PART II

Technical Manual

For

Intercropping

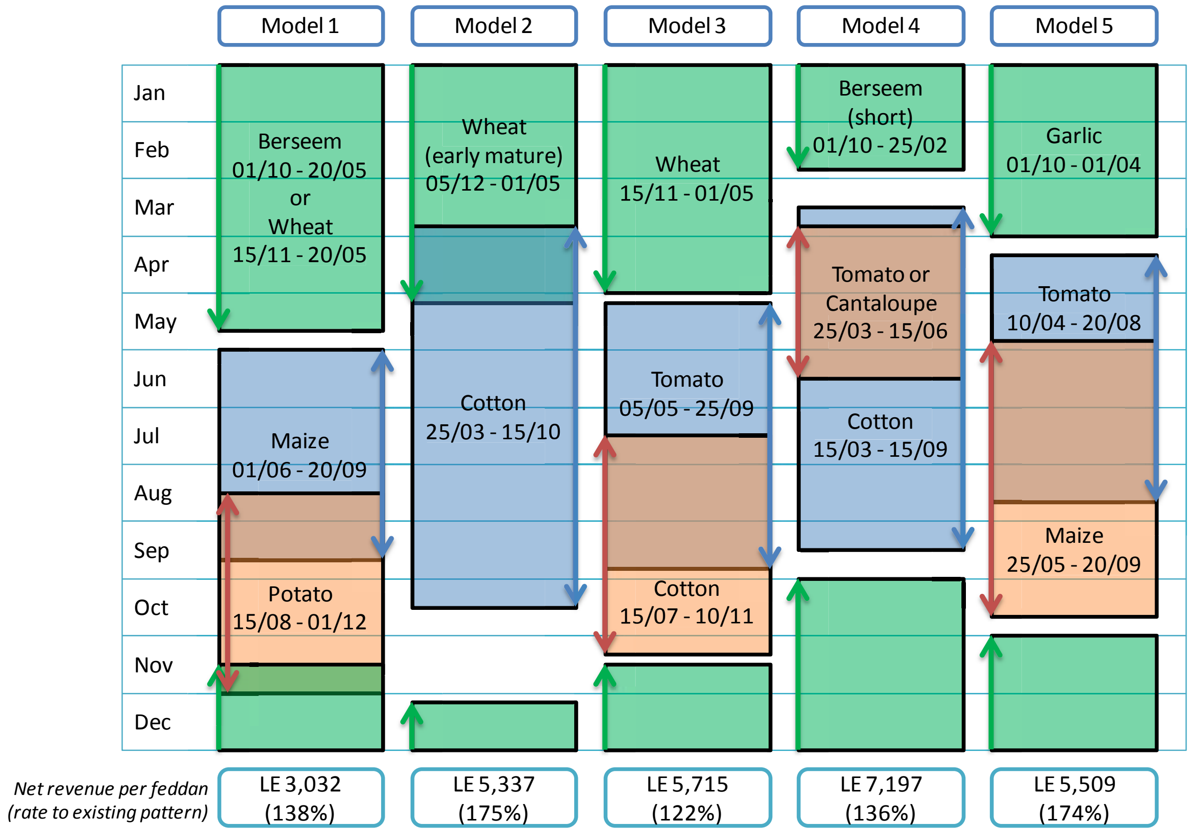
Intercropping

1. Concept

The intercropping systems of cash crops with traditional crops could be a possible solution to increase cash income of small-scale and non-commercialized farmers. Most of the small-scale farmers in the area use a crop rotation system with wheat, berseem, maize and sorghum, mainly for home consumption. Such farmers have only a small income from the surplus of those traditional crops. High cost and high risk of cash crop production makes them hesitative.

In the IMAP, the intercropping method was taken as a possible way to commercialize small-scale farmers. The principal advantage of the intercropping systems is higher land productivity caused by highly intensive land use. A secondary advantage is the shifting of the harvest time in some cases.

Various types of the intercropping systems were verified from technical, economical and social aspects in the Agricultural Production Intensification Project (APIP) from 1995 to 2005. In the course of many trials made in Fayoum, Beni Suef and Minia, following one-year patterns of intercropping was more acceptable than two-year patterns. The net income from the intercropping patterns was 122% to 175% higher than that from the existing cropping patterns.



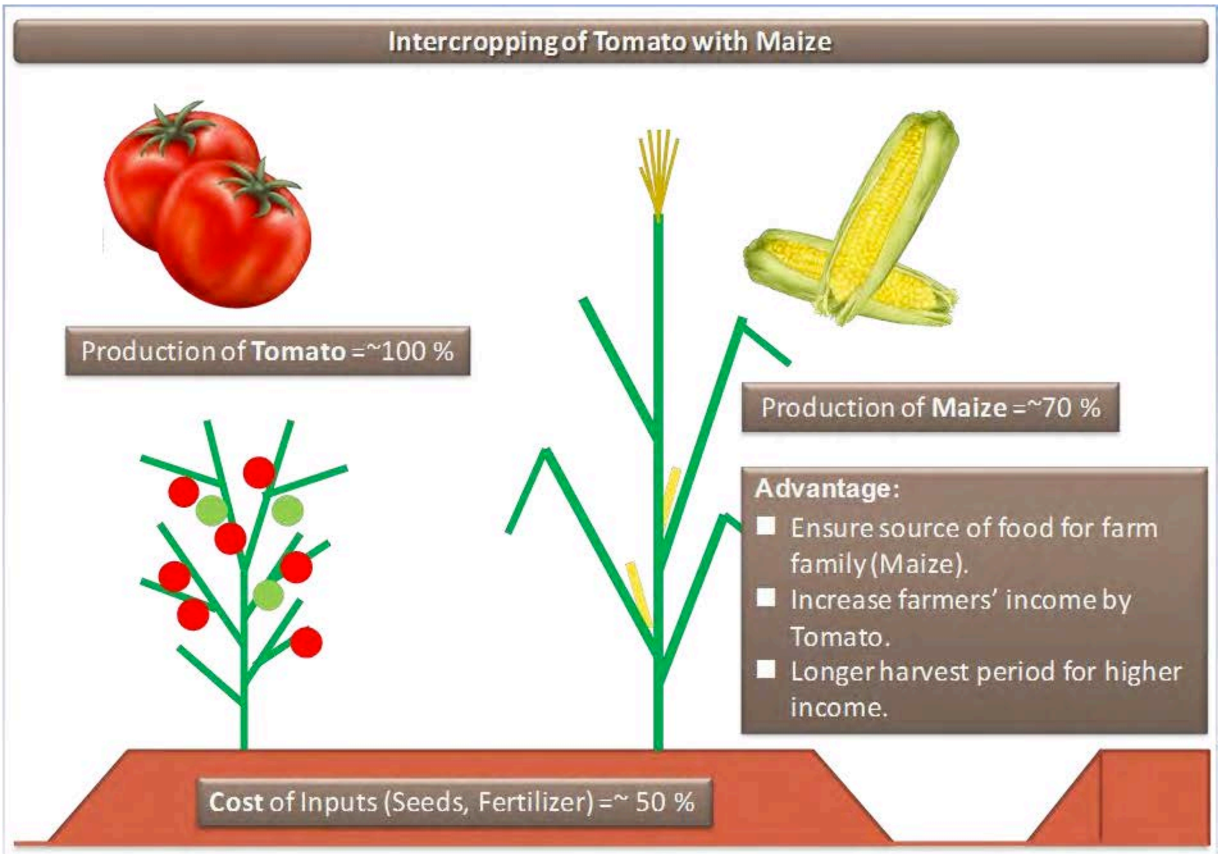
Intercropping Systems in One Year Cycle Verified in APIP

Advantage and Disadvantage of Intercropping System

Advantage	Disadvantage
• Intensive use of farmland • Lower production cost compared with separate cropping system • Higher profit in a certain period • Shifting of harvest season	• Technical know-how and skills required • General risk on cash crops in production and marketing

2. Procedure

In the pilot project of the IMAP, the intercropping of tomato with maize was employed as a typical pattern. It was a modified pattern of Model 5 developed by the APIP (refer to figure above).



Idea of Intercropping of Tomato with Maize

The actual cropping calendar in Minia and Assiut is shown in the following table.

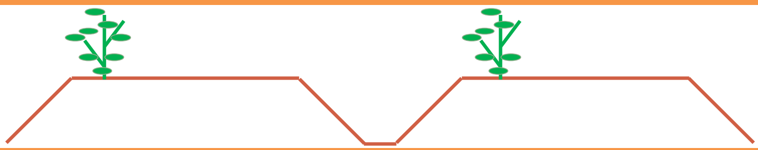
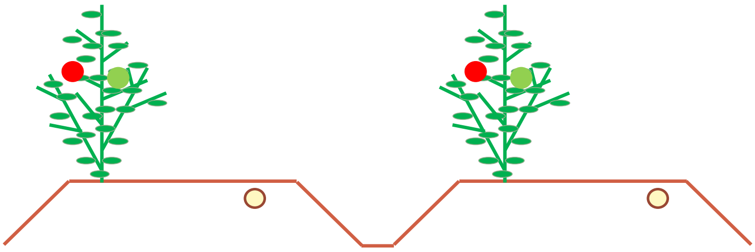
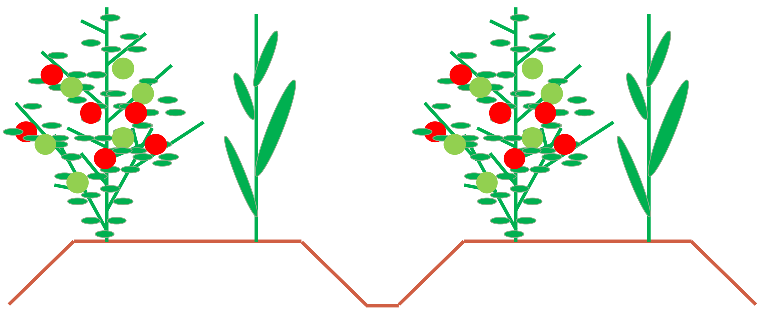
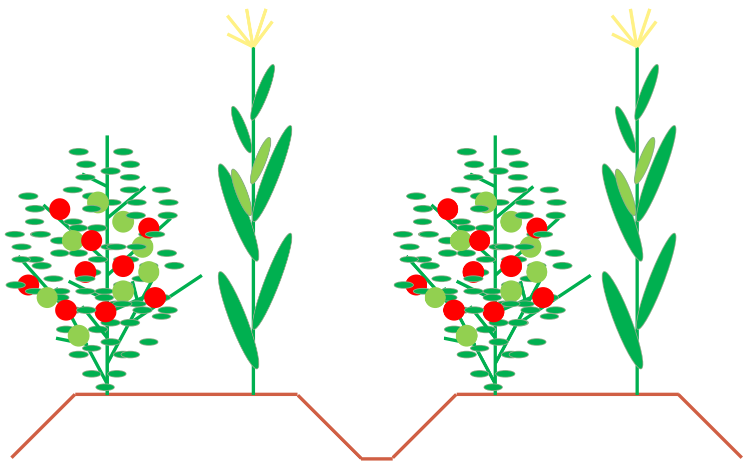
Cropping Calendar for Intercropping of Tomato with Maize

Time	Major Work (Tomato)	Major Work (Maize)	Description
Early April	Seedling preparation		• Sowing tomato seeds in seedling tray • Hybrid varieties tolerant to hot weather are preferable • About 35 days for nursery preparation
Early May	Land preparation		• Ploughing, Ridge making, Application of compost and chemical fertilizers, etc.
Mid. May	Transplanting		• Transplanting of tomato seedling • Irrigation, Fertilizer application, Weeding, etc.
Late June		Sowing	• Sowing hybrid maize seeds after 30 - 40 days from tomato transplanting
Late July	Harvesting		• Start of tomato harvesting • Harvesting shall continue
Late Oct.		Harvesting	• Harvest maize after about 120 days from sowing



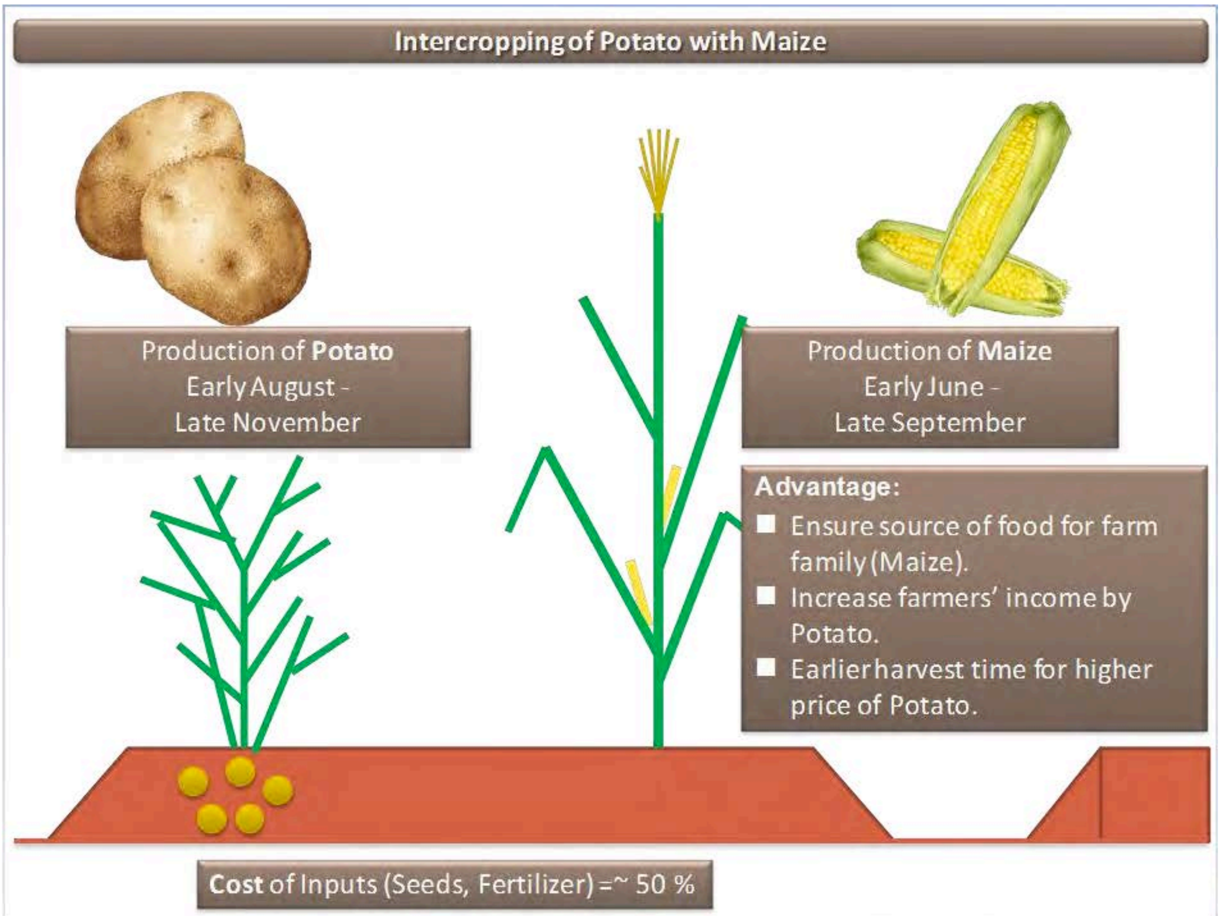



The growth pattern of the two crops is illustrated below.

Timing	Growth Pattern
1) Transplanting of tomato seedlings on one side * Mid-May	
2) Sowing of maize seeds on other side * Late June	
3) Production of tomato * Two months after tomato transplantation	
4) Production of tomato and maize * Four months after maize sowing * Production of tomato can continue until winter season	

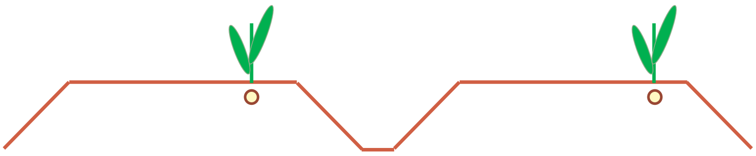
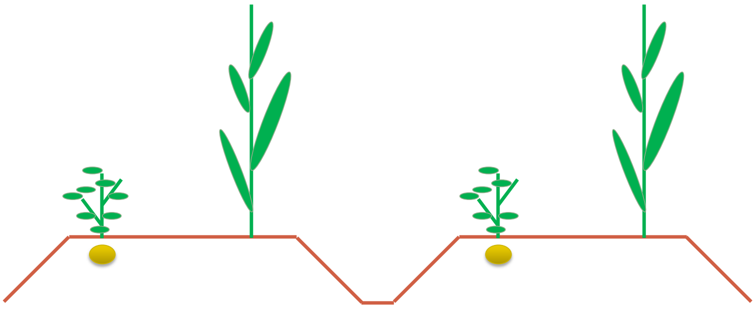
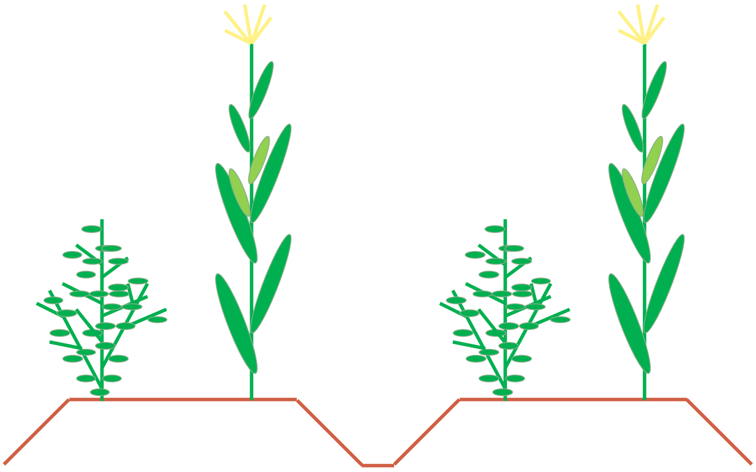
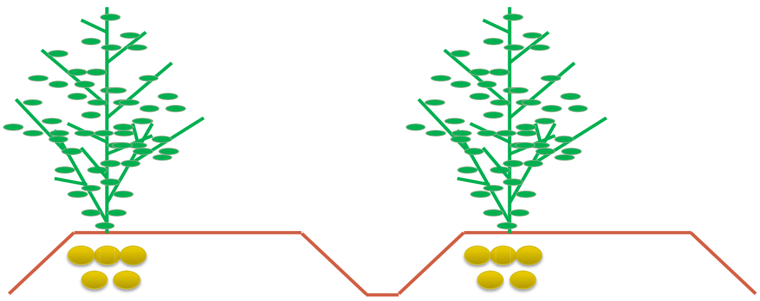
Growth Pattern of Tomato and Maize using Intercropping System

Another possible pattern is the combination of potato and maize, although the trial of this pattern was not realized in the pilot project of the IMAP. It was a modified pattern of Model 1 developed by the APIP (refer to figure above).



Idea of Intercropping of Potato with Maize

The anticipated growth pattern of potato and maize is illustrated below.

Timing	Growth Pattern
1) Sowing of maize seeds on one side * Early June	
2) Sowing of potato on other side * Mid August	
3) Production of maize * Late September	
4) Production of Potato * Late December	

Growth Pattern of Potato and Maize under Intercropping System

3. Techniques and Considerations

The pilot project of the IMAP provided several technical findings, as described below.

- **Variety**: Hybrid varieties of tomato resistant to high temperature, such as Super Jackal, Typhoon, Agyat 16, shall be used for the summer season, even though the price of seeds or seedlings is much higher than local ones. As the hybrid tomatoes grow vigorously, wider space is necessary.
- **Direction**: The ridge shall be prepared in a direction of North to South considering the direction of sunlight and wind. Maize shall be planted only in rows to ensure good ventilation.
- **Ventilation**: The natural ventilation on the farmland is necessary to lessen humidity in order to prevent outbreak of plant diseases. The vegetation surrounding the farmland could affect the humidity.
- **Pest**: Tuta Absoluta (Tomato Leaf Miner) is a newly invading pest for vegetables in Egypt. In the case of chemical insecticides, various kinds shall be safely used for complete control. Bio-control against Tuta Absoluta is also a possible way as verified in Assiut.
- **Harvest**: Tomatoes can produce fruits continuously (more than one year) with proper management. As longer harvest may give higher income, control of plant growth and plant protection are important techniques for tomato production.

4. Way Forward

The intercropping system of tomato with maize is one of the possible combinations of cash crop and traditional crop. Tomato cultivation in summer season was difficult for some farmers in the pilot project, especially with the planting method and plant protection method. Any other possible combination of the crops shall be verified under the agricultural extension system using the demonstration farms.

Besides the intercropping, tiny vegetable gardens could be a chance to start commercial farming for small-scale farmers. So this kind of trial and support shall be considered by the local government.

PART III

Technical Manual

For

Bio-fertilizers and Bio-control

First Edition

Japan International Cooperation Agency
Egypt Office

2012

Technical Manual for Bio-Fertilizer and Bio-Control in Upper Egypt

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This manual is published under 'The Project for Master Plan Study for Rural Development through Improving Marketing of Agricultural Produce for Small Scale Farmers in Upper Egypt (IMAP)' headed by Mr. Akihiko Hata and implemented by JICA technical cooperation program in 2010-2012.

Table of Contents

Vision of Bio-Fertilizer and Bio-Control

Provide safe and delicious foods for our children.

Improve environment eliminating chemical residues.

Gain more profits from agricultural production.

1.Introduction

1-1. What is the 'Minia University Bio-Fertilizer Center'?

The Minia University established its Bio-Fertilizer Center chaired by the Vice Principal of the University in November 2004. The board members consist of the Vice Principal of the University, the Head of the Central Laboratory of Organic Agriculture, and five professors expertized in microbial genetics, horticulture and farming. Prof. Dr. Omar F. Dakhlyis, a plant genetics expert, is one of the chief members operating the Bio-Fertilizer Center to produce bio-fertilizer using microorganisms. He has isolated effective microorganisms from soils all over Egypt and in Minia Governorate including all districts and tested them in laboratory and fields since 1982. In 1995, he introduced the first effective strain of Azotobacter to the Ministry of Agriculture and Land Reclamation, and finally identified three kinds of microorganisms which are very effective on the rhizospherical development of plant roots, absorption of minerals in soils, plant growth, improvement of fruits in size/taste/shelf life period, and enhancement of plant immunity against pathogens/pests. The tests were conducted using physical, chemical and biological analysis. The Bio-Fertilize Center has released Nitrogena, Phosphorena, Potassina, EM, Torchoderma, etc. The Bio-Fertilizer Center is open to any farmers and officers enough microbiological information to meet farmers' desires under the local conditions.

1-2. What is the 'Central Laboratory of Organic Agriculture (CLOA)'?

CLOA was established by the Mini-trial Decree No. 1952 in 2002 in order to focus on expanding the concept of organic agriculture to meet local and foreign demands. CLOA is located in the Agricultural Research Center, No. 9, Cairo University Street, Giza, Egypt. The objectives of its activities are:

- i) Dissemination of organic agricultural technology according to the international standard methods for various crops; Global GAP and United States Organic Farming Practice.
- ii) Promotion of the concept of organic agriculture and enhancement of qualified human resources.
- iii) Provision of the services on registration, inspection and certification for organic agriculture.
- iv) Research on actual problems such as huge use of chemical fertilizer and pesticide.
- v) Arrangement of training courses to public and private sectors in different disciplines of organic farm management, and
- vi) Publication of extensive materials for organic agriculture.

CLOA manufactures and releases input for organic agriculture such as microorganisms, plant growth hormone, micro-elements and organic acid compounds. One of the significant activities is preparation of systematic programs and recommendation in packaged microbial controlon plant nutrition and pests. The function of CLOA is very important to direct Egyptian sustainable agriculture, and CLOA has released the major products for organic agriculture shown in the following table:

Available Farm Inputs Produced by CLOA

Product Name	Contents	Function
Rhizobacteria	Nitrogen fixed microorganisms	Activation of plant root and support intake of minerals in soils
Kalsfeen	Calcium solution	Supply of Calcium to plants to resist pests
Blight Stop	Torchoderma	Resistance to fungi diseases
Clean Root Liquid	Bacillus subtilis	Resistance to pathogens in root for nursery
Namastop	Bacillus thuringensis	Resistance to nematodes in soils and larva
Anti-insect	Plant extract	Reduction of aphis, white fly, leaf miner, mites and thrips
Phytoseiulusmacropilis	Phytoseiulusmacropilis	Natural enemy insect against red spider mite
Kherat Compound	Anti-oxidant organic acid	Strengthening of plant immunity system
Humic No.1	Organic acid	Maintenance of soil pH and reduction of fertilizer

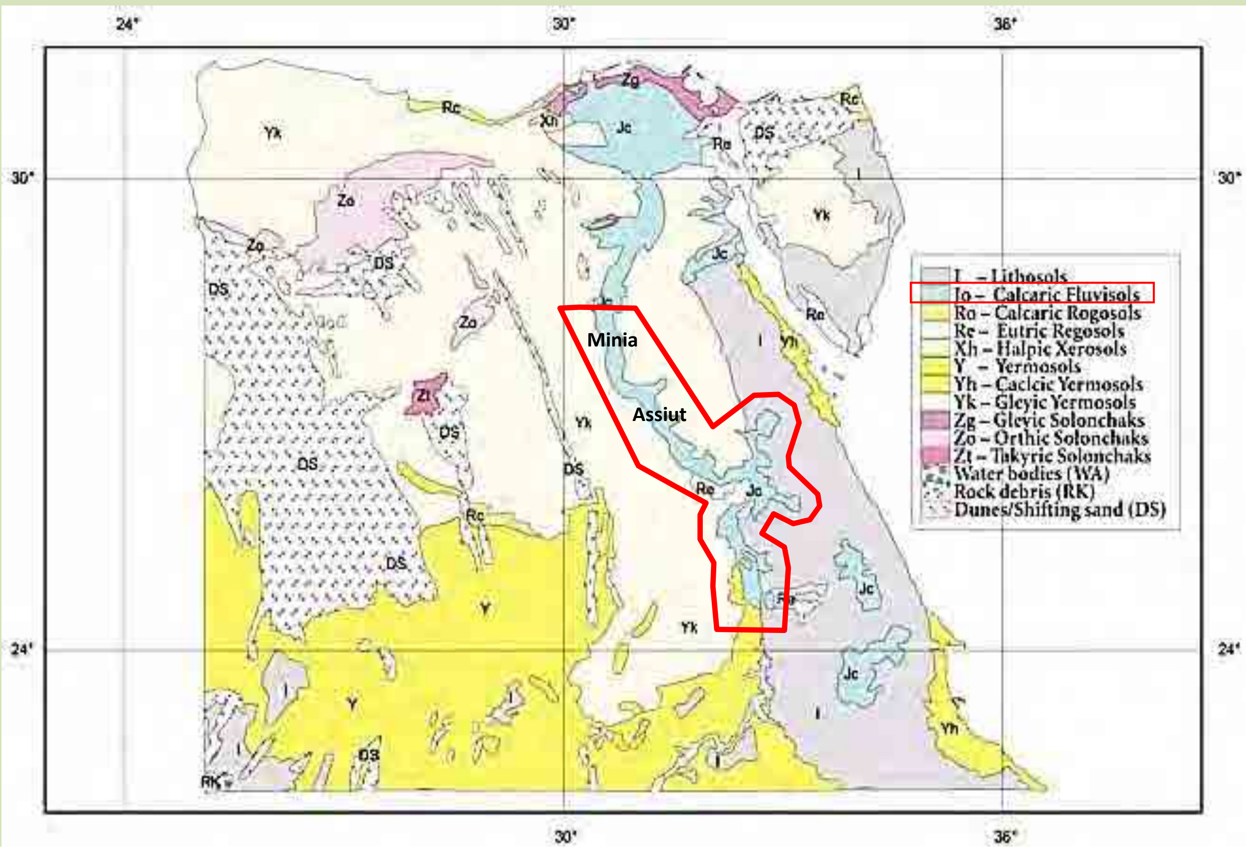
CLOA appoints the senior researcher, Dr. Emad El-din Foaud Said Refai, to the Assiut Station of the Agricultural Research Center. He is the responsible and capable person to conduct bio-control technologies.

1-3. What is 'EM'?

The concept of effective microorganisms (EM) was developed by Prof. Dr. Teruo Higa, University of the Ryukyu, Okinawa, Japan. Initially EM was developed for agriculture. After a process of trial and error in research work, the successful combination was developed in 1982 for practical application. EM consists of mixed cultures of beneficial and naturally-occurring microorganisms that can be applied as inoculants to increase the microbial diversity of the ecosystem. Research has shown that the inoculation of EM cultures to the ecosystem can improve water and soil quality, microbial balance, the growth, yield and quality of crops, animal health, and life balance and variety. EM contains selected species of microorganisms including predominant populations of lactic acid bacteria, yeasts, smaller numbers of photosynthetic bacteria, and other types of microorganisms. All of these are mutually compatible with one another and can coexist in liquid culture.

EM is not a substitute for other management practices. It is, however, an added dimension for optimizing the best environmental management practices such as liquid and solid waste treatment (composting). When Effective Microorganisms increase as a community in the ecosystem, populations of native effective microorganisms are also enhanced. Thus, the micro flora becomes rich and microbial ecosystems in the environment become well balanced, where specific microorganisms (especially harmful microorganisms) do not increase. EM Research Organization Ltd. Co. (EMRO) is a management company to protect the intellectual property of EM and research in the world. In Egypt, some agents such as the Minia University Bio-Fertilizer Center and Islamic Co. (Sohag) are producing under the license of the Ministry of Environment.

2. Soils in Upper Egypt



Source: Fertilizer Use in Egypt, FAO

Most of the soils in cultivated land in Egypt are clayey to loamy in texture. About 420 thousand ha are sandy and calcareous. The average results of physical and chemical analyses of soils, sampled at various locations to represent the various types of soils, are shown in the table. The results indicate a wide range of physical and chemical characteristics. The organic matter content is low, and so accordingly is the concentration of total nitrogen.

With regards to the alluvial soils (clayey and loamy clay), available phosphorous determined by Olsen's method is generally moderate. The results indicate that available (soluble and exchangeable) potassium extracted with a neutral solution of ammonium acetate is high, and this is characteristic of most Egyptian alluvial soils. Micronutrients are above the critical limits, as determined by the DTPA method. Levels of available phosphorus, potassium and micronutrients are fairly low on calcareous and sandy soils.

Physical and Chemical Analysis of Various Soil Types by Region

Item	North Delta	South Delta	East Delta	West Delta	Middle & Upper Egypt
Soil texture	Clayey	Clayey	Sandy	Calcareous	Loamy clay
pH	7.9-8.5	7.8-8.2	7.6-7.9	7.7-8.1	7.7-8.5
Percent total soluble salts	0.2-0.5	0.2-0.4	0.1-0.6	0.2-0.6	0.1-0.5
Percent calcium carbonate	2.6-4.4	2.0-3.1	1.0-5.1	11.0-30.0	2.6-5.3
Percent organic matter	1.9-2.6	1.8-2.8	0.35-0.8	0.7-1.5	1.5-2.7
Total soluble N (ppm)	25-50	30-60	10-20	10-30	15-40
ppm available P (Olsen)	5.4 -10	3.5-15.0	2-5.0	1.5-10.5	2.5-16
ppm available K (amm. acetate)	250-500	300-550	105-350	100-300	280-700
Available Zn (DTPA) (ppm)	0.5-4.0	0.6-6.0	0.6-1.2	0.5-1.2	0.5-3.9
Available Fe (DTPA) (ppm)	20.8-63.4	19.0-27.4	6.7-16.4	12-18	12.4-40.8
Available Mn (DTPA) (ppm)	13.1-45	11.2-37.2	3-16.7	10-20	8.2-51.6

Source: Fertilizer Use in Egypt, FAO

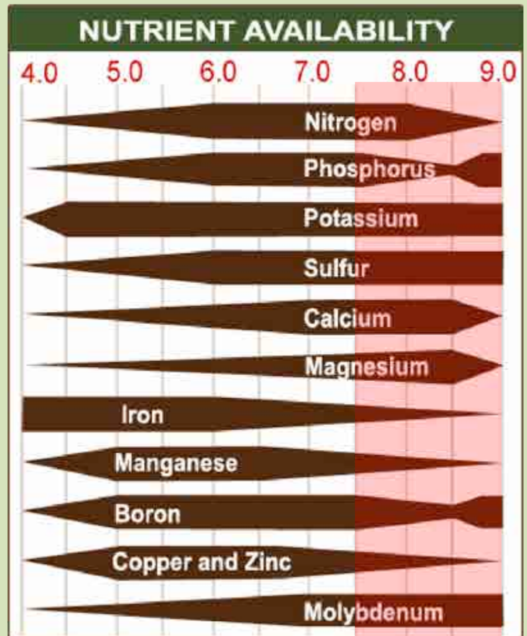
The JICA study team surveyed the soil character in the Minia Governorate with the cooperation of the Soil Laboratories of Minia University and the Minia Agricultural Directorate. The soil experts comment that the pH of soils in Upper Egypt is lying in between 7.5 and 9.0. Total Nitrogen, Cu and Fe of old lands are higher than new lands. Total Phosphorous, Mg and Mn are rich in both lands. Application of potassium should be considered.

Physical and Chemical Analysis of Land Types in Minia Governorate

Land	Moisture%	Organic matter %	N (ppm)	P (ppm)	Gypsum needs (ton/ feddan)	Na	K	Mg	Cu	Zn	Mn	Fe	Physical Composition			
						soluble salts extract 1: 5 m equivalent / 100 g soil			DTPA extract (ppm)				Sand %	Silt %	Clay %	Texture
Old Land	7.0	2.50	38.5	6.0	0.00	0.39	0.03	0.13	4.40	0.60	10.00	11.40	8	43	49	Silty clay
	18.2	1.98	30.5	22.0	0.00	0.37	0.03	0.15	4.20	0.48	7.50	9.60	7	42	51	Silty clay
	12.5	2.68	41.2	29.0	0.00	1.39	0.06	0.28	4.40	1.64	14.50	11.40	11	44	45	Silty clay
	9.3	3.00	46.1	26.0	0.15	0.63	0.04	0.12	3.70	0.88	8.00	10.60	10	43	47	Silty clay
	12.1	3.10	47.7	19.0	0.00	0.69	0.05	0.27	2.70	1.04	10.00	11.40	12	42	46	Silty clay
New Land	12.9	1.37	21.1	33.0	0.50	2.21	0.12	0.27	1.90	0.72	15.00	8.20	54	11	35	Sandy clay loam
	15.1	1.92	29.5	14.0	0.10	0.91	0.04	0.21	1.50	0.48	20.00	8.20	54	12	34	Sandy clay loam

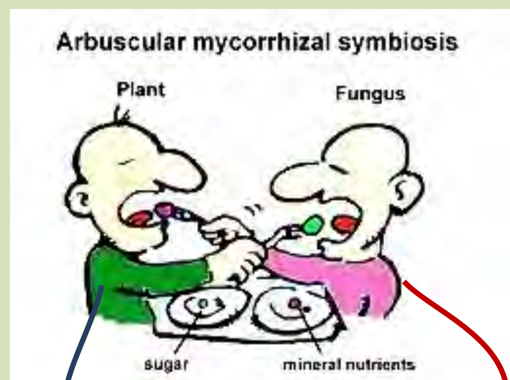
Source: JICA Study Team 2012

Most of the small-scale farmers are suffering from the high costs of chemical fertilizers in the high demand season. One of the solutions is application of these micro-organisms to utilize nitrogen gas in the air, phosphorus in the soil and potassium in the soil. The other main issue is that soils in the Nile Valley generally show alkalinity due to salts such as sodium carbonate (Na_2CO_3), sodium chloride ($NaCl$) and calcium carbonate ($CaCO_3$). These salts prevent the absorption of phosphorus (P), potassium (K), iron (Fe), manganese (Mn), boron (B), Copper (Cu) and Zinc (Zn) from the root systems of crops. As a result, the crops cannot grow well.



Soils in agricultural lands in Upper Egypt are found in pH 7.5-9.0.

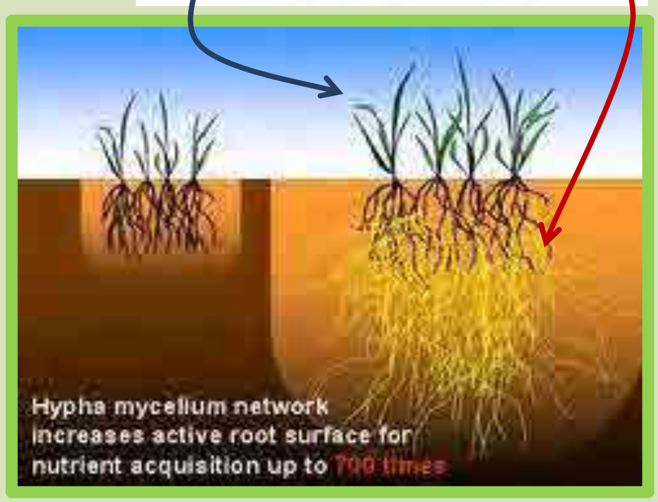
The Mycorrhizae fungus and plant root systems have a co-existing relationship. The fungus puts out hyphae into the surrounding soil. These absorptive hyphae increase the area of the root system and therefore the plant can access water and nutrients. The water and nutrients absorbed by the hyphae are exchanged for sugars produced by the plant. Mycorrhizal plants usually perform and survive better than those without this symbiotic relationship. Arbuscular Mycorrhiza (AM) fungus has a vital function in the absorption of phosphorous and the prevention of phosphorous, iron and manganese deficiencies in alkaline soils.



The solutions of alkalinity soils are;

i) Use of microorganisms,
ii) Use of fermented composts,
iii) Use of organic acids, or,
iv) Use of gypsum.

We recommend using microorganisms shown in the next chapter for increase of hyphae and mycelium network in root cells.

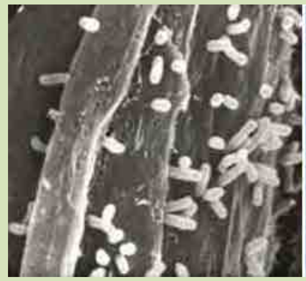


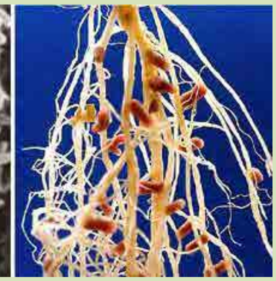
Source: http://www.agro-genesis.com/product_cropscience_microbes.html

3. Microorganisms for Agriculture

3.1 Nitrogena

General:





Nitrogena can be used for all organic agricultural crops such as bean crops, fodder crops, vegetables, fruits and ornamental plants. Nitrogena contains complex symbiotic bacteria to fix nitrogen gas found in alfalfa and beans, and non-symbiotic free bacteria to fix nitrogen gas found in fodder crops, vegetables, fruits and ornamental plants such as Rhizobium, Azotobacter and Azospirillum.

Benefits:

- Saves 100% of chemical nitrogen fertilizer for bean crops
- Saves 40-50% of chemical nitrogen fertilizer for fodder crops, vegetables, fruits and ornamental plants
- Increases the crops' production to 15-25% and improves the quality of crops
- Helps to grow roots and increases absorption of nutrient elements by plants
- Improves the chemical and natural properties of soil
- Increases the fertility of land and improves it
- Decreases pollution and some fatal diseases
- Increases resistance against the rotting diseases in rhizosphere
- Decreases the costs of inputs and increases production

Application Ratio of Nitrogena

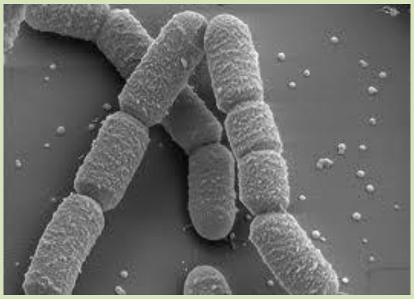
Crops	Liquid type	Powder type
Alfalfa, Beans (lentil, lupine, soybean, peanut)	5 liter/feddan	1 kg/feddan
Field crops (wheat, barley, maize, sugarcane)	5 liter/feddan	1 kg/feddan
Vegetables and Ornamental Plants	5 lit/feddan (at two times after germinating and before flowering)	
Fruits	5 lit/feddan (at two times at the beginning of growing and during flowering)	

Caution:

- Keep the package away from heat, chemicals and direct sunshine.
- Don't use fungicide with Nitrogena.
- Don't use the Nitrogina after the expired date.

3.2 Phosphorina

General :



Phosphorina can be used for all organic agricultural crops such as beans, fodder crops, vegetables, fruits and ornamental plants. Phosphorina can save phosphorus fertilizers for field crops, fruits, vegetables, ornamental plants and medical plants. Phosphorina contains phosphate solubilizing bacteria (PSB) found in fodder crops, vegetables, fruits and ornamental plants, such as Bacillus megatherium.

Benefits:

- Saves 100% of phosphorus fertilizers, including superphosphate at the first 2 years
- Reduces environmental pollution from residue of chemical fertilizers
- Increases development of root systems and leaves and protects from pests
- Increases the crop yields at 20–30 %
- Improves plant growth
- Improves soil fertility (diversification of bacteria in soils)
- Reduces the costs of farm inputs

Caution:

- Keep the package away from heat, chemicals and direct sunshine.
- Don't mix Phosphorina with pesticides or chemicals fertilizers.
- If using a sprayer, wash the tank before using Phosphorina.
- Don't use the Phosphorina after the expired date.

Application Ratio of Phosphorina

Crops	Liquid type	Powder type
Alfalfa, Beans (lentil, lupine, soybean, peanut)	5 liter/feddan	1 kg/feddan
Field crops (wheat , barley, maize , sugarcane)	5 liter/feddan	1 kg/feddan
Vegetables and Ornamental Plants	5 lit/feddan (at two times after germinating and before flowering)	
Fruits	5 lit/feddan (at two times at the beginning of growing and during flowering)	

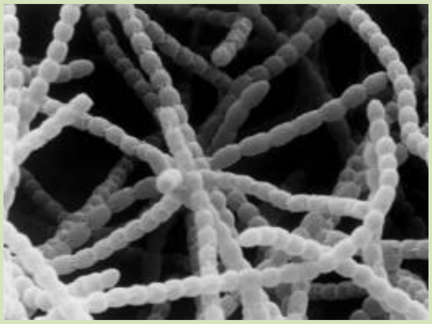
Important Information:

- Usually the plants can utilize only 30% of chemical phosphate fertilizers in applied weights. Other residues remain in deep soils or drained water.

- This absorbing ratio of phosphate is decreasing where the soils indicate more than pH7.5.
- The microorganisms in Phosphorina provide phosphorus from naturally-existing soils which converts to the ionized acid. And they make it available to absorb the plant roots.

3.3 Potassina

General:



Postassina can be used for all organic agricultural crops such as bean crops, fodder crops, vegetables, fruits and ornamental plants. Postassina contains potassium solubilizing bacteria (PSB) found in fodder crops, vegetables, fruits and ornamental plants, such as Streptomyces.

Benefits:

- Ionizes potassium carbonate naturally existing in clay soils
- Encourages fruit growth in terms of absorption by plant roots
- Saves chemical fertilizer of potassium sulfate to more than 50-100 %
- Increases the yield at 15- 25%
- Reduces the costs of farm inputs
- Produces streptomycin to control pathological bacteria

Application Ratio of Potassina

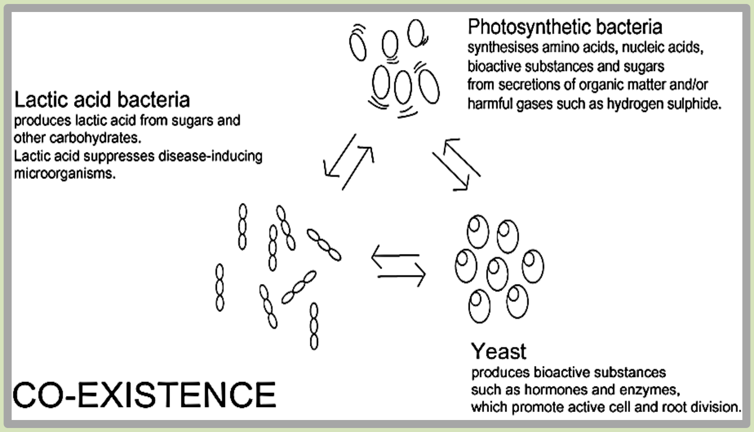
Crops	Liquid type	Powder type
Beans (lentil, lupine, soybean, peanut)	5 liter/feddan	1 kg/feddan
Field crops (wheat , barley, maize , sugarcane)	5 liter/feddan	1 kg/feddan
Vegetables and Ornamental Plants	5 liter / feddan	
Fruits	Once after cultivation and once before flowering	
Ornamental, Medical and Aromatic plants	5 liter/feddan	

Caution:

- Don't mix Potassina with chemical fertilizers or herbicides.
- Use Potassina with disinfectant fungi.
- Store away from high temperature or direct sunrays.
- Wash tank of sprayer before using Potassina.

3.4 EM

Effective Microorganisms is contained of three families of principal microorganisms; Photosynthetic, Lactic acid bacteria and Yeast, and has their respective functions. However, Photosynthetic bacteria could be considered the pivot of EM activity. Photosynthetic bacteria support the activities of other microbes. This phenomenon is termed "Co-existence and Co-prosperity".



Source: EM Research Organization

The enhancement of populations of EM in soils by its application promotes the development of existing beneficial soil microorganisms. Thus, the micro flora of the soil becomes abundant. AS a result, the soil develops a well-balanced microbial system. In this process, soil specific microbes (especially harmful species) are suppressed, thereby reducing microbial species that cause soil-borne diseases. In contrast in these developed soils, the Effective Microorganisms maintain a symbiotic process within rhizosphere, and plant roots also secrete substances such as carbohydrates, amino and organic acids and active enzymes. Effective Microorganisms use these secretions for growth. During this process, they also secrete and provide amino and nucleic acids, and a variety of vitamins and hormones to plants. Furthermore, EM in the rhizosphere coexists in plants. Therefore, plants grow exceptionally well in soils which are dominated by Effective Microorganisms.

<u>Photosynthetic bacteria (Rhodopseudomonas spp)</u>

The photosynthetic or phototropic bacteria are a group of independent, self-supporting microbes. These bacteria produce synthetic substances from the secretion of roots, organic matter and/or harmful gasses (e.g., hydrogen sulfide), by using sunlight and heat of soil as sources of energy. The useful substances developed by these microbes include amino acids, nucleic acid, and bioactive substances and sugars, all of which promote plant growth and development.

The metabolites developed by these microorganisms are absorbed directly into plants and act as substrates for increasing beneficial microbial populations. For example, Arbuscularmycorrhiza (AV) is increased due to the availability of nitrogenous compounds (amino acid) which are secreted by the photosynthetic bacteria. AV in turn enhances the solubility of phosphates in soils, thereby supplying unavailable phosphorus to plants. AV can also coexist with Azotobacter and Rhizobium, thereby increasing the capacity of plants to fix atmospheric nitrogen.

Lactic acid bacteria (Lactobacillus spp)

Lactic acid bacteria produce lactic acid from sugars and other carbohydrates, developed by photosynthetic bacteria and yeast. Therefore, some foods and drinks such as yoghurt and pickles have been made with Lactic acid bacteria from ancient times. However, Lactic acid is a strong sterilizing compound, and suppresses harmful microorganisms and enhances decomposition of organic matter. Moreover, Lactic acid bacteria such as lignin and cellulose ferment these materials, thereby removing undesirable effects of decomposed organic matter.

Lactic acid bacteria has the ability to suppress disease inducing microorganisms such as Fusarium, which occur in continuous cropping programs under normal circumstances; species such as Fusarium weaken crop plants, thereby exposing plants to disease and increasing pest population such as nematodes. The use of lactic acid bacteria reduces nematode populations and controls the propagation and spread of Fusarium, thereby inducing a better environment for crop growth.

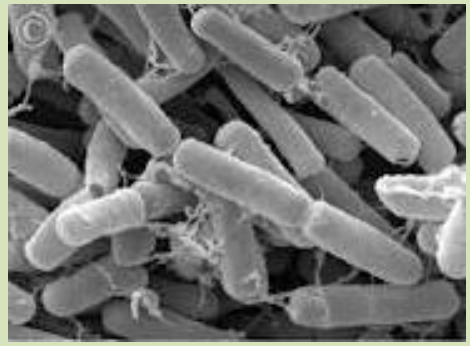
Yeast (Saccharmyces spp)

Yeasts synthesize antimicrobial and other useful substances required for plant growth from amino acids and sugars secreted by photosynthetic bacteria, organic matter and plant roots. Bioactive substances such as hormones and enzymes produced by yeasts promote active cell and root division. These secretions are also useful substrates for Effective Microorganisms such as lactic acid bacteria and Actinomycetes.

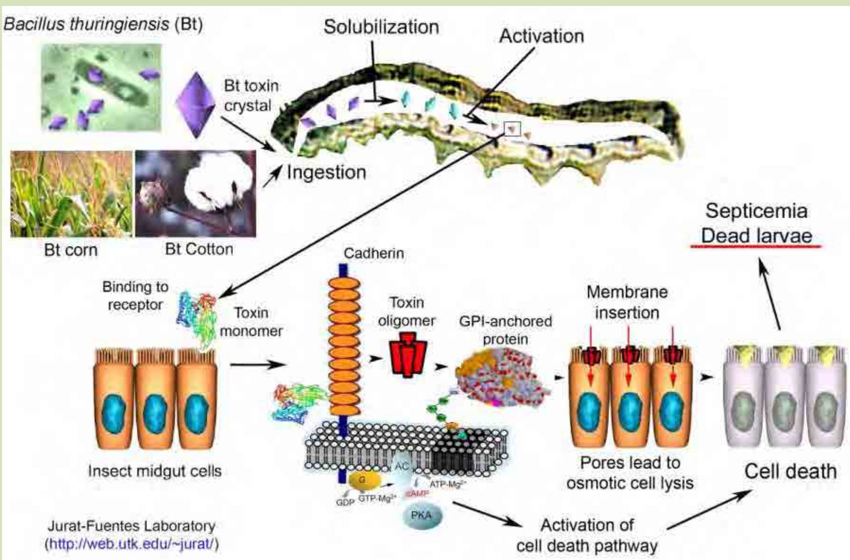
3.5 Trichoderma

Several strains of Trichoderma have been developed as bio-control agents against fungal diseases of crops and nematodes to plant roots. The various mechanisms include antibiosis, parasitism, inducing host-plant resistance and competition. Trichoderma readily colonizes plant roots, and some strains are rhizosphere competent, and also attack parasites that otherwise gain nutrition from other fungi. They have evolved numerous mechanisms for both attack of other fungi and for enhancing plant and root growth. Most bio-control agents are from the species T. harzianum and T. viride. The bio-control agent generally grows in its natural habitat on the root surface, and so affects root disease in particular, but can also be effective against foliar diseases. The continuous cultivation of a single crop may cause the appearance of nematodes.

3.6 Bt



Bacillus thuringiensis (Bt) was found in a disease of silkworms by a Japanese sericulture researcher in 1901. Bt has been used to control insect pests since the 1920s, and produces the crystal toxin that attacks the guts of pests and kills them internally. These crystal toxins are good agricultural tools for growing plants. Instead of using chemicals that may have adverse effects on humans, genetic engineers integrate the Bt toxin into the plant's genome. These Btcrystal toxins are proven safe for humans and kill off species of pests, which are susceptible to the Bt endospore. The mechanism is shown in the figure.



http://web.utk.edu/~jurat/Btresearchtable.html

In Egypt, effective strains of Bt are preserved by CLOA, and the researcher had tested them for Tuta absoluta. Also, Bio-Tech Co. produces the Bt agent.

Leading scientists and officers for bio-fertilizer and bio-control

4. Bio-Fertilizer Program

The bio-fertilizer of **Nitrogena**, **Phosphorina**, **Potassina** and **EM** can be diluted in irrigation water. The bacteria are active for 3 months after production. Please confirm the expiration periods. The applying volume is 5 liter/feddan for each bacterium for old lands and 10 liter/feddan for new lands. According to the biological conditions in soils, adjust the applying volume. The following application programs are stated for old lands.

4.1 Deciduous Tree Fruits

Grape, Peach, Plum, Apple, Apricot, Fig, Pomegranate

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grape, Apple, Fig, Pomegranate	→	→	→	→	→		→	harvest →	→			→
Bio-Fertilizer	EM	N	P	K	N							M
Peach, Plum, Apricot	→	→	→	→	→	→	→	harvest →	→			→
Bio-Fertilizer	EM	N	P	K	N							M

Abbreviations: M (manure), EM (Effective Microorganisms), N (Nitrogena), P (Phosphorina), K (Potassina)

- Prepare compost with manure, sorghum/wheat chopped wastes, bran, molasses, water and EM (100:10:1:1:10:1), and cover the compost with fertilizer sacks to avoid drying. The inside temperature should be controlled at less than 60℃. If the compost heats up from high temperatures, turn over the compost. If the compost smells of strong ammonia, do not use it. It is recommended to prepare in a net house to avoid insects and direct sunshine.

Materials of EM Compost

Material	Q'ty	Remarks
manure	1000kg	
straw	100kg	sorghum, maize
bran	10kg	wheat
molasses	10kg	
water	100lit	no chlorine
EM	10lit	
fertilizer sack	20 pcs	for cover

- If not making compost, add 5 liter/feddan of EM into irrigation water after broadcasting manure.
- Add 5 liter/feddan of Nitrogena in irrigation water at the beginning of February in case of Peach, Plum/Apricot and at the end of February in case of other deciduous tree fruits, nitrogen fertilizer (such as urea and nitrate) does not need to be added.
- Add 5 liter/feddan of Phosphorinain to irrigation water between the beginning and end of March.
- Add 5 liter/feddan of Potassina into irrigation water between the beginning and end of March.

- Repeatedly add 5liter/feddan of Nitrogena between the beginning and end of May.
- Depending on soil conditions, add chemical fertilizer at the same time and with the same kinds, but decrease to only 50% of the previously added volume of nitrogen, phosphate, potash or compound fertilizers.

4.2 Broadleaf Tree Fruits

<u>Citrus, Mango, Banana, Guava, Olive</u>

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus, Mango, Banana, Guava, Olive	→	→	→	→	→	→	→	harvest →	→	→		
Bio-Fertilizer	M	EM	N	P	K	N						

Abbreviations: M (manure), EM (Effective Microorganisms), N (Nitrogena), P (Phosphorina), K (Potassina)

- Prepare compost with EM.
- If not making compost, add 5 liter/feddan of EM into irrigation water after broadcasting manure.
- Add 5 liter/feddan of Nitrogena in irrigation water at mid-March.
- Add 5 liter/feddan of Phosphorina at mid-April.
- Add 5liter/feddan of Potassina at mid-May.
- If not making compost, add chemical fertilizer, but decrease to only 50% of the previously added volume of nitrogen and phosphate fertilizers.
- Repeatedly add 5liter/feddan of Nitrogena at mid-June.
- Depending on soil conditions, add chemical fertilizer at the same time and with the same kinds, but decrease to only 50% of the previously added volume of nitrogen, phosphate, potash or compound fertilizers.

4.3 Field Crops and Legumes

<u>Wheat, Maize, Sorghum, Alfalfa, Broad bean, Soybean, Peanut</u>

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat, Broad bean	→			harvest	→				→	→ △	→	→
Bio-Fertilizer	K								M	EM	N	P
Maize, Sorghum				→	→ △	→	→	→	→	harvest		
Bio-Fertilizer				M	EM	N	P	K				
Soybean, Peanut				→	→ △	→	→	→	harvest →	→		
Bio-Fertilizer				M	EM	N	P	K				
Alfalfa (example for 4 times harvest per year)	→	→ →	→ harvest	→	→ →	→ harvest	→	→ →	→ harvest	→	→ →	→ harvest
Bio-Fertilizer	EM	N P		EM	NP		EM	NP		EM	NP	

Abbreviations: M (manure), EM (Effective Microorganisms), N (Nitrogena), P (Phosphorina), K (Potassina) ,
△ Seeding

- Prepare compost with EM.
- If not making compost, add 5 liter/feddan of EM into irrigation water after broadcasting manure.
- Add 5 liter/feddan of Nitrogena in irrigation water at first irrigation after seeding.
- Add 5 liter/feddan of Phosphorina at second irrigation.
- Add 5liter/feddan of Potassina at third irrigation.
- Depending on soil conditions, add chemical fertilizer at the same time and with the same kinds, but decrease to only 50% of the previously added volume of nitrogen, phosphate, potash or compound fertilizers.
- Do not add nitrogen fertilizer to legumes.

4.4 Vegetables

Potato, Tomato, Eggplant, Garlic, Onion, Other Vegetables

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Potato								△				harvest
Bio-Fertilizer							M	EM	N	P	K	
Tomato (summer)	△							harvest				
Bio-Fertilizer	EM	N	P	K		N	P					M
Tomato (winter), eggplant	harvest							△				
Bio-Fertilizer		N	P				M	EM	N	P	K	
Garlic				harvest					△			
Bio-Fertilizer	N						M	EM	N	P	K	
Onion				harvest								△
Bio-Fertilizer	P	K								M	EM	N

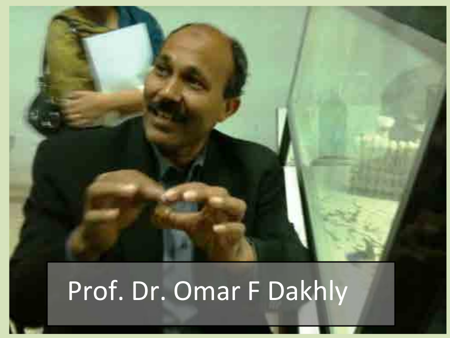
Abbreviations: M (manure), EM (Effective Microorganisms), N (Nitrogena), P (Phosphorina), K (Potassina) ,
△ Seeding/ Seedling

- Prepare compost with EM.
- If not making compost, add 5 liter/feddan of EM into irrigation water after broadcasting manure.
- Add 5 liter/feddan of Nitrogena in irrigation water at first irrigation after seeding.
- Add 5 liter/feddan of Phosphorina at second irrigation.
- Add 5liter/feddan of Potassina at third irrigation.

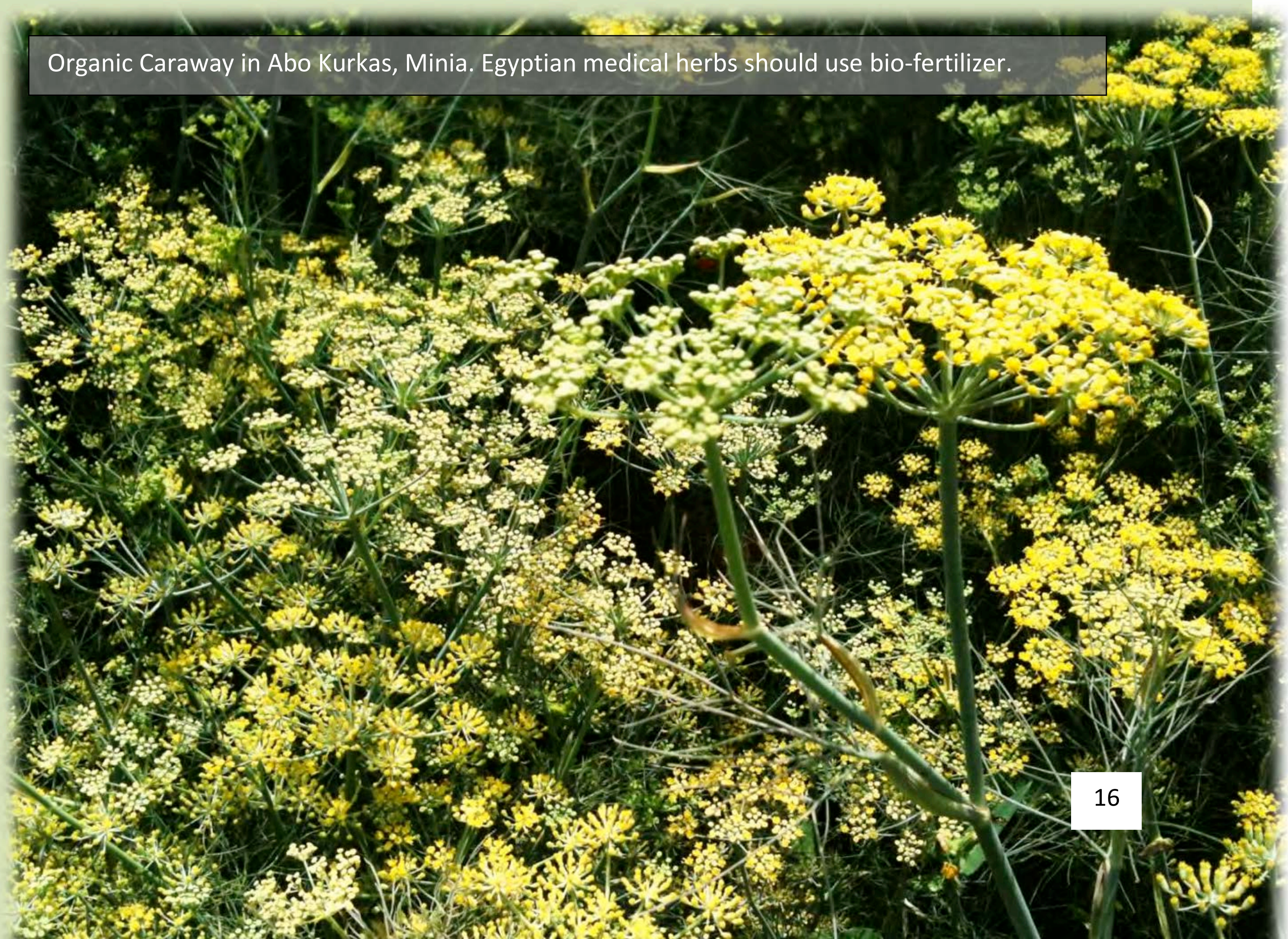
- Depending on soil conditions, add chemical fertilizer at the same time and with the same kinds, but decrease to only 50% of the previously added volume of nitrogen, phosphate, potash or compound fertilizers.
- For tomato, repeatedly add 5liter/feddan of Nitrogena and Phosphorina after the first Friday.
- For garlic, repeatedly add 5liter/feddan of Nitrogena after 2 months from the date of adding Potassina.

Remarks;

- There is the powder type of bio-fertilizer with Nitrogena and Phosphorina for preparation of seedlings (needs to be deleted), at the application rate of 1kg/feddan for the clay soils and 2kg/feddan for the desert soils. Mix the bio-fertilizer with 0.5kg sugar or molasses and 1 liter water, and then put them on the seeds on a plastic bed. Seeds should be planted directly and then irrigated. This bio-fertilizer is contained vermiculite and bark compost (called ‘peat moss’ in Egypt).


Prof. Dr. Omar F Dakhly

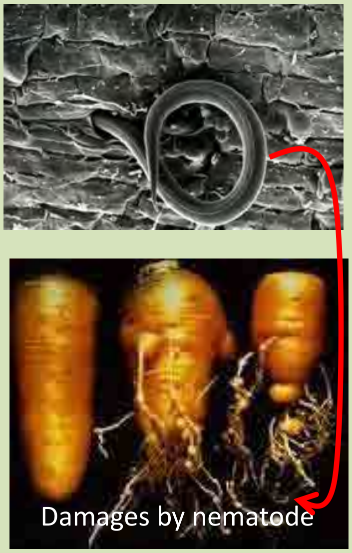
- There are special types of Nitrogena for each field crop, vegetable and fruit. Please ask Minia University Bio-Fertilizer Center.


Organic Caraway in Abo Kurkas, Minia. Egyptian medical herbs should use bio-fertilizer.

5. Bio-Control Program

Nematode Damage

- Nematodes are slender worms, typically less than 2.5 millimeters long. The smallest nematodes are microscopic in size. Depending on the species, a nematode may be beneficial or detrimental to plant health. From agricultural perspectives, two categories of nematodes exist. Predatory nematodes kill pests like cutworms and pest nematodes. Root-knot nematodes attack plants and act as vectors, spreading plant viruses between crop plants, and crops can be damaged.
- Use Trichoderma.
  Fruit trees: Stop providing fertilizer. Add 5 liter/feddan of Trichoderma in irrigation water in March (if possible).
  Field Crops and Vegetables: Stop providing fertilizer. Add 5 liter/feddan of Trichoderma in irrigation water 2 weeks before cultivation.


Damages by nematode

Root Rotting Fungal Damages

- Use Trichoderma.
  Fruit trees: Stop providing fertilizer. Add 5 liter/feddan of Trichoderma in irrigation water in March.
  Field Crops and Vegetables: Stop providing fertilizer. Add 5 liter/feddan of Trichoderma in irrigation water 2 weeks before cultivation.
- Use EM. Lactic acid bacteria in EM attack pathogenic fungi. Use Potassina. Streptomycin kills pathogenic fungi. If following the bio-fertilizer programs, root-rotting diseases will be depressed. But drain of water should be considered in lower lands.


Phytoseiulusmacropilis

Insect Damages

- Use Anti-insect produced by CLOA. Spray to plant leaves mainly for moths, white flies, leaf miners and thrips.
- Use Phytoseiulusmacropilis produced by CLOA for red spider mite.
- Use EM bio-pesticide.
  Mix with materials in the table and ferment for 4 weeks at least. Dilute in water at 1:50 and spray to plant leaves mainly for aphids.

EM Bio-Pesticide

Material	Q'ty	Remarks
EM	1lit	
water	20lit	no chlorine
vinegar	1lit	
fresh chilli	1kg	chopped
garlic	1kg	chopped
tobacco	250g	dried leaves
Calcium	10g	
molasses	1kg	
plastic container	1pc	

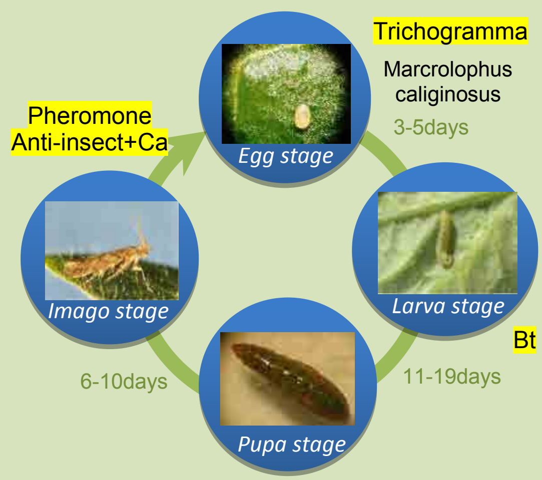
6. Bio-Control for TutaAbsoluta

Tuta absoluta is one of the most dangerous pests of tomato which is posing a serious threat to tomato production across the Mediterranean and Middle East regions. This pest is crossing borders rapidly and devastating tomato production substantially.

The Solanaceae family is considered mainly the host for Tuta absluta, especially as it was noticed that Tuta absoluta likes tomato then eggplant, potato, pepper as it has the ability to infect other crops from fabacea like broad bean and also for some harmful plants in tomato farms like wormseed, blackcurrant and tobacco.

Tutaabsoluta control is undergoing major challenges due to its capability of rapidly developing resistance against conventional insecticides. Some populations of Tuta absoluta have become resistant to organophosphate and pyrethroid pesticides.

Tuta absoluta can breed between 10-12 generations in a year. This high generation creates adaption to environment and chemical pesticides. The life cycle periods are 20 days at 30°C, 30 days at 25°C and 60 days at 15°C. The life cycle of Tuta absoluta is: egg, larvae, pupa and imago. It should be considered biological control in each stage.



Bio-Control in Each Stage

<u>Egg stage:</u>

The female imago lays eggs on the surface of the tomato leaf, and sometimes on the bottom of the tomato leaf, on the apical bud or the surface of tomato tree. The female imago lays 40-50 eggs in the lab despite being able to lay more than 200 eggs in nature; the egg is oval shaped and cream colored.

Trichogramma application is recommend in this stage.

- The Trichogramma parasite is very small, with a length between 0.17-1.16mm.

- The Life cycle is very short with a maximum of 10 days depending on the breeding temperature.
- Trichogramma parasitizes on the eggs of various families of pests and has successfully controlled squamous winged pests.
- Trichogramma attacks the host in the form of eggs, which leads to breaking the life cycle.
- Trichogramma has a high capability to find hosts.
- The imagoes of Trichogramma feed on floral nectar and honeydew.
- Install Trichogramma Cards at the rate of 30pcs/feddan in the early morning or evening to avoid high temperature. After 10 days, change the cards.
- Trichogramma is produced by the Plant Protection Institute in Assiut and Sugar Refinery Companies.

Trichogramma achaeae

CLOA started to breed Macrolophus caliginosus in 2012. Macrolophus is a bug belonging to the family of Miridae, the order Hemiptera or Heteroptera. It is endemic of the Mediterranean area. The body of an adult individual is oblong, downy, light-yellow, 2.7–3.7 mm in length.

Macrolophus caliginosus

- Macrolophus caliginosus attacks all stages of the White flies, spiders, insects and eggs and the larvae of Tuta absoluta.
- Releasing density is at an average of 1-1.5 predators per every square meter.
- For the best results, it is recommended to release the predator at the first stage of cultivation.

Larva stage:

Leaf mining larvae are the most dangerous and harmful for tomatoes, and they grow in four stages. The sizes are 1.6 mm long in the 1st larvae stage and 2.8 mm long in the 2nd stage. The bodies are a green color in these stages. Notice that the 1st and 2nd larvae stages affect leaves. In the 3rd larvae stage, the sizes become 4.7 mm long with a reddish color. In 4th stage, the sizes become 7.7 mm long with a black spot near the forehead and this spot is distinguished from Potato tuber moths.

Bt application is recommend in this stage.

- Dilute 1lit of Bt solutions into 150 lit of water without chlorine.
- Spray 2-3 lit/feddan of Bt solutions with water every 2 weeks.
- The volume of Bt solutions can be adjusted depending on plant growth and temperature. After flowering of plants and high temperature requires 3 liter/feddan.
- The expiration period of living Bt solutions is 2 weeks from laboratory production.

Pupa stage:

Larvae turn into pupa instar which stop feeding and movement (sleep) and become a spiral shaped, brown colored cocoon by making silk lines at the end of the fourth instar in soils, on leaf surfaces or in wrinkled leaves.

Imago stage:

The size of the moth is small, measuring 4.5-12 mm long after stretching its wings. Males are darker than females, and females have grey wings and bead-like antenna. They are active in the early morning and during sunset but hide themselves between leaves during the majority of the daytime.


Installation of trap

Pheromone trap installation and Anti-Insect application are recommended in this stage.

- Sex inducing pheromone for female is used.
- Prepare traps. Plastic container (5lit capacity) of mobile oil can be used. Hang pheromone from top. Put water 1cm deep. Install the traps at the height of 30-40cm. Change pheromones and water every 10 days. Install 2 traps/feddan.
- Anti-Insect is plant extract and not harmful to human bodies. Ca solution makes the membranes of plant leaf cells strong.
- Dilute 1lit of Anti-Insect solutions and 1 lit of Ca solution into 150 lit of water without chlorine.
- Spray 2-3 lit/feddan of the mixed solution with water every 2 weeks.
- The volume of the mixed solutions can be adjusted depending on plant growth and temperature. After flowering of plants and high temperature requires 3 liter/feddan.


Pheromone in trap

All stages:

Use bio-fertilizer such as EM, Nitrogena, Phosphorina and Potassina. Treatment of plant health is important prior to use of bio-control materials.

All bio-control materials such as Trichogramma, Bt Solution, Pheromone, Anti-Insect and Ca Solution are available in CLOA. For the latest information, please contact CLOA.


Achieved 5.4 Brix %

Box: Production of Trichogramma at Assiut Agricultural Directorate

Trichogramma can parasitize to varieties of moths.

Trichogramma is produced in Assiut Agricultural Directorate under the supervision of Plant Protection Institute of ARC.

For multiplication of Trichogramma, the eggs of the Angoumois grain moth are used. The eggs are put on adhesive paper.

Imagoes of Trichogramma are released in the bottle with the egg paper. Trichogramma parasitizes the eggs.

Cut the paper into small pieces with different days of parasite application. Package them. DO NOT USE with CHEMICAL PESTICIDE.

7. Benefits of Application of Bio-Fertilizer and Bio-Control

Cauliflower in bucket with fermented compost

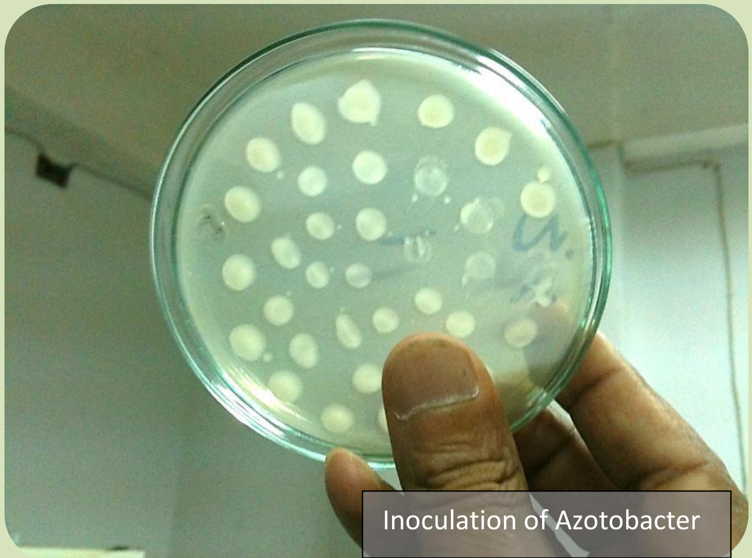
Very sweet iceburg lettuce

Very large cabbage

High yield tomato without pest damage

Onion with very long shelf life

Wheat with developed roots (left)



Inoculation of Azotobacter

For detail information, please contact to:

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The Project for the Master Plan Study for Rural Development through Improving Marketing of Agricultural Produce for Small Scale Farmers in Upper Egypt (IMAP)