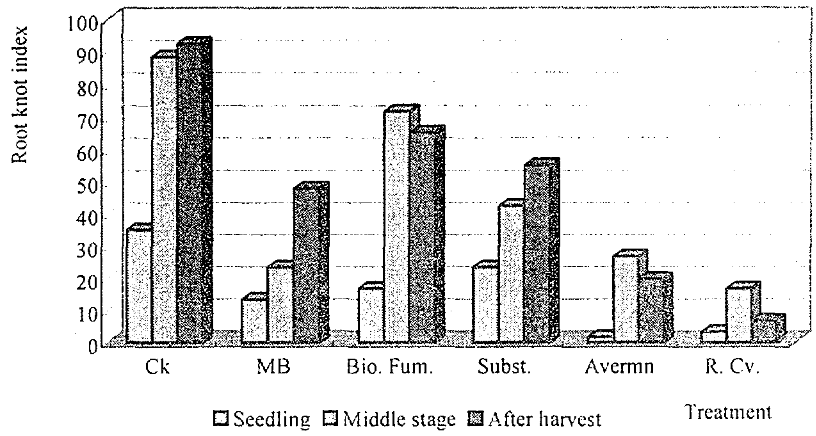


Fig 1.4. -Root knot index in tomatoes for different treatments at different crop stages.

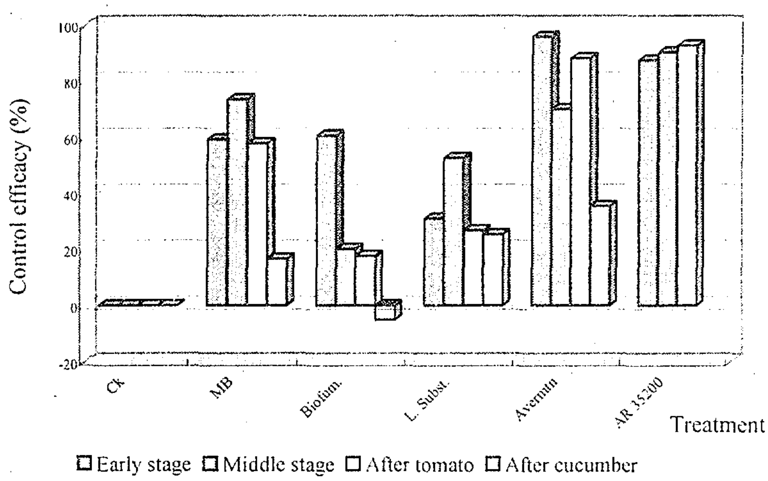


Fig. 1.5.- Control efficacy of different treatments at different crop stages.

After the treatments, the tomato plants grown in soil treated with MB and avermectin showed a smaller incidence of root-knot nematodes. These two treatments and bio-fumigation also showed a significant reduction in the root-knot index when compared with the control plants. After the tomato crop, the avermectin and MB treatments maintained the observed reduction in the incidence of root-knot nematodes and root-knot index. After the cucumber crop, only the plants that grew in the avermectin treated plots showed a significant reduction in the root-knot index.

The resistant tomato cultivar (AR-35200) showed a low root-knot incidence and index. This could be the effect of resistance breaking due to high temperatures (over 28 °C) that occurred in the soil during July and August 1998.

EFFECT OF THE TREATMENTS ON WEEDS

Before planting, the 27th July 1998, the seedbeds were inspected, no weeds were seen and no nematode symptoms were observed in the root balls of the plant seedlings.

A fortnight after transplanting, weeds were recorded in 1 m^2 for every plot. Species detected were:

Portulaca oleracea L.
Amaranthus retroflexus L.
Digitaria adscendens H.B.K.
Eleusine indica (L.) Gaertn
Trigonotis peduncularis (Treu.) Benth

Also, the presence of nematodes and symptoms of root knot nematodes were recorded in the weed's root ball. The results of this analysis can be seen in Table 1.6.

Table 1.6. - Weeds and nematode incidence in the weed 15 days after planting the autumn tomato crop.

TREATMENT		REPLICATE			AVERAGE
		I	II	III	
CONTROL	Weed species	2	2	2	2
	Nematode species	5	4	10	6.3
	Knots in the roots	+	+	+	
MB	Weed species	2	2	2	2
	Nematode species	4	2	2	2.7
	Knots in the roots	-	-	-	
BIO-FUMIG.	Weed species	2	3	2	2.3
	Nematode species	5	3	12	7.3
	Knots in the roots	+	+	+	
SUBSTRATE	Weed species	4	4	2	3.3
	Nematode species	10	11	8	9.7
	Knots in the roots	+	+	+-	
AVERMECTIN	Weed species	2	2	2	2
	Nematode species	5	6	5	5.3
	Knots in the roots	-	-	-	

After the treatments, there were weeds present in all plots. However, the roots of the weeds in the plots treated with MB and avermectin were free of root-knot nematodes.

EFFECT OF TREATMENTS ON YIELD

EFFECT OF THE TREATMENTS IN THE AUTUMN TOMATO CROP

The weight of the largest 10 fruits collected was recorded regularly along the cropping season. The results are shown in Table 1.7 and Fig. 1.6. The yield for all plots was recorded regularly from Oct 3rd to Nov 16th 1998. Accumulative yield along the productive period is shown in Table 1.8 and Fig 1.7 Total yield is shown in Table 1.8 and Fig. 1.8.

Table 1.7. -Average weight (kg) of the 10 largest fruits along the productive period

	DATE								
TREATMENT	**13-Oct**	**23-Oct**	**26-Oct**	**30-Oct**	**6-Nov**	**9-Nov**	**11-Nov**	**13-Nov**	**Avg**
CONTROL	2,03	2,58	2,73	2,68	2,72	2,65	2,70	2,37	2,56 **b**
MB	2,43	2,65	2,76	3,11	3,31	2,99	3,25	3,15	2,96 **a**
BIOFUMIG.	2,30	2,43	2,68	2,87	3,14	2,94	2,61	2,73	2,71 **ab**
SUBSTRATE	2,24	2,84	2,97	2,89	2,97	2,88	2,78	2,57	2,77 **ab**
AVERMECTIN	2,33	2,75	2,68	2,91	3,31	2,97	3,26	2,98	2,90 **a**

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

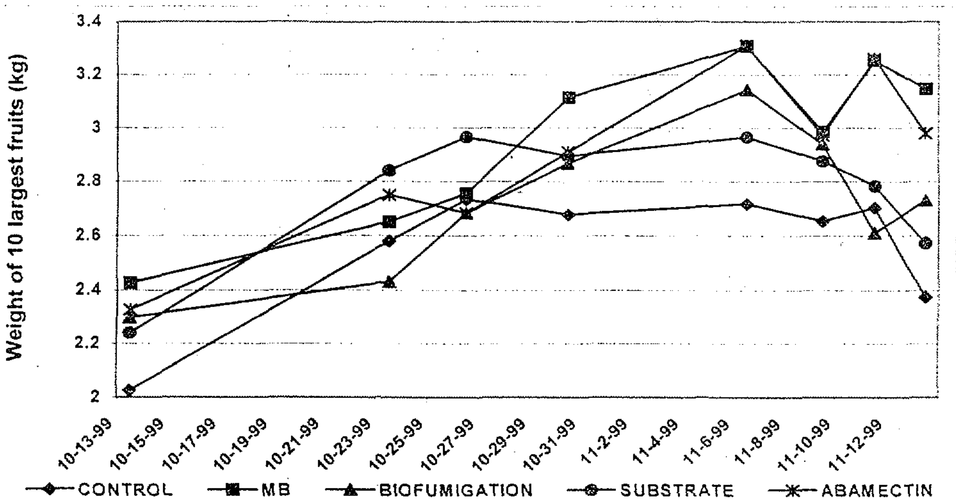


Figure 1.6. - Weight of 10 largest fruits, temporal series.

Table 1.8.- Autumn tomato. Yield (Kg in 27.5 m^2) along the productive period

DATE	3/10	6/10	9/10	11/10	13/10	16/10	18/10	20/10	23/10	26/10	30/10	2/11	6/11	9/11	11/11	13/11	16/11
MEANS					**10 days**				**20 days**			**30 days**			**40 days**		**45 days**
Ck	0.07	1.03	4.03	10.43	**19.50 bc**	60.50	90.23	95.87	**105.73 c**	119.63	136.50	**151.00 b**	182.67	194.27	**214.20 c**	227.10	**233.53 d**
MB	2.70	12.13	23.90	49.80	**64.70 a**	111.83	147.47	154.97	**166.43 a**	181.50	203.60	**221.57 a**	259.03	272.77	**295.53 a**	313.83	**319.73 a**
BIOF	0.13	2.47	10.77	26.57	**40.77 abc**	85.93	128.33	137.40	**148.90 b**	163.93	187.10	**201.80 a**	243.57	259.80	**277.17 a**	299.10	**307.47 ab**
SUB	0.27	3.37	7.77	21.83	**36.57 bc**	77.77	116.07	125.90	**139.10 b**	158.60	178.60	**202.67 a**	235.07	249.93	**267.27 ab**	280.07	**288.27 bc**
ABA	3.50	7.70	16.63	32.57	**43.63 ab**	88.30	118.97	129.40	**143.03 ab**	162.30	183.67	**203.00 a**	240.27	252.70	**277.80 a**	292.93	**301.27 ab**
AR*	0.00	0.00	0.00	8.17	**17.73 c**	47.07	68.23	80.73	**93.73 c**	103.90	127.57	**149.57 b**	195.90	216.23	**237.73 bc**	257.23	**262.23 c**

*Resistant cultivar AR-35200. Treatments with the same letter are not significant different according to a Duncan´s Multiple Range Test, signification level is 5%.

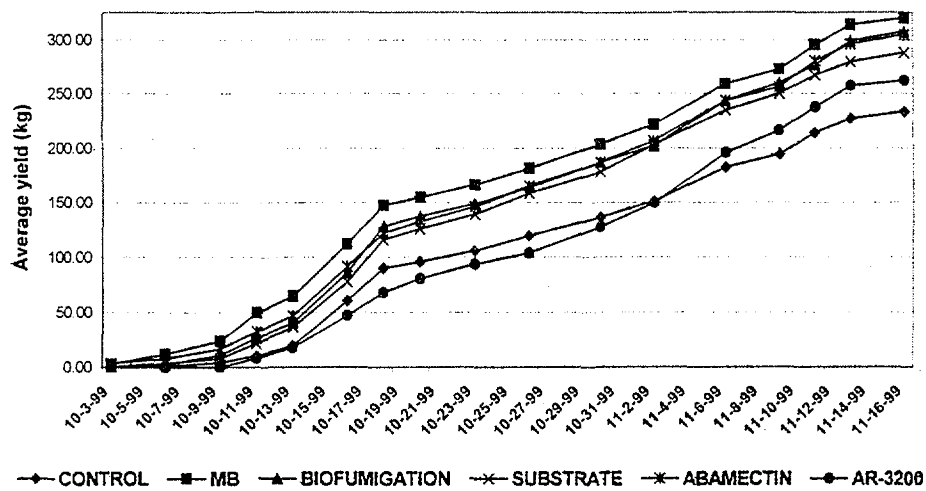


Figure 1.7.- Autumn tomato. Yield (kg in 27.5 m^2) temporal series

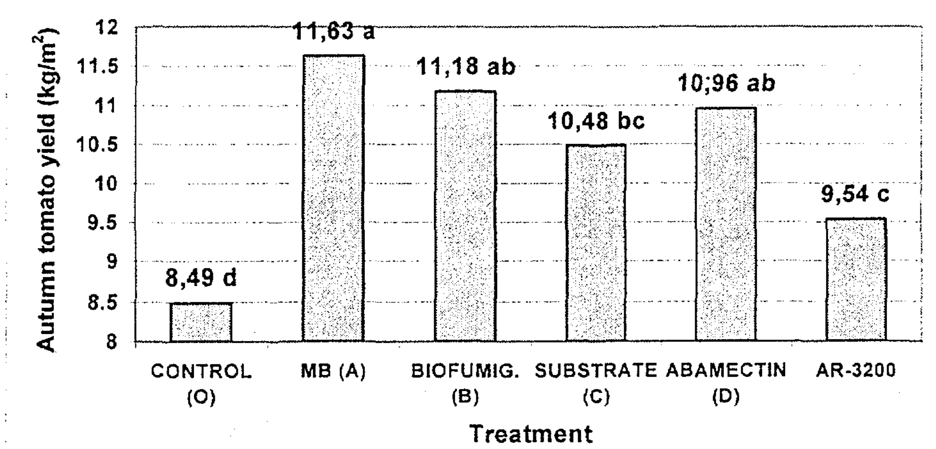


Figure 1.8.- The yield autumn tomato. Treatments with the same letter are not significantly different in a Duncan´s Multiple Range Test, signification level is 5%.

Larger tomato fruit was produced in the plots treated with MB and avermectin. However, the difference between the fruit size in the MB and avermectin treatments was not significant different to that in the bio-fumigation and local substrate. All treatments produced higher yields than the control. There was not significant difference between the treatments with MB, avermectin and bio-fumigation. The resistant tomato AR-35200 is a late cultivar, and the yield is not comparable with the local cultivar.

EFFECT OF THE TREATMENTS IN THE SPRING CUCUMBER CROP

The yield for all plots was recorded regularly from May 11[th] to June 21[st] 1999. Accumulative yield along the productive period is shown in Table 1.9 and Fig. 1.9. Total yield, with an indication of the commercial grade fruits and non-commercial or defective cucumbers, is shown in Fig. 1.10.

Table 1.9.- Spring cucumber. Yield (kg in 27.5 m^2) along the productive period

DATE	11/5	13/5	15/5	18/5	21/5	24/5	26/5	28/5	30/5	1/6	3/6	5/6	7/6	9/6	11/6	13/6	15/6	17/6	19/6	21/6
MEANS					10 days					21 days					31 days					41 days
CON	3.1	12.0	16.8	20.8	25.5	33.4	42.3	54,2	59.6	66.9	80.6	87.9	95.8	102.4	110.3	119.4	126.3	132.4	138.0	143.3 a
MB	5.4	17.2	22.2	29.2	35.0	43.9	54.9	68.5	75.0	83.1	97.4	107.0	117.2	125.9	135.3	146.0	154.0	160.5	166.6	172.3 a
BIOF	2.5	8.0	11.1	14.3	18.4	24.4	32.6	42.1	47.5	54.5	66.6	73.1	81.3	88.4	96.8	106.1	112.1	117.3	123.0	129.3 a
SUB	3.8	14.1	19.3	23.3	28.4	37.2	48.4	61.8	67.5	75.6	87.7	96.0	105.8	115.0	122.6	132.1	138.9	144.2	149.1	155.3 a
ABA	2.5	12.8	19.6	24.9	29.0	35.7	47.0	60.2	65.6	72.6	86.0	93.5	102.6	110.7	120.8	131.1	137.6	145.1	152.5	159.1 a

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

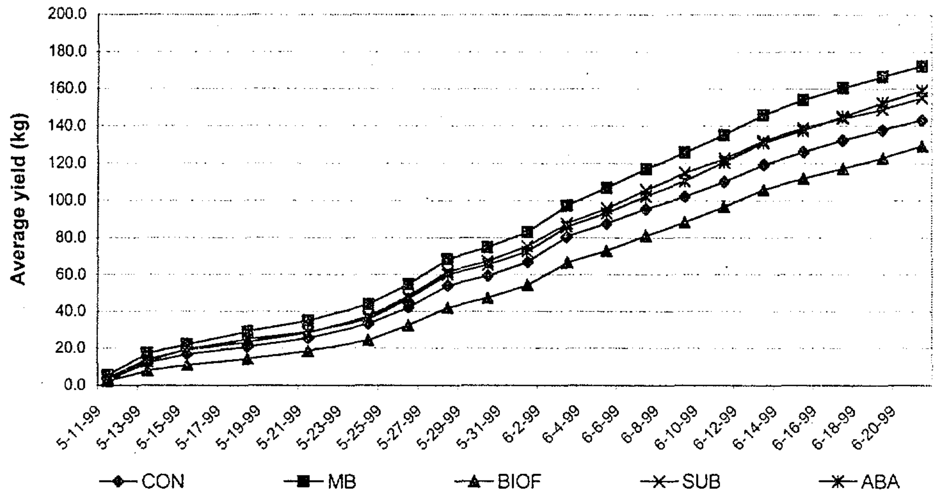


Figure1.9.- Spring cucumber. Yield (kg in 27.5 m²) temporal series

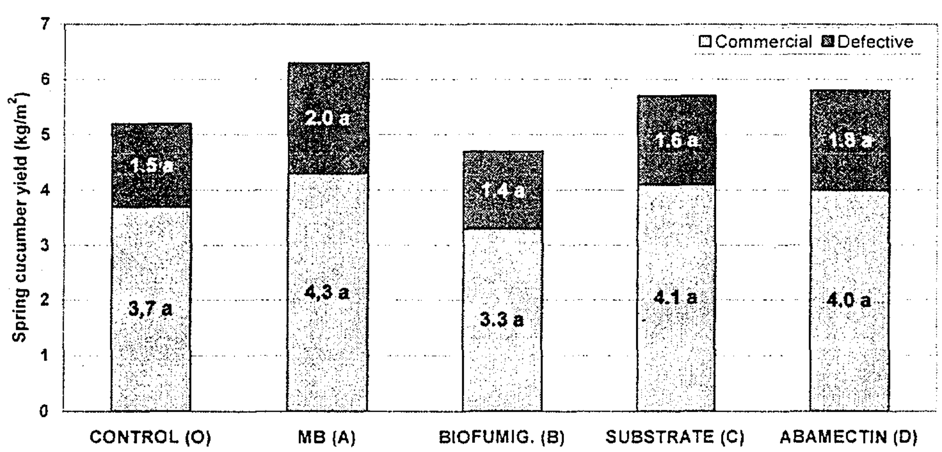


Figure 1.10.- Spring cucumber yield. Treatments with the same letter are not significant different in a Duncan's Multiple Range Test. signification level is 5%.

Although a slight higher yield was obtained in the MB treated plots, there were not significant differences in the spring cucumber yield obtained with MB, control and the alternatives proposed. Also, there was not significant difference between treatments for the fruit that was defective and not suitable for the market.

COSTS

ENVIRONMENTAL COST

Table 1.10.- Estimated environmental cost of the treatments in Beijing

Treatment	Minus	Plus	OVERAL
CONTROL	None	Use of waste	Very low
MB	Use of ODS + plastics	None	Very high
BIOFUMIGATION	Use of plastics + conventional pesticides	Use of waste	Low
SUBSTRATE	Use of conventional pesticides	Use of waste	Low
AVERMECTIN	Use of natural origin pesticide	None	Low
AR-3200	Use of resistance genes	Less pesticide usage	Very low

ECONOMIC COST

Because the difficult to estimate the seed costs in the PRC and because the latter production period of this cultivar as compared with the local one, the economic cost was not calculated for the multi-resistant cultivar AR-35200 grown during the Autumn season. The tomato and cucumber yields were commercialized in the farm. The price of the produce was variable with a different price every time it was sold (Table 1.11). The price of the yields during the two campaigns can be seen in Fig. 1.11.

Table 1.11. - Autumn tomato and spring cucumber crops. Price of the yield (US $)

Autumn tomato crop (1998)

DATE	3/10	6/10	9/10	11/10	13/10	16/10	18/10	20/10	23/10	26/10	30/10	2/11	6/11	9/11	11/11	13/11	16/11
UD $	0.138	0.150	0.163	0.163	0.138	0.125	0.138	0.150	0.225	0.250	0.275	0.250	0.213	0.200	0.200	0.175	0.175

Spring cucumber crop (1999)

DATE	11/5	13/5	15/5	18/5	21/5	24/5	26/5	28/5	30/5	1/6	3/6	5/6	7/6	9/6	11/6	13/6	15/6	17/6	19/6	21/6
UD $	0.150	0.138	0.175	0.188	0.163	0.188	0.163	0.138	0.113	0.138	0.113	0.113	0.113	0.113	0.113	0.100	0.075	0.088	0.088	0.063

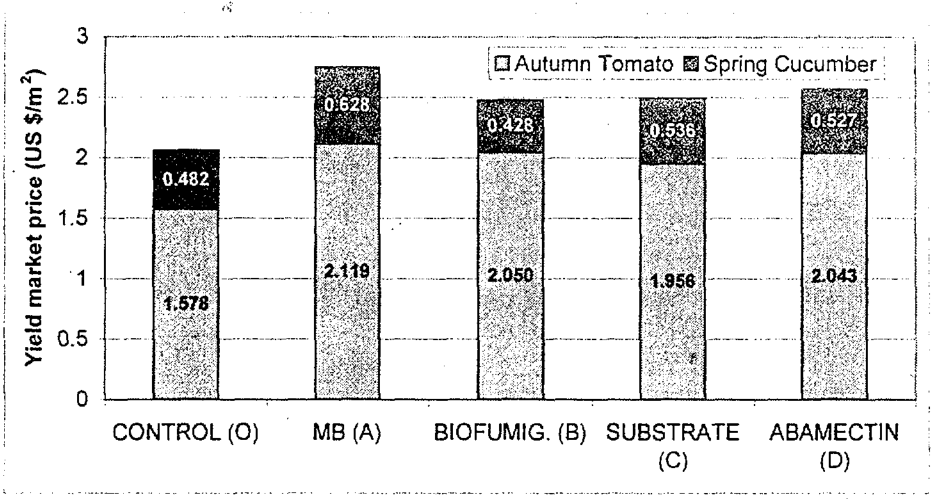


Figure 1.11.- Yield market price (US $/m^2) for the two seasons.

Considering the two crops and depending on the soil treatments, 1 m^2 of the land will give a minimum gross yield of 2.06 (25 % less than MB) for untreated soil and a maximum of 2.75 US$ in the MB treated soil. The alternatives proposed yielded 2.48 US$ (9.8% less than MB) for bio-fumigation, 2.49 US$ (9.3% less than MB) for the local substrate and 2.57 US $/m^2 (6.4% less than MB) for avermectin.

The operational costs of the methyl bromide application and that of the alternatives proposed are shown in Table 1.12 through Table 1.14. When possible, the cost associate to each item is based on the international market price.

Table 1.12.- Summary of incremental costs

Alternative	Cost per year (US $ / ha)
Avermectin	-245.0
Local substrate	+349.5
Bio-fumigation	+758.1

Table 1.13.- Methyl bromide application costs using 682g cans

ITEM	Amount/ha	Unit	US$/Unit	Cost US$/ha			
				Year 1	Year 2	Year 3	Year 4
Methyl bromide	495	kg	3.4	1683.0	1683.0	1683.0	1683.0
Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0
Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
			TOTAL COSTS	**2876.0**	**1963.0**	**2876.0**	**1963.0**

Table 1.14. - Incremental cost of the alternatives proposed for tomato and cucumber in Beijing

BIO-FUMIGATION	ITEM	Amount/ha	Unit	US$/Unit	COST US$ / ha			
					Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	495	kg	3.4	1683.0	1683.0	1683.0	1683.0
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
TOTAL SAVINGS (A)					**1963.0**	**1963.0**	**1963.0**	**1963.0**
Extra costs	Residues of cabbage or cruciferous crops*	20	t	35.0	700.0	700.0	700.0	700.0
	Wheat straw	20	t	31.1	621.1	621.1	621.1	621.1
	Fresh cattle manure	30	t	40.0	1200.0	1200.0	1200.0	1200.0
	Extra labor	20	w/d	10.0	200.0	200.0	200.0	200.0
TOTAL EXTRA COSTS (B)					**2721.1**	**2721.1**	**2721.1**	**2721.1**
INCREMENTAL OPERATING COSTS (B-A)					**+758.1**	**+758.1**	**+758.1**	**+758.1**

Table 1.14. (Cont.)

LOCAL SUBSTRATE IN LINES					COST US$ / ha			
	ITEM	Amount/ha	Unit	US$/Unit	Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	495	kg	3.4	1683.0	1683.0	1683.0	1683.0
	Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
TOTAL SAVINGS (A)					**2876.0**	**1963.0**	**2876.0**	**1963.0**
Extra costs	Wheat straw	20	t	31.1	622.0	622.0	622.0	622.0
	Composted cattle manure	15	t	60.0	900.0	900.0	900.0	900.0
	Peat (**)	60	m^3	14.0	840.0	840.0	840.0	840.0
	Extra labor	40	w/d	10.0	400.0	400.0	400.0	400.0
TOTAL EXTRA COSTS (B)					**2762.0**	**2762.0**	**2762.0**	**2762.0**
INCREMENTAL OPERATING COSTS (B-A)					**-114.0**	**+799.0**	**-114.0**	**+799.0**

AVERMECTIN					COST US$ / ha			
	ITEM	Amount/ha	Unit	US$/Unit	Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	495	kg	3.4	1683.0	1683.0	1683.0	1683.0
	Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
TOTAL SAVINGS (A)					**2876.0**	**1963.0**	**2876.0**	**1963.0**
Extra costs	Avermectin (95%)	180	g	11.7	2106.0	2106.0	2106.0	2106.0
TOTAL EXTRA COSTS (B)					**2106.0**	**2106.0**	**2106.0**	**2106.0**
INCREMENTAL OPERATING COSTS (B-A)					**-770.0**	**+280.0**	**-770.0**	**+280.0**

(*) The cost of this material could be reduced to zero if residues from a previous crop are used. (**) Using a locally made compost instead of commercial peat could reduce the cost of this material.

CONCLUSIONS

ADVANTAGES OF THE PROPOSED ALTERNATIVES

1. Avermectin is revealed as a good alternative to MB. It showed a good root-knot nematodes control in tomato, with efficacy being similar to that obtained with MB. The cost of the treatments with avermectin is lower than that of MB and of other alternatives tested. The profit obtained by using avermectin is higher than that of MB. The application of avermectin is rather simple and the product is easy to handle. Avermectin is not phytotoxic, plantation can be done after treatment avoiding the waiting time associated with MB fumigation or other products and techniques like solarization or bio-fumigation. The amount needed is very small (180 g/ha) and extra saving in store and transport is relevant. The mammalian toxicity of the product is low.

2. Bio-fumigation produced a good promotion of tomato growth, and the date of ripening was 3 days earlier than with other techniques. The tomato yield obtained in the plots treated with bio-fumigation was similar to that in the MB treated plots. It has neither toxicity nor pollution effects to the environment.

3. Local substrate in bands displayed good control efficacy on the population of root knot nematode. It had also good promotion to the growth of tomatoes. The ripening of tomatoes was 3 days earlier. The alternative has neither toxicity nor pollution and can also improve the soil characteristics.

4. Resistance cultivars are good alternatives to MB. The resistant cultivar tested showed good resistance to root-knot nematodes throughout the growth period. The yield of the cultivar was quite high.

DISADVANTAGES OF THE PROPOSED ALTERNATIVES

1. Avermectin is effective only to control nematodes, mites and insects, but it is not effective in the control of soil-borne fungal diseases, it needs to be combined with fungicides. The resistance of the pests to avermectin needs to be further investigated in order to avoid possible resistance breaking effects.

2. The effectiveness of bio-fumigation is affected by the weather and soil conditions. The time for treatment and the harvest of cruciferous vegetables may not meet so that the raw materials for bio-fumigation may not be available when needed. The formulation for bio-fumigation needs to be further tested and optimized for effectiveness and costs.

3. The treatment with local substrate is tedious, it is more labor and time consuming than other techniques. At the present moment the cost of artificial substrate is too high, a new formulation with low cost and high efficacy need to be further tested.

4. The multirresistant tomato variety used was not the appropriate for the area. The color of the fruit is not accepted by the market and the production is later than that of the local varieties.

FARMERS ACCEPTANCE

Alternative	**Acceptance by farmers**
Bio-fumigation	++
Local substrate	++
Avermectin	+++
Multi-resistant cultivars	?

(+): poor; (++): fair; (+++): good; (?): not enough tested.

EXPERIMENT 2: HEBEI
(STRAWBERRY)

GENERAL INFORMATION AND RESPONSIBLE PERSONS

SUB-SECTOR: STRAWBERRY

SYSTEM: STRAWBERRY UNDER PLASTIC HOUSE

ODS USE IN SUB-SECTOR (1998): 660,0 t (396 t ODP)

SUB-SECTOR BASELINE (1995-1998): 402,5 t (241,5 t ODP)

Crop history:	9 July-13 November 1997:	Treatments
	19 November 1997-30 April 1998:	Strawberry
	23 July-6 September 1998:	Treatments
	31 October 1998- 18 April 1999:	Strawberry
Site Location:	Mancheng county, Hebei.	
Contact at site:	Mr. Zang Jinhe	
Tel:	+86-312-7071143	
Joined institution:	Hebei Agro-Environmental Monitoring Station:	
Chief:	Ms. Hu Yuqing and Mr Huang Yubin	
Tel:	+86-311-6684384	
Technical backup:	IPP-CAAS	
Advisors	Mr. Yuan Huizhu	
Tel:	+86-10-62815941	
Fax:	+86-10-62894863	
E-mail:	sygs@public.east.cn.net	

China started to grow strawberry in 1915. The strawberry developed very slow for a long time because the farmers did not pay much attention to it. The cultivating area of strawberry gradually increased after 1950's. Due to reformation and economical development, there was a fast increasing demand for strawberry in 1980's, and there are more than 20 provinces growing strawberry now. The planting area is up to 20,000 ha., which mainly growing regions are Hebei province, about 41% of total area of China. The other mainly growing regions are Shandong province, (about 2600 ha., mainly in Yantai city), Liaoning province (about 300 ha., mainly in Dandong), Jilin provience (about 2000 ha.), Zhejiang province, Jiangsu province, Beijing and Shanghai municipality.

THE SITE

It has a history of 45 years for strawberry to be cultivated in Mancheng since 1953. Strawberry production has become the most important income path for farmers in Mancheng with the market economic development since the Open-up of China in 80s. Fig. 2.1 shows the area of strawberry growing in Mancheng county, Hebei province.

However, soil-borne diseases have become a big problem because of the continuous cropping. The diseases cause seeding death and reduce the yield loss of 40-90% in general. It is urgent to solve the problem. In order to find methods that can help farmers to cultivate strawberry continuously, the County Agricultural Bureau began to test techniques including rotation, guest-soil from corn field, soil fumigation with methyl bromide, etc., since early 90s. They began consume methyl bromide in large area since 1992. The technique using artificial was successfully developed in strawberry planting in 1995.

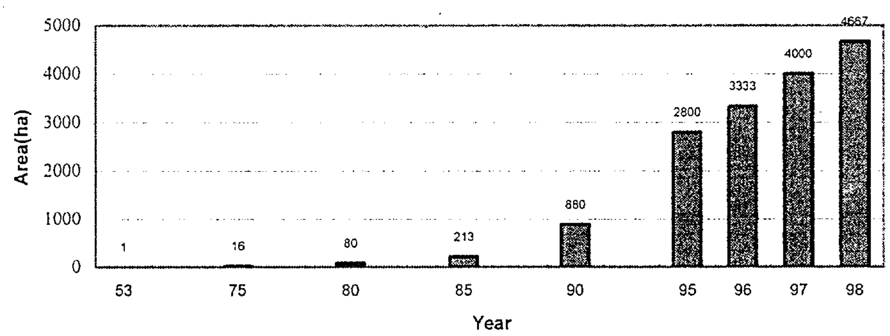


Fig. 2.1- Area of strawberry growing in Mancheng County, Hebei Province

Mancheng County owned a population of 424 thousand people and locates in the east foot of Taihang Mountain. It is a semi-mountainous area. The total area is 718 square kilometers where 33,000 ha of land are devoted to agriculture. The climate is typical continental climate. The average annual precipitation is about 600 mm. The frost-free period is 12.3℃ per year and the highest is 43.3℃, occurring in July, and the lowest -20℃, occurring in January. Fig.1 shows the monthly average temperature. The yearly average temperature on soil surface is 14.4℃. The soil temperature is 13.9℃ at 5-cm depth and 14.0℃ at 10-cm depth.

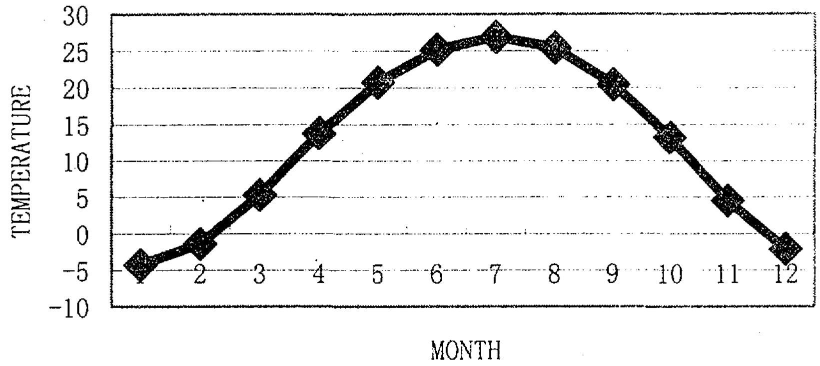


Fig.2.2- The annual average temperature in Mancheng

The soil is sandy–loam and irrigation is by local drip system using polyethylene flexible tube. Most of the water used in the area is underground water. The irrigation water variables are in Table 2.2.

Table 2.1. -Irrigation water characteristics in Mancheng

Variable	
EC (μs/cm)	400
Acid strength (mg/L $CaCO_3$)	306
Alkalinity (mg/L $CaCO_3$)	55
Eaton's Index	251

Main phytopathological problems in the area are caused by *Botrytis cinerea* (gray mold of strawberry, which is controlled with dichlofluanid and dicarboximide fungicides (iprodione and vinclozolin). Virus is a major problem mainly SMV and SMYEV. A serious soil borne disease appears when the plant is in flower and start to produce fruit, the causal agent is unknown (possible Verticillium wilt). Main problems in the area can be found in Table 2.2.

Table 2.2.- Main problems in strawberry crops in Mancheng

Disease	Affected area (ha)	Control means
Fusarium oxysporum (Schletchtendahl)	1200	MB
Sphaerotheca macularis (Wallrex Fr.)		Rotation, change soil, fungicides
Rhizoctonia sp	1000	
Instects	500	Insecticides
Aphids	350	
Weeds	2200	Black mulch and hand picking

THE TRIAL

The trial was conducted in 3 plastic tunnels of 333 m^2 (*c.* 0.5 Chinese mu) with watering by local drip system. Each tunnel was divided in eight plots with an area of 22.5 m^2. The data was collected discarding the border plants, and the final area for each plot was *c* 16 m^2 (4 x 4) containing *c.* 250 plants (15 plants/m^2). On account of strong local concern to use pesticides, an IPM approach was designed in combination with the main alternatives: soil-less cultivation with local substrates, cultivation in new land, soil solarization, steam sterilization and the granular fumigant Dazomet. Preventive chemical treatments with fungicides were applied. Weed control was achieved by mulching with black plastic. Other chemical alternatives as treatments against virus vector organisms were applied when needed.

The trial consisted in the follow up of two strawberry seasons with treatments before each season.

THE TREATMENTS

First season (1997-98). Each tunnel (8 plots) with 1 alternative (4 replicates) along side with MB (3 replicates) and control plot (1 replicate).

0 Control: the land was prepared in the usual way of the area and remains untreated.

A MB: the land was plugged and worked correctly, then was covered with plastic. MB was then applied and the land sealed for 6 days when it was opened for aeration. Final dosage was 42.5 g m^{-2}.

B Solarization (Local Bio-fumigation): the land was prepared for treatment and the materials for solarization added (sterilized chicken manure: 0,015 m^3 / m^2; wheat straw: 2 kg/m^2). Then the soil was cover with plastic and watered. The soil remained covered with plastic for 20 days. Soil temperature was 46 °C for more than 12 days.

C Local substrate, soil-less cultivation: local substrate made of expandable vermiculite like clay material, peat and sterilized chicken manure was used to fill growing beds as described in Fig. 2.3.

D New soil from corn fields: soil from corn fields with no history of strawberry cultivation was used to fill growing beds as described in Fig. 2.3. Old soil was retired and 4.8 m^3 of corn field soil was used to fill a space of 4 x 4 x 0.3 m.

Second season (1998-99). Each tunnel (8 plots) with 3 alternatives along side with MB and control plots.

02 Control: the land was prepared in the usual way of the area and remains untreated.

A2 MB: the land was plugged and worked correctly, then was covered with plastic. MB was then applied and the land sealed. The plastic remained sealed for 45 days before it was opened. Final dosage was 42.5 g m^{-2}.

B2 Solarization (Local Bio-fumigation): the land was prepared for treatment and the materials for solarization added (sterilized chicken manure: 0,015 m^3 / m^2; wheat straw: 2 kg/m^2). Then the soil was watered and covered with wave selective plastic sheet (REPSOL CP129). The soil remained covered with plastic for 45 days.

C2 Steam pasteurization: a Mayer Gmbh & Co S350 Steam generator was used. The plots were steamed till soil temperature at 10 cm reached 90 °C (about 1h 30′ to 2h 00′). Then the plots remained covered with the tarps for 1 hour. To avoid reinfectations the treated plots were covered with a thin plastic film until strawberry transplantation.

D2 Dazomet: Basamid® (BASF) at 10 g / m^2 was applied evenly in the soil surface and incorporated into the soil. Then the plots were watered and cover with REPSOL CP129 plastic sheet for 45 days.

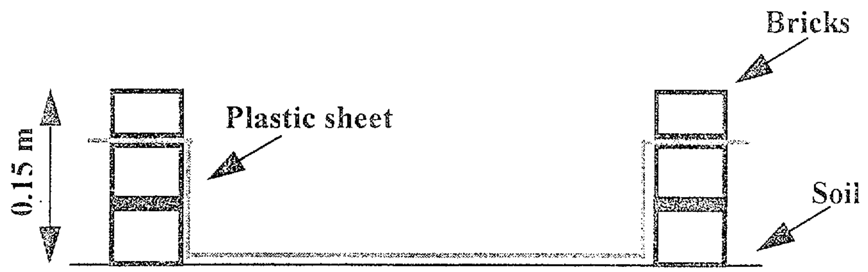


Fig. 2.3. -Scheme of a brick growing bed used for treatments C, D and C2

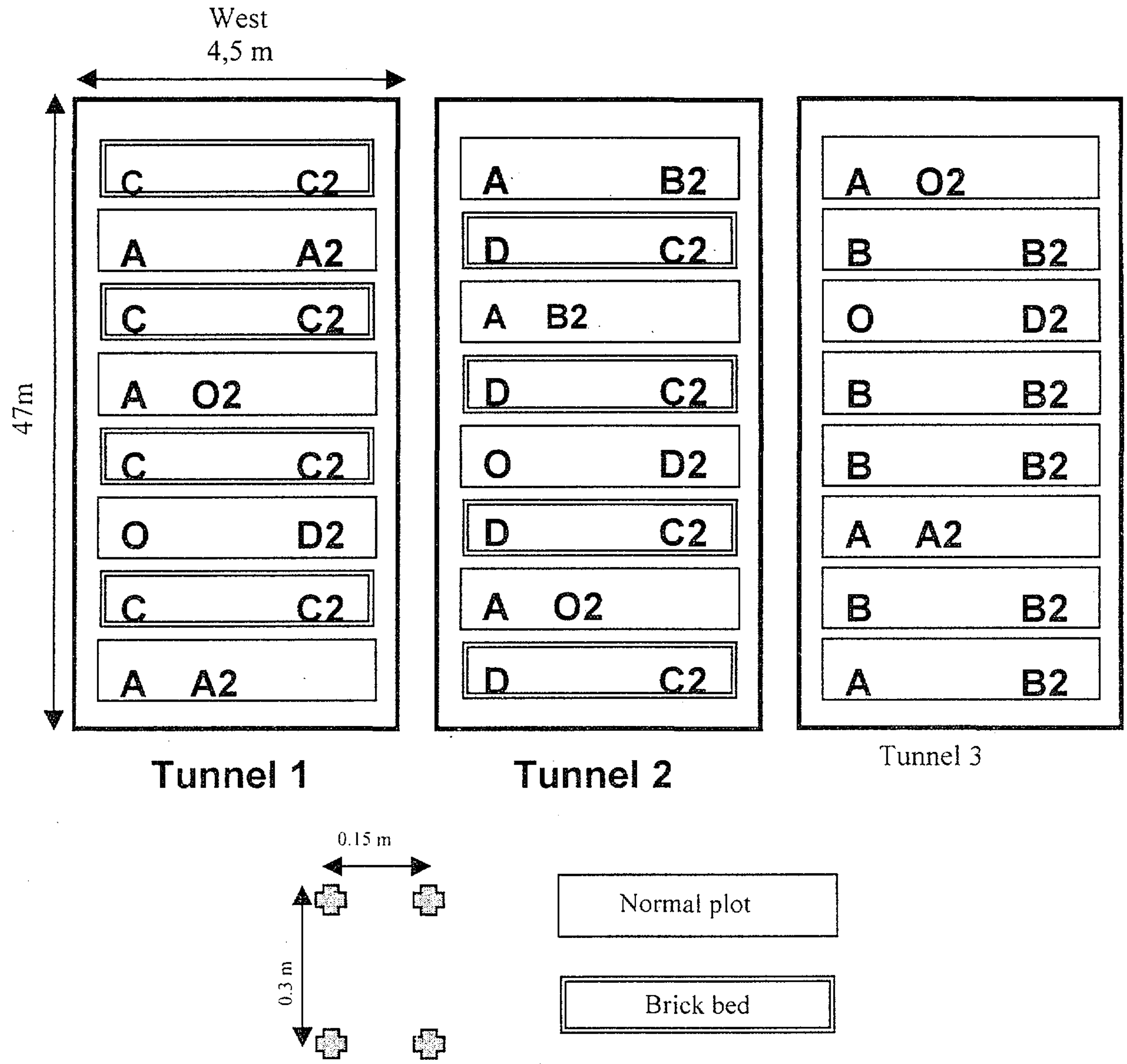


Figure 2.4.- Experiment layout for Mancheng.

The letters on the left indicates the treatments during the 1st season (1997-98), letters on the right indicates the treatments during the 2nd season (1998-99).

THE PLANTS

The first season the strawberry plants were locally obtained "All Star" cultivar from the Duanwang Strawberry Institute Nursery.

In the second season, four new strawberry cultivar were introduced from spain. In every plot, two rows of each cultivar ("All Star", "Camarosa", "Chancuatro", "RB-

11" and "Seascape") were planted. Because no enough plants were available, cultivar "Seascape" was only planted in Tunnel 1. Five cultivars were planted in Tunnel 1 and four in Tunnels 2 and 3.

EFFECT OF TREATMENTS ON PATHOGENS AND WEEDS

EFFECT OF THE TREATMENTS IN SOIL FUNGI

Soil fungi was recorded in a quantitative manner during three periods: 1st season after the crop, 2nd season during and after the crop. Three to four dishes per sample were analyzed and the results are summarized in Table 2.3.

Table 2.3.- Evolution of soil fungi during the trial (c.f.u/g soil)

	Fo	Fs	Fr	Fm	Cy	Pyth	Phytop	TOTAL
Treatment			1st season, after the crop (27 May 1998)					
CONTROL (O)	188±85	213±125	113±48		88±25			600±274
MB (A)	89±102	45±68	28±44		61±74			223±155
BIO-FUMIG. (B)	67±76	17±29	33±58		33±29			150±173
SUBSTR. (C)	125±119	188±175	13±25		138±138			463±312
NEW SOIL (D)	88±103	75±96	150±192		75±98			388±484
			2nd season, during the crop (5 March 1999)					
CONTROL (O2)	1945±1575	2111±977		556±536		667±500		5278±2700
MB (A2)	111±192	56±96		278±347		500±441		945±1005
BIO-FUMIG. (B2)	405±793	476±597		619±880		1619±1551		3119±2170
STEAM SUBSTR. (C2)	458±417	1084±674		750±844		250±215		2542±821
STEAM N. SOIL (C2)	125±160	333±360		0		583±500		1042±479
DAZOMET (D2)	278±255	444±419		111±192		1500±1922		2333±2489
			2nd season, after the crop (10 June 1999)					
CONTROL (O2)	0	222±192		111±96		167±167	1000±1202	1500±1000
MB (A2)	0	56±96		0		333±441	1111±1058	1500±763
BIO-FUMIG. (B2)	95±189	48±82		238±383		310±244	1167±903	1858±1238
STEAM SUBSTR. (C2)	42±84	0		42±84		0	417±726	500±794
STEAM N. SOIL (C2)	0	0		250±500		375±210	1500±1810	2125±1802
DAZOMET (D2)	0	111±96		0		278±255	500±333	889±631

Fo: *Fusarium oxysporum*; Fs: *Fusarium solani*; Fr: *Fusarium roseum*; Fm: *Fusarium moniliforme*; Cy: *Cylindrocarpon* spp.; Pyth: *Pythium* spp.; Phyt: *Phytophthora* spp. Figures indicate average±standard deviation.

The results obtained are very variable, however, all groups of fungi present in the untreated plots were also present in the methyl bromide treated plots, in many instances with similar or larger numbers. After the 1st season and during the crop in the 2nd season, all treatments reduced the fungi in the soil. After the 2nd season crop, only the local substrate treated with steam and dazomet reduced the number of soil fungi.

EFFECT OF THE TREATMENTS IN SOIL NEMATODES

Nematodes were extracted eliminating fine particles (silt and sand) from 200 cc rhyzospheric soil and nematodes separated by centrifugation. The nematodes recovered were stored in vials with formol for further study. Nematode population was studied during three periods: before and after the treatments and after the crop. data is shown in Table 2.4.

Table 2.4.- Nematode populations at different stages during the trial

TREATMENT	Free living nematodes	*Aphelenchoides* spp	*Aphelenchus* spp	*Tylenchus* spp	*Meloidogyne* spp	TOTAL
1st season after the crop (27 May 1998)						
CONTROL (O)	63±20	2±3	15±10	6±9	0	86±23
MB (A)	297±202	0	1±2	10±13	0	308±196
BIO-FUMIG. (B)	22±25	0	8±7	6±11	0	36±40
SUBSTR. (C)	328±62	9±15	29±41	0	0	366±101
NEW SOIL (D)	95±43	10±11	45±16	42±41	0	192±77
2nd season, during the crop (5 March 1999)						
CONTROL (O2)	567±209	0	14±17	7±12	0	588±206
MB (A2)	557±578	8±13	7±1	0	0	572±590
BIO-FUMIG. (B2)	1124±931	29±22	20±11	2±6	0	1176±952
STEAM SUBST. (C2)	2588±1931	17±16	31±53	0	0	2637±1925
STEAM N. SOIL (C2)	517±101	22±12	28±16	7±9	0	573±109
DAZOMET (D2)	463±165	3±5	12±12	1±2	0	479±163
2nd season, after the crop (10 June 1999)						
CONTROL (O2)	1439±607	86±61	52±21	59±26	0	1635±696
MB (A2)	2244±2329	2±4	2±4	2±4	0	2251±2335
BIO-FUMIG. (B2)	2376±1365	103±112	36±40	70±61	9±21	2594±1462
STEAM SUBST. (C2)	2965±1656	0	2±5	0	0	2967±1658
STEAM N. SOIL (C2)	1704±100	121±45	57±43	24±17	0	1906±169
DAZOMET (D2)	1520±456	139±241	24±21	79±131	41±70	1803±892

Figures indicate average±standard deviation.

The variation associated to this analysis is high, but all groups of nematodes present in the untreated plots were also present in the methyl bromide treated plots. in many instances with similar or larger numbers. which is an indication of poor control. Small populations of *Meloidogyne* sp appeared in the 2nd season in the solarization and dazomet treatments.

EFFECT OF THE TREATMENTS IN WEEDS

Weed presence in the plots (plants/m^2) was recorded in spring 1998 and 1999 in the areas that were not uncovered the black plastic mulch (Fig.2.5).

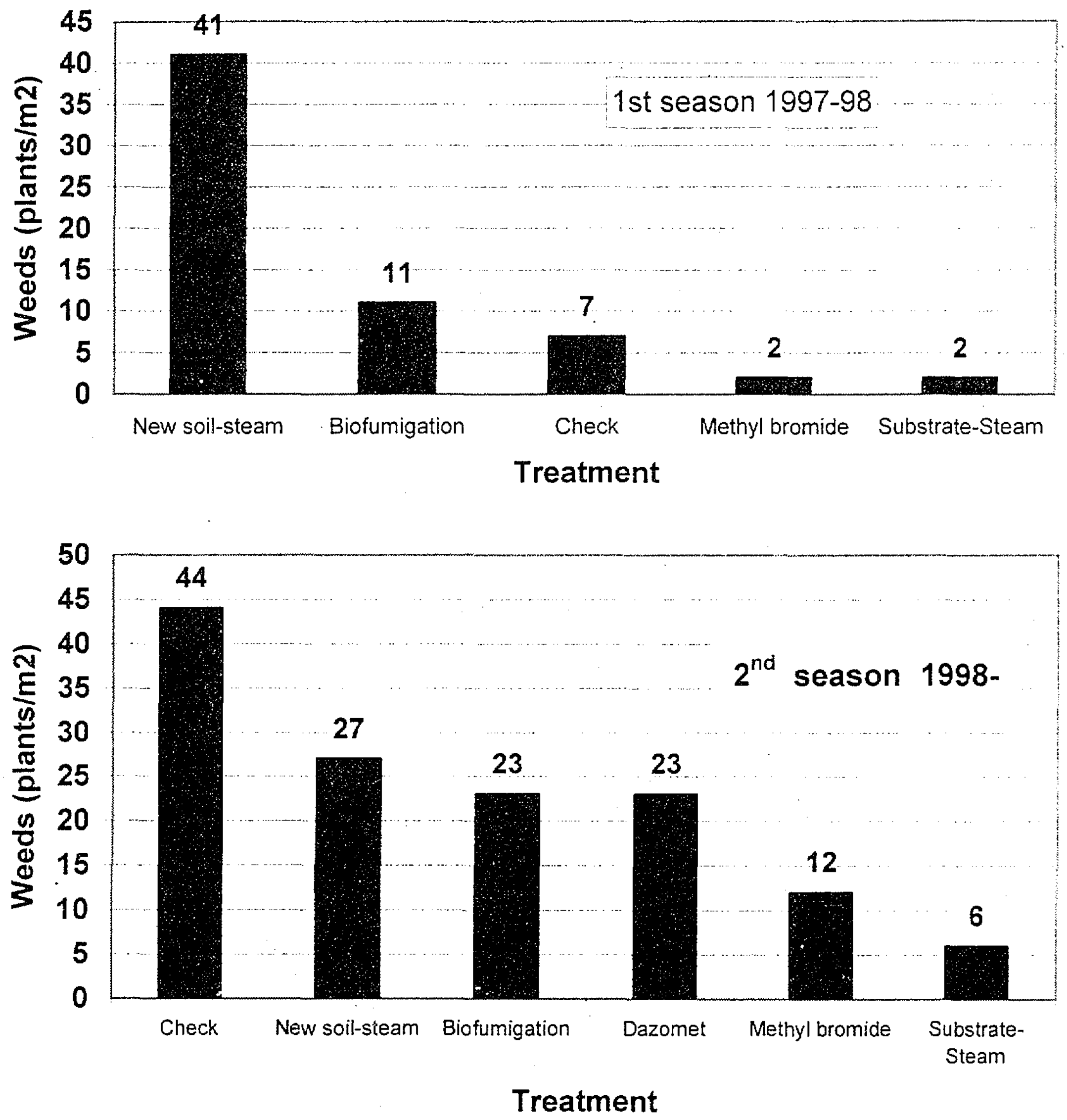


Fig.2.5.- Weed incidence in strawberry plots

In the 1st season, very few weeds were found in the local substrate and MB plots. The larger number of weeds appeared in the soil from corn fields and solarization plots, it is possible that seeds were introduced with the soil and materials for solarization.

In the 2^{nd} season, all treatments significantly reduced the number of weeds. The average weed reduction as compared with the untreated plots was 58.64 %. The most effective treatment was the steamed local substrate (86.36 % reduction) followed by methyl bromide (72.73 % reduction). Solarization and dazomet reduced weeds almost to a half (47.7 % reduction) of that recorded in the control plots. The less effective treatment was the steamed new soil from corn fields (38.64 % reduction), probably because the seed bank was originally larger than that of the natural soil and substrates.

SOIL- BORNE DISEASE INCIDENCE IN STRAWBERRY PLANTS

Wilted plants suspected to be affected by soil borne disease were recorded regularly in the two seasons until the end of harvest period (Figs. 2.6-2.9). Also, after 1 moth of transplanting during the 2^{nd} season, the transplant success for the different cultivars tested was recorded (Fig. 2.10).

In the 1^{st} season, a remarkable good control of wilting was achieved with all alternatives proposed. At the end of the crop all the treatments reduced the number of wilted plants (81.57 % average reduction) as compared with the untreated plots (45.30 % wilt). The most effective treatments were local substrate (1,1 % wilt; 97.57 % reduction), new soil (soil from corn field) (3.0 % wilt; 93.38 % reduction) and solarization (8.1 % wilt; 82.12 % reduction) treated plots. There was a poor control of wilting in the MB treated plots, a significant percentage (21.20 %) of the plants were affected by soil borne disease, probably strawberry black root rot (SBRR) complex (Figs. 2.6 & 2.7).

In the 2^{nd} season, at the end of the crop all the treatments reduced the number of wilted plants (79.50 % average reduction) as compared with the untreated plots (24.05 % wilt). The most effective treatments were steam (1.34 % wilt; 94.44 % reduction) and methyl bromide (1.07 % wilt; 95.55 % reduction) treated plots. Wilted plants in the dazomet plots were less than ½ (52.59 % reduction) and in the solarization plots less than ¼ (75.80 % reduction) to these found in the untreated plots (Fig. 2.8 & 2.9). The efficacy of the dazomet treatment was variable, probably due to dosage adjustment and to an uneven distribution of the chemical in the soil.

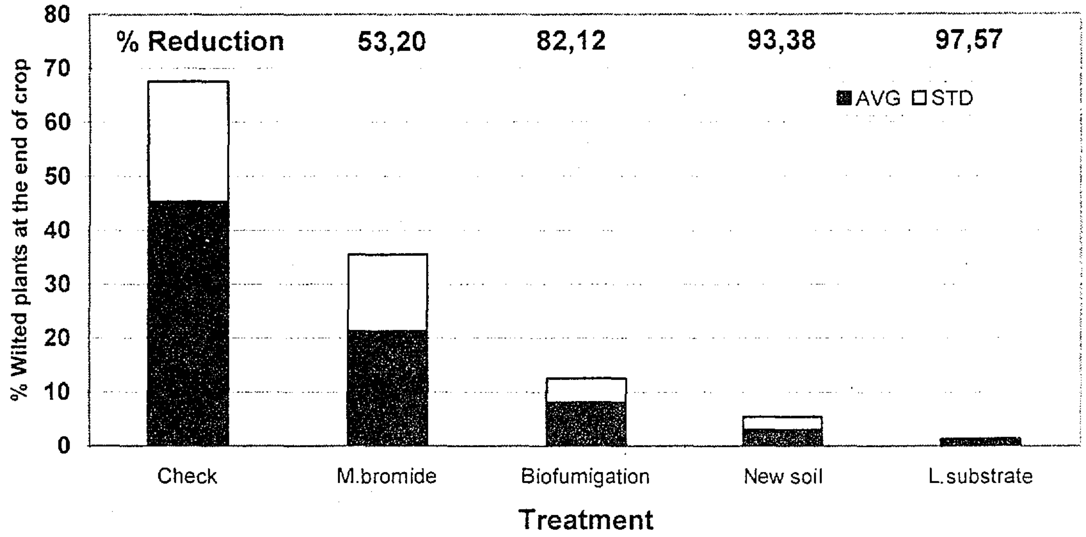


Fig.2.6.- Soil-borne disease incidence, wilted plants at the end of the 1st season

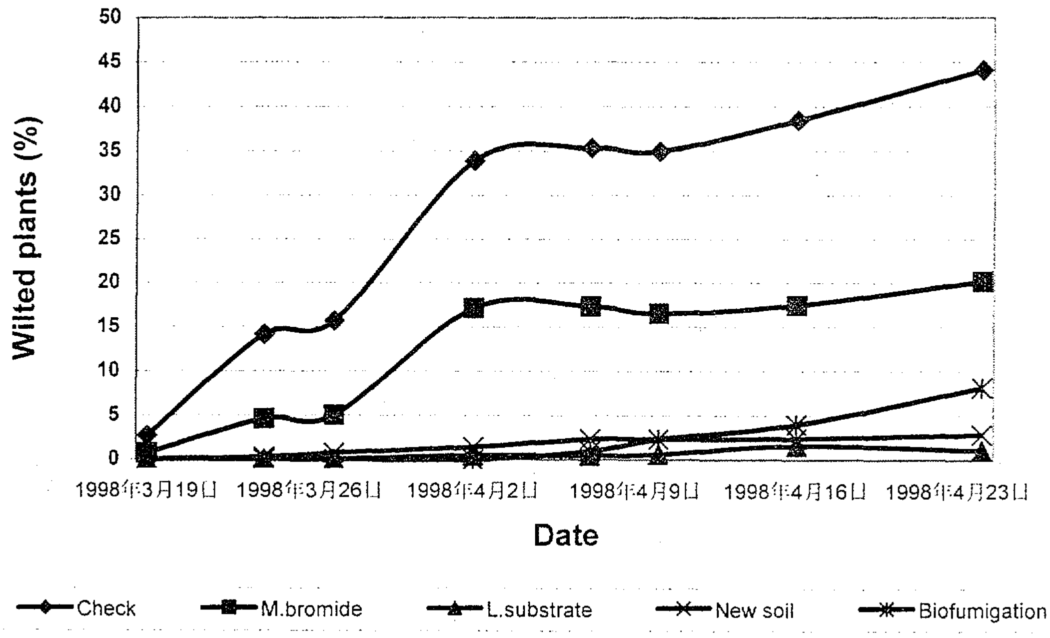


Fig.2.7.- Wilted strawberry plants recorded during the harvest period in the 1st season

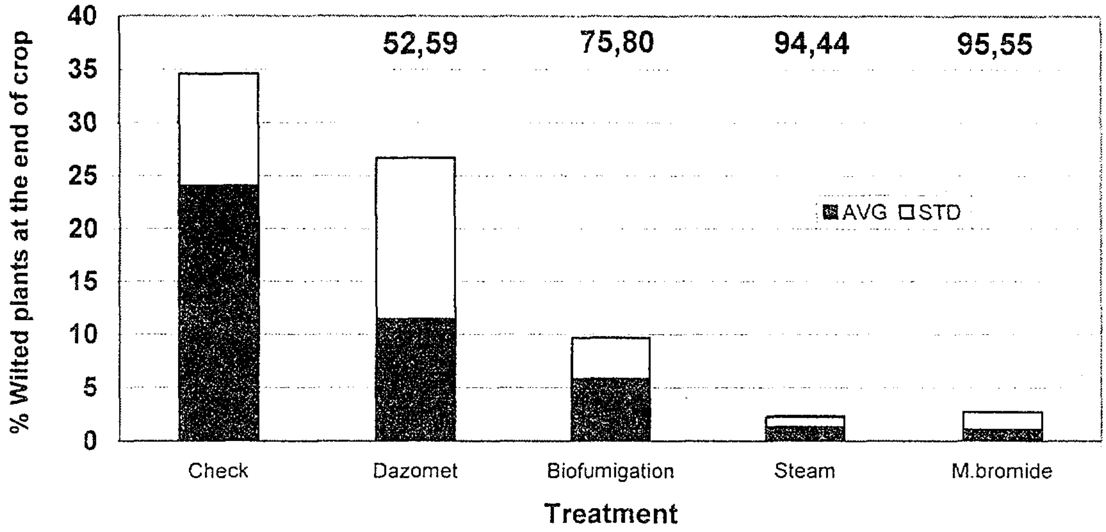


Fig.2.8.- Soil-borne disease incidence, wilted plants at the end of the 2nd season

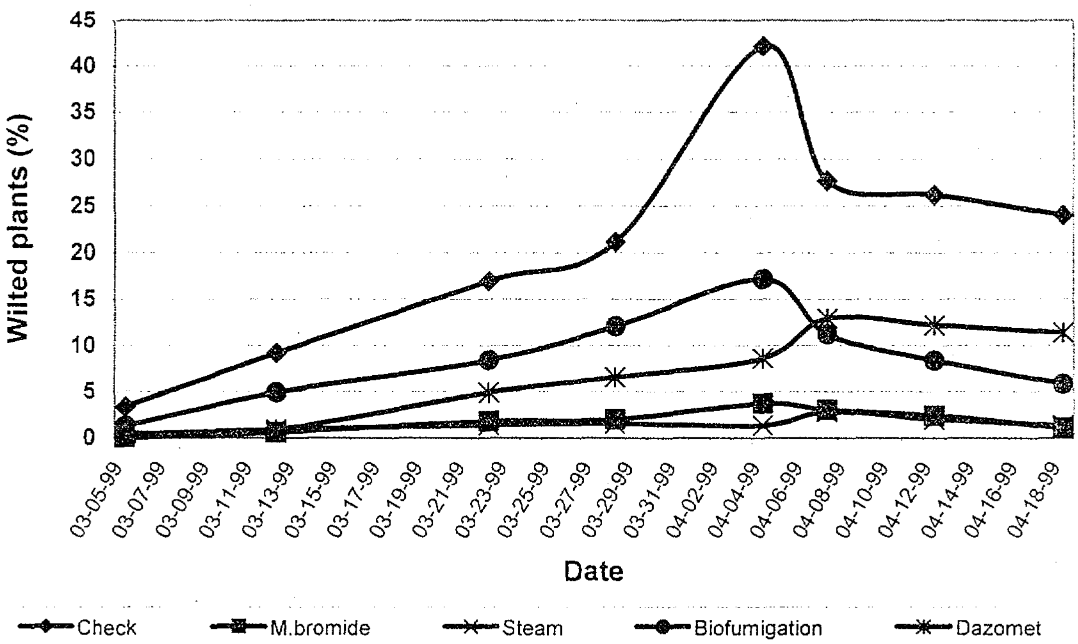


Fig.2.9.- Wilted strawberry plants recorded during the harvest period in the 2nd season

During the harvest period, an increase in the number of wilted plants was observed at the end of March and the first weeks of April. This was probably due to plant stress due to drought combined with the beginning of the second strawberry production cycle (see Fig. 2.23).

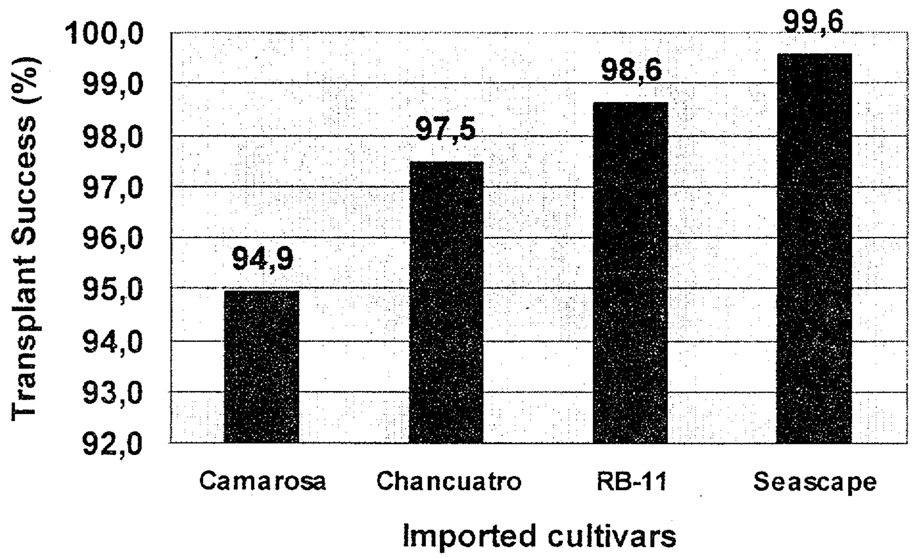


Fig.2.10.- Transplant success of imported strawberry cultivars in the 2nd season

Even though the new strawberry cultivars suffered air and road transport and were thoroughly washed at arrival in China, the crop establishment and the growth of all imported plants was very good. The transplant survival rate was higher than 94 % in all cultivars, and a remarkable 99.6 % transplant success was obtained for cultivar "Seascape" where only 2 plants out of 474 planted needed to be replanted. Survival rate for the local cultivar "All Star" was low, less than 75%.

EFFECT OF TREATMENTS ON PLANT VIGOR AND QUALITY

Just before fruiting, the high (Figs 2.11, 2.13 & 2.14) and number of floral bunches per plant (Figs. 2.12, 2.15 & 2.16) were recorded during the two seasons. At this time it was considered that the plant high was stabilized at its maximum. In addition, in the 2nd season, the sugar content of the different cultivars tested was recorded (Fig. 2.17).

1ST SEASON (1997-98)

The strawberry plants grown in treated plots were higher than those grown in the untreated plots. There was 15,25 % average increase in the high of the plants as compared with the plants grown in the untreated plots (13,93 cm). The highest plants were found in the plots with soil from corn fields (17,55 cm; 20,63 % increase) followed by the solarization plots (16.53 cm; 15,73 % increase) (Fig 2.11).

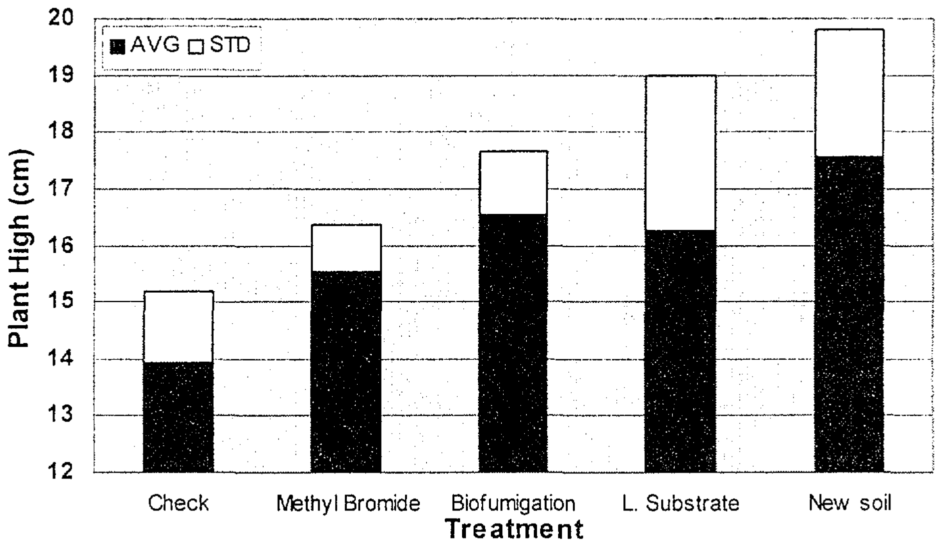


Fig.2.11.- 1st season. High of strawberry plants grown in the different treatments

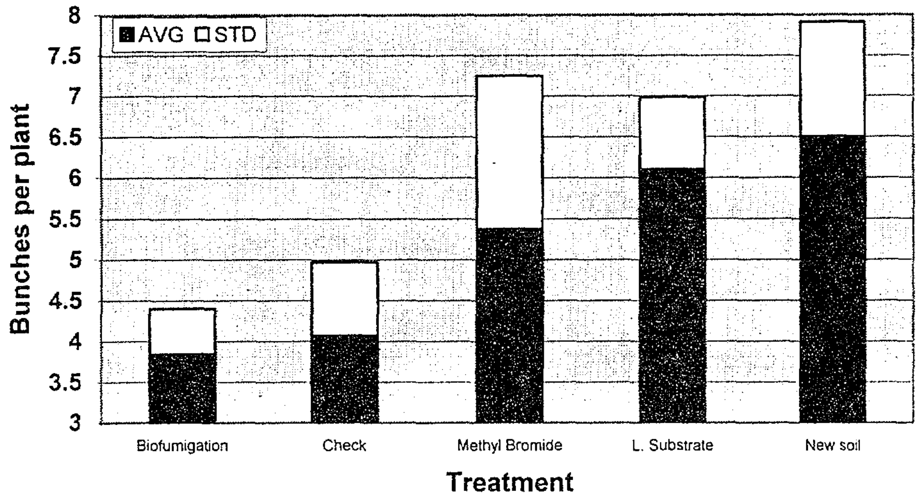


Fig.2.12.- 1st season. Floral bunches of strawberry plants

The strawberry plants grown in substrate (6,10 bunches/plant; 50,00 % increase) and new soil from corn field (6,50 bunches/plant; 59,80 % increase) had more floral bunches than those grown in the untreated (4,07 bunches/plant), methyl bromide (5,38 bunches/plant) and solarization (3,85 bunches/plant) plots (Fig 2.12).

2ND SEASON (1998-99)

In general, the strawberry plants grown in treated plots were higher than those grown in the untreated plots. There was 13,84 % average increase in the high of the plants as compared with the plants grown in the untreated plots (9,89 cm). The highest plants were found in the methyl bromide treated plots (11,53 cm; 16,60 % increase) followed by the steamed plots (11,44 cm; 15,71 % increase) (Fig 2.13).

In relation with the cultivars tested, the imported cultivars were significant higher than the local cultivar "All Star" (8,30 cm). The average increase in the high of the imported strawberry cultivars as compared with "All Star" was 42,32 %, with cultivar "RB-11" the highest (13,61 cm; 63,95 % increase) and "Chancuatro" the shortest (10,49 cm; 26,30 % increase) (Fig 2.14).

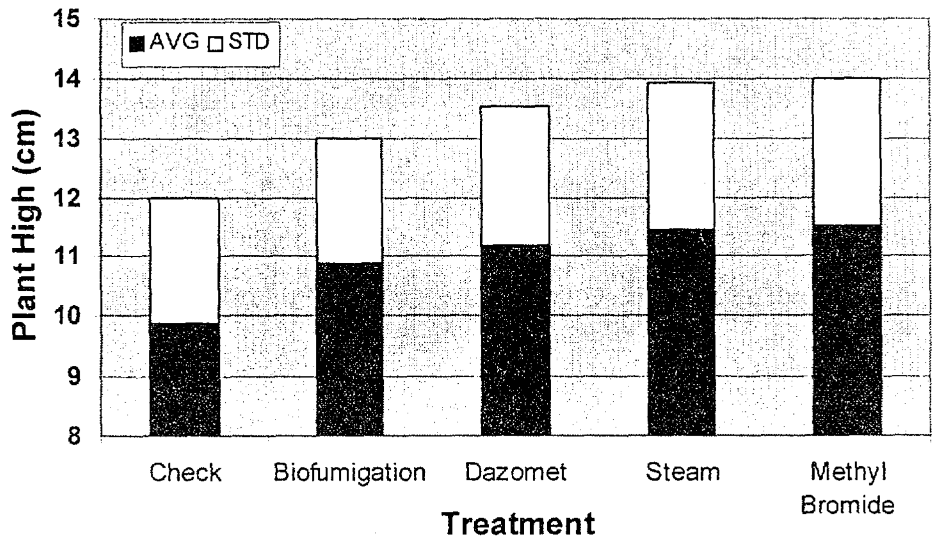


Fig.2.13.- 2nd season. High of strawberry plants grown in the different treatments

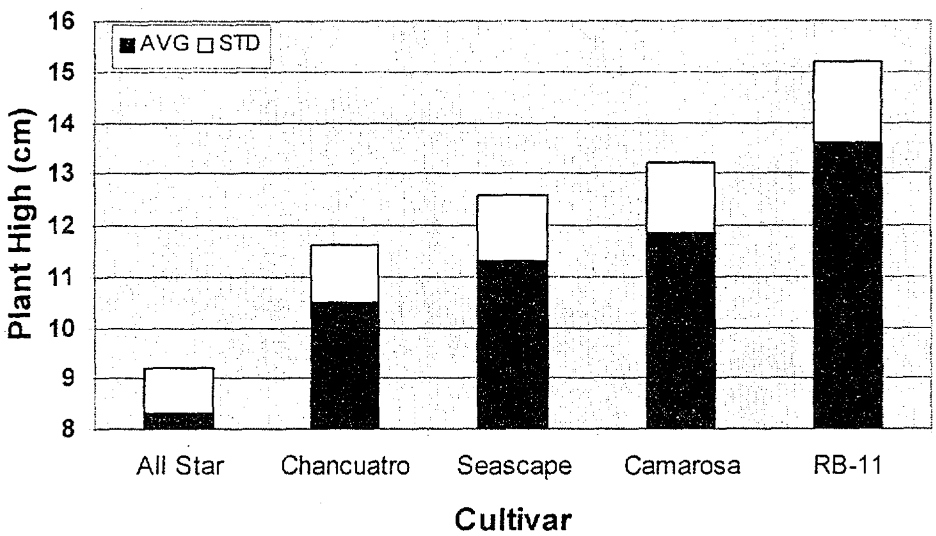


Fig.2.14.- 2nd season. High of the strawberry cultivars tested

The strawberry plants grown in treated plots had more floral bunches than those grown in the untreated plots. There was 12.59 % average increase in the number of bunches per plant as compared with the plants grown in the untreated plots (5.22 bunches/plant). The plants with more bunches were found in the methyl bromide treated plots (6.18 bunches/plant; 18.53 % increase) followed by the plots treated with dazomet (5.94 bunches/plant ; 13.90 % increase) (Fig 2.15).

In relation with the cultivars tested, the imported cultivar "Seascape" was the one producing more floral bunches (6.53 bunches/plant) followed by the local cultivar "All Star" (6.02 bunches/plant). The imported cultivar "RB-11" produced less bunches per plant (5.15), 27.42 % less than "Seascape" and 17.58 less than "All Star" (Fig 2.16).

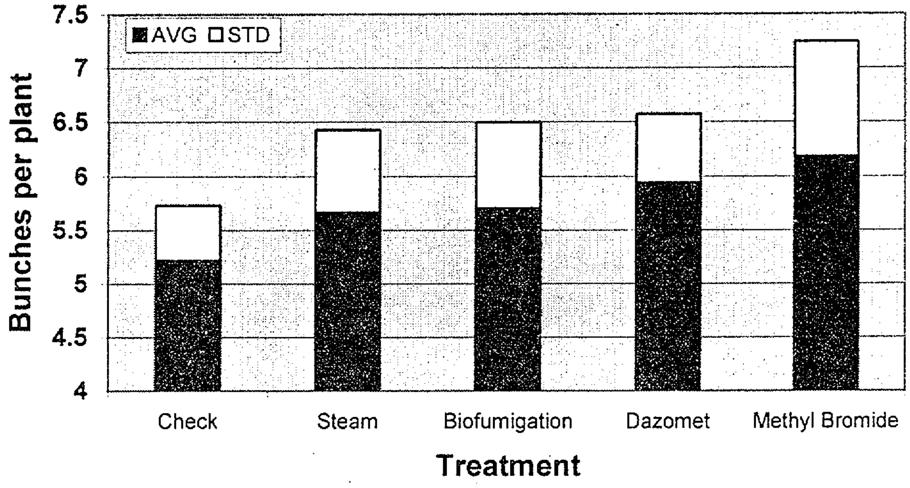


Fig.2.15.- 2nd season. Floral bunches of strawberry plants

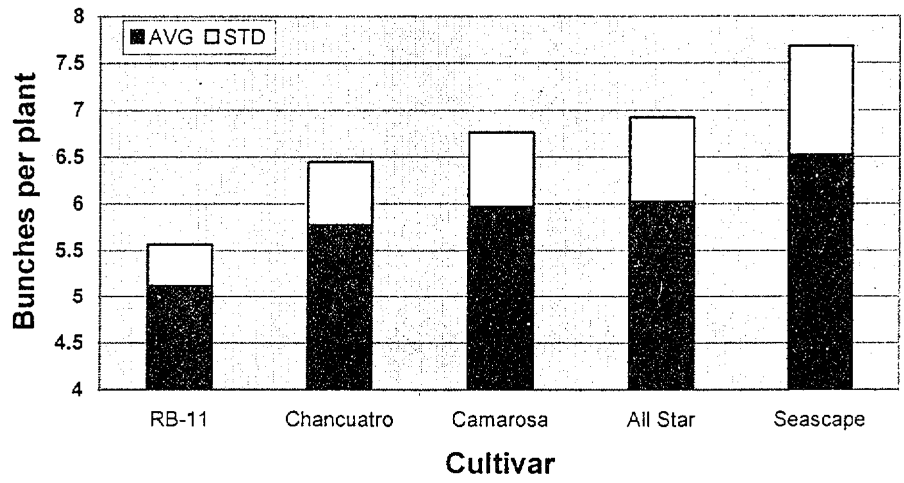


Fig.2.16.- 2nd season. Floral bunches of the strawberry cultivars tested

On 8th March, a sample of fruit was taken for sugar content recordings (Fig 2.17). At harvest time, the cultivar "Camarosa" was the one with highest sugar content (5.8 %) whereas "Chancuatro" (3.9 %) and "Camarosa" (4.8 %) showed the lowest sugar content. The local cultivar "All Star" and the imported "RB-11" had similar sugar content (5.55%).

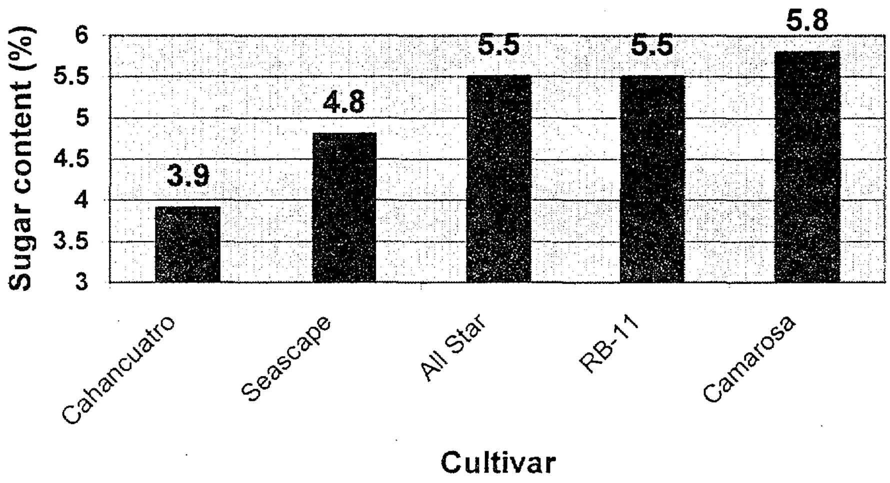


Fig.2.17.- 2nd season. Sugar content of strawberry fruit

EFFECT OF TREATMENTS ON YIELD

1ST SEASON (1997-98)

The strawberry yield was recorded regularly during the 45 harvest days (16 March-30 April 1998). The number of plants per plot was known and the yield in (g/plant) was calculated. Strawberry yield in kg/ha was then calculated assuming the plant density used in the area (15 plants / m^2;150000 plants/ha), and the price is *c.* 0.75 US$/kg (6 RMB/kg).

All the alternatives proposed produced a yield increase (average increase excluding MB 108.81 %) when compared with that obtained in the untreated plots. The best results were obtained in the solarization plots with a yield increase of 126.5 %, followed by the local substrate with 101.8 % and last new soil from corn field with an average increase of 98.1 % (Fig. 2.18).

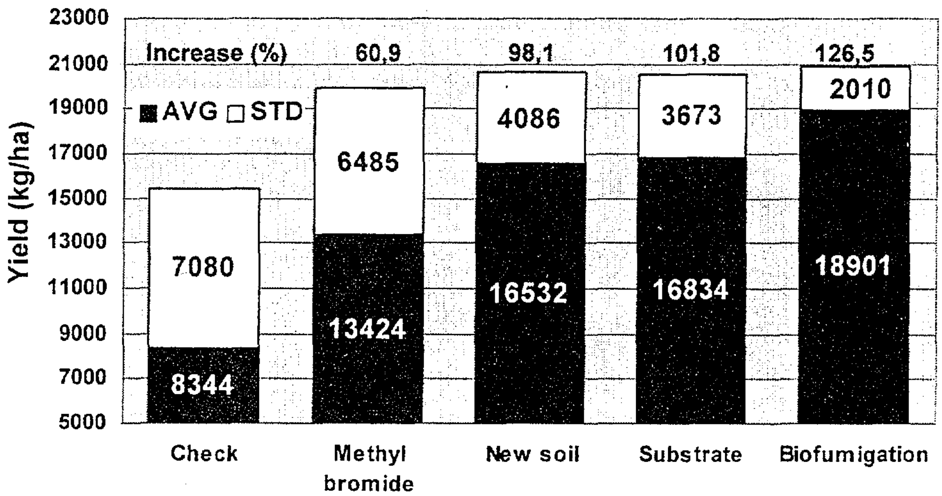


Fig. 2.18.- Strawberry total yield in Mancheng, 1st season (1997-1998)

2ND SEASON (1998-99)

The strawberry yield was recorded regularly during the 54 harvest days (23 February-18 April 1999). The number of plants per plot was known and the yield in (g/plant) was calculated. Strawberry yield in kg/ha was then calculated assuming the plant density used in the area (15 plants / m^2;150000 plants/ha), and the price is *c.* 0.75 US$/kg (6 RMB/kg).

All the alternatives proposed produced a yield increase (average increase excluding MB 47.4 %) when compared with that obtained in the untreated plots. The best results were obtained in the steamed plots with a yield increase of 84.2 %, followed by dazomet with 41.1 % and last solarization with an average increase of 17 % (Fig. 2.19).

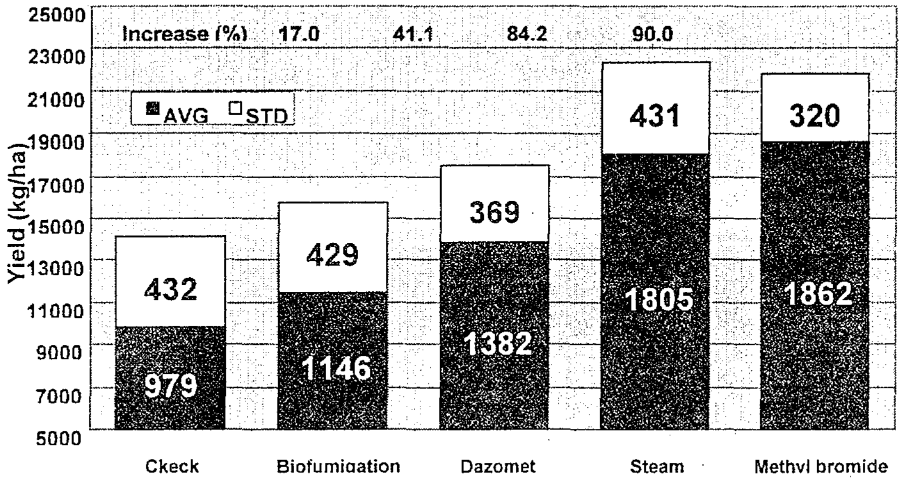


Fig. 2.19.- Strawberry total yield in Mancheng, 2nd season (1998-1999)

The yield in the plots was influenced by the treatments applied to the same plots during the previous season (1997-1998). When considering this, the yield obtained in the second season in the local substrate plots treated with steam was higher (92.8 % increase) than that obtained in the MB plots (90.0 % increase) (Fig. 2.20).

An envisaged alternative to methyl bromide was to increase yields by introducing new technologies, because of this four strawberry cultivars imported from Europe were tested. All cultivars produced high quality and a higher yield (average increase 46.8 %) than the local cultivar "All Star". Cultivar "RB-11" ("Torero") produced a 67.0 % and Chancuatro 48.4 % more (Fig. 2.21).

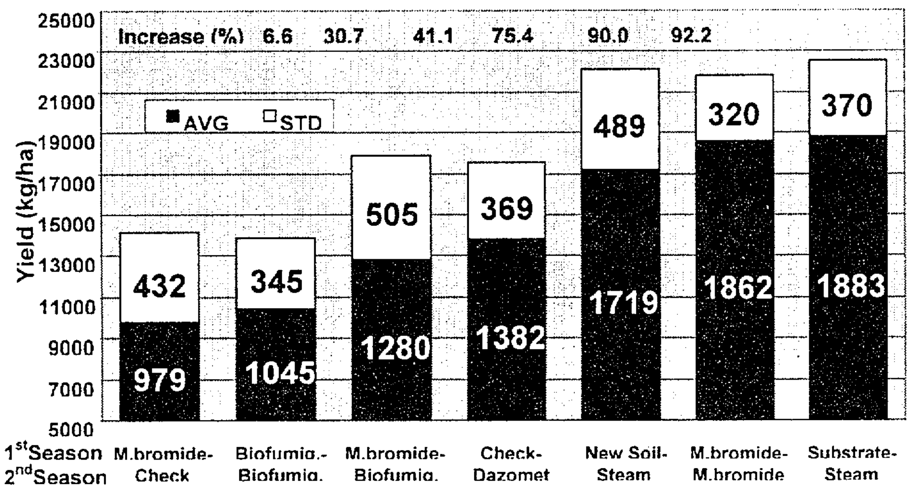


Fig. 2.20.- Strawberry yield in the 2nd season (1998-1999), with an indication of the treatments done in the same plots during the previous season (1997-1998)

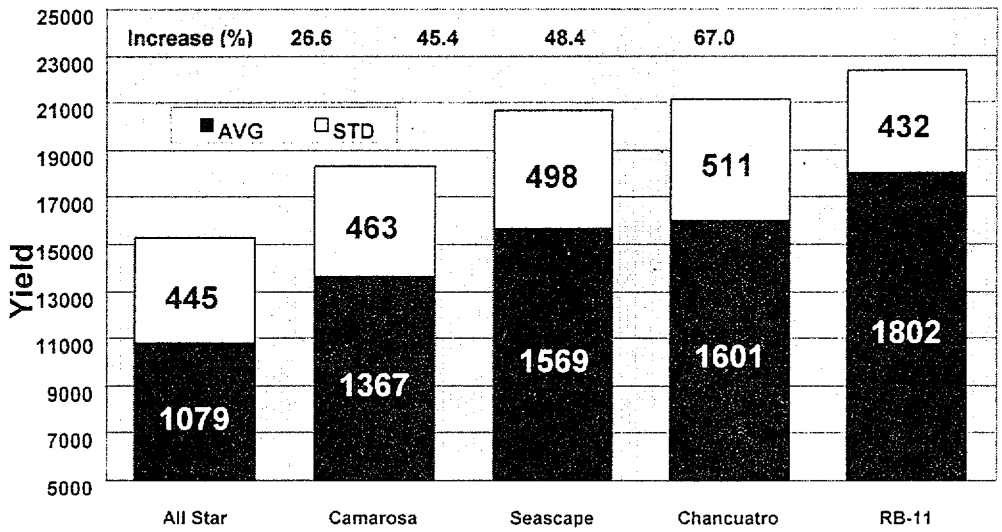


Fig. 2.21.- Yield of the cultivars tested in Mancheng, 2nd season (1998-1999)

When comparing the performance of the imported cultivars grown in plots treated with alternatives with that of the local cultivar "All Star" in the methyl bromide plots, all cultivars produced higher yields in the steam treatment, also cultivar "RB-11" ("Torero") and "Chancuatro" produced more in the dazomet and "RB-11" in the solarization plots. Therefore, a combination of new cultivars and alternative treatment could be also envisaged as an alternative to methyl bromide (Fig. 2.22).

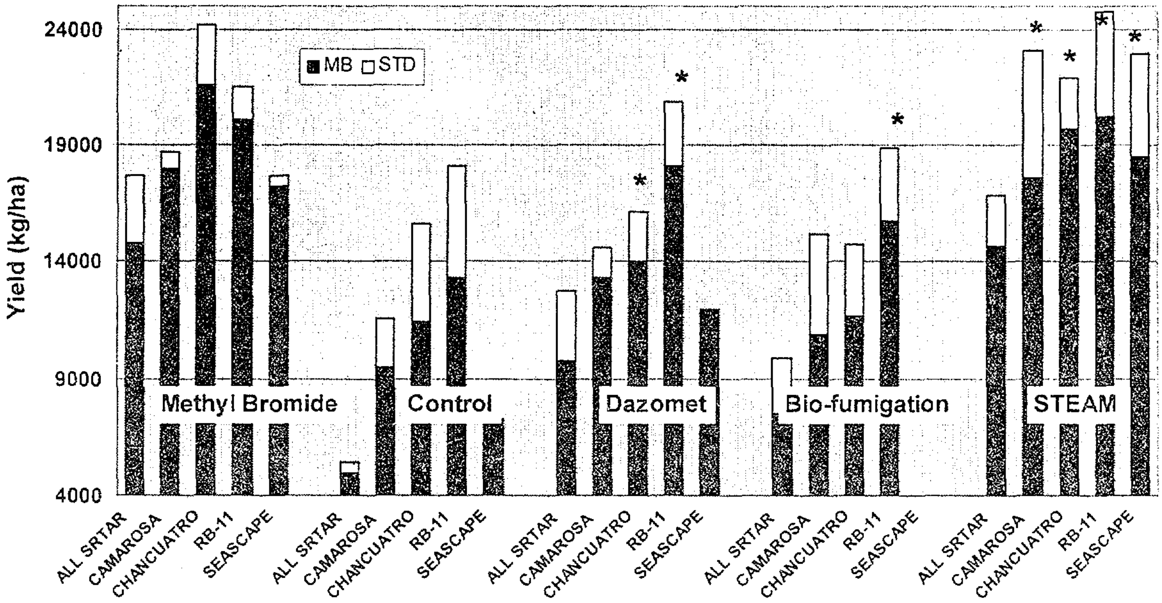


Fig. 2.22.- Yield of the cultivars in the different treatments. 2nd season (1998-1999). (*) cultivar grown with an alternative treatment to MB with higher yield than the local cultivar "All Star" grown with MB

Precocity is an important agronomic factor in the strawberry sector, this is because prices at the beginning of the season are higher. It is known that strawberry yields are earlier in methyl bromide treated plots, this was also observed during our trial, whereas a small delay in the yield could be observed in the steamed plots (Fig. 2.23).

However, this effect can be also obtained by managing the genetic resources available for strawberry. Cultivar "Seascape" is a neutral day cultivar that produces strawberry very precocious. In our trial, cultivar "Seascape" produced more than 30% of its yield during the first two weeks of harvest (Fig 2.24).

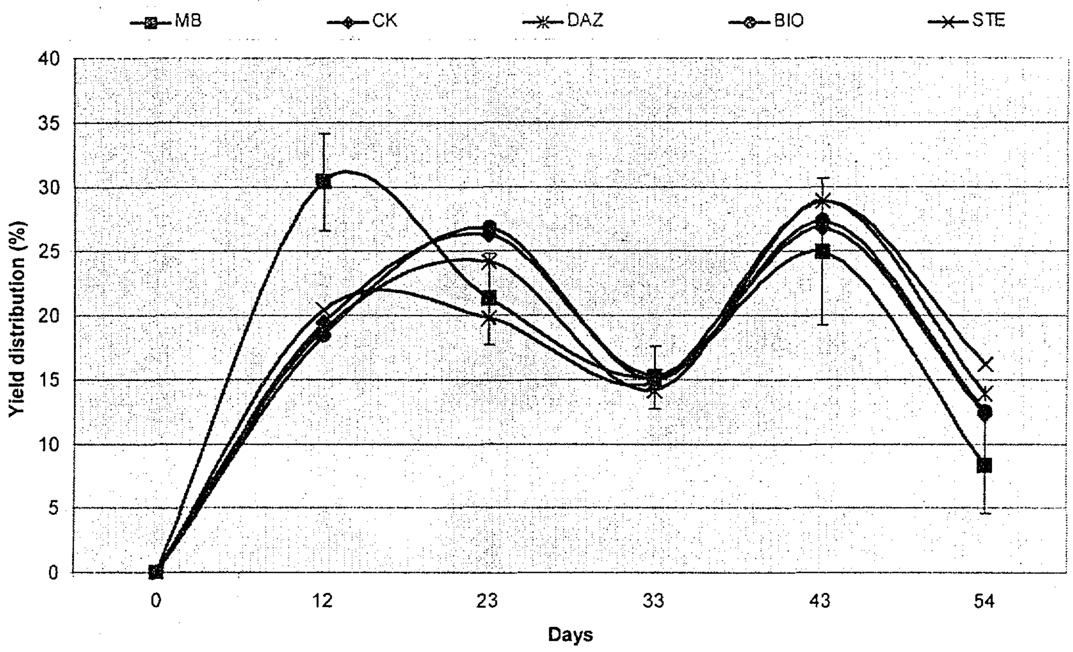


Fig. 2.23.- Strawberry yield distribution in relation with treatments, 2nd season

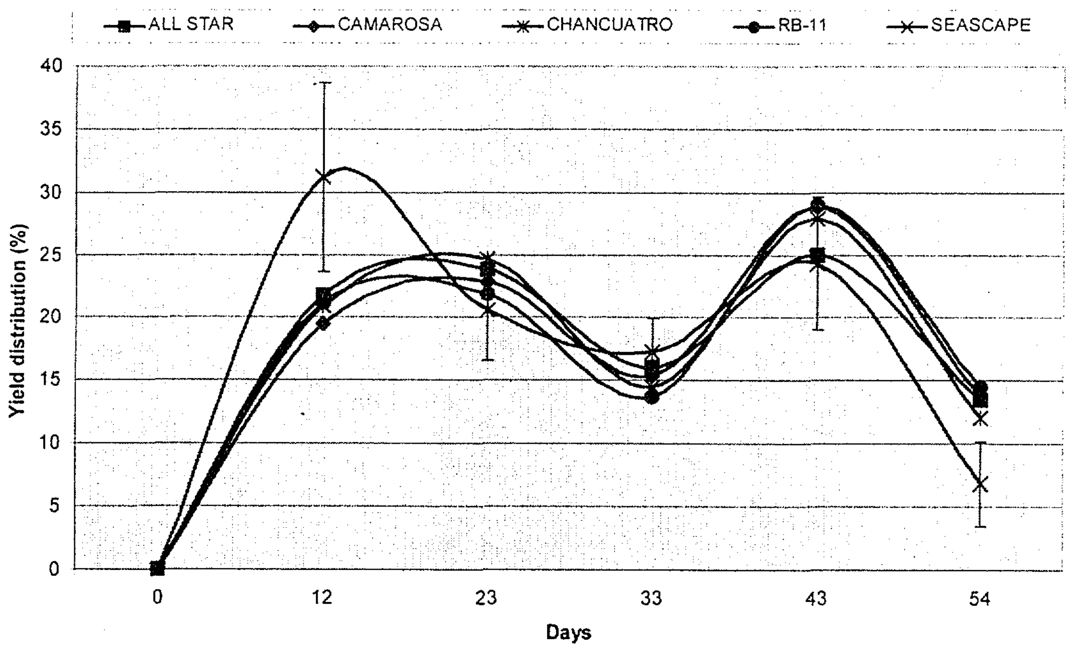


Fig. 2.24.- Strawberry yield distribution in relation with cultivars, 2nd season

COSTS

ENVIRONMENTAL COST

Table 2.5.- Estimated environmental cost of the treatments in Hebei

Treatment	Minus	Plus	OVERAL
CONTROL	None	None	Very low
MB	Use of ODS + plastics	None	Very high
DAZOMET	Use of bio-cide fumigant	None	Moderate
SOLARIZATION	Use of plastics + conventional pesticides	Use of waste	Low
SUBSTRATE	Use of conventional pesticides	Use of waste	Low
NEW SOIL OR ROTATION	Use of conventional pesticides	None	Low
STEAM	Use of petrol and conventional pesticides	None	Moderate
NEW CULTIVARS	None	Less pesticide usage	Very low

ECONOMIC COST

The Yield was estimated after calculating the yield per plant in each plot, and multiplying by the normal plant density of 150000 plants/ha used in the area. The price of the yield was calculated based in a market price of 0.75 US $/kg (6 RMB/kg).

Because it is possible that no a single alternative could be the most suitable for replacing MB, all possible combinations of the alternatives tested during the 2 year trial were considered. Basically it is a combination of the alternatives tested each year and the strawberry cultivars used. The results are shown graphically in Fig. 2.25 where a bar with a different pattern was included to indicate the usual cropping system in the area consisting of MB every season and the local cultivar "All Star" (MB-MB-(All Star)).

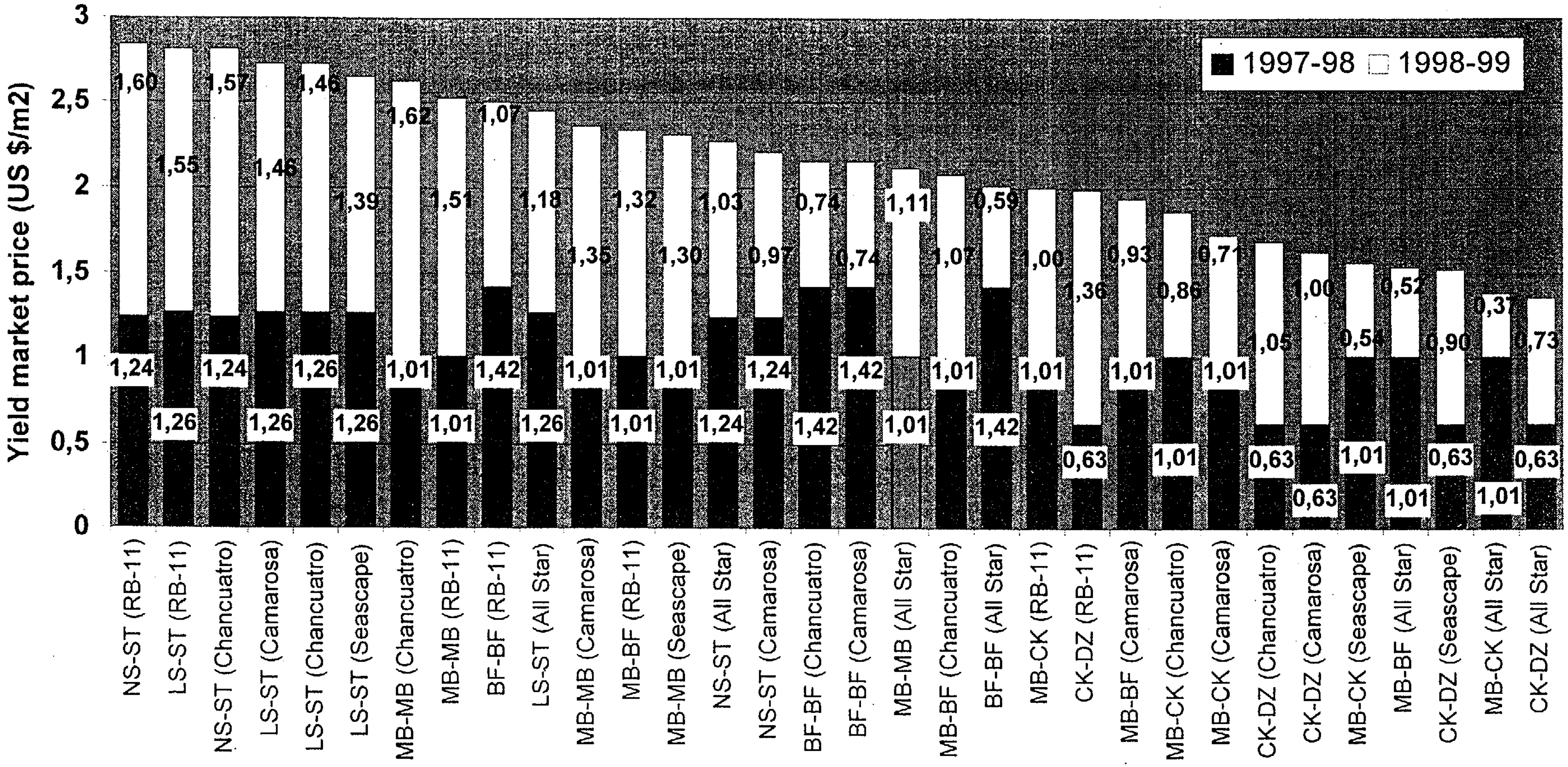


Figure 2.25.- Strawberry trial, average yield market price (US $/m^2) for the two seasons and all the alternatives tested. First two letters in the labels indicate alternative tested during the 1st season, second two letters alternatives tested in the same plots during the 2nd campaign. In brackets the strawberry cultivar used during the 2nd season is indicated. CK: untreated control; MB: methyl bromide; LS: local substrate; NS: new soil from corn fields; BF: local solarization; ST: Steam; DZ: Dazomet.

Considering the two crops and depending on the soil treatments and the strawberry cultivar used, 1 m^2 of the land will give a minimum gross yield of 1.36 (35.9 % less than the conventional system) and a maximum of 2.84 US$ (34% more than the conventional system).

There were 12 alternatives in which no MB was used in the two-year trial that produced higher yields than the conventional system. These included the use of solarization during: the two seasons in combination with new cultivars (BF-BF (Camarosa, Chancuatro & RB-11)); all treatments that imply the use of substrates (LS) and new soil (NS) in combination with steam (ST) and with all cultivars including the local cultivar.

In general, the average production of all alternatives that included methyl bromide in the 1st and/or 2nd season yielded 2.02 US$/$m^2$, whereas that of the alternatives that did not included methyl bromide was 2.25 US$/$m^2$ (11,4% more, 2300 US$/ha more).

The operational costs of the methyl bromide application and that of the alternatives proposed are shown in Tables 2.6-2.8. When possible, the cost associate to each item is based on the international market price.

Table 2.6.- Summary of incremental costs (US $ / ha)

Alternative	**Cost per year (US $ / ha)**	**Using new cultivars**
Solarization	-1185.6	+426.9
Local substrate	+1256.0	+2868.5
New soil from corn field		
Into an existing plastic house	+265.0	+1877.5
Rotating plastic house location	-47.7	+1564.8
Steam	+2531.5	+4144.0
Dazomet	-111.2	+1501.3

(*) If new cultivars are to be used, an extra incremental cost of 1612,5 US$/ha have to be added to the incremental cost of the proposed alternatives.

Table 2.7.-Methyl bromide application cost using 682g cans

ITEM	Amount/ha	Unit	US$/Unit	Cost US$/ha			
				Year 1	Year 2	Year 3	Year 4
Methyl bromide	425	kg	3.4	1453.4	1453.4	1453.4	1453.4
Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0
Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
Sterilized Chicken manure	15	t	124.2	1863.4	1863.4	1863.4	1863.4
			TOTAL COSTS	**4509.8**	**3596.8**	**4509.8**	**3596.8**

Table 2.8.-Incremental cost of the alternatives proposed for strawberry in Hebei

BIOFUMIGATION					COST US$ / ha			
	ITEM	Amount/ha	Unit	US$/Unit	Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	425	kg	3.4	1453.4	1453.4	1453.4	1453.4
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
	Sterilized Chicken manure	15	t	124.2	1863.4	1863.4	1863.4	1863.4
TOTAL SAVINGS (A)					**3596.8**	**3596.8**	**3596.8**	**3596.8**
Extra costs	Fresh chicken manure	160	m^3	9.9	1590.1	1590.1	1590.1	1590.1
	Wheat straw	20	t	31.1	621.1	621.1	621.1	621.1
	Extra labor	20	w/d	10.0	200.0	200.0	200.0	200.0
TOTAL EXTRA COSTS (B)					**2411.2**	**2411.2**	**2411.2**	**2411.2**
INCREMENTAL OPERATING COSTS (B-A)					**-1185.6**	**-1185.6**	**-1185.6**	**-1185.6**

DAZOMET					COST US$ / ha			
	ITEM	Amount/ha	Unit	US$/Unit	Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	425	kg	3.4	1453.4	1453.4	1453.4	1453.4
TOTAL SAVINGS (A)					**1453.4**	**1453.4**	**1453.4**	**1453.4**
Extra costs	Dazomet	100	kg	12.4	1242.2	1242.2	1242.2	1242.2
	Extra labor	10	w/d	10.0	100.0	100.0	100.0	100.0
TOTAL EXTRA COSTS (B)					**1342.2**	**1342.2**	**1342.2**	**1342.2**
INCREMENTAL OPERATING COSTS (B-A)					**-111.2**	**-111.2**	**-111.2**	**-111.2**

Table 2.8 (Cont.)

LOCAL SUBSTRATE					COST US$ / ha				
	ITEM	**Amount/ha**	**Unit**	**US$/Unit**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Savings	Methyl bromide	425	kg	3.4	1453.4	1453.4	1453.4	1453.4	1453.4
	Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0	913.0
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0	100.0
	Sterilized Chicken manure	15	t	124.2	1863.4	1863.4	1863.4	1863.4	1863.4
TOTAL SAVINGS (A)					**4509.8**	**3596.8**	**4509.8**	**3596.8**	**4509.8**
Extra costs	Vermiculite	1000	m^3	7.5	7453.4	0.0	0.0	0.0	0.0
	Peat	625	m^3	14	8750.0	0.0	0.0	0.0	0.0
	Bricks	350000	units	0.0186	6510.0	0.0	0.0	0.0	0.0
	Sterilized chicken manure	20	t	124.2	2484.5	0.0	0.0	0.0	0.0
	Polyethylene (70g/m^2) for bed	1000	kg	1.3	1304.3	0.0	0.0	0.0	0.0
	Extra labor	50	w/d	10.0	500.0	0.0	0.0	0.0	0.0
TOTAL EXTRA COSTS (B)					**27002.2**	**0.0**	**0.0**	**0.0**	**0.0**
INCREMENTAL OPERATING COSTS (B-A)					**22492.4**	**-3596.8**	**-4509.8**	**-3596.8**	**-4509.8**

STEAM					COST US$ / ha			
	ITEM	**Amount/ha**	**Unit**	**US$/Unit**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Savings	Methyl bromide	425	kg	3.4	1453.4	1453.4	1453.4	1453.4
	Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
TOTAL SAVINGS (A)					**2646.5**	**1733.4**	**2646.5**	**1733.4**
Extra costs	Fuel-oil	20000	L	0.2	4472.0	4472.0	4472.0	4472.0
	Electricity	1000	kW	0.1	99.4	99.4	99.4	99.4
	Extra labor	15	w/d	10.0	150.0	150.0	150.0	150.0
TOTAL EXTRA COSTS (B)					**4721.4**	**4721.4**	**4721.4**	**4721.4**
INCREMENTAL OPERATING COSTS (B-A)					**2074.9**	**2988.0**	**2074.9**	**2988.0**

Table 2.8 (Cont.)

NEW SOIL INTO AN EXISTING PLASTIC HOUSE					COST US$ / ha			
	ITEM	Amount/ha	Unit	US$/Unit	Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	425	kg	3.4	1453.4	1453.4	1453.4	1453.4
	Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
TOTAL SAVINGS (A)					**2646.5**	**1733.4**	**2646.5**	**1733.4**
Extra costs	Transfer soil	5000	m3	0.6	3105.6	0.0	3105.6	0.0
	Polyethylene (70g/m^2) for bed	1000	kg	1.3	1304.3	0.0	1304.3	0.0
	Extra labor	50	w/d	10.0	500.0	0.0	500.0	0.0
TOTAL EXTRA COSTS (B)					**4909.9**	**0.0**	**4909.9**	**0.0**
INCREMENTAL OPERATING COSTS (B-A)					**2263.4**	**-1733.4**	**2263.4**	**-1733.4**

NEW SOIL ROTATING PLASTIC HOUSE LOCATION					COST US$ / ha			
	ITEM	Amount/ha	Unit	US$/Unit	Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	425	kg	3.4	1453.4	1453.4	1453.4	1453.4
	Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
TOTAL SAVINGS (A)					**2646.5**	**1733.4**	**2646.5**	**1733.4**
Extra costs	Labor for moving the plastic house	150	w/d	10.0	1500.0	0.0	1500.0	0.0
	Extra labor for preparing the soil	30	w/d	10.0	300.0	0.0	300.0	0.0
	Base fertilizer (sterilized chicken manure)	20	t	124.2	2484.5	0.0	2484.5	0.0
TOTAL EXTRA COSTS (B)					**4284.5**	**0.0**	**4284.5**	**0.0**
INCREMENTAL OPERATING COSTS (B-A)					**1638.0**	**-1733.4**	**1638.0**	**-1733.4**

NEW STRAWBERRY CULTIVARS					COST US$ / ha			
	ITEM	Amount/ha	Unit	US$/Unit	Year 1	Year 2	Year 3	Year 4
Savings	Local cultivars	150000	Plants	0.025	3750.0	3750.0	3750.0	3750.0
	25 % extra for replants*	37500	Plants	0.025	937.5	937.5	937.5	937.5
TOTAL SAVINGS (A)					**4687.5**	**4687.5**	**4687.5**	**4687.5**
Extra costs	New cultivars	75000	Plants	0.08	6000.0	6000.0	6000.0	6000.0
	5 % extra for replants*	3750	Plants	0.08	300.0	300.0	300.0	300.0
TOTAL EXTRA COSTS (B)					**6300.0**	**6300.0**	**6300.0**	**6300..0**
INCREMENTAL OPERATING COSTS (B-A)					**1612.5**	**1612.5**	**1612.5**	**1612.5**

(*): Replants needed as estimated during the demonstration trials.

CONCLUSIONS

ADVANTAGES OF THE PROPOSED ALTERNATIVES

1. Local substrate is a good alternative which can provide higher yields than MB.

2. Solarization is a good alternative which is easy to apply and with low cost. The results during the 1st season were excellent and better than MB. The average yield increase was 126.5% compared with the untreated plots. It has neither toxicity nor pollution effects to the environment and can also improve the soil characteristics.

3. New soil produced similar results to that obtained with MB during the 1st season. Rotation is widely in use in the area. The alternative has neither toxicity nor pollution and can also improve the soil characteristics.

4. Steam is very effective in controlling soil-borne diseases. it could be a complementary alternative to treat substrates or small oil areas when soil-borne diseases appear.

5. Dazomet should be a promising alternative. it need to test further and optimized the application method.

6. Alone or in combination with other techniques. the use of new strawberry cultivars is a promising alternative to MB. During the 2nd season. an average yield increase 46.8% was obtained when compared with that obtained with the local cultivar.

DISADVANTAGES OF THE PROPOSED ALTERNATIVES

1. Local substrate is expensive. There is a lack of appropriate infrastructure to provide the materials and the local prices for the materials needed are too high. New formulation with a lower cost needs to be developed.

2. The effectiveness of solarization is not stable. which was affected by the weather. soil conditions and the materials used. In general. solarization is a good alternative. which is easy to apply and cost is low. If the efficacy is stable. solarization will be a promosing alternative in China.

3. The use of new soil into an existing plastic house is time and labor consuming and is not considered a viable alternative to MB. Crop rotation. although widely in use in the area. is not considered an appropriate alternative and the extension is difficult due to the low acceptance of this technique by the farmers.

4. Steam is expensive. the steam equipment requires a supply of water and electricity that can't be ensured in many rural areas. The road conditions in many locations in the field are not suitable for the transport of the steam equipment.

5. The yield of dazomet was low in the experiment. The dosage and application technique need to be further tested. Other fumigation materials. including MB. are also affected by weather conditions and management as it happened during the 1st season.

6. The availability of new cultivars is low and the cost of the imported new cultivars. when available. is too high. There is not technical expertise nor appropriate infrastructure to produce high quality plants.

FARMER'S ACCEPTANCE

Alternative	**Acceptance by farmers**
Solarization	++
Local substrate	++
Dazomet	+
Steam	+
New soil into existing plastic house	+
Rotation moving plastic house every two years	++
New strawberry cultivars	+++

(+): poor; (++): fair; (+++): good

TRIAL 3: SHANDONG
(TOMATO AND PEPPER)

GENERAL INFORMATION AND RESPONSIBLE PERSONS

TRIAL CROP: VEGETABLES
SYSTEM: AUTUMN TOMATO AND SPRING HOT PEPPER
ODS USE IN SUB-SECTOR (1998): 410.0 t (246 t ODP)
SUB-SECTOR BASELINE (1995-1998): 227.5 t (136.5 t ODP)

Crop history:	7 July 1998:	Treatments
	July 1998-January 1999:	Tomato
	April 1999-July 1999:	Hot pepper
Site Location:	Xishuiqu Village, Qingzhou City, Shandong Province	
Contact at site:	Mr. Cui Fuxin, Director of the Bureau of Agriculture	
Tel:	+86-536-3230721	
Joined institution:	Beijing Agro-Environmental Monitoring Station:	
Chief:	Ms. Sun Guilan (Deputy Director)	
Tel:	+86-531-8938795	
Technique backup:	IPP-CAAS	
Advisors:	Mr. Peng Deliang and Dr. Duan Xiayu	
Tel:	+86-10- 62815611/62815946	
Fax:	+86-10-62894863	
E-mail:	dlpeng@public2.east.cn.net /xiayud@public.east.cn.net	

THE SITE

The site is located in Qingzhou City, Shandong Province. Qingzhou is located between the Luzhong Mountains in the southwest and the Lubei plain in the northeast. With more than 20% of the land devoted to agriculture, Shandong is one of the main agricultural regions in China. Rotation is widely used to control pest and diseases, including a large variety of crops like vegetables, cucurbits, beans, peanuts, cotton, etc., in alternation with wheat and corn. Tomato, cucumber and pepper are major economic important vegetables. Fertilization is with organic manure mainly. Traditional irrigation system is by flooding using underground water. This system was considered inadequate for the planned trial design and, in order to avoid soil-borne disease spread (mainly root knot nematodes and fusarium wilt), a drip irrigation system supplied by UNIDO was installed in June 1998.

Average temperature and rainfall area for the period January-July 1999 in the trial area is shown in Fig. 3.1. In general, the climate is a sub-humid monsoon, with annual average temperature of 12.7 °C and 191.7 days of frost-free period. Maximum average temperatures occurs in July, which is 26.3 °C and the lowest in January, which is –2.9 °C. The average yearly precipitation is 705.1 mm that occurs mainly in the summer with 62.3% of it, 18.5% in the autumn, 14.4% in the spring and only 4.9% in the winter.

The type of soil in the trial is medium loam. Soil physical and chemical characteristics determined from 15 composite samples that were taken before the treatments can be found in Table 3.1. The irrigation water variables are in Table 3.2.

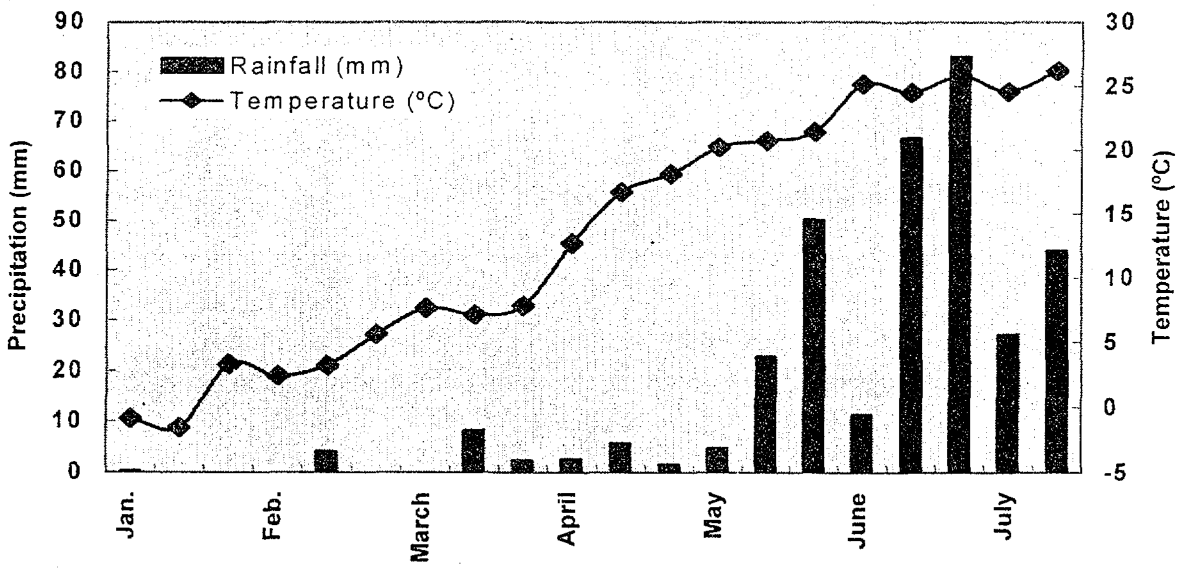


Figure 3.1. -Temperatures and rainfall in Qingzhou area

Table 3.1. -Soil characteristics in the experimental field in Qingzhou before treatments

Variable	Mean	STD
EC (µs/cm)	650.64	42.80
Organic Matter (%)	1.31	0.27
N (mg/kg)	52.87	6.07
P (mg/kg)	220.62	12.36
K (mg/kg)	291.86	11.73
Cu (mg/kg)	0.027	0.002
Zn (mg/kg)	0.055	0.005
Mn (mg/kg)	0.030	0.003
K_2O (%)	0.816	0.012
Na_2O (%)	0.0678	0.002
CaO (%)	0.245	0.022
Fe_2O_3 (%)	1.015	0.023

n=5

Table 3.2.- Irrigation water characteristics in Qingzhou

Variable	
pH	7.29
Total N (mg/L)	0.98
Total P (mg/L)	74
Cl^- (mg/L)	67.5
F (mg/L)	0.72
CN	< 4.0

THE TRIAL

The design of the experiment was of three completely randomized blocks, each with one replicate per treatment. The area of the plot was 29.7 m^2. Following the usual management in the area, only one treatment per year was applied in July 1998, before the cash crop, tomato (132 plants/plot) that was harvested in January 1998. After the tomato crop a spring crop of hot pepper (168 plants/plot) was planted and harvested in July 1999. Along the year, care was taken during tillage in not to displace the treatments and in maintaining the original plots. The following up of the trial was done in the autumn tomato crop and the spring hot pepper.

THE TREATMENTS

O Control: the land was prepared in the usual way of the area and remains untreated.

A MB: this treatment was done in the usual way. The land was plugged and worked correctly, then was covered with plastic. MB was then applied and the land sealed for 7 days with plastic mulch till 14th July 1998 when it was opened for aeration. The final dosage was 68.8 g/m^2.

B Local bio-fumigation: the land was prepared for treatment and the 7th July, fresh chicken manure was added, mixed and applied evenly in the soil at a rate of 7.5 kg m^{-2}. The soil was watered and covered with plastic mulch. The soil remained covered with plastic for 7 days till July 14th.

C Local substrate in bands, soiless cultivation: A substrate made of a mixture of decomposed chicken manure and decomposed wheat husk was used (1:2 ratio in weight). The land was opened by deep plugging and the substrate deposited. The plants grow in the soilless band of substrate (Fig. 3.3).

D. Dazomet: Basamid® (BASF) at 15 g / m^2 was applied evenly in the soil surface and incorporated into the soil. Then the plots were watered and cover with plastic sheet for 7 days.

THE PLANTS

Autumn tomato crop: Two tomato cultivars were used:

a) Chinese Yi Jia La with resistance to TMV. Planted in Blocks 2 & 3 and in plots (**A**), (**B**) and half of (**D**) in Block 1.

b) AR-35200 a long life, determined growth cultivar, with multiple resistance to TMV, root knot nematodes, Verticilosis, Fusariosis (Race 2) and *Stemphylium*. Planted in plots (**O**), (**C**) and half (**D**) in Block 1.

Spring hot pepper:

a) 168 plants of yellow hot pepper cultivar Yang Jiao Huang in each plot.

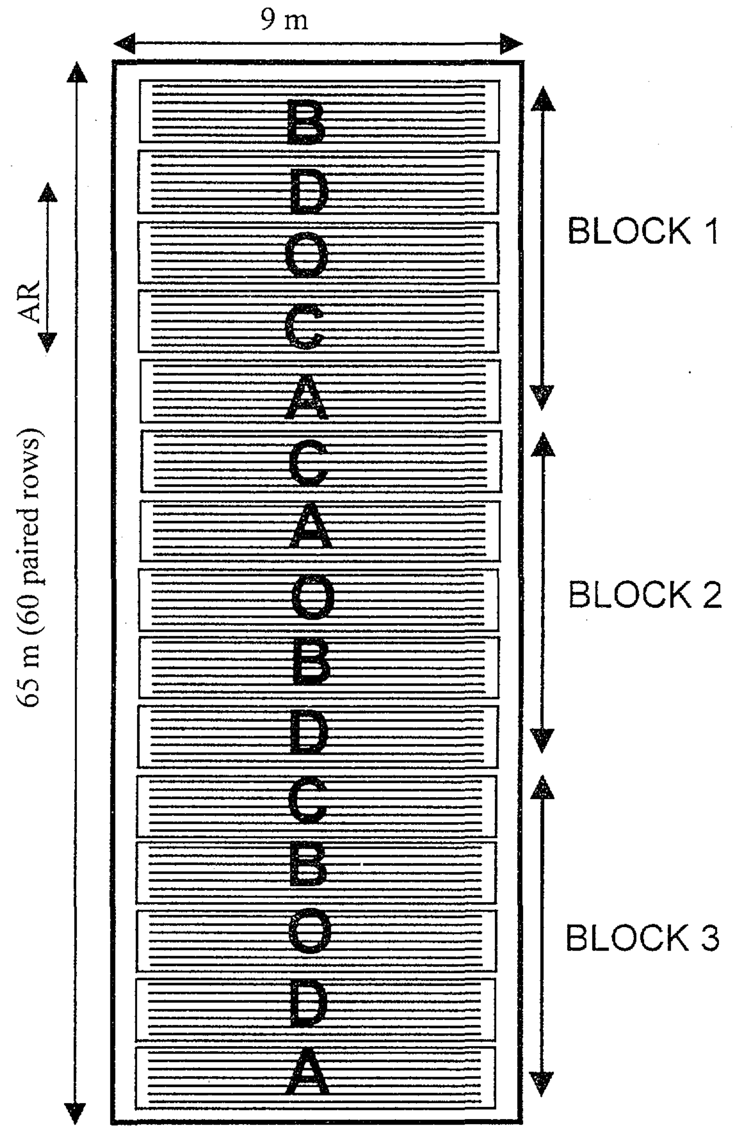


Fig. 3.2. -Trial layout for Qingzhou site.

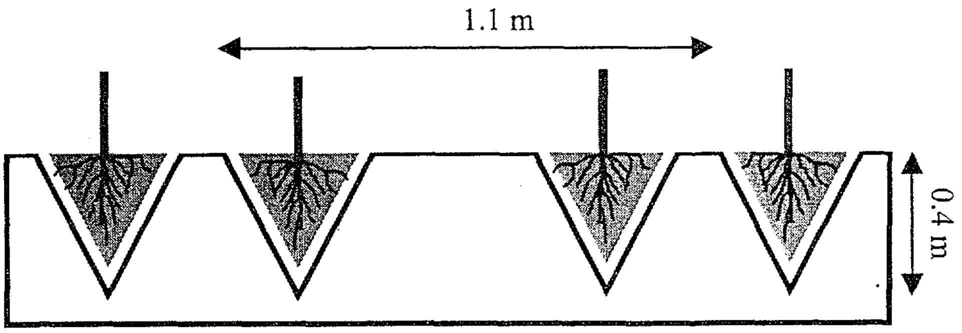


Fig. 3.3. - Scheme of soilless cultivation in Qingzhou.

EFFECT OF TREATMENTS ON SOIL FERTILITY

Soil samples were taken for soil fertility after the tomato crop (January 15 1999) and after the pepper crop (July 12 1999). The results of the analysis are shown in Table 3.3.

Table 3.3. - Fertility analysis after the two cropping seasons in Qingzhou.

Soil analysis after autumn tomato crop (January 15 1999)										
TREATMENT	**pH**	**EC (as/cm)**	**O.M. (%)**	**N (mg/kg) (Alk. Hydr.)**	**P (mg/kg)**	**K (mg/kg)**				
Control	8.30 a	5933 c	1.630 a	144.97 c	283.30 a	378.67 a				
Methyl bromide	6.53 c	6800 b	1.486 a	266.83 a	305.63 a	447.67 a				
Bio-fumigation	6.87 c	6700 b	1.640 a	223.70 b	314.27 a	355.33 a				
Local substrate	7.53 b	6333 bc	1.740 a	239.60 ab	301.13 a	378.00 a				
Dazomet	7.30 b	7500 a	1.666 a	208.57 b	278.03 a	376.00 a				
	K_2O (mg/kg)	**Na_2O (mg/kg)**	**CaO (mg/kg)**	**MgO (mg/kg)**	**Cu^{2+} (mg/kg)**	**Zn^{2+} (mg/kg)**	**$Fe^{2,3+}$ (mg/kg)**	**Mn^{2+} (mg/kg)**	**MoO_4^{2-} (mg/kg)**	**HBO_4^- (mg/kg)**
Control	0.870 a	0.065 a	0.254 a	1.033 ab	0.823 a	0.543 a	4.853 c	26.033 b	0.047 a	0.232 a
Methyl bromide	0.867 a	0.069 a	0.188 a	1.030 ab	0.810 a	0.573 a	4.900 bc	28.100 a	0.046 a	0.232 a
Bio-fumigation	0.817 b	0.072 a	0.253 a	1.034 ab	0.840 a	0.547 a	4.910 bc	27.967 a	0.048 a	0.256 a
Local substrate	0.801 b	0.062 a	0.245 a	1.045 a	0.823 a	0.553 a	5.050 a	27.933 a	0.047 a	0.233 a
Dazomet	0.815 b	0,064 a	0.254 a	1.024 b	0.843 a	0.597 a	5.017 ab	28.500 a	0.047 a	0.236 a
Soil analysis after spring pepper crop (July 12 1999)										
TREATMENT	**pH**	**EC (as/cm)**	**O.M. (%)**	**N (mg/kg) (Alk. hydr.)**	**P (mg/kg)**	**K (mg/kg)**				
Control	7.97 a	6100 c	1.817 ab	167.83 d	296.33 b	383.33 c				
Methyl bromide	6.73 c	6800 b	1.777 b	295.97 a	328.87 ab	466.67 a				
Bio-fumigation	6.97 c	6733 b	1.840 ab	256.40 b	277.57 b	439.67 b				
Local substrate	7.50 b	6433 bc	1.957 a	273.37 b	356.17 a	396.67 c				
Dazomet	7.37 b	7633 a	1.873 ab	229.10 c	328.53 ab	397.67 c				
	K_2O (mg/kg)	**Na_2O (mg/kg)**	**CaO (mg/kg)**	**MgO (mg/kg)**	**Cu^{2+} (mg/kg)**	**Zn^{2+} (mg/kg)**	**$Fe^{2,3+}$ (mg/kg)**	**Mn^{2+} (mg/kg)**	**MoO_4^{2-} (mg/kg)**	**HBO_4^- (mg/kg)**
Control	0.857 a	0.061 a	0.340 a	1.026 ab	0.763 b	0.487 a	4.923 a	25.167 b	0.039 b	0.227 b
Methyl bromide	0.858 a	0.064 a	0.260 a	1.021 b	0.760 b	0.490 a	5.013 a	26.067 ab	0.038 b	0.229 b
Bio-fumigation	0.809 b	0.068 a	0.254 a	1.027 ab	0.787 ab	0.490 a	4.973 a	26.267 ab	0.042 ab	0.231 ab
Local substrate	0.796 b	0.061 a	0.247 a	1.048 a	0.803 ab	0.530 a	5.000 a	26.200 ab	0.043 ab	0.232 ab
Dazomet	0.805 b	0.061 a	0.252 a	1.026 ab	0.827 a	0.523 a	5.007 a	26.500 a	0.046 a	0.236 a

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

In the plots treated with MB, a significant reduction of pH is observed, this might influence the availability of nutrients (macro and micro nutrients) for the plants in the soil. Electric conductivity (EC) is also increased in the plots treated with methyl bromide, this effect is higher for the other chemical fumigant dazomet. Available N, P and K are also higher in the MB treated plots.

EFFECT OF TREATMENTS ON PATHOGENS

EFFECT OF THE TREATMENTS IN SOIL FUNGI

Komada selective method was used. The method was done in a quantitative manner after each crop. Three to four dishes per sample were analyzed and the results are summarized in Table 3.4.

Table 3.4. -Evolution of soil fungi during the trial (c.f.u/g soil)

	Fo	Fs	Fr	Cy	TOTAL
TREATMENT	After the autumn tomato crop (February 1999)				
CONTROL (O)	117 **b**	233 **bc**	117 a	0 a	467 **bc**
MB (A)	33 **b**	67 **c**	67 a	50 a	217 **c**
BIOFUMIG. (B)	117 **b**	383 **ab**	67 a	50 a	617 **bc**
SUBSTRATE (C)	467 **a**	633 **a**	17 a	100 a	1217 **a**
DAZOMET (D)	283 **ab**	183 **bc**	383 a	17 a	867 **ab**
	After the spring hot pepper crop (July 12 1999)				
CONTROL (O)	1517 **a**	1033 **a**	233 a	67 a	2850 **a**
MB (A)	900 **ab**	183 **c**	133 a	200 a	1417 **b**
BIOFUMIG. (B)	1000 **ab**	917 **ab**	133 a	100 a	2150 **ab**
SUBSTRATE (C)	967 **ab**	1017 **ab**	250 a	33 a	2267 **ab**
DAZOMET (D)	517 **b**	550 **bc**	183 a	33 a	1283 **b**

Fo: *Fusarium oxysporum*; Fs: *Fusarium solani*; Fr: *Fusarium roseum*; Cy: *Cylindrocarpon* spp. Treatments with the same letter are not significant different according to a Duncan's Multiple Range Test, signification level is 5%.

The treatment with MB was effective in reducing the fungal soil population and this effect lasted for the two crops. There was not significant difference between the total number of c.f.u. in the MB treated plots at the end of the last crop and the alternatives proposed. Also Dazomet reduced the number of fungi in the soil after the hot pepper crop.

SOIL-BORNE DISEASE INCIDENCE IN STRAWBERRY PLANTS

The most serious problem that appeared during the trial was hot pepper root rot (*Phytophthora capsici*). Dead plants due to the vascular soil-borne disease were recorded regularly in the spring pepper until the end of the crop. The percentage of dead plants at the end of the crop is shown in Fig. 3.4.

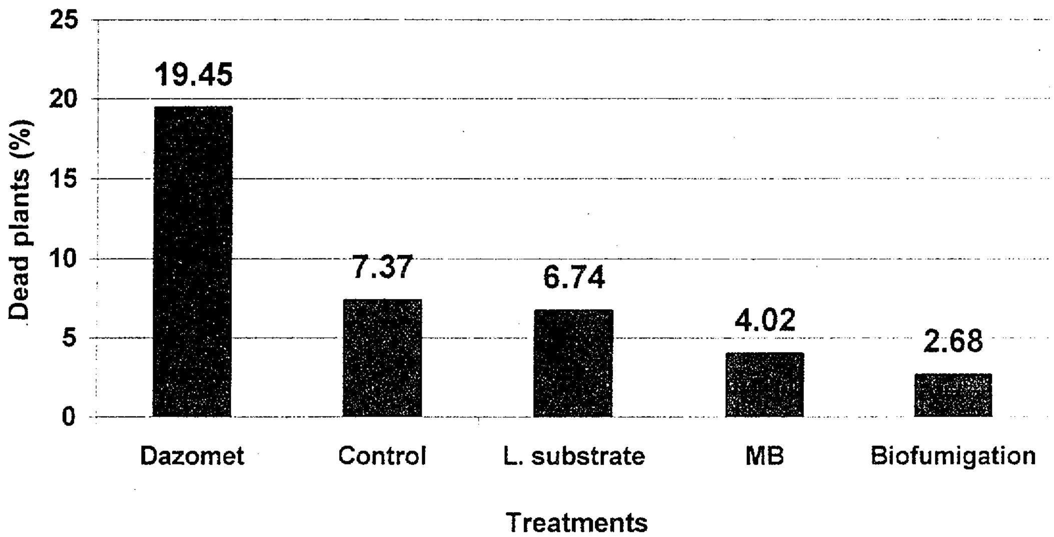


Fig. 3.4. -Dead hot pepper plants in the trial at Qingzhou.

The incidence of the disease was less severe in the bio-fumigation plots with only 2.7 % dead plants, whereas almost 20 % of the plants died by root rot in the dazomet treated plots.

EFFECT OF THE TREATMENTS IN SOIL NEMATODES

Nematodes were extracted eliminating fine particles (silt and sand) from 200 cc rhyzospheric soil and nematodes separated by centrifugation. The nematodes recovered were stored in vials with formol for further study. Nematode population was studied at three periods: before treatments, after treatments during the autumn tomato crop; at the end of the spring hot pepper crop, data is shown in Table 3.5.

Table 3.5. -Nematode populations at different stages during the trial

TREATMENT	Free living nematodes	*Helicotylenchus* spp	*Meloidogyne* spp	TOTAL
Before treatments (June 1998)				
AVERAGE	886.4±617.6	253.0±206.3	19.0±12.9	1237.1±736.2
After treatments during the autumn tomato crop (November 1998)				
CONTROL (O)	183.0 **ab**	163.7 a	108.3 a	472.3 a
MB (A)	173.3 **ab**	0.0 a	0.0 a	173.3 a
BIO-FUMIG. (B)	78.7 **bc**	86 a	41.0 a	214.3 a
LOCAL SUBSTR. (C)	207.3 **a**	259.7 a	10.7 a	493.0 a
DAZOMET (D)	55.7 **c**	76.3 a	0	138.7 a
After the spring pepper crop (July 1999)				
CONTROL (O)	5064.7 **bc**	27.7 a	5.7 a	5182.0 **bc**
MB (A)	7607.0 **a**	0.0 a	0.0 a	7632.0 **a**
BIO-FUMIG. (B)	6672.7 **ab**	12.7 a	0.0 a	6776.3 **ab**
LOCAL SUBSTR. (C)	3033.3 **c**	16.3 a	0.0 a	3262.3 **c**
DAZOMET (D)	4081.0 **c**	62.0 a	2.3 a	4168.3 **c**

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

The variation associated to this analysis is high. After the treatments the only alternative that showed a significant reduction of nematodes in the soil was dazomet, MB did not show a significant reduction in soil nematodes. After the second crop the number of nematodes in the plots with dazomet and local substrate was significant lower than that in the untreated plots.

Because the only nematode causing problems in the Qingzhou area is root knot nematodes, the root knot index was also recorded after the tomato crop, data is shown in Table 3.6. Table 3.6, together with Fig. 3.5, shows also the control efficacy of the different treatments.

Table 3.6. Incidence and root knot index in tomato after the crop

TREATMENT	n	Root knot incidence (*)	Root knot index (**)	Control efficacy (%)
CONTROL	10	85.0 **a**	58.75 **a**	
MB	10	0.0 **c**	0.00 **d**	100
BIO-FUMIGATION	10	84.7 **a**	52.50 **ab**	10.64
L. SUBSTRATE	10	70.0 **a**	30.00 **bc**	48.94
DAZOMET	10	30.0 **b**	9.17 **cd**	84.39
RESISTANT CUL.***	10	0.0	0.00	100

***) % Of plants showing symptoms of root knot nematodes. **) Index is based on a 0-4 scale. ***) No statistical analysis was performed for this treatment. Treatments with the same letter are not significant different according to a Duncan's Multiple Range Test, signification level is 5%.**

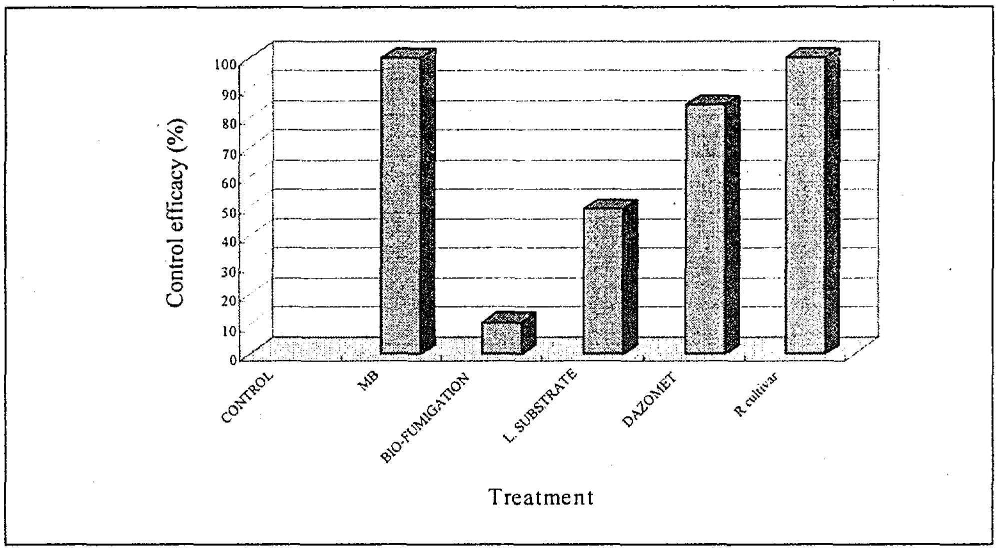


Fig. 3.5. -Control efficacy of different treatments in tomato crop in Qingzhou.

After the tomato crop, the plants grown in soil treated with dazomet showed a smaller incidence of root-knot nematodes, this treatment and local substrate also showed a significant reduction in the root-knot index when compared with the control plants. The resistant tomato cultivar (AR-35200) showed a complete resistance to root-knot nematode population present in the area.

EFFECT OF TREATMENTS ON YIELD

EFFECT OF THE TREATMENTS IN THE AUTUMN TOMATO CROP

The yield for all plots was recorded regularly from Sep 14th 1998 to Jan 12th 1999. Accumulative yield along the productive period is shown in Table 3.7 and Fig 3.6.

Table 3.7. -Accumulative average yield (kg/29.7 m^2) along the productive period

DATE	14/0	22/09	30/09	06/10	12/10	17/10	21/10	25/10	29/10	03/11	06/11	10/11	13/11	17/11	20/11
Ck *	2.10	4.95	15.70	24.95	34.90	**44.15** c	54.90	66.55	77.90	93.65	104.70	117.75	**129.65** d	142.70	153.15
MB	2.93	6.50	19.70	32.57	46.87	**60.37** a	75.33	91.50	107.50	129.30	144.10	162.40	**177.20** a	194.67	209.67
BIOF*	2.63	5.53	18.07	28.33	38.63	**48.47** c	60.37	73.50	86.57	105.27	116.77	131.70	**143.33c**	157.93	170.23
SUB	2.25	4.75	15.05	24.05	35.65	**45.95** c	57.25	69.45	81.85	99.05	110.35	125.30	**137.50cd**	151.95	164.05
DAZ*	2.75	5.80	18.20	29.40	42.05	**53.65** b	66.65	80.55	94.45	114.40	126.95	143.70	**156.40** b	174.45	188.25

DATE	24/11	27/11	30/11	03/12	07/12	10/12	14/12	17/12	21/12	25/12	29/12	01/01	06/01	12/01
Ck	166.60	178.20	190.15	201.55	215.90	226.90	**245.15** c	258.30	272.70	289.00	305.70	315.45	330.90	**346.80** c
MB	228.57	243.80	257.83	272.40	290.40	304.87	**323.10** a	338.17	354.57	371.73	389.30	402.87	420.87	**439.70** a
BIOF	186.70	200.87	214.67	228.17	244.60	256.93	**274.70** b	288.33	304.10	320.77	338.07	350.77	367.87	**385.83** b
SUB	179.60	192.90	206.15	218.50	234.35	247.55	**265.45** b	279.20	294.15	311.30	327.55	339.75	356.10	**373.55** b
DAZ	206.05	221.35	236.95	252.45	271.60	287.45	**306.25** a	321.60	338.10	355.65	373.75	387.45	405.85	**424.70** a

***Resistant cultivar AR-35200 was planted, the averages shown is the mean of two plots that were planted with the local cultivar. Treatments with the same letter are not significant different according to a Duncan´s Multiple Range Test, signification level is 5%.**

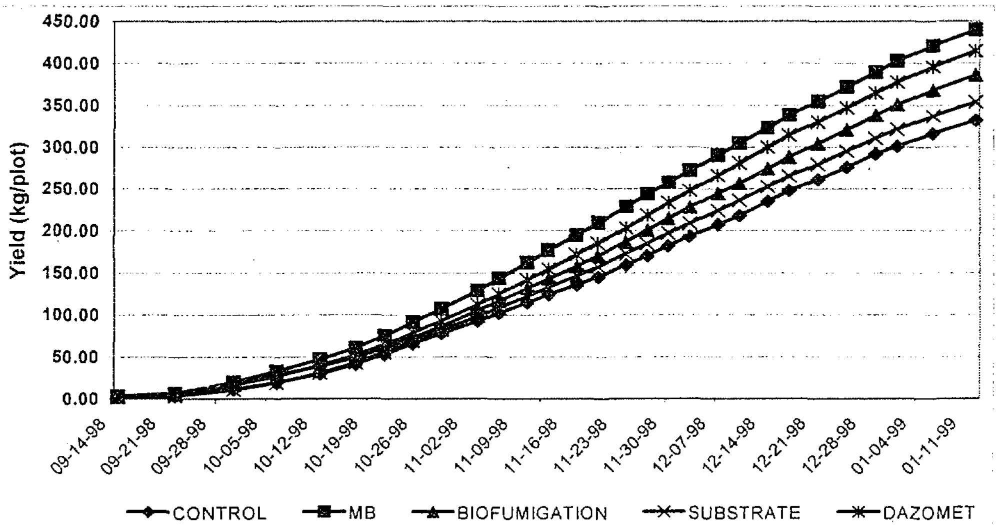


Figure 3.6.- Autumn tomato yields, temporal series

All alternatives proposed produced significant higher yields than the control. There was not significant difference between the treatments with MB and dazomet. The resistant tomato AR-35200 is a late cultivar and the yield is not comparable with that from the local cultivar.

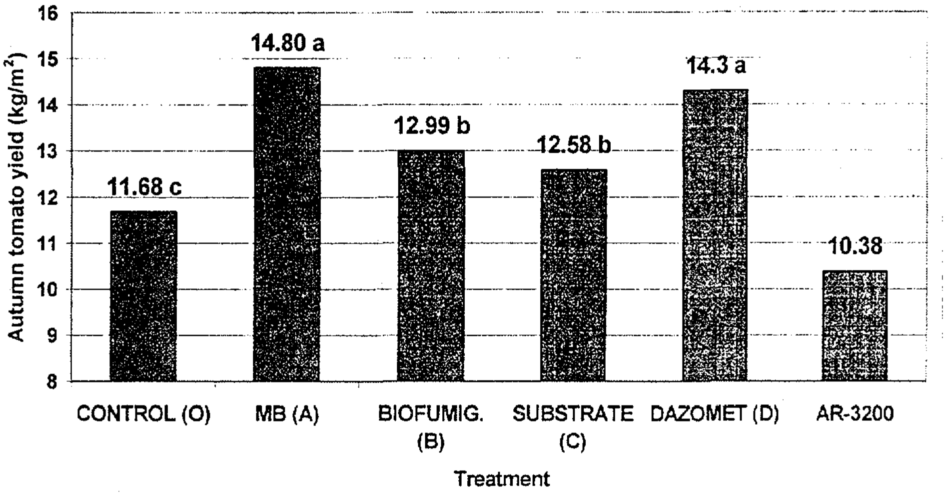


Figure 3.7. -Autumn tomato yield. Treatments with the same letter are not significantly different in a Duncan's Multiple Range Test, signification level is 5%.

EFFECT OF THE TREATMENTS IN THE SPRING HOT PEPPER CROP

The yield for all plots was recorded regularly from March 28th to July 11th 1999. Accumulative yield along the productive period is shown in Table 3.8 and Fig 3.8. Total yield is shown in Fig 3.9.

Table 3.8. Yield of spring hot pepper along the productive period (kg in 29.7 m^2).

DATE	28/3	3/4	9/4	15/4	23/4	30/4	5/5	12/5	18/5	23/5	28/5	3/6	10/6	16/6	22/6	6/7	15/6	11/7
CON	2.67	7.13	12.30	20.00	32.50	48.13	60.47	79.97	96.37	112.07	126.03	140.90	156.43	169.20	180.57	191.70	200.90	215.20
MB	2.67	7.00	12.07	20.07	32.73	48.30	60.97	81.67	99.37	115.37	130.57	146.97	163.87	177.73	190.20	201.03	210.60	223.10
BIOF	2.67	7.03	11.90	20.43	33.93	50.23	63.27	84.50	104.20	120.70	136.57	153.03	169.87	183.60	196.70	208.83	219.50	235.40
SUB	2.73	7.13	11.60	20.37	34.93	52.30	67.00	88.93	109.70	126.20	144.00	162.20	181.17	196.67	210.90	224.03	235.30	251.87
DAZ	3.30	8.53	14.47	24.33	39.93	58.27	72.97	95.40	114.53	129.60	145.93	161.57	176.87	189.43	200.97	211.67	221.53	235.83

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

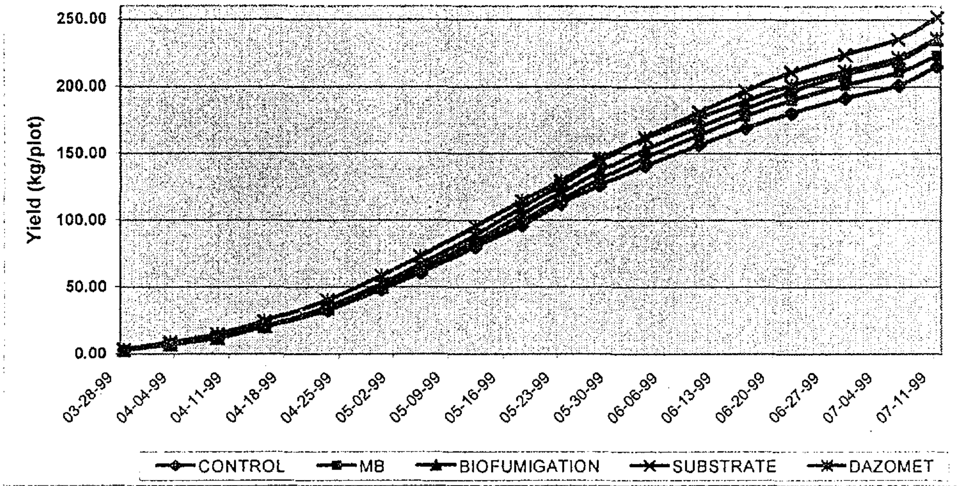


Figure3.8. -Spring cucumber. Yield (kg in 27.5 m^2) temporal series

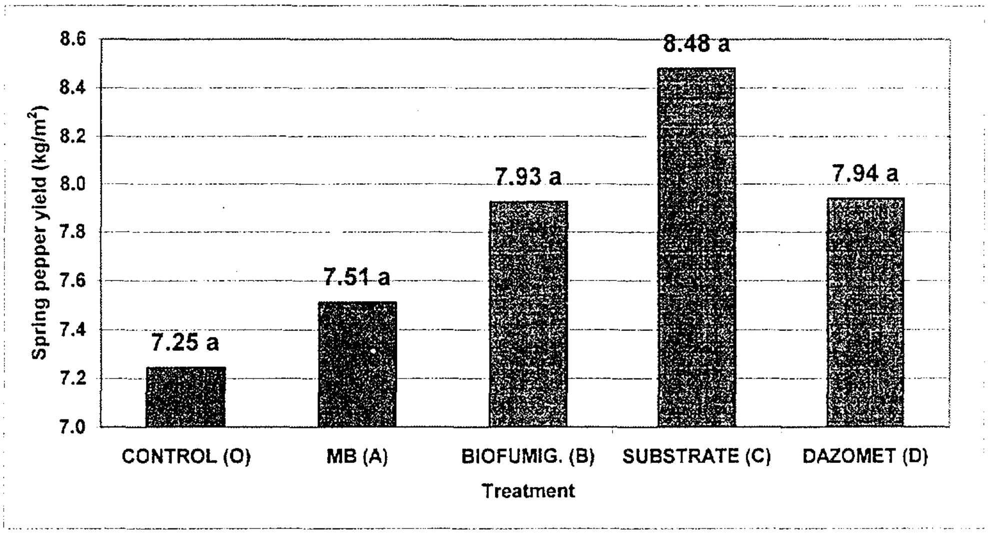


Figure 3.9. -Spring pepper yield. Treatments with the same letter are not significant different in a Duncan´s Multiple Range Test, signification level is 5%.

Because an incidence during the second season where high amounts of chicken manure was applied to one half of the tunnel, the variation between blocks was high and not significant differences were obtained between treatments. Higher pepper yield was obtained in the plots treated with the alternatives, comparing with the untreated plots, the yield increase was 18.0% for local substrate, 9.5% for dazomet 9.4% for bio-fumigation.

COSTS

ENVIRONMENTAL COST

Table 3.9.- Estimated environmental cost of the treatments in Beijing

Treatment	Minus	Plus	Overall
CONTROL	None	None	Very low
MB	Use of ODS + plastics	None	Very high
BIOFUMIGATION	Use of plastics + conventional pesticides	Use of waste	Low
SUBSTRATE	Use of conventional pesticides	Use of waste	Low
DAZOMET	Use of soil fumigants + plastics	None	Moderate
AR-35200	Use of resistance genes	Less pesticide usage	Very low

ECONOMIC COST

Because the difficult to estimate the seed costs in the PRC and because the latter production period of this cultivar as compared with the local one, the economic cost was not calculated for the multi-resistant cultivar AR-35200 grown during the Autumn season. The tomato was commercialized in the farm. The price of the produce was variable with a different price every time it was sold (Table 3.10). For the spring hot pepper, the price was the same during the campaign and was sold at 2,8 RMB/kg (0.35 US $/kg) The price of the yields during the two campaigns can be seen in Fig. 3.10.

Table 3.10. -Price of the yield (US $) for autumn tomato in Qingzhou.

	Autumn tomato crop			
DATE	**14-Sep to 17-Oct**	**21-Oct to 17 Nov**	**20 Nov to 17 Dec**	**21 Dec to 12 Jan**
UD $	0.3	0.25	0.2	0.15

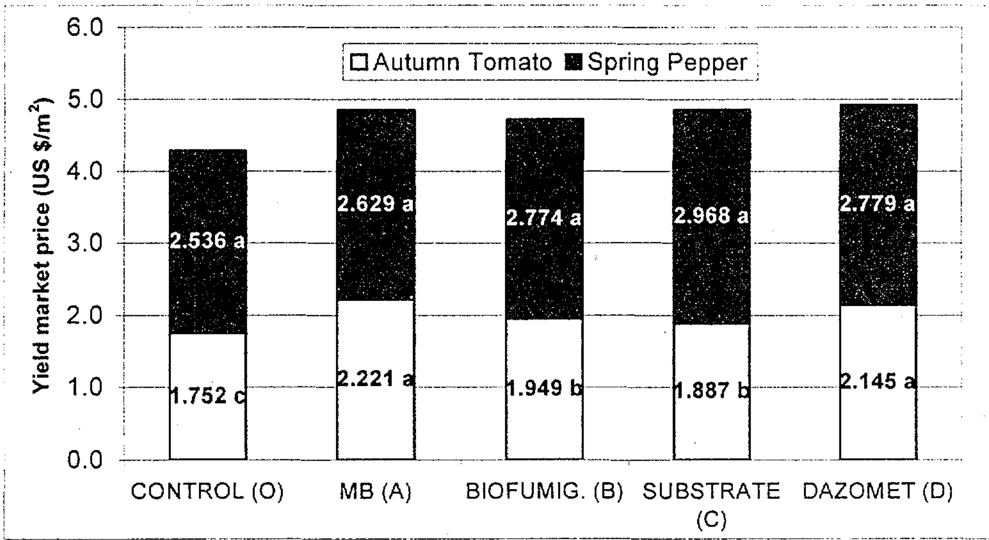


Figure 3.10. -Yield market price (US $/m^2) for the two seasons.

Considering the two crops and depending on the soil treatments, 1 m^2 of the land will give a minimum gross yield of 4.29 (11.6 % less than MB) for untreated soil and a maximum of 4.92 US$. The alternatives proposed yielded almost the same that MB, 1 m^2 yielded 4.92 US$ (1.5 % more than MB) for dazomet, 4.86 US$ (0.1 % more than MB) for the local substrate and 4.72 US $/m^2 (2.6 % less than MB) for bio-fumigation.

The operational costs of the methyl bromide application and that of the alternatives proposed are shown in Tables 3.11 to 3.13. When possible, the cost associate to each item is based on the international market price.

Table 3.11.- Summary of incremental costs

Alternative	Cost per year (US $ / ha)
Local substrate	-2294.6
Bio-fumigation	-835.2
Dazomet	-379.2

Table 3.12. -Methyl bromide application costs using 682g cans

ITEM	Amount/ha	Unit	US$/Unit	Cost US$/ha			
				Year 1	Year 2	Year 3	Year 4
Methyl bromide	688	kg	3.4	2339.2	2339.2	2339.2	2339.2
Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0
Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
			TOTAL COSTS	**3612.2**	**2699.2**	**3612.2**	**2699.2**

Table 3.13. -Incremental cost of the alternatives proposed for tomato and hot pepper in Shandong

BIO-FUMIGATION		Amount/ha	Unit	US$/Unit	COST US$ / ha			
	ITEM				Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	688	kg	3.4	2339.2	2339.2	2339.2	2339.2
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
TOTAL SAVINGS (A)					**2619.2**	**2619.2**	**2619.2**	**2619.2**
Extra costs								
	Fresh chicken manure	160	m^3	9.9	1584.0	1584.0	1584.0	1584.0
	Extra labor	20	w/d	10.0	200.0	200.0	200.0	200.0
TOTAL EXTRA COSTS (B)					**1784.0**	**1784.0**	**1784.0**	**1784.0**
INCREMENTAL OPERATING COSTS (B-A)					**-835.2**	**-835.2**	**-835.2**	**-835.2**

Table 3.13. (Cont.)

LOCAL SUBSTRATE IN LINES	ITEM	Amount/ha	Unit	US$/Unit	COST US$ / ha			
					Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	688	kg	3.4	2339.2	2339.2	2339.2	2339.2
	Polyethylene (70g/m^2) for cover	700	kg	1.3	913.0	0.0	913.0	0.0
	Labor for covering and applying MB	18	w/d	10.0	180.0	180.0	180.0	180.0
	Labor for uncovering	10	w/d	10.0	100.0	100.0	100.0	100.0
TOTAL SAVINGS (A)					**3532.2**	**2619.2**	**3532.2**	**2619.2**
Extra costs	Decomposed wheat husk	15	t	22.5	341.0	341.0	341.0	341.0
	Composted chicken manure	27	t	16.3	440.1	440.1	440.1	440.1
TOTAL EXTRA COSTS (B)					**781.1**	**781.1**	**781.1**	**781.1**
INCREMENTAL OPERATING COSTS (B-A)					**-2751.1**	**-1838.1**	**-2751.1**	**-1838.1**

DAZOMET	ITEM	Amount/ha	Unit	US$/Unit	COST US$ / ha			
					Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	688	kg	3.4	2339.2	2339.2	2339.2	2339.2
TOTAL SAVINGS (A)					**2339.2**	**2339.2**	**2339.2**	**2339.2**
Extra costs	Dazomet	150	kg	12.4	1860.0	1860.0	1860.0	1860.0
	Extra labor	10	W/d	10	100	100	100	100
TOTAL EXTRA COSTS (B)					**1960.0**	**1960.0**	**1960.0**	**1960.0**
INCREMENTAL OPERATING COSTS (B-A)					**-379.2**	**-379.2**	**-379.2**	**-379.2**

CONCLUSIONS

ADVANTAGES OF THE PROPOSED ALTERNATIVES

1. Local substrate in bands displayed good control of root knot nematodes. The cost of the technique is low and the yields obtained were reasonable in the autumn tomato and higher than MB in the spring pepper. The alternative has neither toxicity nor pollution and can also improve the soil characteristics.

2. Bio-fumigation did not showed a good control of root knot nematodes. The cost of the technique is low and the yields obtained were reasonable in the autumn tomato and higher than MB in the spring pepper. It has neither toxicity nor pollution effects to the environment and can also improve the soil characteristics. Overall, the results obtained can be qualified as excellent, especially if we consider the short time given for the treatment and that no cruciferous plant residues were added. The treatment lasted only 7 days when it is always recommended to have the soil covered with plastic for a minimum of 20 days.

3. Dazomet is revealed as a good alternative to MB. The cost of the technique is lower than that for MB and the yields obtained were similar in the autumn tomato and higher than MB in the spring pepper.

4. The use of resistant cultivars is a good alternative to MB. The resistant cultivar tested was not affected by root-knot nematodes and showed high tolerance to air-borne pathogens and pests like leaf mold caused by *Fulvia fulva* (formerly *Cladosporium fulvum*), various viral diseases and leaf miner (*Liriomyza sativae*). This implies that these cultivars can be grown with less conventional pesticides.

DISADVANTAGES OF THE PROPOSED ALTERNATIVES

1. The treatment with local substrate is tedious, it is more labor and time consuming than other techniques. New formulation with low cost and high efficacy need to be further tested.

2. The effectiveness of bio-fumigation is affected by the treatment time, weather and soil conditions. The formulation for bio-fumigation needs to be further tested and optimized for effectiveness and costs.

3. Dosage and application technique needs to be improved for effectiveness against soil-borne fungi and nematodes.

4. The multiresistant tomato variety used was not the appropriate for the area. The color of the fruit is not accepted by the market and the production is later than that of the local varieties.

FARMER'S ACCEPTANCE

Alternative	**Acceptance by farmers**
Bio-fumigation	++
Local substrate	++
Dazomet	+++
Multiresistant cultivars	?

(+): poor; (++): fair; (+++): good; (?): not in use

TRIAL 4: HUBEI
(TOBACCO SEEDBEDS)

GENERAL INFORMATION AND RESPONSIBLE PERSONS

SUB-SECTOR: TOBACCO
SYSTEM: TOBACCO SEEDBEDS TWO-YEAR TRIAL
ODS USE IN SUB-SECTOR (1998): 1100,0 t (660,0 t ODP)
SUB-SECTOR BASELINE (1995-1998): 605,0 t (363,0 t ODP)

Crop history:	25 February-4 March 1998:	Treatments
	March-April 1998:	Tobacco seedbeds
	12 February-24 February 1999:	Treatments
	April-May 1999 (re-seeded):	Tobacco seedbeds
Site Location:	1st year: Cuijaba village, Enshi, Hubei.	
	2nd year: Sadi village, Enshi, Hubei.	
Contact at site:	Mr. Xiang Zhenjin	
Tel:	+86-718-8224561	
Joined institution:	Hubei Agro-ecological Environmental Monitoring Station:	
Chief:	Ms. Lu Xiaoying (Senior Agronomist)	
Tel:	+86-27-88786373	
Fax:	+86-27-87880911	
Technical backup:	IPP-CAAS	
Advisors	Mr. Cao Aocheng	
Tel:	+86-10-62894863/62815940	
Fax:	+86-10-62894863	
E-mail:	nopt@public.east.cn.net	

THE SITE

Hubei Province locates at the middle reaches of Yangtzi River in (108°30'-116°10', 29°05'-33°20'). The annually sunlight time is 1200-2200 hours in average. The average annual temperature is 15-17℃, and participants 800-1700 mm. The weather is monoon of sub-tropic zone. The topography is complex and the types of soil are various. These provide advantageous conditions for growing of different sorts of tobacco. Hebei Province has more than 300 years history of growing tobacco. The main varieties are cured tobacco, burley tobacco and sun-cured tobacco. The growing area was 102,170 ha with a total yield of 199,879 t and averaged 1956 kg/ha (1997). There are three tobacco cultivation areas in Hubei, i.e., Enshi, Xiangfan and Yichang. The areas of tobacco growing are 63.4%, 15.58% and 3.44%, respectively, of the total. Burley tobacco is the main variety in Enshi.

There are 25 infectious tobacco diseases according to several years' investigations to diseases and insect pests in tobacco after 1990's. Among them, there are 16 fungal diseases, 3 bacterial diseases, 5 viral diseases and 1 nematode species. Damping-off of diseases, Anthracnose of tobacco, Black shrank of tobacco, Black root rot of tobacco, MTV, CMV, PTY, TEV occur commonly throughout the province and have heavy damage. There are 156 insect pests. Among them, root cutworm, tobacco aphid and *Heliothis assulta* commonly occur in the province and cause heavy damage. tobacco aphid can transmit also tobcco viruses.

The results of investigations to pests carried out in recent years showed that *Colletotrichum* sp. occurred commonly in tobacco seedbeds. The incidence was 15-20%. Anthracnose of tobacco was the most serious disease during maturing stage. The incidence was 30% in some county and was up to 100% in some serious infected fields. Black shrank of tobacco, Black root rot of tobacco and bacterial wilt of tobacco were the most important root and stem diseases. Black shrank of tobacco was the most serious one. The incidence was 8% in Enshi. Root cutworm was the most important soil insect. The rate of damage was 5-10% with maxmum of 80%.

Enshi (109°39'-109°58', 29°50'-30°39') being a major area for Burley tobacco (*Nicotiana longiflora*) cultivation. Cuijiaba is located in the Wu Shan mountainous system 50 km north east from Enshi (c. 500 m.a.s.l). Average temperature and rainfall in the area for 1997 are shown in Fig. 4.1. In general, the Enshi area is included into the middle sub-tropical monsoon climate, with annual average temperature of 14 °C and 1815,2 mm precipitation.

Enshi dedicates 21.8 % of its dry farm land to tobacco, in 1996, 6510 ha of burley and 2810 ha of flue-cured tobacco were grown with a yield of 30710 t, in 1997 the area was increased to 6780 ha and 4880 ha respectively. Main cultivars are Chinese 2E, JB80, 8301 and EB4. In Enshi, *c.* 100 ha of tobacco seedbeds are planted each year.

Seedbeds are prepared in late February early March in small tunnels of 1.2 x 6 m. The soil is plugged and sieved, density of seeds is *c.* 400 / m^2 (1 g / 7.5 m^2), seeds are forced to germinate using a transparent plastic mulch. Coated tobacco seeds are available since 1996. They also use $CuSO_4$, formalin and $AgNO_3$ for seed treatment. Other fungicides used are carbendazim, ridomil (metalaxyl), quintozene and chlorothalonil.

The tobacco seedlings (80-90 days) are then transplanted to the field in late April. Tobacco harvest time start in late August till early October.

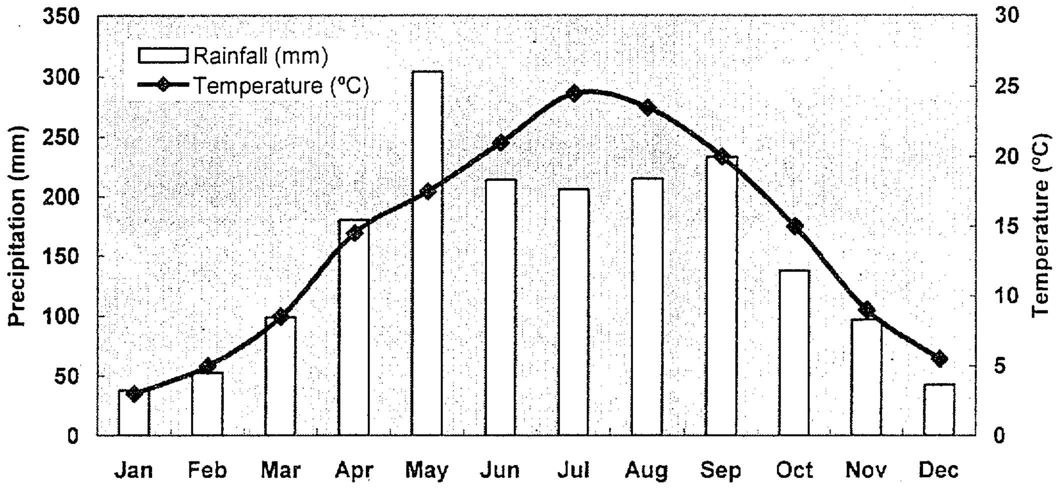


Figure 4.1.- Average monthly temperatures and rainfall in the Enshi area

Table 4.1.- Soil characteristics in the experimental fields in Cuijaba and Shadi for the two trials

Variable	1st Season	2nd Season
pH	6,58	7,2
Organic Matter (%)	2,96	2,50
CEC (cmol/kg)	10,50	18,20
C/N	10,10	11,2
EC (ms/cm)	0,52	0,56
Total N (%)	0,17	0,13
Total P (%)		0,91
Total K (%)	1,39	1,77
Effective N (mg/kg)		125,00
Effective P (mg/kg)	496,9	96,36
Effective K (mg/kg)		377,16

Table 4.2.- Water characteristics in Cuijaba

Variable	
CE (µS/cm)	200
Alkalinity (ppm $CaCO_3$)	35
Acid strength (ppm $CaCO_3$)	162
Eaton´s index	127

The main phytopathological problems in the area associated to tobacco seedbeds are antracnose (*Colletotrichum nicotianae*), Damping off (*Phithium aphanidermatum*), wild fire (*Pseudomonas syringae* pv *tabaci*) and vascular disease caused by *Phytophthora parasitica* var. *nicotianae*.

THE TRIAL

The trial was conducted in plastic covered seedbeds of 7.5 m^2 (1.2 x 6 m) using burley coated seeds. The trial consisted in the follow up of two tobacco seedbeds seasons.

For the first season (February 1998) the experiment consisted of 18 plastic tunnels that were arranged in three completely randomized blocks with 6 treatments and 1 replicate per block. In the second season (February 1999), the trial consisted of 12 plastic tunnels arranged in three completely randomized blocks with 5 treatments and 1 replicate per block (two float substrates were in the same plastic tunnels).

In order to gain expertise for the float tray technique, in September-October 1998, a network was set up with 10 farmers that, with the technical advice and supervision of the personnel from the local and regional environmental stations, took care of a small seedbed. It was intended to make the farmers familiar with the technique and also to establish an effective exchange of information between farmers and technical personnel leading to a better knowledge of the technique. At the same time, small trials were designed to optimize a local substrate suitable for use in the floating technique during the second season (Feb-1999). Then in February 1999, at the same time that the large 2nd season trial, all farmers made a larger seedbed consisting of 4 trays and with different substrates.

THE TREATMENTS

First season (1998). 18 seedbeds in three completely randomized blocks with 4 alternatives, MB and control.

0 Control: the land was prepared in the usual way of the area and remains untreated.

A MB: this treatment was done in the usual way. The land was plugged and worked correctly, then was covered with plastic. MB was then applied and the land sealed for 4 days with plastic mulch till 28th Feb 98 when it was opened for aeration. Final dosage was 95 g/m^2.

B Burn soil: this is a local soil sterilization technique that consists in burning the soil in the site with organic matter previous to seedling. The treatment was conducted in the usual way filling the seedbed (*c.* 3 cm) with sieved treated soil.

C Suspended trays I: locally made rigid polyethylene trays were used. The trays were filled with a substrate made of river sand, sawdust and carbonized rice husk (3:1:1). Seeding time was 28 February.

D. Suspended trays II: locally made rigid polyethylene trays were used. The trays were filled with a substrate made of river sand and sawdust (3:1). Seeding time was 28 February.

E. Dazomet: Basamid® (BASF) at 14 g / m^2 was applied evenly in the soil surface and incorporated into the soil. Then the plots were watered and cover with a plastic sheet for 8 days. This treatment was seeded on the 16 March, two weeks after the other treatments.

Second season (1999). 12 seedbeds in three completely randomized blocks with 3 alternatives, MB and control. Seeding time was 24th Feb. Because heavy snow and management problems, the germination was poor and the trial was re-seeded the 13th April 1999.

02 Control: the land was prepared in the usual way of the area and remains untreated.

A2 MB: this treatment was done in the usual way. The land was plugged and worked correctly, then was covered with plastic. MB was then applied and the land sealed for 6 days with plastic mulch till 18th Feb 99 when it was opened for aeration. Final dosage was 95 g/m^2.

B2. Dazomet: Basamid® (BASF) at 15 g / m^2 was applied evenly in the soil surface and incorporated into the soil. Then the plots were watered and cover with a plastic sheet for 26 days till the 22nd Feb 99.

C2 Floating trays I: expandable polystyrene (EPS) trays were used. The trays were filled with a substrate imported from the EU and specifically formulated for the float technique in tobacco seedbeds.

D2. Floating trays II: expandable polystyrene (EPS) trays were used. The trays were filled with a Chinese substrate optimized by different tests made during 1998.

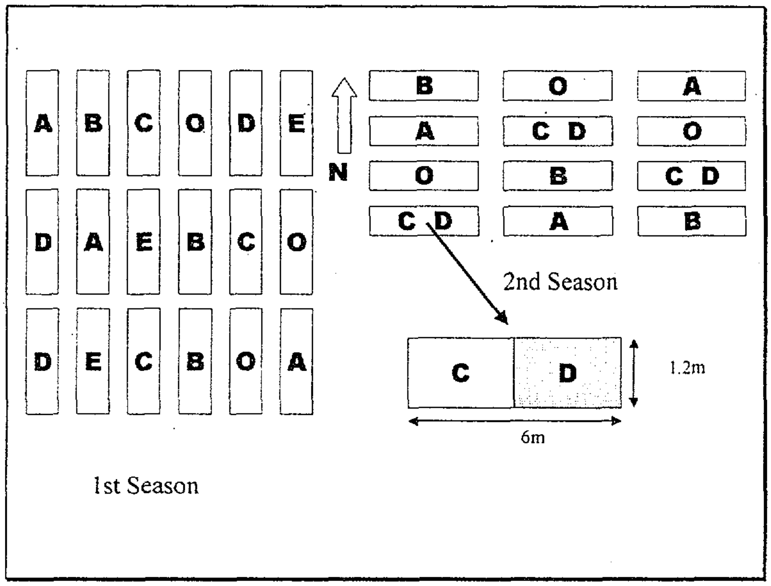


Fig. 4.2.- Trial layout for Cuijaba and Sadi.

SUBSTRATE OPTIMIZATION AND FARMER'S NETWORK

SUBSTRATE OPTIMIZATION

Three trials were done in a glasshouse at IPP-CAAS premises in Beijing, the aim was to find a local substrate suitable for the tobacco seedbeds in floating trays. During the trials, many combinations (1 to 4 components) of locally available materials were tested (Table 4.3).

Table 4.3.- Optimization of local substrate for tobacco seedbeds

	Substrate composition (%)							
Code	Rice husk	Carbonized rice husk	Pine sawdust	Vermiculite	Forest soil	Germination (%)	g/plant	Fresh weight (10 biggest plants)
				1st Trial				
1	100					0	0	0
2		100				0	0	0
3			100			33,3	0.45	8,68
4				100		36,7	0.59	12,88
5	50	50				0	0	0
6	50		50			45,0	1,66	33,28
7	50			50		21,7	8,89	108,28
8		50	50			18,3	0.31	2,80
9		50		50		35,0	177,48	110,68
10			50	50		25,0	1.98	1.78
11		33.3	33.3	33,3		36,7	0.76	14.71
12	33.3	33.3		33,3		6,7	1,72	
13	33.3		33.3	33.3		75,0	1,59	33,88
14		33.3	33,3	33.3		36,7	0.66	12,78
EU1		Imported substrate				88,3	3.99	72,60
				2nd Trial				
15				50	50	58,3	0.54	11,01
16		33.3		33,3	33,3	73,3	2,25	33,58
17			33.3	33,3	33,3	75,0	0,95	15,28
18		25	25	25	25	61,7	1,00	16,68
19					100	0	0	0
EU2		Imported substrate				88,3	3.99	72,60
				3rd Trial				
20		40	10	50		80,0	1,27	19,38
21		20	20	60		75,0	0,78	12,38
22		10	30	60		66,7	0,46	8,58
23		30	10	60		50,0	1,49	20,38
23		10	20	70		85,0	0,70	12,28
25		20	10	70		93,3	1,51	25,60
26		10	10	80		60,0	1,01	16.78
27		20		80		68,3	0,90	18,50
28			20	80		0	0	0
29		10		90		0	0	0
30			10	90		41,7	0.29	4.08
EU3		Imported substrate				85.0	1.22	15.31

No one component substrate produced good tobacco germination. Substrates that included in the formulation composted forest leaf (forest soil) did not give good results, germination was late and the plants grew very weak. From the different combinations tested, it was recognized that the proportion of vermiculite in the substrate should not be less than 50%.

Chosen local substrate composition was 50% vermiculite, 20% carbonized rice husk, 10% pine sawdust and 20% sand. The sand was included in the formulation attending to the results obtained during the first year trial, where the local substrate that included river sand give reasonably good results. This was the Chinese substrate that was then used by the farmers and in the floating tray II treatment during the 2nd season in 1999. The analysis of this substrate and the imported one is in Table 4.4.

Table 4.4.- Analysis of the local and imported substrates

	pH	EC (ms/cm)	OM (%)	Total N (%)	Total P (%)	Total K (%)	N (A.H) (mg/kg)	P (mg/kg)	K (mg/kg)	CEC (mmol/kg)	C/N
Imported	7,16 a	0,43 a	5,23 a	0,17 a	0,91 b	0,48 b	137,40 a	200,50 b	475,73 a	119,9 a	18,03 a
Chinese	7,13 a	0,43 a	2,34 b	0,09 b	0,94 a	1,39 a	25,03 b	232,33 a	265.23 b	129,2 a	14,43 a

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

Although there are remarkable similarities in the physique-chemical characteristics between the two substrates (pH, EC, Cation Exchange Capacity and carbon-nitrogen ratio), the distribution of macronutrients (N, P, K) are quite different. The availability of N and K is lower for the local Chinese substrate. It would be possible to ameliorate the results obtained with the local substrate by adjusting N and K and other parameters not shown like density, granulometry and water retention capacity.

FARMER'S NETWORK

During September-October 1998, 10 farmers from the Sadi area were selected and instructed by the Enshi Agro-environmental Protection Station Personnel in the floating tray technique. Each farmer received a package with all the necessary materials to set up a small seedbed between October and November. The results are summarized in Table 4.5.

Table 4.5.- Results from the floating trays in the farmer's network (Oct-Nov 1998).

Farmer	Seeding time	Seeds/cell	% germination
Tang Yingfu	13 Oct	1	26,48
Zhen Xinren	13 Oct	1	32,58
Zhen Xinjiai	14 Oct	1	53,03
Zhen Ping	14 Oct	1	38,26
Zhen Wen	30 Oct	2	80,68
		2	79,17
Zhen Zuoling	30 Oct	2	81,06
		2*	96,21
Zhen Chengmei	30 Oct	2	89,77
		2*	94,70
Zhen Xinhai	30 Oct	2*	91,29
		2*	91,67
Zhen Xiren	30 Oct	2*	94,70
		2*	89,77
Zhen Xinmei	10 Nov	2	0,00

(*) A thin layer of substrate was added after seeding.

Although, the cold weather conditions in November did not allow finishing the trials, the viability of the technique for the area was recognized by the farmers that also gain expertise in the technique. Germination was very good when using 2 coated seeds in each cell (82,67±4,8). The rate of germination was further improved by more than 10% when a thin layer of substrate was added after seedling (93,06±2,5).

In February 1999, 4 trays, seeds (E Yan 1, Hubei tobacco No. 1) and different substrates were given to each farmer to set up a larger seedbed. The farmers used two seeds per cell and covered the seeds with a thin layer of substrate. Germination rate (%) and seedling classification in 3 categories was recorded, the results are summarized in Tables 4.6-4.7.

Table 4.6.- Germination rate in the different substrates used by the farmers (Feb. 1999)

Farmer	Substrate A	Substrate B	Substrate C	Substrate D
Tang Yingfu	80,1	78,5	71,0	
Zhen Xinren	81,5		75,3	
Zhen Xinjiai	81,2	78,9	69,8	
Zhen Ping	81,1	79,5	69,1	
Zhen Wen	82,3		85,0	0,0
Zhen Zuoling	75,9		80,5	3,4
Zhen Chengmei	81,4		51,2	0,6
Zhen Xinhai	79,6	80,5	85,1	
Zhen Xiren	80,5	68,1	80,5	0,4
Zhen Xinmei	76,2			0,8
Average	79,98	77,10	74,17	1.04
STD	2,21	5,09	10,61	1.35

Substrates: (A) EU Imported substrate; (B) Chinese substrate I (50%Vermiculate+20%Sand+20%Canbonized rice husk+10%Saw dust); (C) Chinese substrate II (60%Sand+20%Sawdust+20%Carbonized rice husk); (D) Chinese substrate III (Carbonized rice husk).

Table 4.7.- Classification of tobacco seedlings obtained by farmers using floating trays

	Substrate A			Substrate B			Substrate C			Substrate D		
Farmer	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Tang Yingfu	29,5	49,8	20,7	5,0	51,5	43,5	5,8	31,2	63,0			
Zhen Xinren	21,7	55,4	22,9				10,5	28,1	61,4			
Zhen Xinjiai	37,8	52,1	10,1	10,5	50,8	38,7	10,1	25,8	64,1			
Zhen Ping	32,0	55,6	12,4	9,1	56,8	34,1	0,0	32,5	67,5			
Zhen Wen	30,5	56,1	13,4				0,0	10,1	89,9	0,0	0,0	0,0
Zhen Zuoling	29,4	30,1	40,5				0,5	31,3	68,2	38,9	27,8	33,3
Zhen Chengmei	10,6	57,3	32,1				0,0	10,5	89,5	33,3	0,0	66,7
Zhen Xinhai	33,4	51,9	14,7	5,5	52,8	41,7	0,0	30,8	69,2			
Zhen Xiren	29,8	48,1	22,1	5,8	45,9	48,3	0,0	5,8	94,2	0,0	0,0	100
Zhen Xinmei	10,1	34,5	55,4							25,0	50,0	25,0
Average	26,48	49,09	24,43	7,18	51,56	41,26	2,99	22,90	74,11	24,3	19,45	56,25
STD	9,40	9,37	14,39	2,46	3,93	5,31	4,55	10,84	13,12	17,18	24,22	34,29

Substrates: (A) EU Imported substrate; (B) Chinese substrate I (50%Vermiculate+20%Sand+20%Canbonized rice husk+10%Saw dust); (C) Chinese substrate II (60%Sand+20%Sawdust+20%Carbonized rice husk); (D) Chinese substrate III (Carbonized rice husk).

The imported substrate (Substrate A) was the best, with a germination rate of 79.98 % and a low variation. The sum of class 1 and 2 seedlings, which corresponds to the seedlings that can be transferred to the field, was also very good (75,57 %). Under the conditions of our trial and using substrate A, the percentage of viable cells was 60,44 %, which is correct. This figure is what we would expect from a standard seedbed in a commercial scale nursery.

Substrate B performed well in germination (77.10 %) but the useful seedlings (class 1 and 2) was low (58,74 %). The percentage of viable cells for this substrate was 45,29 %.

EFFECT OF TREATMENTS ON PESTS, PATHOGENS AND WEEDS

EFFECT OF THE TREATMENTS IN SOIL FUNGI

Komada selective method was used. The method was done in a quantitative manner during four periods: before and after the treatments during the first year, and after treatments and after the trial during the second year. Three to four dishes per sample were analyzed and the results are summarized in Table 4.8.

Table 4.8.- Evolution of soil fungi during the trial (c.f.u/g soil)

	Fo	Fs	Fr	Cy	TOTAL
TREATMENT		1st season, before treatments (February 1998)			
All the field (soil)	13,33±30,55	380,00±140,00	6,67±11,55	13,33±11,55	513,33±133,17
		1st season, after treatments (March 1998)			
CONTROL (O)	550,00 **ab**	1150,00 **a**	0,00 a	0,00 a	1700,00 **a**
MB (A)	0,00 **c**	100,00 **c**	0,00 a	0,00 a	100,00 **c**
BURN SOIL (B)	700,00 **a**	1000,00 **a**	0,00 a	0,00 a	1700,00 **a**
SUSP I (C)	150,00 **bc**	350,00 **bc**	0,00 a	150,00 a	650,00 **b**
SUSP II (D)	0,00 **c**	350,00 **bc**	0,00 a	0,00 a	350,00 **bc**
DAZOMET (E)	450,00 **ab**	750,00 **ab**	50,00 a	150,00 a	1400,00 a
		2nd season, after treatments (February 1999)			
CONTROL (O2)	950,00 **a**	183,33 **a**	133,33 a	100,00 a	1366,67 **a**
MB (A2)	0,00 **b**	0,00 **b**	0,00 a	0,00 a	0,00 **b**
DAZOMET (B2)	116,67 **b**	50,00 **b**	100,00 a	33,33 a	300,00 **b**
		2nd season, after the trial (June 1999)			
CONTROL (O2)	2166.67 **a**	516.67 **ab**	0.00 a	16.67 a	2700.00 **a**
MB (A2)	266.67 **b**	633.33 **a**	283.33 a	100.00 a	1016.67 **b**
DAZOMET (B2)	2250.00 **a**	333.33 **abc**	16.67 a	16.67 a	2883.33 **a**
FLOAT I (C2)	483.33 **b**	166.67 **bc**	100.00 a	133.33 a	883.33 **b**
FLOAT II (D2)	166.67 **b**	50.00 **c**	100.00 a	133.33 a	450.00 **b**

Fo: *Fusarium oxisporum*; Fs: *Fusarium solani*; Fr: *Fusarium roseum*; Cy: *Cylindrocarpon* spp. Treatments with the same letter are not significant different according to a Duncan's Multiple Range Test. signification level is 5%.

The treatment with MB was effective in reducing the fungal soil population, however this effect only lasted for one crop. The results obtained with dazomet were variable, being effective in reducing soil fungi only in the 2nd trial. The fungal population in the substrates was always smaller than in the soil.

EFFECT OF THE TREATMENTS IN SOIL NEMATODES

Nematodes were extracted eliminating fine particles (silt and sand) from 200 cc rhyzospheric soil and nematodes separated by centrifugation. The nematodes recovered were stored in vials with formol for further study. Nematode population was studied during four periods: before and after the treatments during the first year, and after treatments and after the trial during the second year, data is shown in Table 4.9.

Table 4.9.- Nematode populations at different stages during the trials

TREATMENT	Free living nematodes	*Aphelenchoides* spp	*Aphelenchus* spp	*Tylenchus* spp	*Meloidogyne* spp	TOTAL
1st season, before treatments (February 1998)						
	20,50	0,00	17,50	68,50	3,00	118,00
1st season, after treatments (March 1998)						
CONTROL (O)	50,00	70,00	19,00	0,00	0,00	171,00
MB (A)	4,00	0,00	0,00	0,00	0,00	4,00
BURN SOIL (B)	47,00	66,00	18,00	0,00	0,00	175,00
SUSP I (C)	0,00	0,00	0,00	0,00	0,00	0,00
SUSP II (D)	0,00	0,00	0,00	0,00	0,00	0,00
DAZOMET (E)	0,00	0,00	0,00	0,00	0.00	8.00
2nd season, after treatments (February 1999)						
CONTROL (O2)	62,33 a	0,00	0,00	41,33 a	79,67 **a**	236,33 **a**
MB (A2)	23,67 a	0,00	0,00	14,67 a	25,67 **b**	79,33 **b**
DAZOMET (B2)	29,00 a	0,00	0,00	30,67 a	38,33 **ab**	119,67 **b**
2nd season, after the trial (June 1999)						
CONTROL (O2)	1420,67 **a**	291,00 a	24,67 **a**	352,00 **a**	8,00 **a**	2096,33 **a**
MB (A2)	1626,67 **a**	2,33 a	0,00 **b**	0,00 **b**	0,00 **b**	1629,00 **a**
DAZOMET (B2)	1103,00 **a**	78,00 a	2,33 **b**	38,00 **b**	0,00 **b**	1221,33 **a**
FLOAT I (C2)	193,00 **b**	2,00 a	0,00 **b**	2,00 **b**	0,00 **b**	197,00 **b**
FLOAT II (D2)	55,33 **b**	0,00 a	0,00 **b**	2,33 **b**	0,00 **b**	57.67 **b**

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

When comparing with the untreated plots, all alternatives proposed significantly reduced the populations of nematodes. There were not significant differences between dazomet and MB treated plots, nor neither in the total nematode population nor in any of the identified groups.

EFFECT OF THE TREATMENTS IN WEEDS

Weed presence in the different treatments was recorded during the two trials in the spring 1998 (Fig. 4.3) and 1999 (Figs. 4.4 & 4.5).

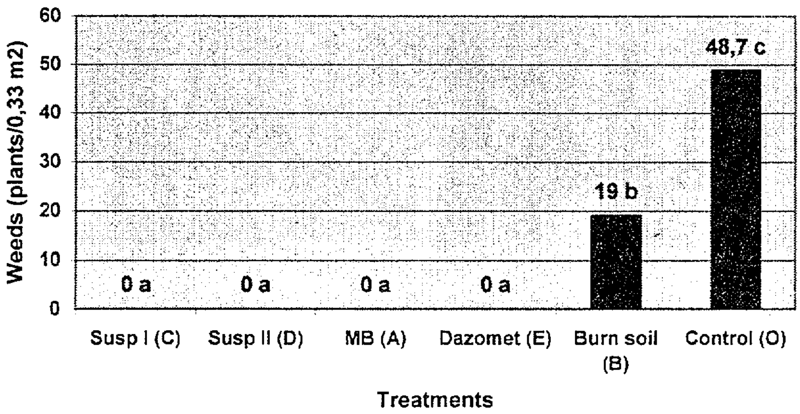


Fig.4.3.- Weed incidence in tobacco seedbeds. 1st season 1998

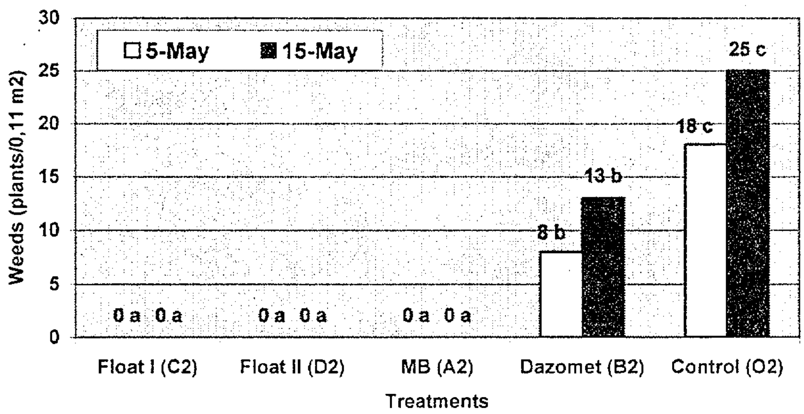


Fig.4.4.- Weed incidence in tobacco seedbeds. 2nd season 1999

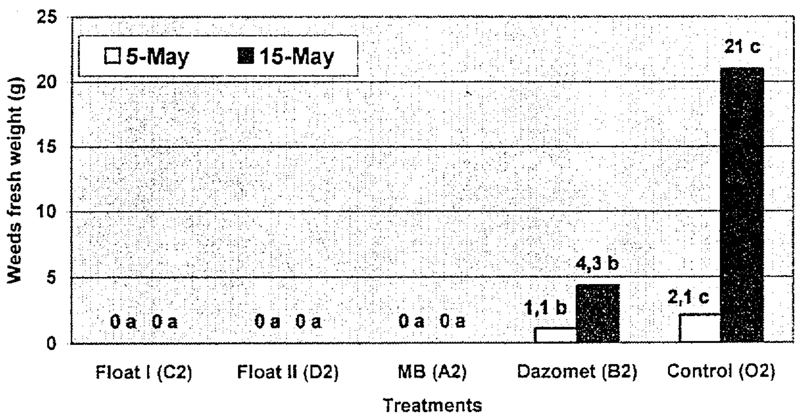


Fig.4.5.- Weed weight in tobacco seedbeds. 2nd season 1999

During the 1st season all treatments significantly reduced the number of weeds. Total weed control was achieved in tobacco seedbeds in soil with dazomet and MB, and when using substrates with the suspended trays treatments. Only partial control was achieved with the local technique of burn soil.

During the 2nd season all treatments significantly reduced the number of weeds. Total weed control was achieved in tobacco seedbeds when using substrates with the floating tray treatments. Only partial control was achieved with dazomet.

Although only partial control was achieved with dazomet during the 2nd season of tobacco seedbeds, the development of the weeds was much lower than in the control. The average fresh weight of weeds in the dazomet plots was 0.33 g/plant whereas that for the control plots was 0.84 g/plant as recorded on the 15th may 1999.

EFFECT OF THE TREATMENTS IN OTHER PATHOGENS AND PESTS

During the 2nd season, the incidence of anthracnose of tobacco (*Colletotrichum nicotianae*) and black cutworm (*Agrotis ypsilon*, Noctuidae: Lepidoptera) were recorded in spring. The results are shown in Fig. 4.6.

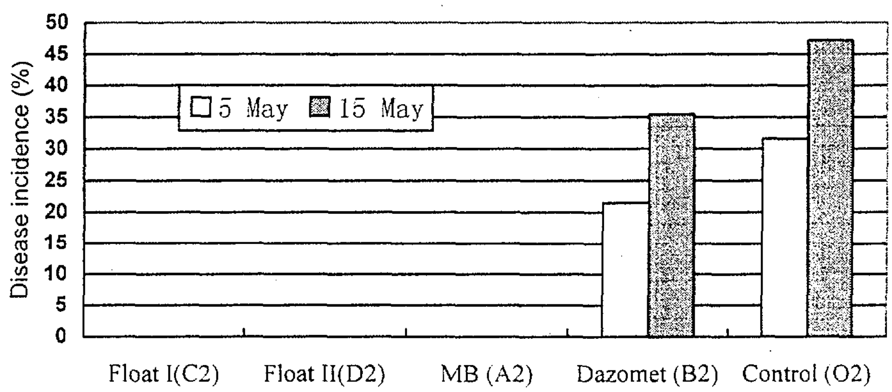


Fig.4.6.- Incidence of anthracnose in tobacco seedbeds. 2nd season 1999

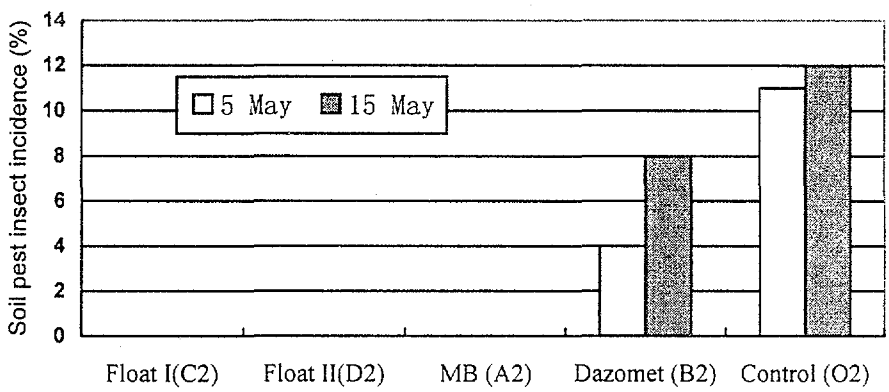


Fig.4.7.- Incidence of cut worm in tobacco seedbeds. 2nd season 1999

A total control of anthracnose and black cut worm was achieved in the floating tray treatments and in the MB. Only partial protection was achieved with dazomet.

EFFECT OF TREATMENTS ON TOBCCO SEEDLING QUALITY

EFFECT OF THE TREATMENTS IN THE 1ST SEASON (FEBRUARY 1998)

GERMINATION

Germination of tobacco seeds was recorded periodically since the 20th March. For treatments in soil, an area of 33.3 cm^2 (equivalent to *c.* 100 seeds) was examined. For the treatments in trays 108 cells were examined in one point per plot. The results are shown in Fig. 4.7 and Table 4.10.

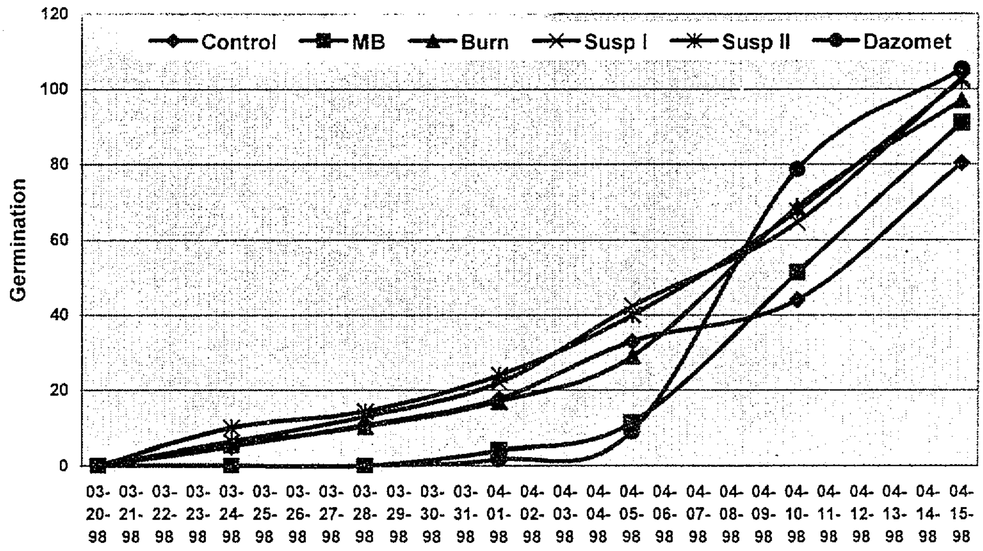


Fig.4.8.- Germination of tobacco seeds in Cuijaba (20 Mar-15 Apr 1998)

Table 4.10.- Germination of tobacco seeds in Cuijaba.

Treatments	Seeding date	20-Mar	24-Mar	28-Mar	1-Apr	5-Apr	10-Apr	15-Apr
Control	**1-Mar**	0.00	5.00	10.67	17.67	33.00 **b**	44.00 **b**	80.33 **b**
MB	**1-Mar**	0.00	0.00	0.00	4.00	11.33 **c**	51.33 **b**	91.00 **ab**
Burn	**1-Mar**	0.00	5.67	10.33	17.00	29.00 **b**	68.67 **ab**	97.00 **ab**
Susp I	**28-Feb**	0.00	6.33	13.00	22.00	42.33 **a**	64.67 **ab**	103.00 **a**
Susp II	**28-Feb**	0.00	10.00	14.33	24.00	40.00 **a**	67.67 **ab**	102.33 **a**
Dazomet	**16-Mar**	0.00	0.00	0.00	1.67	9.00 **c**	78.67 **a**	105.33 **a**

Treatments with the same letter were not significant different in a Duncan's multiple range with a confidence limit of 5%

A delay in germination was observed for the seeds from the MB treatment that did not start to germinate till the 1st April. Although seeded *c.* 15 days later than the other treatments, the best germination was observed for dazomet. Seed germination in the suspended trays and burn soil treatments was appropriate.

VIGOR

High and weight of plants were recorded on the 29th April. Best developed plants were chosen from each plot, the aerial part of 60 plants was measured and 100 plants were weighted. Best treatments were MB and Suspended trays I (Fig. 4.8).

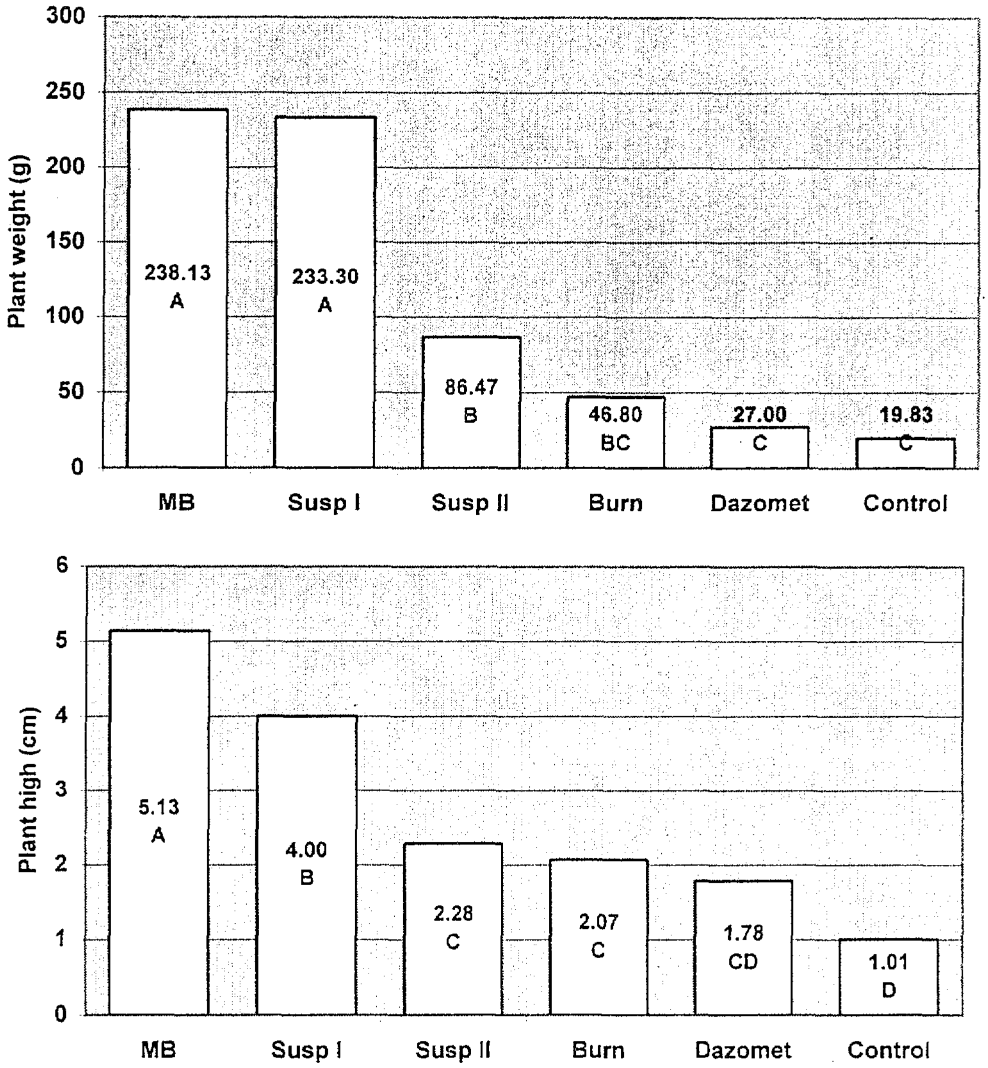


Fig.4.9.- Tobacco plant high and weight (29 April).

The results for Dazomet are underestimated, this treatment was seeded at a later time and no recordings were made after April 29th. There were significant differences between the Suspended trays treatments I and II, with the second producing smaller and less vigorous plants than the first one.

EFFECT OF THE TREATMENTS IN THE 2ND SEASON (FEBRUARY 1999)

GERMINATION

After re-seeding the trial on the 13th April 1999, the germination of tobacco seeds was recorded the 5th May (Fig. 4.9). The seeds in the local substrate start to germinate the 26th of April and in the local substrate three days later.

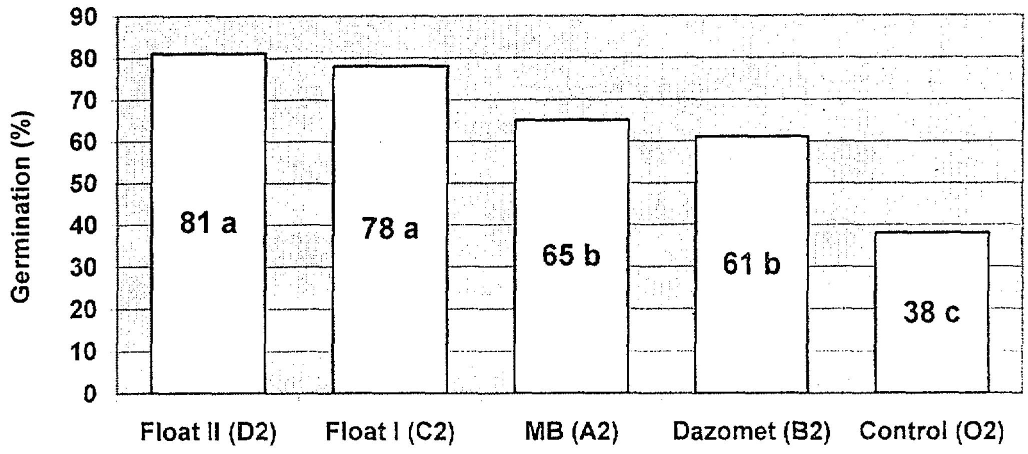


Fig.4.10.- Tobacco germination (5 May 1999).

The percentage of tobacco germination in floating trays was very good and higher than that in the MB treated plots (22,3 % increase). There were not significant differences in the rate of germination between MB and dazomet.

VIGOR

The number of true leaves, high and weight of tobacco plants were recorded on the 27th May 1999. The results are shown in Table 4.11 and Fig. 4.10. Also, a classification of the seedlings was made; class 1 and 2 seedlings were appropriate for planting whereas seedlings in class 3 were considered too small to transfer to the soil (Table 4.12 and Fig 4.11).

Table 4.11.- Vigor parameters detailed by qualities and weighted means obtained during the 2nd season.

	True leaves			Plant high (cm)			Fresh weight (g/100 plants)			WEIGHTED MEANS		
Treatment	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	Leaves (pairs)	High (cm)	Weight (g/100p)
Control (O2)	0,00c	4,75b	3,66b	0,00c	3,91a	1,92ab	0,0	39,33b	20,63a	3,74 d	2.07 b	15.58 c
MB (A2)	6,13 ab	4,97ab	4,22ab	6,14a	4,27a	2,07a	183,07a	64.93a	14,97a	4.95 b	4.06 a	68.95 a
Dazomet (B2)	0,00c	5,31a	3,59b	0,00c	3,05b	1,33bc	0,0c	67,10a	16,03a	4,28 c	2.04 b	37.12 b
Float I (C2)	6,33a	5,25a	4,66a	5,80 ab	3,82a	1,78abc	120,33b	45,63b	17,03a	5,60 a	4.36 a	70.37 a
Float II (D2)	5,95b	5,09ab	4,12ab	5,14b	3,6ab	1,25c	108,67b	42.33b	13,67a	4.91 b	3.39 a	42.00 b

Treatments with the same letter were not significant different in a Duncan's multiple range with a confidence limit of 5%

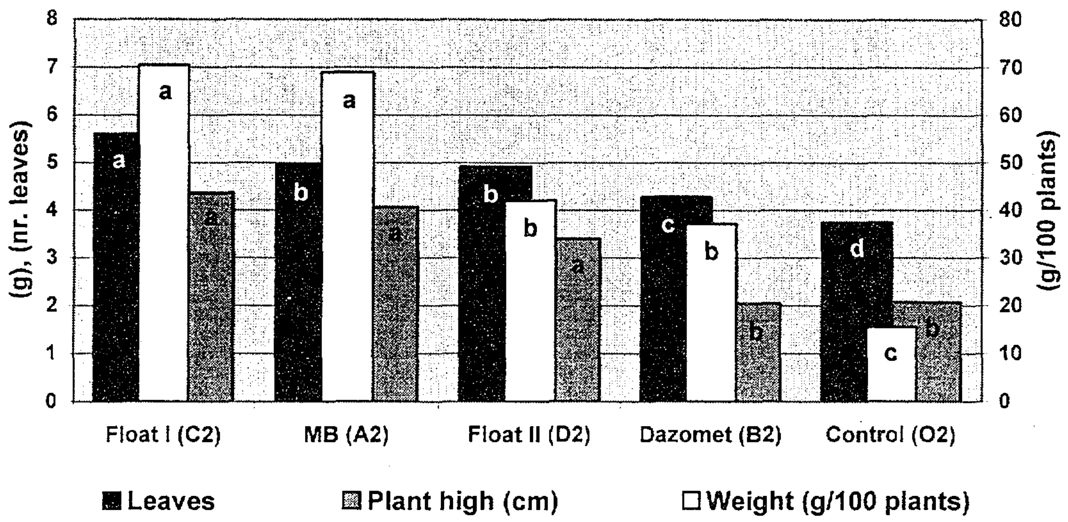


Fig.4.11.- Weighted means of vigor parameters from tobacco seedlings

All treatments produced more vigorous plants than in the untreated plots. The seedlings grown in floating trays with imported substrate had a significant higher number of leaves than these in the MB treated plots. The plant high and the number of leaves of the seedlings grown in floating trays with local substrate and in MB were similar, but the later had a significant higher weight. This may be due to nutrient deficiencies (mainly N and K) in the local substrate.

Table 4.12.- Classification of tobacco seedlings obtained during the 2nd season.

	Replicate I			Replicate II			Replicate III			MEAN		
Treatment	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**
Control (O2)	0,0	7,6	92,4	0,0	8,0	92,0	0.0	6,8	93,2	0,0 **d**	7,47 **d**	92.53 **a**
Methyl bromide (A2)	9,6	62,0	28,4	12,8	66,8	20,4	16,8	67,2	16,0	13,06 **b**	65,37 **ab**	21,6 **c**
Dazomet (B2)	0,0	36,0	64,0	0,0	50,0	50,0	0.0	38,0	62,0	0,0 **d**	41,33 **c**	58.67 **b**
Float I (C2)	38,4	51,2	10,4	34.0	58,0	8.0	36,0	56,9	7,1	36,13 **a**	55.37 **b**	8.50 **c**
Float II (D2)	4,4	53,2	42,4	12,0	78,0	10,0	4.6	82,4	13,0	7,0 **c**	71,20 **a**	21.8 **c**

Treatments with the same letter were not significant different in a Duncan's multiple range with a confidence limit of 5%

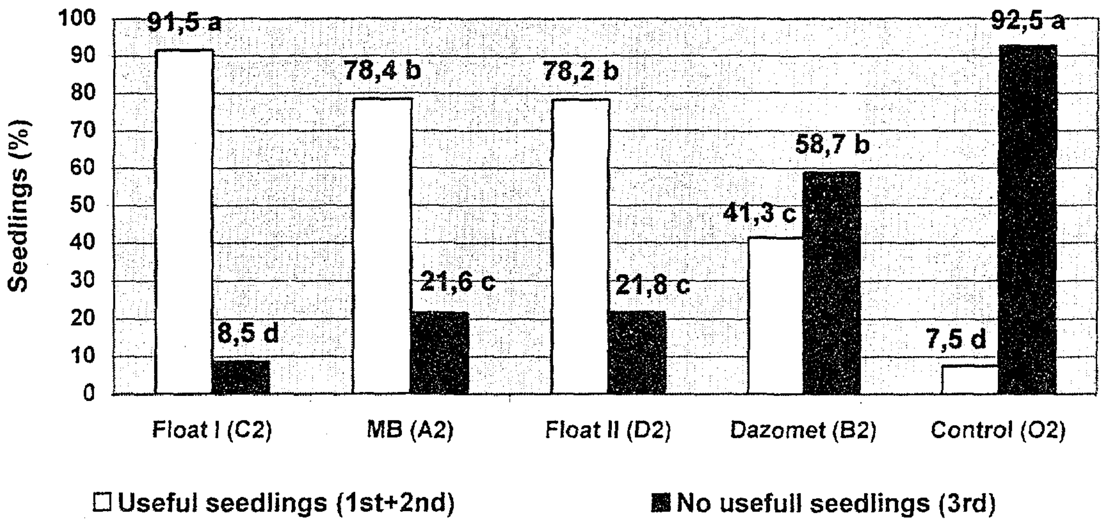


Fig.4.12.- Proportion of useful and no useful tobacco seedlings during the second season

When compared with the untreated plots, all treatments produced an increase in the quality of tobacco seedlings. The best quality tobacco plants were obtained with the floating trays using imported substrate (36,13 % 1^{st} quality) followed by MB (13,06 %) and floating trays using local substrate (7,0 %).

Floating tray technique using imported substrate, produced more plants suitable for transplant than MB, and no significant differences were found for this parameter between MB and floating trays using local substrate.

The results obtained with the floating trays were very good, the number of viable cells (% tray cell that will produce plants suitable for transplant) when using local substrate was 60,05 %, and this figure reached 74,12 % when imported substrate was used.

After the tobacco seedbeds experiment, the local technician and farmer Mr. Zhen Xinjie planted 100 seedlings from MB treatment and floating trays with imported substrate, respectively, to the fields. After the tobacco was harvest and dried by airing, the yield of tobacco was measured. The results were presented in Table and Fig.

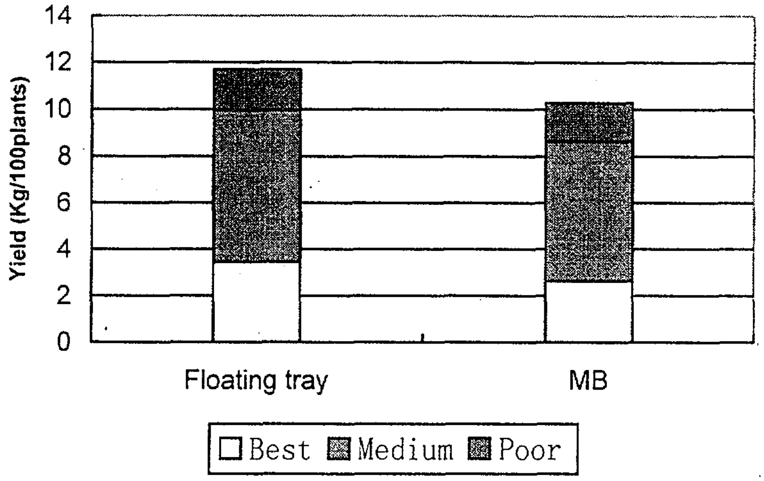


Fig.4.13.- Proportion of tobacco quality after harvest

Table 4.13. -Value of tobacco after harvesting.

RMB/100plants

	Best	Medium	Poor	Value RMB	Increased benefit
Floating seedlings	3.45	6.5	1.75	77.00	17.1%
MB seedlings	2.65	6	1.63	65.76	

***Local price: Excellent RMB10Yuan/Kg; Good 6Yuan/Kg; 2Yuan/Kg for poor ones**

Another farmer purchased seedlings from floating trays and planted 0.05 ha. He grew also 0.05 ha conventional seedlings. The yield from the former was 150Kg and it was 142.1Kg for the conventional ones.

The above result showed that floating tray could get better seedlings and better yield than conventional and MB treatments.

COSTS

ENVIRONMENTAL COST

Table 4.14.- Estimated environmental cost of the treatments in Enshi

Treatment	Minus	Plus	OVERAL
CONTROL	None	None	Very low
MB	Use of ODS + plastics	None	Very high
BURN SOIL	CO_2 production + conventional pesticides	Use of waste	Low
IMPORTED SUBSTRATE	Use of conventional pesticides and soluble fertilizers	None	Low
LOCAL SUBSTRATE	Use of conventional pesticides and soluble fertilizers	Use of waste	Low
DAZOMET	Use of bio-cide fumigant	None	Moderate

ECONOMIC COST

Because there is not a market price associated to tobacco seedlings, the economic analysis will be based upon the costs of the application for each technique.

It is know, and is costume in the area, that a conventional seedbed of 7,2 m^2 in soil will give enough tobacco plants (1100-1200) for transplanting to 1 Chinese mu (660 m^2) open-field tobacco (*c.* 110 m^2 will produce plants for 1 ha open-field tobacco).

Considering the number of viable cells per tray at 70%, one expandable polystyrene (EPS) tray (0,36m x 0,7m) with 260 cells will produce 182 tobacco seedlings. For one Chinese mu, 6,5 EPS trays (total area of 1,64m^2) are needed (*c.* 25 m^2 will produce plants for 1 ha open-field tobacco, *c.* 100 trays).

The operational costs of the methyl bromide application and that of the alternatives proposed are shown in Tables 4.14-4.16. When possible, the cost associate to each item is based on the international market price.

Table 4.15.- Summary of incremental costs

Alternative	Cost per year (US $ / ha open field tobacco)
Burn soil	-28,04
Dazomet	-13,07
Float using local substrate	+11,81
Float using imported substrate	+41,31

Table 4.16.- Methyl bromide application costs using 682g cans (for 1ha open-field tobacco; 110 m^2 seedbed)

ITEM	Amount/110m²	Unit	US$/Unit	Cost US$/110m²			
				Year 1	Year 2	Year 3	Year 4
Methyl bromide	10,45	kg	3,4	35,53	35,53	35,53	35,53
Polyethylene (70g/m²) for cover	7,7	kg	1,3	10,01	0,0	10,01	0,0
Labor for covering and applying MB	1	w/d	10,0	10,0	10,0	10,0	10,0
Labor for uncovering	1	w/d	10,0	10,0	10,0	10,0	10,0
			TOTAL COSTS	**65,54**	**55,53**	**65,54**	**55,53**

Table 4.17.- Incremental cost of the alternatives proposed for tobacco seedbeds in Enshi

BURN SOIL					COST US$/110m²			
	ITEM	**Amount/110m²**	**Unit**	**US$/Unit**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Savings	Methyl bromide	10,45	kg	3,4	35,53	35,53	35,53	35,53
	Polyethylene (70g/m²) for cover	7,7	kg	1,3	10,01	0,00	10,01	0,00
	Labor for covering and applying MB	1	w/d	10,0	10,00	10,00	10,00	10,00
	Labor for uncovering	1	w/d	10,0	10,00	10,00	10,00	10,00
TOTAL SAVINGS (A)					**65,54**	**55,53**	**65,54**	**55,53**
Extra costs	Soil transport and materials for burning*	4,5	m³	5,0	22,50	22,50	22,50	22,50
	Extra labor	1	w/d	10,0	10,00	10,00	10,00	10,00
TOTAL EXTRA COSTS (B)					**32,50**	**32,50**	**32,50**	**32,50**
INCREMENTAL OPERATING COSTS (B-A)					**-33,04**	**-23,03**	**-33,04**	**-23,03**

Table 4.17 (Cont.)

DAZOMET					COST US$/110m²			
	ITEM	Amount/110m²	Unit	US$/Unit	Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	10,45	kg	3,4	35,53	35,53	35,53	35,53
TOTAL SAVINGS (A)					**35,53**	**35,53**	**35,53**	**35,53**
Extra costs	Dazomet	1,65	kg	12,40	20,46	20,46	20,46	20,46
	Insecticide for Agrotis	2	appl.	1,00	2,00	2,00	2,00	2,00
TOTAL EXTRA COSTS (B)					**22,46**	**22,46**	**22,46**	**22,46**
INCREMENTAL OPERATING COSTS (B-A)					**-13,07**	**-13,07**	**-13,07**	**-13,07**

FLOATING TRAYS USING IMPORTED SUBSTRATE					COST US$/110 m²			
	ITEM	Amount/110 m²	Unit	US$/Unit	Year 1	Year 2	Year 3	Year 4
Savings	Methyl bromide	10,45	kg	3,40	35,53	35,53	35,53	35,53
	Polyethylene (70g/m²) for cover	7,7	kg	1,30	10,01	0,00	10,01	0,00
	Labor for covering and applying MB	1	w/d	10,00	10,00	10,00	10,00	10,00
	Labor for uncovering	1	w/d	10,00	10,00	10,00	10,00	10,00
TOTAL SAVINGS (A)					**65,54**	**55,53**	**65,54**	**55,53**
		Amount/25 m²			**COST US$/25 m²**			
Extra costs	EPS Trays	100	unit	0,95	95,00	0,00	0,00	0,00
	Substrate	0,5	m³	75,00	37,50	37,50	37,50	37,50
	Fertilizer	7,5	kg	0,12	0,90	0,90	0,90	0,90
	Bricks	560	unit	0,02	11,20	0,00	0,00	0,00
	Plastics	3,8	kg	1,30	4,94	0,00	4,94	0,00
	Fungicide treatment	3	appl.	0,10	0,30	0,30	0,30	0,30
	Hypochlorite solution 10% for washing trays	0,25	m³	2,00	0,00	0,50	0,50	0,50
	Extra labor for making the pools**	2	w/d	10,00	20,0	20,0	20,0	20,0
	Extra labor for filling and seeding	1	w/d	10,00	10,0	10,0	10,0	10,0
	Extra labor for washing materials	0,5	w/d	10,00	0,00	5,00	5,00	5,00
TOTAL EXTRA COSTS (B)					**179,84**	**74,20**	**79,14**	**74,20**
INCREMENTAL OPERATING COSTS (B-A)					**+114,3**	**+18,67**	**+13,60**	**+18,67**

Table 4.17 (Cont.)

FLOATING TRAYS USING LOCAL SUBSTRATE					**COST US$/110 m²**			
	ITEM	**Amount/110 m²**	**Unit**	**US$/Unit**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Savings	Methyl bromide	10,45	kg	3,4	35,53	35,53	35,53	35,53
	Polyethylene (70g/m²) for cover	7,7	kg	1,3	10,01	0,0	10,01	0,0
	Labor for covering and applying MB	1	w/d	10,0	10,0	10,0	10,0	10,0
	Labor for uncovering	1	w/d	10,0	10,0	10,0	10,0	10,0
TOTAL SAVINGS (A)					**65,54**	**55,53**	**65,54**	**55,53**
		Amount/25 m²			**COST US$/25 m²**			
Extra costs	EPS Trays	100	unit	0,95	95,00	0,00	0,00	0,00
	Vermiculite for the substrate	0,25	m^3	20,00	5,00	5,00	5,00	5,00
	Other materials	0,25	m^3	10,00	2,50	2,50	2,50	2,50
	Fertilizer	7,5	kg	0,12	0,90	0,90	0,90	0,90
	Bricks	560	unit	0,02	11,20	0,00	0,00	0,00
	Plastics	3,8	kg	1,30	4,94	0,00	4,94	0,00
	Fungicide treatment	3	appl.	0,10	0,30	0,30	0,30	0,30
	Hypochlorite solution 10% for washing trays	0,25	m^3	2,00	0,00	0,50	0,50	0,50
	Extra labor for making the pools**	2	w/d	10,00	20,0	20,0	20,0	20,0
	Extra labor for filling and seeding	1	w/d	10,00	10,0	10,0	10,0	10,0
	Extra labor for washing materials	0,5	w/d	10,00	0,00	5,00	5,00	5,00
TOTAL EXTRA COSTS (B)					**149,84**	**44,20**	**49,14**	**44,20**
INCREMENTAL OPERATING COSTS (B-A)					**+84,30**	**-11,33**	**-14,40**	**-11,33**

(*) The cost of this material is approximate and could be reduced to zero if local residues from the farm are used. (**) The cost could be reduced if the pools remain in place from one season to the other.

CONCLUSIONS

ADVANTAGES OF THE PROPOSED ALTERNATIVES

1. Floating trays is revealed as a very good alternative to MB that also provide several advantages to the fumigant. The germination rate, nr of leaves, plant high and fresh weight of the tobacco plants that were obtained with the floating tray technique were higher than with any other technique. The seedlings produced were healthy, more uniform and of higher quality than in the MB treated plots. The yield and income of floating tray seedlings was higher than that of MB seedlings after transplanted.

2. There were not weeds, diseases and soil insects in the floating tray.

3. It was not necessary to transplant twice like MB and tradition methods. The seedlings produced with the floating tray technique are easier to handle and can be transferred directly to the production fields and they do not need recovery period. So, floating tray can save a lot of labor and time.

4. Floating tray can keep moisture in seedbeds. It prevents from drought problems in arid regions.

5. With the floating tray technique a higher number of seedlings are obtained by area unit, 1030 to 700 plants/m^2 whereas a maximum of 160 plants/m^2 are obtained with MB. In 1998 *c.*1100 ha of tobacco seedbeds were treated with MB in China, if the floating tray technique were to be used, only 250 ha are necessary to get the same number of plants, and 850 ha of land could be used for other porpoises.

DISADVANTAGES OF THE PROPOSED ALTERNATIVES

1. Floating tray is a good alternative, but the best results were obtained with imported substrate, that is expensive for the local farmers. If the fertility of the local substrate is improved and the tobacco seedlings are cultured in greenhouse, then the farmers will accept this technique rapidly. In the Enshi area where the tobacco is cultivated between 800 and 1000 m above the sea level, the temperatures are low in February and March with frequent snow precipitation, in March. If greenhouses are available to protect the seedbeds and to ensure the seedlings, the extension of the floating tray technique will be very fast.

2. Dazomet dosage and application technique needs to be improved for effectiveness against soil-borne fungi, nematodes and weeds.

3. Local soil burn technique was not an effective alternative to MB.

FARMER´S ACCEPTANCE

Alternative	Acceptance by farmers
Burn soil	+
Dazomet	++
Float using local substrate	+++
Float using imported substrate	+++

(+): poor; (++): fair; (+++): good; (?): not in use.

TRIAL 5: JILIN
(GINSENG)

GENERAL INFORMATION AND RESPONSIBLE PERSONS

SUB-SECTOR: CHINESE MEDICINAL HERBS
SYSTEM: GINSENG, ONE-YEAR TRIAL
ODS USE IN SUB-SECTOR (1998): 130,0 t (78,0 t ODP)
SUB-SECTOR BASELINE (1995-1998): 54,0 t (32,4 t ODP)

Crop history:	14 April-30 April 1998:	Treatments
	14th April 1998:	Ginseng plantation
	June-July 1998	Data collection
	25th October 1998:	Ginseng replant
	June-July 1999	Data collection
Site Location:	Southern Branch Town, Jingyu County, Jilin.	
Contact at site:	Mr. Cui Hongming	
Tel:	+86-439-9005112	
Joined institution:	Jilin Agro-environmental Monitoring Station:	
Chief:	Mr. Li Jingzhu (Senior Agronomist)	
Tel:	+86-431-5958741	
Fax:	+86-431-2715474	
Technical backup:	IPP-CAAS	
Advisors	Mr. Cao Aocheng & Mr. Jian Guiliang	
Tel:	+86-10-62894863/62815940	
Fax:	+86-10-62894863	
E-mail:	nopt@public.east.cn.net	

THE SITE

Jilin Province is the main ginseng producer in China with 5000 ha cultivated representing 50% of the national production. Ginseng is cultivated in the Southern Mountain areas where a significant population of peasants is dedicated to its cultivation.

The site was located at Southern Branch town, Jinyu County, Jilin [illegible]ovince, which was 760m above sea level. The average annually precipitation 7[illegible]mm.The average annually temperature is 2℃. Average air temperatures in the area [illegible]e below 0℃ until late March when the frozen soil starts to melt. Average daily temperatures in the trial site during April 1998 are shown in Fig. 5.1

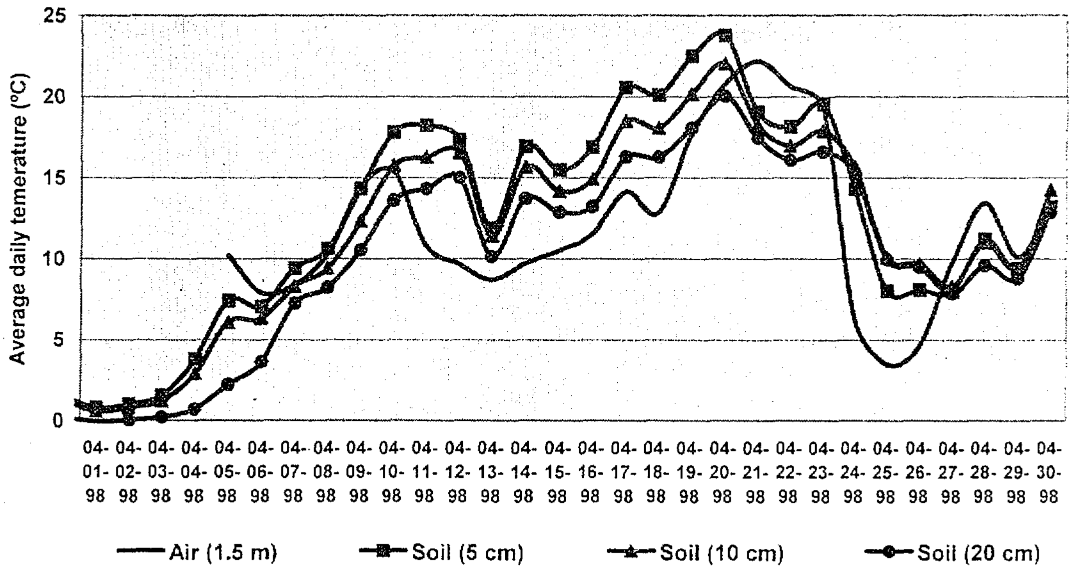


Fig. 5.1.- Average daily soil and air temperatures in site in April 1998

Ginseng is a very demanding crop that necessitates specific characteristics for cultivation. It is grown mainly in forests of oak and linden over 700 m.a.s.l. The type of soil is a brown acid podzol slightly (pH 6 to 5). Soil characteristics in the trial site are shown in Table 5.1.

Table 5.1. Soil characteristics in the experimental fields in Southern Branch Town

Variable		Texture (mm)	%
pH	5,60±0,22	1-0,25	1,27±0,12
Organic Matter (%)	8,38±0,59	0,25-0,05	51,86±4,68
EC (ms/cm)	0,36±0,09	0,05-0,01	5,60±0,22
Total N (%)	0,29±0,02	0,01-0,005	0,36±0,09
Total P (%)	0,084±0,01	0,005-0,001	40,62±4,52
Total K (%)	1,26±0,13	<0,001	0,29±0,02

Numbers indicate mean±standard deviation

Two main types of ginseng are used: Chinese (*Panax ginseng*) and American (*Panax quinquefolium*). American ginseng is more difficult to grow, it has less aerial part, is smaller but have the advantages of having a better shaped (cylinder) root and best prices in the market, but the most important is that do not necessitates transplantation from the seedbeds. American ginseng will complete its cycle from seed to mature plant in 4 years in the same soil, whereas Chinese ginseng necessitates transplantation when the plant is 2 years and will need 3 to four additional years to mature (5 to 6 years).

Ginseng seedbeds are made in spring (late April-early May) and seedlings are transplanted (Chinese ginseng) either in spring or autumn. Harvest can also take place either in spring or autumn. The forest is felled and the soil prepared for cultivation. Growing beds are made by collecting the soil from a 3.3 m plot in the central 1.5 m. From early May to late October (vegetative growing season) shadowing is needed and microtunnels are build with plastic, tree branches are then placed in the ceiling. In late October the shadowing is retired. To protect the crop during the severe winter (latent period) the cultural practices depends on the cultivar. For American ginseng a layer of soil (5 cm) is added, turf and leaves on top and finally a plastic mulch. For Chinese ginseng a layer of soil (15 cm) is added and a thick snow and ice layer is formed, sometimes by the natural rain and snowfall and sometimes is forced by watering. In late April to early May, the top layer of soil and or the mulch are taken off and the shadowing is rebuild.

Due to soil-borne disease incidence, only one crop can be obtained in the same land, once the land has produced one crop, the farmer is forced to move to a new plot to start the cycle by felling new forestland.

Thus, the problem of ginseng in the area could be classified as a replant problem. When ginseng is planted in a previous used land, the success of seedling or transplant is less than 60%. The second year, the plants will lost the secondary roots and by the third year 100% of the plants will be dead. The main agent limiting the second ginseng crop is the fungus *Cylindrocarpon* spp (up to three different species) which may remain viable in the soil for up to 32 years, making rotation without treatment virtually impossible.

At the present moment no MB is used in the region, but it could be considered as a relevant potential consumer for the future. Cultivation of ginseng is causing a serious environmental damage to the forestall resources of the area and recently the Chinese Government is restricting the fall of forest for this porpoise. In order to sustain the ginseng sector in the region, it is necessary to introduce technology that allow more than one cultivation in the same land which in turn will reduce the fall of forest. Because of this, local farmers are considering to reintroduce MB usage.

MB was used in the 80's to allow a second crop of ginseng in the same land, the practice was abandoned due to the high cost of the technique. In 1994 new trials were started to test alternatives to allow a second cultivation in the same land, but were abandoned due to shortage of funds. Preliminary results showed that only apron 10% of the plants were deceased the first year when planted in an used land in comparison with more than 60% in control plots. The main phytopathological problems of ginseng are shown in Table 5.2.

Table 5.2. Main phytopathological problems in ginseng

Ginseng rust rot (*Cylindrocarpon* spp)
Damping-off (*Rhizoctonia solani*; *Pythium debaryanum*)
Ginseng black spot (*Alternaria panax*)
Phytophthora of ginseng (*Phytophthora cactorum*)
Sclerotinia rot (*Sclerotinia* sp.)
Root knot nematodes (*Meloidogyne hapla*)

Fenaminosulf (fungicide), trichlorphon (insecticide) and fertilizer (N15%, P_2O_5 15%, K_2O 15%) 0.5Kg/plot were used as preplant treatment and fungicide treatments with Amobam, Polioxin, Zineb and $CuSO_4$ (early April, no leaves) and (June, with leaves) are applied during the crop.

THE TRIAL

Due to the special crop exigencies in relation to soil type, alternatives like soiless cultivation were considered of high risk. Rotation is not possible and the topography of the area where ginseng is grown do not allow to introduce machinery *i.e.* steam generation equipment. In addition, no locally available techniques that could be used to allow a second crop of ginseng in the same land were known.

Because MB had litter used in the area, the demonstration experiment did not include a MB treatment. The alternatives proposed were the fumigants dazomet, metam sodium and chloropicrin and available BCA's developed in Beijing for ginseng.

The experiment was conducted in growing beds of *c.* 1.5 x 17 m in a land that was harvested in 1997. Five growing beds were used, each spliced in three plots (1.5 x 5 m) with a separation of 1 m between plots. The experimental design was of three completely randomized blocks with 4 treatments, 1 untreated control and 1 replicate per block.

THE TREATMENTS

The treatments were applied the 14th April and ginseng plantation was the 30th April 1998. Because phytotoxicity of the treatments was observed, the land was replanted the 25th October 1998.

0 Control: the land was prepared in the usual way of the area and remains untreated.

A. Dazomet: Basamid® (BASF) at 30 g / m^2 was applied evenly in the soil surface and incorporated into the soil. Then the plots were watered and cover with a plastic sheet for 7 days.

B Chloropicrin: Chinese manufactured chloropicrin was applied at 120 ml/m^2. The soil was cover with a plastic sheet for 7 days.

C Metam sodium:. Chinese manufactured 35%metam sodium aqueous solutions was applied at 100ml/m^2. The soil was cover with a plastic sheet for 7 days.

D. Biological control agent (BCA): Chinese manufactured BCA based on *Trichoderma* spp. was applied at 26.7g/m^2.

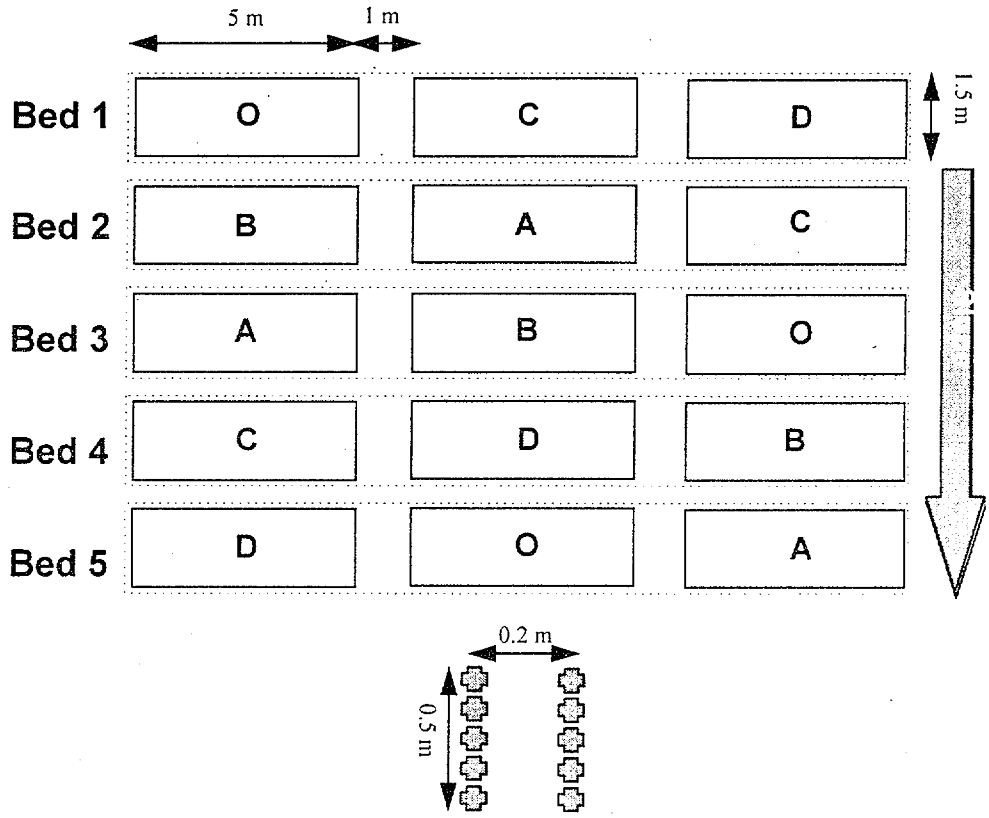


Fig. 5.2.- Trial layout for ginseng

EFFECT OF TREATMENTS ON PESTS, PATHOGENS AND WEEDS

EFFECT OF THE TREATMENTS IN SOIL FUNGI

Komada selective method was used. The method was done in a quantitative manner during three periods: before and after the treatments in 1998, and during the crop in 1999. Three to four dishes per sample were analyzed and the results are summarized in Table 5.3.

Table 5.3.- Evolution of soil fungi during the trial (c.f.u/g soil)

	Fo	**Fs**	**Fr**	**Cy**	**TOTAL**
TREATMENT			**Before treatments (April 1998)**		
All the field	466.90±370.90	178.00±138.74	0.00	155.56±76.96	800.47±520.23
			After treatments (May 1998)		
CONTROL (O)	400.00±469.04	720.00±268.30	120.00±109.54	320.00±228.04	1560.00±260.77
DAZOMET (A)	200.00±244.95	600.00±424.26	280.00±414.73	80.00±109.54	1160.00±1003.99
CHLOROPICRIN (B)	440.00±876.36	840.00±920.90	0.00	0.00	1280.00±1640.73
METAM NA (C)	440.00±219.09	400.00±244.95	120.00±178.89	40.00±89.44	1000.00±565.69
BCA (D)	680.00±769.42	0.00	0.00	120.00±268.33	800.00±678.23
			During the crop (June 1999)		
CONTROL (O)	66.67 **ab**	333.33 a	0.00 a	0.00 **c**	400.00 a
DAZOMET (A)	250.00 **a**	250.00 a	66.67 a	33.33 **bc**	600.00 a
CHLOROPICRIN (B)	0.00 **b**	2600.00 a	0.00 a	116.67 **ab**	2716.67 a
METAM NA (C)	283.33 **a**	250.00 a	16.67 a	0.00 **c**	550.00 a
BCA (D)	83.33 **ab**	483.33 a	66.67 a	150.00 **a**	783.33 a

Fo: *Fusarium oxisporum*; Fs: *Fusarium solani*; Fr: *Fusarium roseum*; Cy: *Cylindrocarpon* spp. Treatments with the same letter are not significant different according to a Duncan's Multiple Range Test, signification level is 5%.

The variation associated to this analysis is high and the results are not conclusive. After the treatments the only alternatives that showed a significant reduction of fungi in the soil were Chloropicrin for *F.oxisporum* and metam Na for *Cylindrocarpon* spp in the analysis done during summer 1999.

EFFECT OF THE TREATMENTS IN SOIL NEMATODES

Nematodes were extracted eliminating fine particles (silt and sand) from 200 cc rhyzospheric soil and nematodes separated by centrifugation. The nematodes recovered were stored in vials with formol for further study. Nematode population was studied during two periods: after the treatments in May 1998 and during the crop in June 1999, data is shown in Table 5.4.

Table 5.4.- Nematode populations at different stages during the trial

TREATMENT	Free living nematodes	*Aphelenchoides* spp	*Aphelenchus* spp	Tylenchids	Criconematids	TOTAL
After treatments (May 1998)						
CONTROL (O)	49.0	0,0	3,7	0.0	0.0	52.7
DAZOMET (A)	66,0	0,0	40,0	10.0	0.0	116.0
CHLOROPICRIN (B)	4,6	0,0	4,6	0,0	0,0	9.2
METAM NA (C)	4,7	0,0	4,7	0,0	0.0	9.4
BCA (D)	170,0	8,6	113,0	0.0	4.5	296.1
During the crop (June 1999)						
CONTROL (O)	267,67 a	0.00 a	24.00 a	28,00 a		319,67 a
DAZOMET (A)	1173,67 a	0.00 a	29.00 a	36,00 a		1238.67 a
CHLOROPICRIN (B)	1589,67 a	0,00 a	192.33 a	21.33 a		1803.33 a
METAM NA (C)	1527.33 a	3,67 a	403.00 a	64.67 a		1998.67 a
BCA (D)	---	---	---	---	---	---

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

As with the fungal analysis, the variation associated to the nematode analysis is high and the results are not conclusive. The observed increase in the population of free living nematodes and some other groups such are the fungivorous *Aphelenchus* spp and *Aphelenchoides* spp in the treated plots may be indicating an effect of the fumigant in the soil. By killing soil organisms, the availability of nutrients is high and bacteriophagous and fungivorous organisms may develop quicker than in the untreated plots.

EFFECT OF THE TREATMENTS IN WEEDS

Weed presence in the different treatments was recorded after the treatments in July 1998 (Fig 5.3).

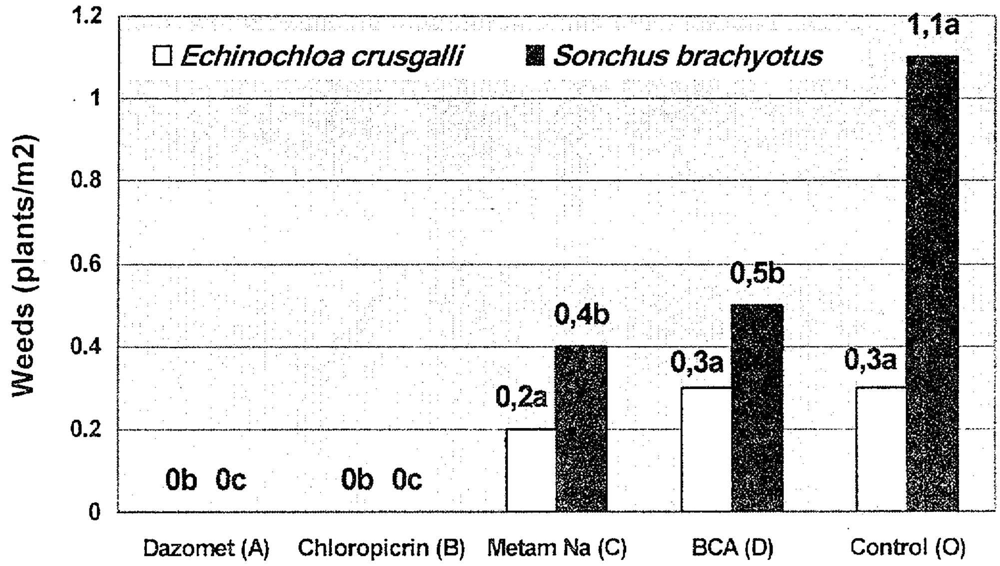


Fig.5.3. Weed incidence in ginseng. July 1998

The chemical treatments significantly reduced the number of weeds. Total weed control was achieved in ginseng with dazomet and chloropicrin. Only partial control was achieved with metam Na.

EFFECT OF TREATMENTS ON GINSENG

PLANT EMERGENCE AND SURVIVAL

The emergence of ginseng plants and survival was recorded in summer 1998 and 1999 in all the plots. Because the ginseng emergence and survival was poor in the treated plots, probably due to phytotoxicity, during the first year, in autumn 1998 new ginseng seedlings were planted in the treated plots. The results are shown in Fig. 5.4.

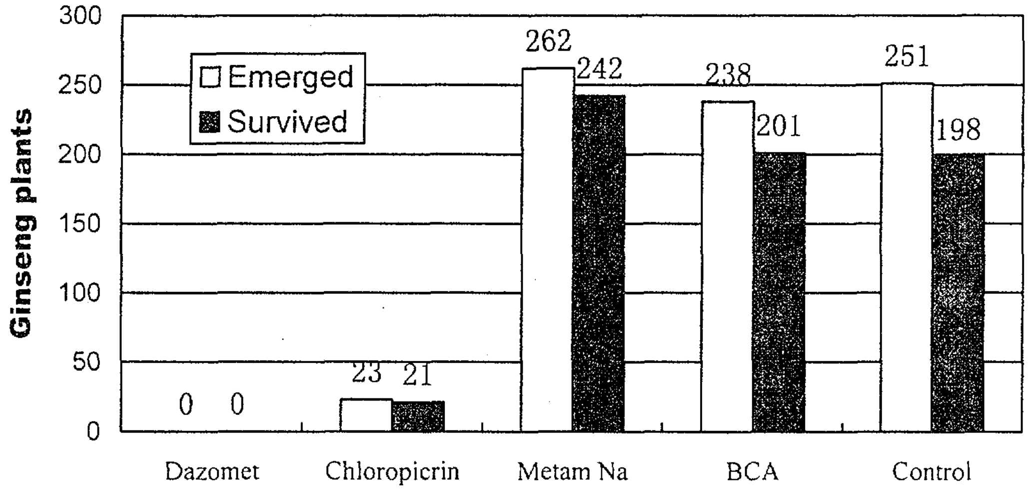


Fig.5.4.- Emerged and survived ginseng plants in summer 1998

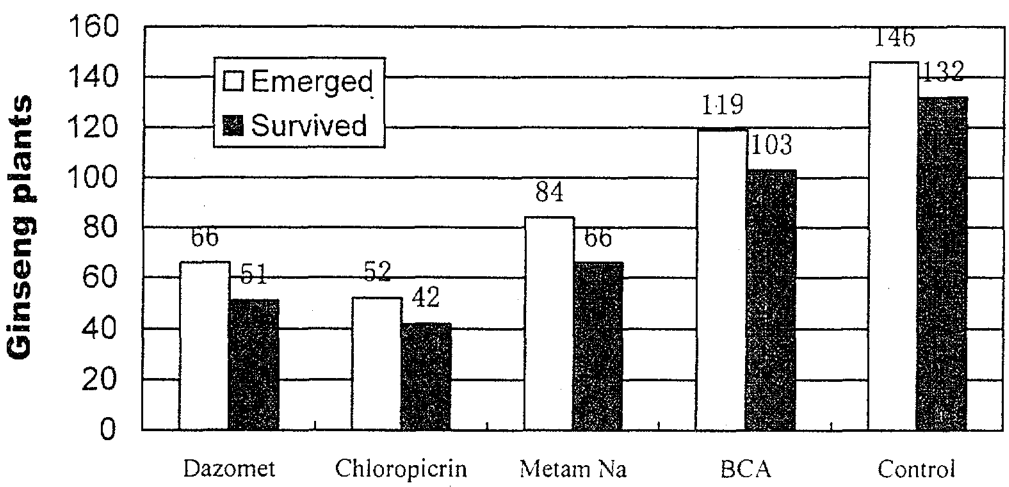


Fig.5.5.- Emerged and survived ginseng plants in 1999

With the exception of metam Na during the first year and the plant emergence observed during the second year, all chemical treatments reduced the emergence and survival of ginseng plants. A phytotoxic effect may be the cause for the results observed. There were no significant differences between the untreated plots and those treated with the biological control agent.

VIGOR

High of ginseng plants, diameter of stem and number of leaves per plant were recorded during summer 1999 (Figs. 5.5-5.7).

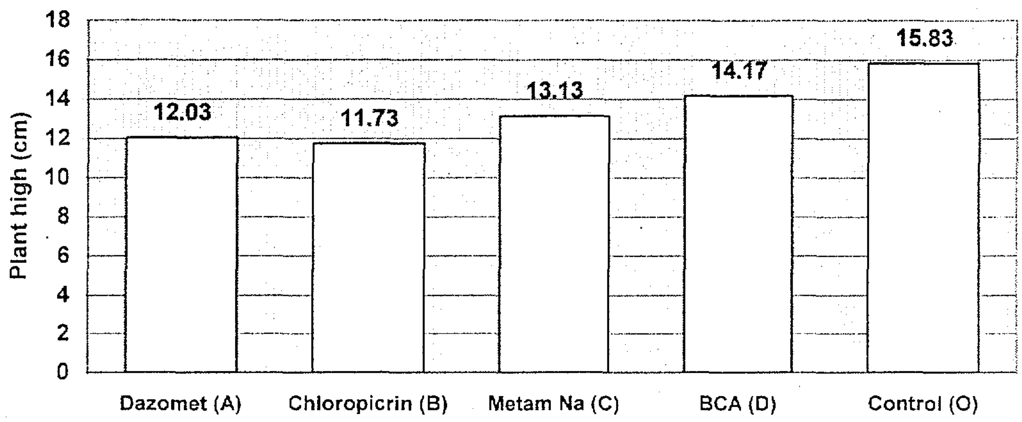


Fig. 5.6.- High of ginseng plants during summer 1999

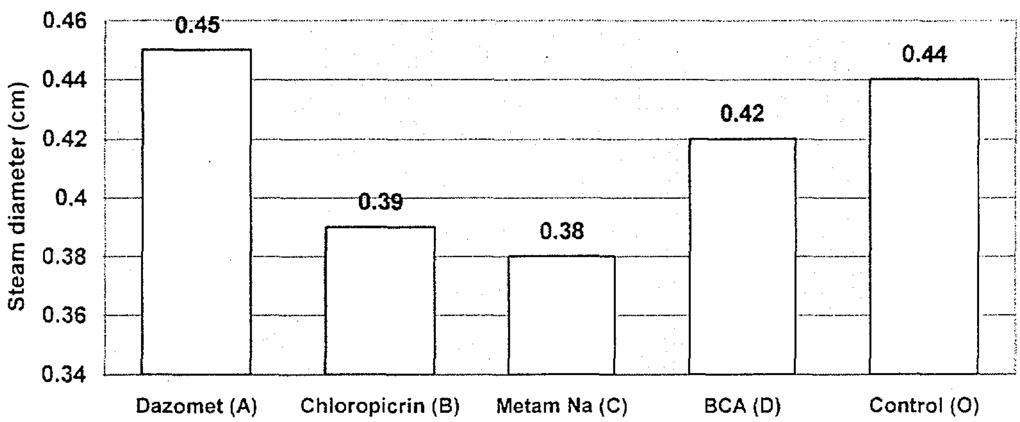


Fig. 5.7.- Steam diameter of ginseng plants during summer 1999

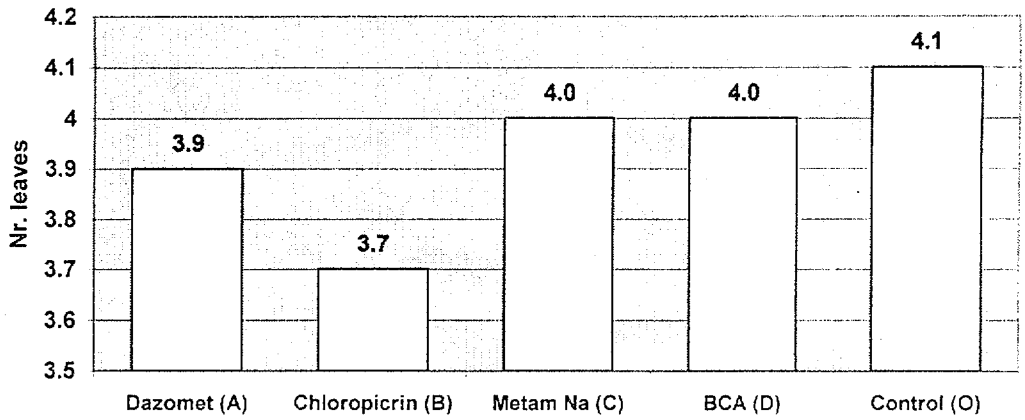


Fig. 5.8.- Nr of leaves of ginseng plants during summer in 1999

There were not significant differences between the treatments in any of the vigor parameters recorded, high of ginseng plants, diameter of stem and number of leaves per plant.

When we dug out ginseng from different treatments, we saw that roots of ginseng in all treatments were rot and ginseng did not grow in the past two years. We observed that new fibrous root of ginseng emerged in part of chloropicrin treatment plots, which showed that chloropicrin had some efficacy to ginseng diseases.

CONCLUSIONS

When growing a second ginseng crop in the same land. None of the alternatives tested were successful in obtaining a reasonable rate of germination or surviving plants. It is possible that the chemical alternatives tested were phytotoxic for ginseng. The biological control agent tested did not give better results than the untreated plots.

During experiment, we found that chloropicrin had some efficacy to control ginseng diseases. If the dosage and application technique of chloropicrin, dazomet and metam sodium were be done more research, those chemicals would be still good alternatives.

The special characteristics of the crop and the area may necessitate more scientific and technical effort for a better understanding of the problem.