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Dissertation subject: ***Tropical crops***

GERMINATION TESTS OF *ABELMOSCHUS ESCULENTUS (L.)* WITH THE SEEDBED BOTTLE METHOD VS A TRADITIONAL SEEDBED (AUROVILLE, INDIA)

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Dedication

"I dedicate my research to my dearest and most faithful friends who, as authentic yogi, know how to feed on light, air, soil and water and have taught me that happiness consists in the simplicity and essence of life: the vegetables.". (Dhartisatra*)*

"[…] *Yogi is a person whose good will is allied with wisdom.."* (Sri Nisargadatta Maharaj)[1]

"[… *] .The purified mind is the faithful servant of the Self, takes charge of external and internal instruments and makes them serve the purpose*." (Sri Nisargadatta Maharaj)[2]

Note 1: from Nisargadatta Maharaj's book "Io sono quello" - Ubaldini Editore ROMA, cap. 44 "The 'I am' is true, all the rest is a deduction" pag.157.

Note 2: from Nisargadatta Maharaj's book "Io sono quello" - Ubaldini Editore ROMA, cap. 46 "Awareness of being is bliss" pag.164.

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Author's note:

The S.B.M. (Seedbed Bottle Method) method, together with all the audiovisual material of this publication (photos, videos, graphs, tables, images and PPT), unless otherwise indicated, have been realized by Domenico Vitiello and have been released in the Public Domain Antiscadenza (PDA) (http://www.anticopyrightpedia.org/?page_id=230).

The idea of the S.B.M. (Seedbed Bottle Method) method, was originally created in 2012 by Domenico Vitiello for the realization of an artistic work by ILIÀJOLIE (http://www.iliajolie.it) and is currently part of the BIOsCAMBIO project (http://www.bioscambio.it): S.B.M. - F.W.T.O.F. (Seedbed Bottle Method - From Waste to Organic Food) (http://www.bottigliasemenzaio.it). In order to participate and / or collaborate on the project, please write to mailto: domenicovitiello1@gmail.com.

List of acronyms

AIR: All India Radio

CSIRO: the Commonwealth Scientific and Industrial Research Organisation

DAC & FW: Department of Agriculture Cooperation & Farmers Welfare

ECR: East Coast Road

FAO: Food Agriculture Organization.

FAOSTAT: Food and Agriculture Organization of the United Nations.

FYM: farmyard manure

F.W.T.O.F.: From Waste to Organic Food (Project)

IAO: Agronomic Institute for Overseas or Istituto Agronomica per oltremare.

IPAR: Agricultural and Rural prospective initiative or Initiative prospective agricole et rural.

LVC: La Via Campesina

KRRS: Karnataka Rajya Raitha Sangha

MoA e FW: Ministry of Agriculture and Farmers' Wellbeing

MSC: Master of Science

NHM: National Horticulture Mission

NBPGR: National Bureau of Plant Genetic Resources

NGO: Non-governmental organization

NSS: National Sample Survey

NV: Natural Vegetation.

OGM: Genetically modified organism

OpenLab: Educational structure for the promotion of the dissemination of scientific culture that operates at the Sesto Fiorentino University Campus

S.B.M.: Seedbed Bottle Method or Metodo Bottiglia Semenzaio

SWOT: Strengths-Weakness-Opportunities-Threats.

NBPGR: National Bureau of Plant Genetic Resources

UNESCO: United Nations Educational, Scientific and Cultural Organization

ZBNF: Zero Budget Natural Farming

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Abstract

The constant increase in consumption of disposable goods, linked to the development model of the industrial society, has led to the introduction of an increasing quantity of waste into the natural environment. In India the refusal of empty bottles and plastic in general has become a serious problem so much to induce the Indian minister for the environment to announce, on the occasion of the "*World Environment Day*", the ban on all single-use plastics by 2022.

What is considered a waste today, only a few years ago was a good to re-use several times.

Europe, to promote an integrated and sustainable waste management, has adopted a policy known as the "*5 R*": "*Collection, Recycling, Reuse, Reduction, Recovery*".

While “*recycling*” involves industries and consists in transforming waste into resource, “*reuse*” is a lifestyle instead, a mental and cultural attitude that provides the ability to reinvent and relocate goods that are still usable.

The *Seedbed Bottle Method* (S.B.M.) of my own invention, easy to do and at no cost, allows you to create a nursery of self-irrigated transplanting plants by reusing several times empty plastic bottles.

Through this experimental work carried out in India, a traditional seedbed was compared to the new S.B.M. seedling bottle method, under the same conditions of light, temperature and type of soil (topsoil). Analyzing the results obtained, the latter proved to be more performing, showing benefits for the germination of the seeds, for the Mean Germination Time (T.M.G.), for the growth and the development of the stem and roots of the *Abelmoschus esculentus L*. seedlings, and has led to a saving of about 1/3 of the irrigation water used and to the production of double dry biomass.

The use of an S.B.M seedbed is therefore a good opportunity to ease family horticulture especially in tropical and developing hot countries such as India.

A – DESCRIPTIVE PART

1 - Introduction

A recent article by Tatiana Schlossberg, appeared in the NY Times on the 20th October 2016, warns us, through an interactive quiz, from the pervasiveness of plastic in everyday life and from the potential harm plastic could be for the planet.

All over the world, the disposal of "*disposable*" plastic has become a major problem and 22,000 tons of plastic reach the ocean every day and form the so-called "*Great Pacific Garbage Patch*", also known as the "*Pacific Trash Vortex*", a huge surface arisen off the Pacific Ocean due to the convergence of waste (plastic above all), from all over the world. It is estimated to be between 700,000 km^2 up to more than 10 million km^2, that is an ever-growing island now as big as the Iberian Peninsula. The greatest potential danger lies in the fact that, as a result of the disruptive action of solar radiation and sea water, these debris will be likely to fragment into smaller and smaller pieces until they become microplastics extremely dangerous for the life of all marine organisms.

Among this garbage plastic bottles play a substantial role.

In this perspective, reusing empty plastic bottles to produce an innovative seedbed can be a good job opportunity as well as an important recovery of consumables. Through the experiment we wanted to study the effects that this kind of seedbed has, in a subtropical area, on an important species of vegetation like the Okra in India, especially for the evaluation of seed germination and plant growth indexes, comparing them with those of a traditional seedbed.

Okra (*Abelmoschus esculentus L.*), a popular plant of the tropical countries, is also a good source of carbohydrates, proteins, dietary fibers, minerals and vitamins. Okra's seeds are normally sown at a depth of 5–6 cm; hence, the germinating seeds are likely to meet mechanical resistance when they grow on the surface. Therefore, the physical properties of the soil, such as density, water retention capacity and compaction play a great role in the germination and birth of seedling. Since germination and seedling development are the pioneering stages for growth, development and yield, the study of germination indices and seedling quality has shown to be highly indicative of the subsequent seeds' yield during the growth period (Khajeh-Hosseini, Lomholt, & Matthews, 2009).

Using a good seedbed is, then, very important for the germination of seeds and the current experiment was undertaken to study the effects of two different types of seedbeds, the one in plastic bottles of my own invention, and the traditional one on the plot of land, comparing them on the Okra's germination indexes as a rapid and reliable test to access the quality and yield of the seedlings.

The S.B.M. method was born around the problem of reusing "*disposable plastics*". It is a simple and ecological idea aimed at creating a "*do-it-yourself*" seedbed for the production of transplanting seedlings from the reuse of empy plastic bottle. Thanks to this, the seedlings produced from the seed can eventually be transplanted with the root ball and not with the bare root.

But of greater importance is that the S.B.M. has several positive implications compared to a traditional seedbed, such as water saving for irrigation, reduced growth of mosquitoes and the use of recycled materials.

Plastic stuff, and in particular plastic bottles, are now part of our daily lives, have brought undeniable advantages in terms of economy, practicality and resistance, benefits that have however been sustained by the environment.

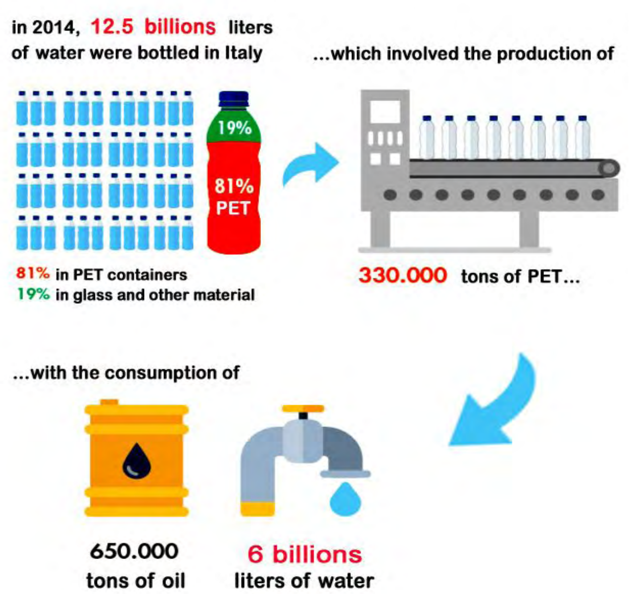


Figure 1 **- Energy consumption for the production of water bottles.**

Since 1960 PET (polyethylene terephthalate) has replaced the glass in the production of bottles, not only for mineral water but also for soft drinks, fruit juices, milk, and so on. PET containers have many advantages compared to PVCs: they are light, cheap, inert and impermeable to gases, and these are the reasons that made PET the most widely used plastic in the packaging of mineral water and non-alcoholic beverages in general.

PET is not exempt from environmental contraindications though, its production requires, in fact, the use of a lot of water and oil and, moreover, the objects at the end of their life must be correctly disposed as they are not biodegradable. Every year the bottling of mineral waters requires the production of an enormous quantity of new plastic, which is released into the environment. To produce 1 kg of PET (which can in turn create about 25 1.5-liter bottles) over 17 liters of water + 2 kg of oil are required **(figure 1)**.

The quality of the water in a plastic bottle, apart from complying with the hygiene parameters of the law, must also take into account the consumption of the resources used for its production and for the packaging of mineral water. And the great use of the resources necessary for the management of the bottling line (production / transport / disposal) is the reason why mineral waters are considered of low eco-sustainability level. **(figure 2)**.

This research work is made of a first descriptive part, which describes the technical characteristics of the two different sowing methods and a second experimental part, in which the data collected from the cultivation trials of the tropical *Okra* species are displayed. These cultivation tests comprise sowing, seedling and growth of seedlings up to the 4th leaf stage, ie seedlings suitable for transplanting.

In the final part there is the analysis and comparison of the results obtained in vivo during all the stages of the experimentation, from the germination of the seeds, to the development of the first real leaves, until the final drying of the plants for weighing and for the evaluation of the quantity of biomass of the SS produced.

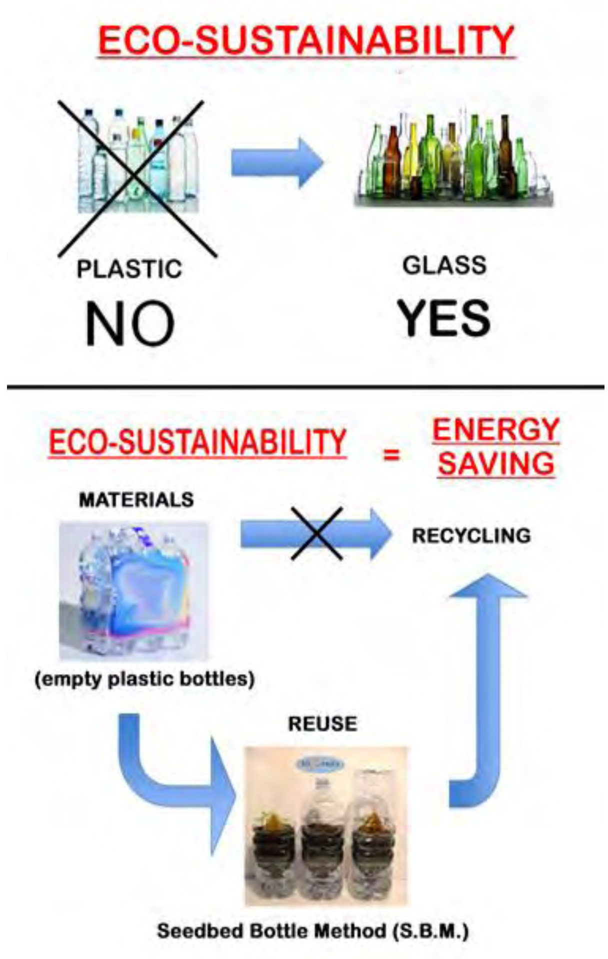


Figure 2** – **At the top: **ecosustainability of totally recyclable glass.** ***At the bottom:*** **energy saving by reusing plastic.**

The S.B.M. is a sub-irrigated sowing bed, which re-runs the optimal growth conditions of the seedlings; this is made possible by the constant presence of water in the sub-irrigation, which favors both the germination of the seeds and the development of the roots in the early stages of the growth of the seedling.

Thanks to the lengthening of the waste life of empty plastic bottles by reusing them, the S.B.M. is also a temporary solution for the disposal of waste of empty plastic bottles before being recycled. Finally, the seedlings produced with this method, have their roots protected from the root ball and are therefore better grounded. They undergo less transplant stress, improving the percentage of engraftment and yield after transplantation in the open field.

1.1 Issues

Today the world faces the fundamental challenge of ensuring that millions of households living in poverty have access to food sufficient to maintain a healthy life. Over the years, Africa, India and all the other PVS have been looking for ways to solve the problem of food insecurity (Omotesho et Al., 2007).

Mkwambisi et Al. (2007), notes that “*despite the persistent economic growth worldwide, food insecurity and unemployment are still a pressing problem in many parts of the PVS*". Musotsi et Al. (2008), reports that malnutrition has been identified as primarily caused by food insecurity while poverty has been proven to be one of the root causes of food insecurity.

Fanrpan (2006), also argues that there is a strong bond between vulnerability to food security and chronic poverty. This means that “*poverty undermines the ability of people to develop livelihood strategies, adaptive behaviours and coping strategies which help to ensure long-term food security*.”

Food insecurity affects both rural and urban households and thus becomes a problem since rural households have a larger number of members than urban households (FAO, 2010). At the same time rural households have greater availability of land and experience in food production than that available in towns for urbanized people; moreover town's food distribution centres upon the daily deliveries of products form rural areas and are consequently more vulnerable than rural areas; this leads people in the town to think up new methods to produce strategic food. (Pardini et al., 2015).

One of the methods, which can be used both in urban and rural areas in family farming, is being able to use the waste as a resource: empty plastic bottles can become a good opportunity to create a hatchery at no cost and that at the same time facilitates the production of transplanting seedlings. The seedling bottle method is suitable for this purpose.

In the family horticulture of tropical countries, rationalizing, optimizing and facilitating the management of the garden through the construction and use of a seedbed is of vital importance, especially in those places where there are difficulties in germination and development of seeds due to adverse climatic, edaphic and parasitic conditions. It is also possible to obtain a higher yield, especially for some species, such as *tomatoes, aubergines, peppers, chilli peppers* and *okra*.

Among the many advantages of using a seedbed, there are:

- *Better yield of planted seeds and, therefore, more seedlings available*.
- *Saving on cultivation times*: thanks to the seedbed, more cycles can be carried out in the same particle and it is possible, for example, to grow a lettuce particle while growing the tomato seedlings, which are transplanted only after the harvest of the salad. This allows you to earn a good month on each crop and in a year you can balance the surface of the vegetable garden to produce more by making more cycles.
- *Optimization in the use of the space in the vegetable garden*: at the time of transplanting the best plants are chosen and each space of the plot is filled with plants that are already formed and strong. During the straight seeding instead some holes remain if a seed does not germinate or a seedling dies prematurely.
- *Saving on the purchase of seeds / seedlings*, because seeds and seedlings are less likely to die.
- *Certainty of using only selected seeds and products from the previous year's crops.*
- *Reduction of parasitic problems*: in the seedbed the seeds are safe from any predators, the plants in a protected environment are less likely to be attacked.
- *Reduction of weeds*: transplanting the seedling already high and formed, controlling weeds will be much easier, especially combining mulch and transplant and the work of tearing the weeds decreases a lot.

Thanks to the S.B.M. method the following additional benefits can also be obtained:

- *Advantages in the growth of seedlings*: the S.B.M. is a sub-irrigation seed system, which facilitates seed germination and creates the optimal growth conditions for seedlings, reducing water consumption.
- *Defense against mosquitoes*: being the S.B.M. a sealed cell, mosquitoes cannot enter the water containers to lay eggs and multiply.
- ✓ *Recovery and reuse of containers for several production cycles*: once the transplant operation is carried out with the root ball that facilitates the rooting of the seedlings in the open field, reducing the transplant stress, the containers can be re-used several times.

The sowing + plant transplantation technique, is obviously doable for almost all the vegetables except for bulbs, tubers and some vegetables with dummy root like carrots and parsnip, which would suffer to be born in the plant pot and undergo the transplantation.

1.2 Justification.

Today the world is facing a global climate change, with rising malnutrition and malnourishment of women and children and people being health conscious and their dietary models moving towards chemical free plants. And recently quite a large number of farmers commited suicide in India. The reality of India is that today rural poverty is in a severe situation. They have no option for engaging themselves in secondary and tertiary sector. This is happening because the government have paid a meagre attention on improving the rural India. Therefore, most people in rural villages carried on their Jhum cultivation and agricultural activities as a major source of livelihood. The technologies which have been used in this primary sector are still primitive. Many crores of rupees are spent by Govt. of India for horticulture and every five-year plan, yet this money and these schemes do not reach the poor people in the rural India. But through a little own saving and the little money of the individual household and the involvement of family members, it produces for self consumption and surplus for the market. Horticultural crops like fruits, vegetables and spices etc., are highly rewarding and therefore, promoting horticulture is the best option to transform the rural economy of India.

By 2050, the global population in India is expected to increase to 3 billion. The challenge of feeding a growing population is discouraging while all the economic sectors depend, to some degree, on ecosystem services like agriculture and allied activities, especially horticultures. Horticulture helps in maintaining a healthy ecosystem, water regulation, pollination, erosion control, and climate and wind regulation and then the world's food safety issues could be solved by paying greater importance to the role of horticulture.

2 - Description of the two nursing methods compared

The two seeding systems differ substantially for the type of irrigation: sub irrigation in the S.B.M. seedbed, sprinkling in the traditional one.

In this chapter we will describe the main features of the two methods compared:

- The Seedbed Bottle Method (S.B.M.);
- The traditional seedbed.

2.1 - The Seedbed Bottle Method (S.B.M.) and its application in nurseries

Photo 1 **- Domenico Vitiello inventor of the S.B.M. and promoter of the BIOsCAMBIO project (http://www.bioscambio.it).**

The Seedbed Bottle Method. (S.B.M) is an invention of the undersigned **(photo 1)** and allows you to create a sub-irrigated seedbed for the production of transplanting seedlings using empty plastic bottles and a normal seeding substrate (soil).

The method is therefore not hydroponic but a standard nursery with soil and sub-irrigation which can be also used in organic farming. Its first version dates back to 2012 and was created within the BIOsCAMBIO online project **(photo 2 - left)**, while the second version of the "*New seedbeds 2014*" receives the 2nd prize of the Cat. A at the contest "*GOOD IDEA!*" organized by OpenLab - a structure of the University of Florence – for the ScienzaEstate 2016 event at the Sesto Fiorentino Scientific and Technological Pole **(photo 2 - right)**.

The online project of BIOsCAMBIO (the community of self-producers/builders for self-consumption) was founded in December 2011 and is addressed to the "*gift-exchange*" of self-produced seeds, as well as vegetative propagation materials and everything else that could be useful as self-production for self-consumption **(photo 3)**. It consists of a website, http://www.bioscambio.it, and a forum, http://www.bioscambio.it/forum, where registered users publish their experiences of self-production/construction and provide their seeds for free exchange.

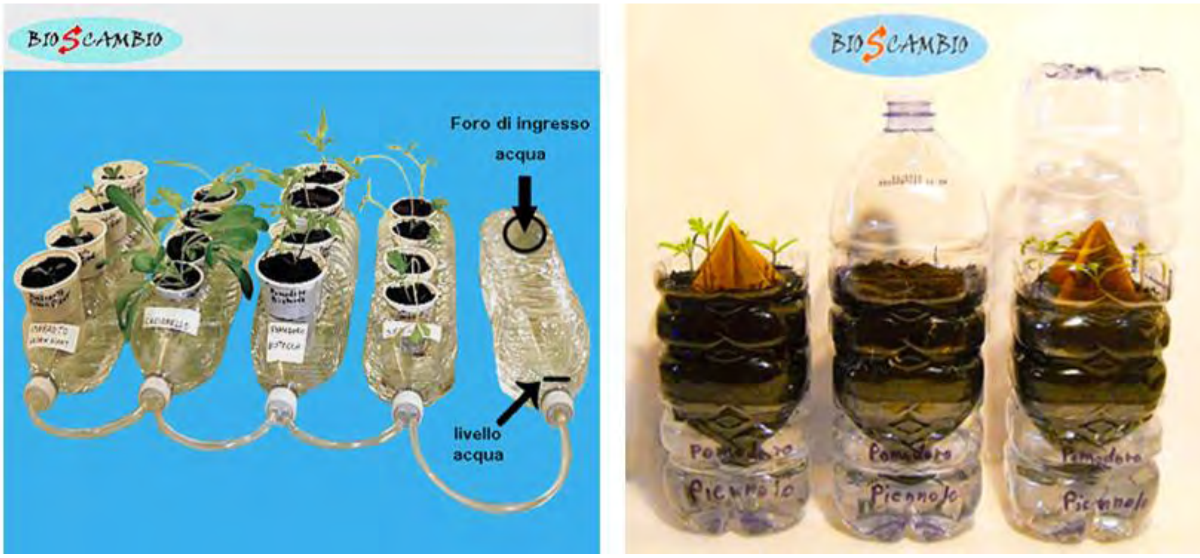


Photo 2 - On the left: **the first version of the S.B.M. of 2012*. On the right*: the new version of the S.B.M. method 2014**

The S.B.M. seedbed is created from empty plastic bottles from which self-irrigating phytocells (sub-irrigation) are gained and the first version of the method was published on a youtube video titled: "*Practical Guide BIOsCAMBIO N.1 - The seedling bottle*" at the following page: https://www.youtube.com/watch?v=e1mwUAxs1ac. This first version used empty plastic bottles with a capacity of 1.5 - 2 liters placed horizontally and with the combined use of 4 disposable plastic cups of 200cc / bottle, inserted in special alveoli made in the bottle.

Subsequently, in March 2014, the method was improved with a model of "seedbed bottle" much simpler and without single-use glasses. A video of about 27 minutes was made of the method and published on the youtube channel of BIOsCAMBIO. entitled: "*BIOsCAMBIO New seedbeds 2014 (S.B.M. - Seedbed Bottle Method)*", https://www.youtube.com/watch?v=hmWkbfQurCw that earned, in 2 years, about 150.000 views and over 500 subscribers to the channel.

For the method of the seedbottle (S.B.M.) we use empty plastic bottle of any brand, shape and size, but the best results are obtained with bottles of 2-2.25 liters capacity. In the current research, the bottle that gave us the best results was the 2.25 liter Coca Cola's due to its volume and strenght because it is indeed a bottle suitable to resist the pressure of carbonated liquids. The early stages of the production of the bottle include:

Photo 3 **- The BIOsCAMBIO online project.**

1) **The choice and the cutout of the bottle**: any empty plastic bottle of any shape and size can be used as a seedbed, but using the 2 liters', which are more capacious, is preferable.

The seed bottle is obtained by making two cuts of the original vacuum of the plastic bottle to get two separate sections from only one bottle: the lowest section serves as a "*water tank*", while the top one, which is turned upside down and inserted in the tank with the cap facing downwards, becomes the "*soil container*" and contains the substrate for sowing. A third median part of the bottle is removed as wastage.

The volume of the tank and the jar obviously varies depending on the shape and size of the bottle but, generally, for the 2 liter plastic bottles, the tank is able to hold about 600 cc of water, while the jar about 500 cc of soil.

To recharge the water tank, simply raise the pot of soil above it and pour water on it until 2/3 of the tank is filled, completely submerge the cap but don't go beyond that level because larger volumes of water can saturate the telluric air making the soil too wet and asphyxiated. Basically the soil is moistened only by rising water by capillarity and by evapotranspiration. Between the cap of the pot containing the soil and the bottom of the tank, a space of about 0,4” must be left to allow stability of the jar on the edges of the tank and to avoid the obstruction of the holes on the cap by the ascent of the water.

Placing the jar on the tank, a faultless adherence is gained with hermetic seal of the sections, which does not allow the loss of water for evaporation and does not allow mosquitoes to lay their eggs in the water.

2) **The drilling of the cap**: to allow the capillary ascent of the water, 4 radial cuts are made on the plastic cap with the tip of a trincet; you can also make some holes with a nail of appropriate size (**photo 4 - last image on the bottom right**).

Photo 4 - **Different types of bottle used (from top to bottom and from left to right): Coca Cola lt. 2.25, Pepsi lt. 2.25, 7 UP lt. 2.25, Sprite lt. 2.25, French lt. 2. *At the bottom right corner*: Caps pierced with a nail (top) and in the shape of a star through a trench (bottom).**

Although it was not necessary for this research work, for the S.B.M. is also possible to do:

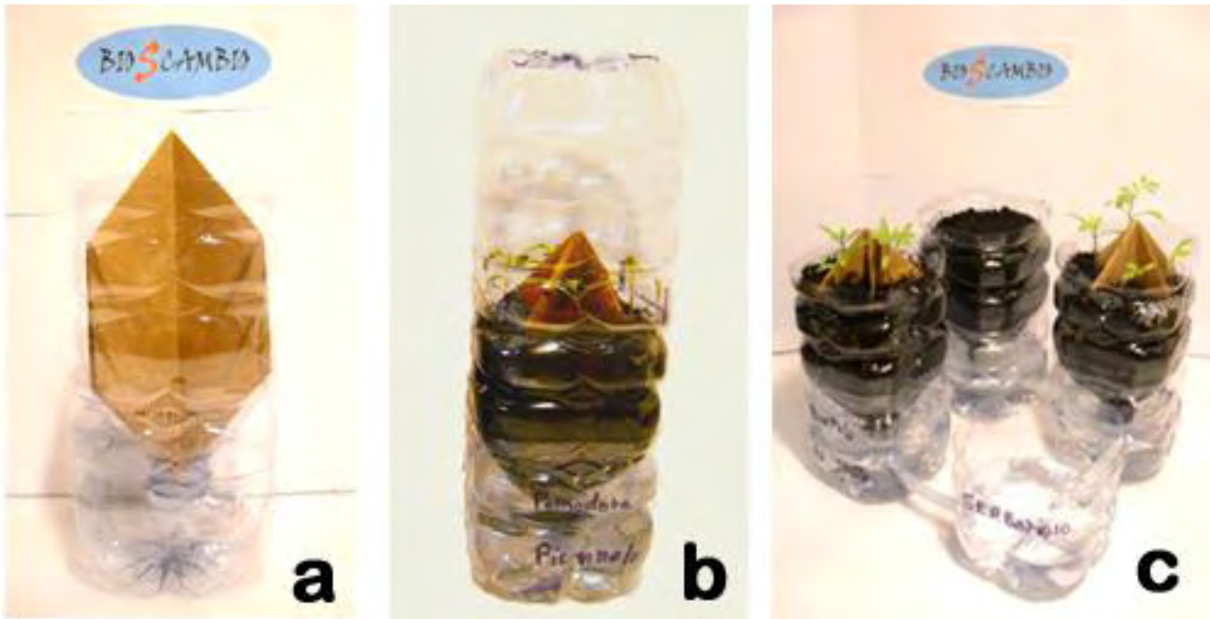


Photo 5 **– a) Paper partition in 4 sectors*.* b) Greenhouse cover of the bottle*.* c) Battery system of 3 bottles connected together + 1 water refill tank (2 bottles are provided with paper divider)*.***

- ***Subdivision into soil departments***: 4 sectors can be created during the repackaging of the seedlings for each bottle using a simple sheet of folded paper (origami method) and this allows you to separate the roots of the 4 seedlings with its own root ball each. **(photo 5 - a**).

- ***Greenhouse roofs for protection against birds, snails and phytophagous insects***: some horticultural species which grow from the seed are immediately prey of insects, birds, snails, etc.; it is then good to protect the sprouts during the first stage of the growth through the creation of a simple interlocking cover on the jars (**photo 5 - b**). From each empty bottle, two covers can be made, one from the lower half and one from the upper half, on which two fins and 4 joints are cut out, as well as the holes for ventilation.

- ***Battery of seedbeds connected to each other***: managing a large nursery, loading the water from each individual bottles becomes too slow and laborious, reason why setting a communication between the tanks becomes necessary (**photo 5 - c**); this way long batteries of S.B.M., exploiting the physical-hydraulic principle of communicating vessels, can be filled with water and it's then possible to restore their levels by pouring water from a single tank which is connected to all the others and is placed at the head of the battery. The connection between the tanks can be made with 8 mm diameter plastic pipes or with a "*hot*" tube with a drilling-welding plier, which is currently being studied and carried out.

2.2 – The traditional method of nursery on a plot of land

The method of the traditional seedbed, used for example by the nursery plants of the Botanical Garden of Auroville, consists of seedling trays with drain holes 20” x 12” **(photo 6 - top)** or a plot of land m 10 x 1,5 for sowing seedlings for growth **(photo 6 - bottom**).

Photo 6* - *At the top:* sprouts in plastic trays cm 50 x cm 30; *At the bottom:* seedbed in raised ground pitches m 10 x 1.5 m. (*Botanical Garden - Auroville)

After the germination, when the seedlings got to the stadium of development of the 2-3 real leaf, each of them is moved into a “polythene bags” (nursery bags) that consists in a little rectangular plastic container-bag, black and 4.7” x 7,9” (**photo 7)** that, filled with soil, takes a cylindrical shape of cm 7,5 diameter at the base for a general volume of cm^3 883 and a content of soil of around cm^3 660.

Usually the irrigation method used for seedbeds and polythene bags is done by sprinkling. There is a restricted-flow system of water which is provided to a control device connected to the supply line storage tanks and rubber irrigation pipe of 0,8" diameter.

Photo 7 **– Traditional cell packs of cuttings in plastic sachets (*Botanical Garden - Auroville*).**

In our experimental seedbed the traditional sowing of the test plants was carried out on a 15,7" x 15,7" small plot of topsoil placed next to each group of S.B.M. bottles and the irrigation was done by pouring water into a 10-liter watering can.

Each plot of topsoil was provided with pointed wooden sticks 10” long to keep cats and birds away **(photo 13 - b).**

3 - Progress and potential of horticulture in india

In India the potential of horticulture raising agricultural production, added value, farm income and employment over the country has been known for long. The Fourth Five Year Plan (1969-74) recognised the importance of this sector. Nevertheless, the need in raising foodgrain production to secure reasonable availability of basic food was so pressing in the past that the promotion of horticulture was considered less important than the production of foodgrain.

Besides politic matters, the green revolution technology has also favored wheat and rice more than any other crop. Towards the late '70s the reliance on imports for meeting food grains demand was almost vanished and a sort of food self-sufficiency was to begin. This led to a turnaround in policy towards diversification and the area under cereal crops started declining for the first time after the years 1983-84. This diversification however did not focus only on horticulture but followed many directions, far from cereals.

The need for diversification in the horticulture sector was acknowledged by the Government of India in the mid-1980s when it started focusing its attention on investment in this sector and hit the real boost in the early 1990s, which overlapped with the liberalisation of the economy. Extending facilities for processing, marketing and storage and the development of irrigated horticulture was one of the targets of the new agricultural policy resolution, 1992, (Government of India, 1993). But still, the success achieved in horticulture is not properly recognised and understood. The general perception is that diversification towards horticulture was led by exports.

Nowadays horticulture has established its credibility in improving the income through increased productivity, generating employment and enhancing exports and, as a result, horticulture has moved from rural confines to becoming a commercial enterprise.

The Department of Agriculture, Cooperation & Farmers Welfare (DAC&FW) of the Ministry of Agriculture & Farmers Welfare (MoA&FW) is the nodal department for overviewing horticulture development in the country. It implements different programmes through the Departments of Horticulture in every country and provides the leadership to coordinate the activities for the promotion of horticulture.

The scenario of horticultural crops in India has become very encouraging. The percentage share of the horticultural output in agriculture has become more than 30% and India has witnessed voluminous increase in horticulture production over the last few years.

Significant progress has been made in expanding the area, resulting in larger production. Over the last decade, the area under horticulture has grown by about 2.7% per annum and the annual production has increased by 7.0%. In 2013-14, the production of horticultural crops was about 283.5 million tonnes in an area of 24.2 million hectares **(table 1).**

Year	Fruits			Vegetables			Flowers & Aromatic			Plantation Crops			Spices			Total		
	A	P	Pdy.	A	P	Pdy.	A	P	Pdy.	A	P	Pdy.	A	P	Pdy.	A	P	Pdy.
1991-92	2874	28632	9.96	5593	58532	10.47				2298	7498	3.26	2005	1900	0.95	12770	96562	7.56
2001-02	4010	43001	10.72	6156	88622	14.40	106	535	5.05	2984	9697	3.25	3220	3765	1.17	16592	145785	8.79
2002-03	3788	45203	11.93	6092	84815	13.92	70	735	10.50	2984	9697	3.25	3220	3765	1.17	16270	144380	8.87
2003-04	4661	45942	9.86	6082	88334	14.52	101	580	5.74	3102	13161	4.24	5155	5113	0.99	19208	153302	7.98
2004-05	5049	50867	10.07	6744	101246	15.01	118	659	5.58	3147	9835	3.13	3150	4001	1.27	18445	166939	9.05
2005-06	5324	55356	10.40	7213	111399	15.44	129	654	5.07	3283	11263	3.43	2366	3705	1.57	18707	182816	9.77
2006-07	5554	59563	10.72	7581	114993	15.17	144	880	6.11	3207	12007	3.74	2448	3953	1.61	19389	191813	9.89
2007-08	5857	65587	11.20	7848	128449	16.37	166	868	5.23	3190	11300	3.54	2617	4357	1.66	20207	211235	10.45
2008-09	6101	68466	11.22	7981	129077	16.17	167	987	5.91	3217	11336	3.52	2629	4145	1.58	20662	214716	10.39
2009-10	6329	71516	11.30	7985	133738	16.75	183	1021	5.58	3265	11928	3.65	2464	4016	1.63	20876	223089	10.69
2010-11	6383	74878	11.73	8495	146554	17.25	191	1031	5.40	3306	12007	3.63	2940	5350	1.82	21825	240531	11.02
2011-12	6705	76424	11.40	8989	156325	17.39	760	2218	2.92	3577	16359	4.57	3212	5951	1.85	23243	257277	11.07
2012-13	6982	81285	11.64	9205	162187	17.62	790	2647	3.35	3641	16985	4.66	3076	5744	1.87	23694	268848	11.35
2013-14	7216	88977	12.33	9396	162897	17.34	748	3192	4.27	3675	16301	4.44	3163	5908	1.87	24198	277352	11.46
2014-15 (2nd Adv. Est)	6358	88819	13.97	9541	168300	17.64	816	3233	3.96	3538	17131	4.84	3163	5908	1.87	23417	283468	12.11

Note: A : Area in '000 ha
P : Production in '000 Tonne
Productivity: Tonne/ha

Sources: (1) 1991-92 to 2010-11 : Indian Horticulture Database, National Horticulture Board (NHB).
(2) 2011-12 to 2014-15 : Horticulture Statistics Division, Department of Agri. & Cooperation.

***Table 1 -* Production and productivity in the whole India area of horticultural crops in the years 1991-92, 2001-02, 2011-12, 2012-13, 2013-14 and 2014-15.**

Out of the six categories, that is, fruit, vegetables, flowers, aromatic crops, spices and plantations, the highest annual growth of 9.5% was seen in fruit production in 2013-14 **(table 2).** The production of vegetables has increased from 58,532 thousand tonnes to 168,300 thousand tonnes from 1991-92 to 2014-15 **(graph 1 - top).**

The annual growth of citrus fruits is quite high (10.48%) in 2013-14.

Fruit has being contributing 12–13% of the total production of fruit over the last few years.

Crops	2010-11 over 2009-10		2011-12 over 2010-11		2012-13 over 2011-12		2013-14 over 2012-13		2014-15 over 2013-14	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
Fruits	–1.4	4.4	5.0	2.1	4.1	6.4	3.4	9.5	–11.9	–0.2
Vegetables	6.4	9.6	5.8	6.7	2.4	3.7	2.1	0.4	1.5	3.3
Flowers	4.4	1.0	33.0	60.2	–8.3	4.7	9.5	1.5	24.4	0.4
Aromatics	0.2	5.6	–0.8	–6.4	10.1	62.2	-11.4	–2.5	1.2	3.4
Plantation Crops	1.3	0.7	8.2	36.2	1.8	3.8	0.9	–4.0	–3.7	5.1
Spices	19.3	33.2	9.3	11.2	–4.2	–3.5	2.8	2.9	0.0	0.0
Total Horticulture Crops	**4.5**	**7.8**	**6.5**	**7.0**	**1.9**	**4.5**	**2.1**	**3.2**	**–3.2**	**2.2**

Source: Horticulture Statistics Division, DAC&FW.

(Growth in %)

Table 2– **Annual growth trends in the area and production of horticultural crops, from 2010-11 to 2014-15.**

In 2013-14, the total production of fruit was the highest in the State of Maharashtra (134.6 lakh tons) followed by Andhra Pradesh (105.11 million tons.

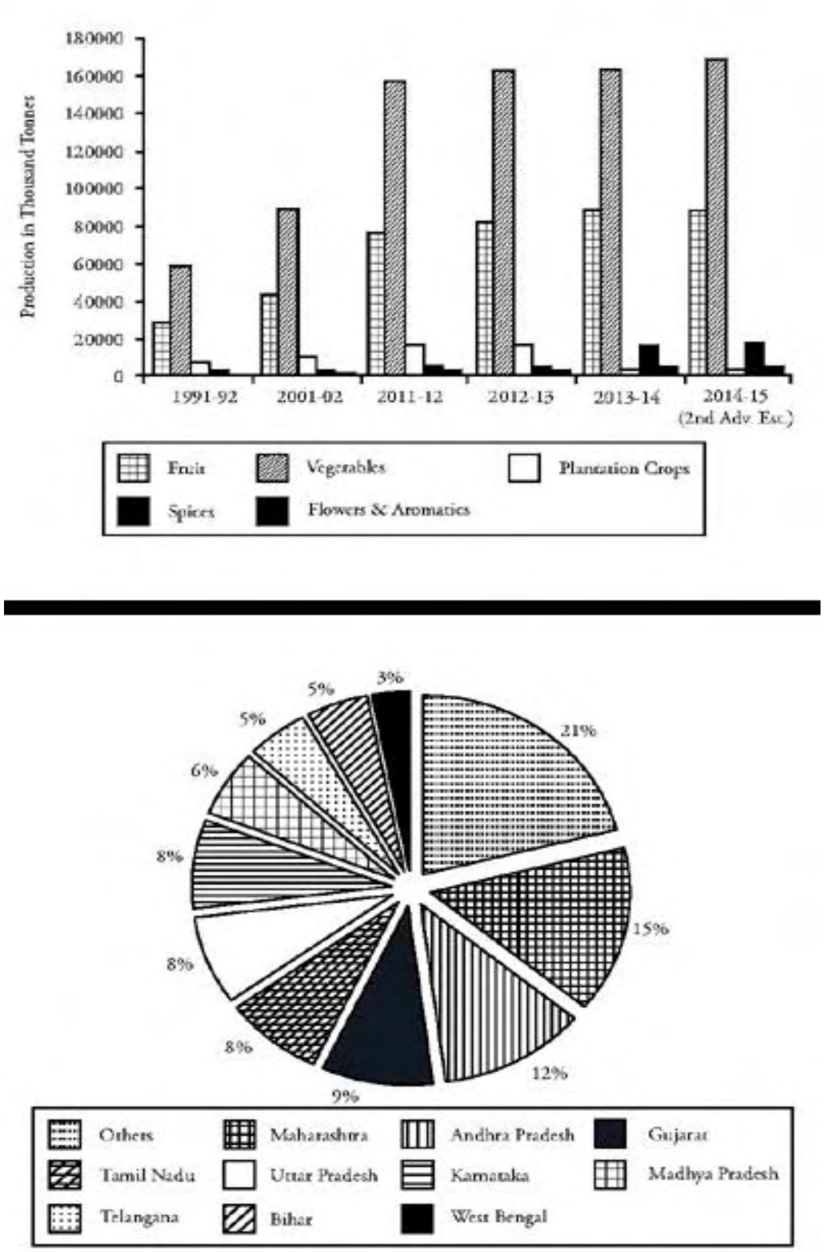
A lakh in the Indian numbering system is equivalent to 100,000 (one hundred thousand) (**graph 1 - below**).

In addition to health improvements, the production of vegetables improves the economy of a Country as it is an excellent source of income and employment. The contribution of vegetables stays higher (59-61%) in horticultural productions from 2010 to 2015, as shown in **graph 2 below**.

In 2013-14, the area cultivated with vegetables is estimated to be 9.4 million, with a production of 162.9 million tons in India. During this time the total plant production was higher in West Bengal (23.045 thousand tons) followed by Uttar Pradesh (18.545 thousand tons). The graphic representation of the production quota of the main vegetable producing countries of 2013-14 is shown in **graph 2 - top left**.

There is a great potential for growing flowering plants. A growing trend in the field of flower production has been seen since 2003-04 (**table 1**). In addition to the beauty of the local landscape, another field of flower production concerns the exports and floriculture is also important for apiculture which provides an alternative source of income for Indian farmers.

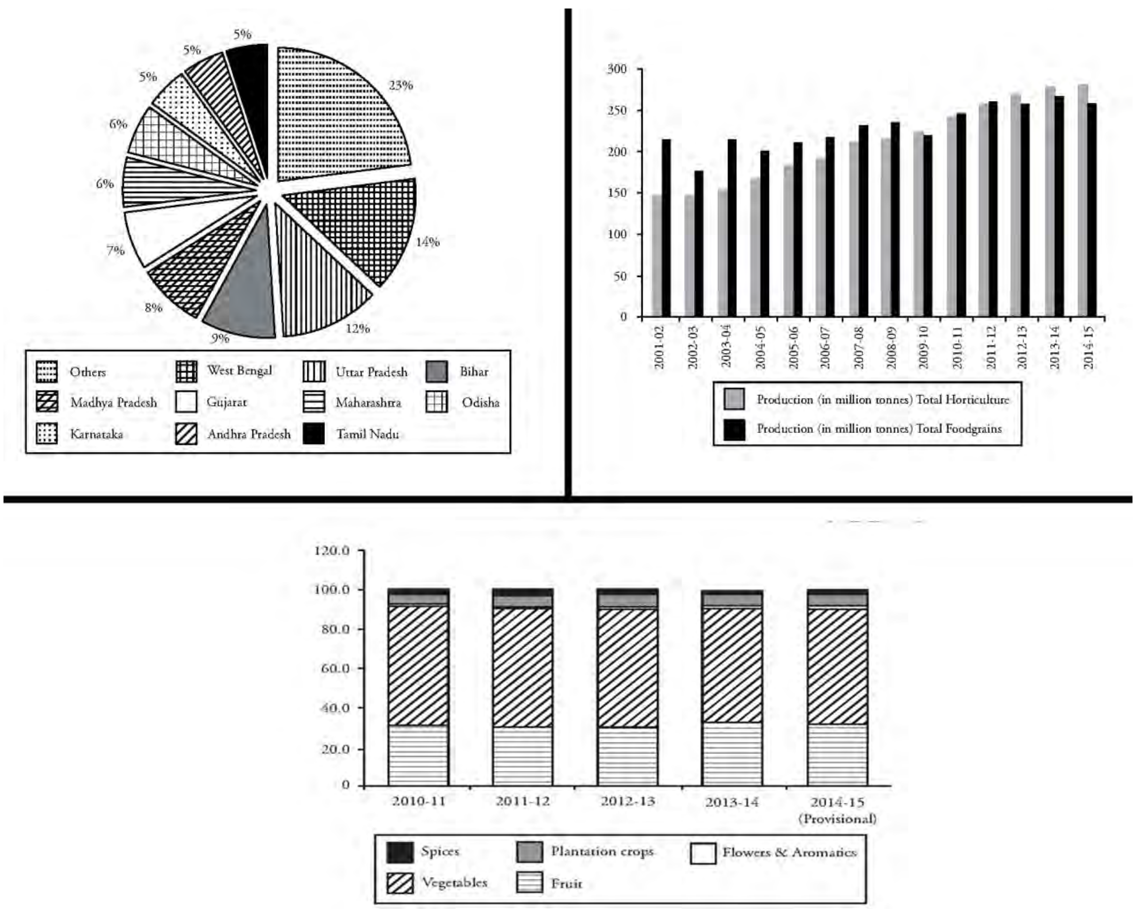
The highest production of flowers (cut) was recorded in Tamil Nadu (343.65 thousand tons) followed by Karnataka (211.50 thousand tons).



Graph 1 – At the top: **production of various horticultural crops over the years (graph based on the data of table 1).** ***At the bottom:*** **Leading Fruit-producing Countries of 2013-14.**

India has witnessed to the displacement of the area from food crops to horticulture in the last five years (from 2010-11 to 2014-15). The area devoted to horticulture has increased by about 18%, while the expansion of the cereal area was only 5%. The production of horticultural crops has exceeded the production of cereals from 2012-13, as shown in **graph 2 - top right**.

Again in **graph 2 - below** the various productions of horticultural crops are compared and it is clear how vegetables outnumber on spices, flowers and fruit.



Graph 2 – On the top left: **Graph of the production quota of the main vegetable producing Countries in 2013-14.** ***On the top right: Comparison between horticultural and cereal production.*** ***At the bottom:*** **Production quota of Various Horticultural Crops.**

3.1 - Socioeconomics aspects

In India the concern for horticulture is very recent, between the 50s and 80s the government focuses on cereal crops of rice and wheat, now that we are on the green revolution and we are food self-sufficient. But the horticulture field gained the attention only between 1980 and 1992; we called it an Era for the Golden Revolution, a timeframe during which everyone talks about vegetables, fruits and vegetables. Only from 2005-06, when the National Horticulture Mission was launched, there have been extraordinary improvements in these fields. India is the second largest producer of fruit and vegetables along with China, but if the rural India had been revitalized by horticultural expansion in its rural villages, the scenario would have changed.

The nutritional intake from fruits and vegetables is higher among urban population than that of rural population. Along with the urbanization, people are likely to increase their calories intake at a higher rate through fruit and vegetables: the rise in calories intake is more than 10% in urban area whereas it is merely 1.89% in rural area over the period 2004-05 to 2009-10. It is estimated that the per capita fruit availability in India is less than 200g per day, which is far below the recommended quantity of 230g per capita per day.

National Horticulture Mission is a sponsored plan launched by the Government of India during the year 2005-06 (Tenth Plan). The aim of this plan is to:

- Provide a holistic growth of the horticulture field in India, enhance horticulture production, develop horticulture to the maximum potential available in the Country and increase the production all the horticultural product (Fruit, Vegetables, Flowers, Plantation crops, Spices, Medicinal Aromatic plants) in the Country.
- Enhance horticulture production, improve nutritional safety and the income support to farm households;
- Establish convergence and synergy among multiple on-going and planned programmes for horticulture development;
- Promote, develop and spread technologies through a seamless blend of traditional wisdom and modern scientific knowledge.
- Create employment opportunities for skilled and unskilled people, especially for unemployed young people.

In order to pursue the above goals, the National Horticulture Mission will be focusing on the areas of horticultural research, development, post harvest management, processing and marketing. The research programmes for horticulture will be concentrating on providing to each Region/Country appropriate technologies, keeping in mind their specific agro climatic and socio-economic conditions.

- **Prospects and Trade of domestic demand**

The prospects of the demand of horticulture crops can be captured from the trend in domestic consumption and trade. National Sample Survey (NSS) data show that consumption of fruit and vegetables is rising at a faster rate compared to other food. Recent data from 61st Round of NSSO for the year 2004-05 show that the share of fruit and vegetable within the total food expenditure has increased in both rural and urban areas **(table 3)**. As rural diets are catching up with urban diets, the increase in share of fruit and vegetable is found to be much higher than that in urban areas.

Particulars	Year	Rural	Urban
Per capita expenditure (Rs.)			
Total Food	1993-94	177.8	250.3
	2004-05	307.6	447.4
Fruits and vegetables	1993-94	21.9	37.2
	2004-05	44.5	70.5
Share of fruits and vegetables in total food expenditure (per cent)			
	1993-94	12.32	14.86
	2004-05	14.47	15.76

Table 3 – Share of the monthly per capita expenditure of fruits and vegetables *(Source: NSSO Report No.509: Household Consumption of Various Goods and Services in India, 2004-05.)*

Rural consumers have spent 14.5 per cent of their total food expenditure on fruit and vegetable in 2004-05 as compared to the 12.32 per cent in 1993-94. In urban area the share increased from 14.86 per cent to 15.76 per cent.

3.2 Zero Budget Natural Farming (ZBNF)

The method of seedbed bottles (S.B.M.) is a simple method, an appropriate technology at a low cost and affordable for everyone, in line with the new models of permacultural and eco-sustainable agriculture, based on organic fertilization, energy savings and positive associations of plant crops. Awareness of the need for a new type of more sustainable agriculture is emerging and spreading all over the world, in the already developed countries as well as in the developing ones. One of these most natural farming movements called "*Zero Budget Natural Farming* (ZBNF)" has also developed in India in response to and against a high-input and hyper-technological agriculture model that is suggested by the multinationals' market and based on the massive use of chemistry (both in the field of fertilizers and crop protection products) and of GMOs, which was the beginning to many problems in India.

Zero Budget Natural Farming (ZBNF) is a set of natural cultivation methods, and also a peasant movement that has spread to various regions of India. It gained a wide success in southern India, especially in the southern Indian region of Karnataka where it first wafted. A rough estimate for Karnataka points out about 100,000 farmer families, while ZBNF leaders claim that numbers could run into millions nationwide. This has been achieved without any formal organization, paid staff or bank account. ZBNF is alive thanks to a spirit of volunteerism among its peasant farmer members, who are indeed the main leaders of the movement.

The *neoliberalization* of the Indian economy has led to a deep agrarian crisis which is causing the small scale agriculture to be not profitable. Privatized seeds, inputs, and markets are inaccessible and expensive for peasants. Indian farmers increasingly find themselves in a vicious cycle of debt because of the high production costs, high interest rates for credit, volatile market prices of crops, rising costs of fossil fuel-based inputs, and private seeds. More than a quarter of a million farmers have committed suicide in India in the past two decades. Many studies have linked farmer’s suicides to debt. Debt is a problem for farmers of every size in India. Under such conditions, ‘zero budget’ farming promises to end the reliance on loans and drastically cut production costs, ending the debt cycle for desperate farmers. The word ‘budget’ refers to credit and expenses, thus the phrase “*Zero Budget*” means without using any credit, and without spending any money on purchased inputs.

"*Natural farming"* means farming *with* Nature and *without* chemicals.

The movement in Karnataka state was born out of the collaboration between Mr Subhash Palekar, who put together the ZBNF practices, and the state farmers association Karnataka Rajya Raitha Sangha (KRRS), a member of La Via Campesina (LVC).

ZBNF farmers are mainly of rural origin, with a small minority of urban people who have recently moved to the countryside. Most of the farmers come from the middle peasantry – they own land and are economically independent. According to a survey carried out by LVC, 100% of ZNBF farmers owned land, and a majority had access to some form of irrigation and owned at least one cow.

4 - Description of the specie analyzed

The experimental tests of cultivation in the SBM nursery for the comparison with the test plants of the traditional nursery took place during a 60 days timeframe, during which the plants were observed from germination until they were removed.

The tropical plant species *Abelmoschus esculentus (L.)* Moench, called *Okra* or *Ladies finger*, has been used for the experiment.

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4.1 - Botanical description and Taxonomy of the *Okra*

Taxonomy: *Okra* was previously included in the genus *Hibiscus*, section *Abelmoschus* in the family *Malvaceae* (Linnaeus, 1753) **(table 4).** The section *Abelmoschus* was subsequently proposed to be raised to the rank of distinct genus by Medikus, in 1787. The wider use of

Name	Okra
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Malvales
Family	Malvaceae
Genus	Abelmoschus
Species	esculentus

S.No	Species
1.	A. moschatus Medikus- subsp. moschatus var. moschatus- subsp. moschatus var. betulifolius (Mast) Hochr- subsp. biakensis (Hochr.) Borss. subsp. tuberosus (Span) Borss.
2.	A. manihot (L.) Medikus- subsp. tetraphyllus (Roxb. ex Hornem.) Borss. var. tetraphyllus - var. pungens
3.	A. esculentus (L.) Moench
4.	A. tuberculatus Pal & Singh
5.	A. ficulneus (L.) W & A.ex. Wight
6.	A. crinitus Wall.
7.	A. angulosus Wall. ex. W, & A.
8.	A. caillei (A. Chev.) Stevels

Table 4 – On the left: **taxonomy of *Okra*. *On the right:* classification in the genus Abelmoschus adopted by IBPGR, 1991**

Abelmoschus was afterwards accepted in the taxonomic and contemporary literature (Hochreutiner, 1924). This genus is different from the genus *Hibiscus* for the features of the calyx, spathulate, with five short teeth, connate to the corolla and caducous after flowering (Kundu and Biswas, 1973; Terrell and Winters, 1974). About 50 species have been described by taxonomists in the genus *Abelmoschus*. The taxonomical revision undertaken by van Borssum Waalkes (1966) and then by Bates (1968) is the most fully documented study of the genus *Abelmoschus*. Taking the classification of van Borssum Waalkes as the starting point, an up-to-date classification was adopted at the International Okra Workshop held at *National Bureau of Plant Genetic Resources* (NBPGR) in 1990 (IBPGR 1991) as given in **table 5.**

Out of the above, the first three species are cultivated, whereas the remaining are wild. The adoption of this new classification requires the amendment of the determination key of *Abelmoschus* to accommodate the distinction between *A. esculentus* and *A. tuberculatus* as well as the distinction between *A. manihot*, *A. tetraphyllus* and *A. callei*. The existing botanical describers (*A. tuberculatus*, *A. manihot* and *A. tetraphyllus*) need to be compared to the variation in the accessions of the basic global collection and other existing collections. The intraspecific classification in A. moschatus, A. tetraphyllus, *A. esculentus* and *A. angulosus* should still receive further attention (IBPGR, 1991).

- **General Description:**

Okra is a 3 to 8 feet tall herbaceous plant with the flower similar to the hibiscus. It is a tropical direct sown vegetable with a 90-100 days cycle. Okra's root consists on a deep taproot system. The botanical features are as indicated below:

- ***Stem:*** the stem is semi-woody and sometimes pigmented with a green or reddish color. It is erect, variable in branching, with many short branches that are joint to the thick semi-woody stem. The stem reaches the height of 3 feet in dwarf varieties, up to 7 or 8 feet in the others.
- ***Leaves:*** The leaves of the stem are lobed and generally hairy, some reaching up to 12 inches in length. They are cordate (heart-shaped), simple, usually palmate, 3-7 lobed and veined; subtended by a pair of narrow stipules. The *okra* leaf is dark green in color and resembles a maple leaf **(photo 8)**.

- ***Flowers:*** *Okra* has perfect flowers (male and female seminal parts in the same flower) and is self-pollinating **(photo 9 - left).** If *Okra* flowers are bagged to exclude pollinators, 100% of the flowers will give seed. It was experimentally found that there is no significant difference in fruit set under open-pollinated, self-pollinated (by bagging alone) and self-pollinated (hand pollination of bagged flowers), which means that it is a potentially self-pollinated crop (Purewal and Randhawa, 1947). The inbreeding depression well pronounced in cross-pollinated crops has not been reported in this crop (Duranti, 1964).

Photo 8 – On the left: **Okra leaves (1st real leaf)*. On the right:* adult leaves of Okra.**

The erect sexual parts consist of a five to nine part stylus, each with a capitate stigma, surrounded by the staminal tube holding numerous filaments (Purewal and Randhawa 1947, Purseglove 1968). The petals wither in the afternoon and usually fall the following day**.**

The flowers get vertical only on the orthotropic axis every two or three days. The flower is axillary and solitary, leaning on a peduncle 2.0 – 2.5 cm long. The flowers are around 2 inches diameter long, with five white to yellow petals with a red or purple spot at the base of each petal. The flower lasts one day only. Each blossom develops a small green pod. The

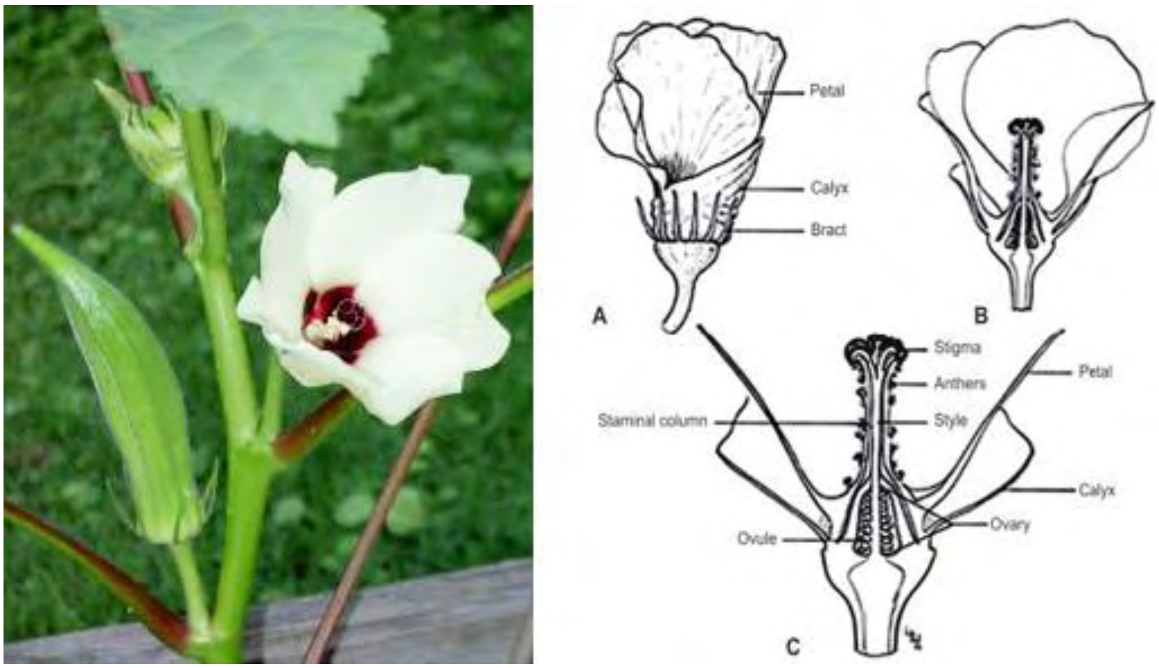


Photo 9 - Okra* flower bud and immature seed pod. *Picture on the right: Okra* flower - side view*; B* longitudinal section*; C* longitudinal section of the stem column*.

flowers are almost always bisexual and actinomorphic. The perianth consists of 5 valvate, distinct or basally connate sepals and 5 distinct petals that are usually basally adnate to the androecium **(photo 9 - right).**

The androecium consists of numerous monadelphous stamens with apically divergent filaments bearing 1-celled anthers. The gynoecium is a single compound pistil of two to many carpels, an equal number of styli or stylus branches, and a superior ovary with two to many locules, each bearing one to numerous ovules. The calyx is completely fused shaping a protective case for the floral bud and spilts into lobes when the bud opens. The calyx, corolla and stamens are fused together at the base and fall off as one piece after anthesis**.**

- ***Fruit:*** The fruit is a stretched conical or cylindrical capsule, comprising, for the most part, five cavities containg ovules (**photo 10 - left**). The fruit is actually a long pod and generally ribbed, which develops in the leaf axil. The fruit is normally yellowish green to green but can sometimes be purple or whitish green. The pods, which are harvested while still tender and

***Photo 10 - Okra* fruit*. On the right: Okra* seeds.**

unripe, are the edible part. They quickly grow into a long (10-30 cm) and narrow (1-4 cm) pod with a beak-shaped spike.

- ***Seeds:*** The *Okra* fruit contains many oval, smooth, striated and dark green to dark brown seeds. Seeds yield of Ladies finger is about 3.5-5.5 kg seeds/ha during summer seasons and 8-10 kg seeds/ha in the rainy season crop. The seed yield generally varies with germination percentage, spacing and season. The seeds are of spheroidal shape, with a 5mm large diameter and weight about g0.07 (**photo 10 - right).**

The seeds are pitched on both sides of the furrows at a spacing of 60 x 30 cm in kharif season (before the monsoon) and 30 x 30 cm in summer season. The ideal sowing time greatly varies depending on climate, breeds and their temperature requirement for growth. Normally the crop is sown between January-March and June-August. The exact month of sowing depends on the region. The hybrid varieties are planted at a spacing of 30” x 12” or 24” x 18”. A pre-soaking irrigation 3-4 days before sowing is beneficial. The seeds germinate in about 4-5 days.

- **Properties and nutritional value:**

The roots and stems of okra are used for clarification of sugarcane juice from which "*gur or jaggery"* or brown sugar is prepared (Chauhan, 1972). Its ripe seeds are roasted, ground and used as a substitute for coffee in some countries. Mature fruit and stems containing crude fibre are used in the paper industry. The extracts from the seeds of the *okra* are an alternative source for edible oil. The greenish yellow edible oil has a pleasant taste and smell and is high in unsaturated fats such as oleic acid and linoleic acid. The oil content of the seed is quite high at about 40%. Okra provides an important source of vitamins, calcium, potassium and other minerals which are often lacking in the diet of developing countries (IBPGR, 1990). The composition of edible part of Okra is given in **Table 5.**

Calories	35.0	Calcium (mg)	66.0
Moisture (g)	89.6	Iron (mg)	0.35
Carbohydrates (g)	6.4	Potassium (mg)	103.0
Protein (g)	1.9	Magnesium (mg)	53.0
Fat (g)	0.2	Copper (mg)	0.19
Fibre (g)	1.2	Riboflavin (mg)	0.01
Minerals (g)	0.7	Thiamine (mg)	0.07
Phosphorus (mg)	56.0	Nictonic acid (mg)	0.06
Sodium (mg)	6.9	Vitamin C (mg)	13.10
Sulphur (mg)	30.0	Oxalic acid (mg)	8.0

***Table 5* - Composition per 100b of edible portion of okra** *(Source: Gopalan et al, 2007).*

Okra is said to be very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Nadkarni, 1927). Its medicinal value has also been reported in curing ulcers and relief from hemorrhoids (Adams, 1975).

4.2 − Diffusion and importance of Okra in the world

Okra Abelmoschus esculentus L. (Moench), is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. This crop is suitable for cultivation in garden crop as well as in large commercial farms. It is commercially grown in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Burma, Japan, Malayasia, Brazil, Ghana, Ethiopia, Cyprus and the Southern United States. India ranks first in the world with 3.5 million tonnes (70% of the total world production) of Okra produced from over 0.35-million-hectare land (FAOSTAT, 2008).

Okra is known by many local names in different parts of the world. It is called *Lady's Finger* in England, *Gumbo* in the United States of America, *Guino-gombo* in Spanish, *Guibeiro* in Portuguese and *Bhindi* in India. It is very popular in India because of the easy cultivation, reliable yield and adaptability to various moisture conditions. Just in India, further different names have been given in different regional languages (Chauhan, 1972). Okra is cultivated for its green non-

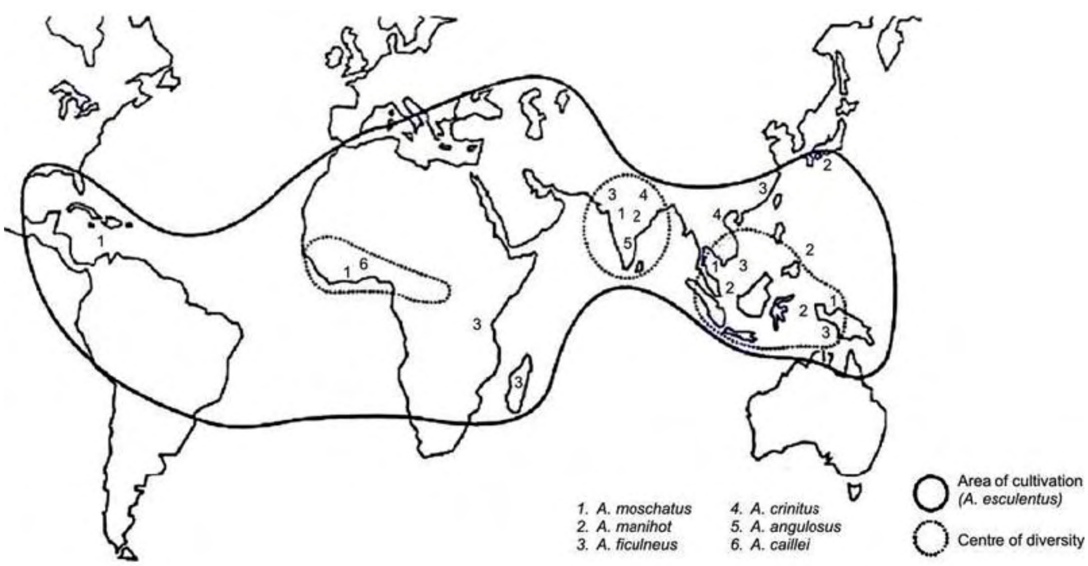


Figure 3 **- Geographical distribution of Abelmoschus species modified from Charrier (1984).**

fibrous fruits or for the pods containing round seeds. The fruits are harvested when unripe and eaten as vegetable. Okra fruit can be cooked in many different ways. *A. esculentus* can be found all around the world from Mediterranean to equatorial areas, as it can be seen from the geographical distribution of cultivated and wild species shown in **figure 3.**

Cultivated and wild species clearly show overlapping in Southeast Asia, which is considered to be the hearth of bio-diversity. The spread of the other species is the result of their introduction to America and Africa. There are two hypotheses concerning the geographical origin of *A. esculentus*. Some authors argue that one putative ancestor (*A. tuberculatus*) is native of Uttar Pradesh in northern India, suggesting that the species have originated from this geographic area. Others, on the basis of ancient cultivation in East Africa and the presence of the other putative ancestor (*A. ficulneus*), suggest that the area of domestication is north Egypt or Ethiopia, but no definitive proof is available today. It is difficult to suggest an external origin of *A. caillei*, only found in West Africa. Its origin by hybridization with *A. manihot* is difficult to accept even if its presence, mentioned in the Flora of West Africa (Hutchinson and Dalziel, 1958) was not recently confirmed in this area and herbarium samples are lacking.

4.3- Okra cultivation In India

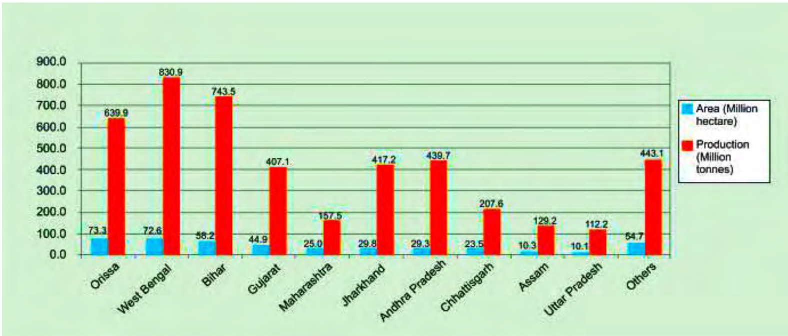
Eight *Abelmoschus* species can be found in India. Out of these*, A. esculentus* is the only known cultivated species. *A. moschatus* is a wild species but is also cultivated for its aromatic seeds, while the other six are truly wild. The wild species live in diverse habitats. The species *A. ficulneus* and *A. tuberculatus* spread over the semi-arid areas in north and northwestern India*; A. crinitus* and *A. manihot* (*tetraphyllus* and *pungens* types) in the tarai range and the lower Himalayas; *A. manihot* (*tetraphyllus* types), *A. angulosus*, and *A. moschatus* in Western and Eastern Ghats; and *A. crinitus* and *A. manihot* (mostly *pungens* types) in the northeastern region, depicting their broad range of distribution in different phytogeographical regions of the Country. Intra as well as interspecific variations do exist in different phyto-geographic areas. Existence of different *Abelmoschus* species in different areas of India observed in a recent survey is shown in **Table 6**.

S.No.	Species	Distribution
1.	A. angulosus	Tamil Nadu, Kerala
2.	A. cancellatus	Uttaranchal, Himachal Pradesh, Uttar Pradesh, Orissa
3.	A. crinitur s	Uttaranchal, Madhya Pradesh, Orissa
4.	A ficulneus	Jammu & Kashmir, Rajasthan, Madhya Pradesh, Chhattisgarh, Maharashtra, TamilNadu, Andhra Pradesh, Uttar Pradesh
5.	A. manihot ssp. tetraphyllus var. tetraphyllus	Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra, Orissa, Chhattisgarh
6.	A. manihot ssp. tetraphyllus var. pungens	Uttaranchal, Himachal Pradesh, Jammu & Kashmir, Assam, Andaman & Nicrobar Islands
7.	A. moschatus ssp. moschatus	Uttaranchal, Orissa, Kerala, Karnataka, Andaman & Nicobar Islands
8.	A. moschatus ssp. tuberosus	Kerala and parts of Western Ghats in Tamil Nadu
9.	A. tuberculatus	Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra

***Table 6* - Distribution of Wild Abelmoschus Species in different Phytogeographical Regions of India.**

Status of Okra Cultivation: in India the major *Okra* producing states are West Bengal, Bihar, Orissa, Andhra Pradesh, Gujarat, Jharkhand, Chattisgarh and Maharashtra.

Data around the area and the production of Okra in the major growing states in 2008-2009 are illustrated in **graph 3.**



***Graph 3* - Cultivation and production of Okra in the various Indian states for the year 2008-2009** (Source: www.nhb.gov.in)

A. manihot sp. *tertaphyllus var. megaspermus hemadri* is only reported from Indian states of Maharashtra, Gujarat and Madhya Pradesh, where it is cultivated in shady hill slopes and hills. *A. tuberculatus* is endemic in India and is the closest relative of cultivated *A. esculentus*. It is widely distributed in semi-arid regions of north and northwestern parts of India including Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, and parts of Andhra Pradesh (Pal et al., 1952).

- **Climate and Soil Requirements:** Okra requires a long, warm and humid growing period. It can be successfully grown in hot humid areas. It is sensitive to frost and extremely low temperatures. For normal growth and development, a temperature between 24°C and 28°C is preferred. At 24°C the first flower bud may appear in the third leaf axil while at 28°C it may appear in the sixth leaf axil. This higher position does not necessarily mean a delay in time because at higher temperatures the plants grow faster, and the higher position is reached earlier. For faster plant growth, higher temperature helps but it delays the fruiting. But at higher temperatures over 40°–42°C, flowers may desiccate and drop, causing yield losses. For the germination of the seeds, a proper soil moisture and a temperature between 25°C and 35°C is needed, with the fastest germination observed at 35°C. Beyond this lapse the germination will be delayed and weak seeds may not even germinate. Adjustment of climatic factors helps in taking at least one (summer) crop in the hills, two or even three (summer, kharif and late kharif) crops in the east, west and north Indian lowlands and almost year-round cultivation under moderate climate in south India. It is grown in sandy or clay soils but due to its well developed tap root system, relatively light, well-drained and rich soils are ideal. As such, loose, friable and well manured loam soils are desirable. A pH of 6.0–6.8 is ideal. The cultivar Pusa Sawani however has some tolerance to salts and thus also to a larger pH range. All the soils need to be pulverized, moistened and enriched with organic substance before sowing.

- **Growth and Development:** *Okra* mainly propagates by seeds and has a 90-100 days cycle. It is generally an annual plant. Its stem is robust, erect, variable in branching and varying from 0.5 to 4.0 metres in height. Leaves are alternate and usually palmately five lobed, whereas the flower is axillary and solitary. *Okra* plants are characterized by indeterminate growth. Flowering is continuous but highly dependent on biotic and abiotic stress. The plant usually bears its first flower one or two months after sowing. The fruit is a capsule and grows quickly after flowering. The greatest increase in fruit length, height and diameter occurs during 4th to 6th day after pollination. It is at this stage that fruit is most often plucked for consumption. The Okra pods are harvested when unripe and high in mucilage, but before becoming highly fibrous. Generally, the production of fibers in the fruit starts from the 6th day of the growth of the fruit and a sudden increase in fibre content is observed from the 9th day. (Nath, 1976). *Okra* plants keep on flowering and fruiting for an indefinite timelapse, depending on the variety, the season and the moisture and fertility of the soil. Infact the regular harvesting stimulates a continued fruiting, so much that it may be necessary to harvest every day in climates where growth is especially vigorous.

Although insects are unnecessary for pollination, the flowers are very attractive to bees and the plants are cross-pollinated. The cross pollination up to the extent of 4-19% (Purewal and Randhawa, 1947; Choudhury et al., 1970; Shalaby, 1972) with maximum of 42.2% (Mitidieri and Vencovsky, 1974) has been reported. The extension of cross-pollination in a particular place will depend on the cultivar, competitive flora, insect population and season.

The observation that a plant is capable of self-pollination has sometimes been made into an argument that isolation of self-pollinators is not necessary. On the contrary, the ability to self-pollinate often has little to do with the amount of cross-pollination that can occur naturally (McCormack, 2004). An isolation distance of 400 meters is required for the production of hybrids seeds in the case of Okra as per Indian minimum seed certification standards (Tunwar and Singh, 1988).

A. esculentus shows a particular kind of seed dormancy, called delayed permeability caused by the structure of the seed coat and particularly by the chalazal plug. A direct relationship between the seed moisture content and delayed permeability with variances between cultivars and moisture contents can be seen. Normal seeds harvested from the plants of the cultivars do not show seed dormancy.

Ladies finger or *Okra*, which is also known as "*Bhindi*", is one of the most important vegetable crops of India. It is grown in the tropical and sub-tropical regions and also in the warmer parts of the temperate regions. *Okra* has a good potential as a foreign exchanger crop and accounts for 65% of the export of fresh vegetables. It is cultivated in 500.000 ha area with the production of 6.000.000 mt and productivity of 9.6 mt/ha (2017-18 National Horticulture Board - Ministry of Agriculture and Farmers Welfare Government of India).

The major *Ladies Finger /Okra* producing states in India are Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pradesh and Karnataka.

- *Climatic Condition*: Ladies finger requires long warm growing season during its growing period. It gives good yield in warm humid condition. It grows best within a temperature range of 22-35°C. It can be successfully grown in rainy season even in heavy rainfall area. *Bhendi* is highly susceptible to frost injury. Seeds fail to germinate when temperature is below 20 °C.
- *Suitable Soil:* Ladies Finger or Bhendi can be grown well in all kinds of soil. But sandy loam and clay-loam soils are best for its cultivation. The optimum pH range is between 6 and 6.8. Soils with high organic matter are preferred so that cartloads of FYM (Farm Yard Manure) or compost should be incorporated during land preparation. Soil should have good internal drainage.
- *Irrigation/Water supply:* The Bhendi crop requires adequate moisture in the soil during summer months for faster growth. Drip irrigation is most suitable as it provides uniform moisture throughout the season. The daily water requirement is 2.4 l/day/plant during early growth stage and 7.6 l/day/plant during the peak growth stage. The irrigation system should be operated daily for 75 minutes during initial growth stage and for 228 minutes during peak growth of the crop with an emitter capacity of 2 l/h. Water supply on each day or on alternate days with on-line type of drippers is preferred.
- *Application of manures and fertilizers:* In order to maximize the yield about 30 t of FYM (Field Yard Manure), 350 kg Super phosphate, 125 kg Murate of Potash and 300 kg Ammonium sulphate should be applied in the rows before sowing for one hectare of land. Nitrogen should be applied through fertigation in three split doses.
- *Weed control:* As *Bhendi* is harvested over a long period, weed control happens to be an important cultural operation. Weeding, thinning and earthling up is the important intercultural operations of *bhendi*. Earthing up in the rows should be done in rainy season crop.

Application of herbicides for controlling weeds in *bhendi* is found effective. *Basalin (Fluchoralin* 48%) 1-2 liter per hectare, and soil application of *Tok-E-25* - 5 liter per hectare effectively controlled the weeds. Shallow rooted inter-row cultivation and hand weeding may be used to minimize weeds in the inter row zone. Black plastic mulch may be used to suppress weed growth, also keeps the soil warm and encourages plant growth.

- *Pests and Diseases:* The control measures for insects, pests and disease depend on the ype and intensity of the problems. The control measures for the main pests and diseases in *Ladies Finger Farming* are stated below.

Flea beetles is the major insect for *Bhendi/Okra*. This can be controlled with row covers or applications of *Rotenone* or *Pyrethrin*.

Bhendi is susceptible to diseases such as *Verticillium*, *Fusarium* and several other fungal diseases in wet season. These diseases can be controlled by proper crop rotation and good garden sanitation.

- *Harvesting:* Flowering begins from 35 to 40 days after sowing. Crop is harvested in 55 to 65 days after planting when pods are 2 to 3 inches long. At this stage the pods are still tender. Larger Okra pods will tend to be tough and fibrous but are good to use for slicing and freezing. Since Okra grows very fast, it should be harvested every two days. The pods should not be allowed to mature on the plant because this will inhibit more pods from developing and will reduce the productivity of the plant. Handling Okra should be done carefully because the pods can bruise easily.

The yield of *Bhendi/Okra/Ladies Finger* varies from 5 – 7 ton/ha in the summer to 8 – 10 ton/ha in the rainy season.

Ladies Finger has a short storage life. A fresh good fruit can be stored for 7-10 days at 7-10 °C temperature and at 90-95% relative humidity. At temperatures below 7 °C *Okra* suffers chilling injury, which results in surface discolouration, pitting and decay.

Harvested *Okra* or *Bhendi* can be easily moved to local vegetable markets.

As vegetable prices are constantly increasing and the crop requires a low investment, this can be a good commercial investment if we owe a land with good management practices.

B) EXPERIMENTAL PART

5.- Overall objective

There are many problems concerning the growth of horticulture in India such as the fact that the villages are never aware of the banking service for investment in the horticulture sector, connectivity and transport remain major obstacles, the irrigation and the fertilizers are missing as well as the cold storage facilities.

Most of the farmers are illiterate and unable to use the horticultural schemes within the NHH (National Horticulture Mission).

There is no awareness to remove harmful insects and rodents, the farmer has not been trained and almost all the farmers invest their savings.

Other problems the lack of market, the use of tools and equipment for traditional agricultural activities such as daos, ax sickles, spades, crober, leverage, etc.

Last but not least is the fact that transplanting plants are never used, but direct seeding in the fields is done instead and great part of the seed gets lost. In regard to this, the focus of my thesis is addressed to the elaboration of a report of my research activities about the facilitation of horticultural crops in poor developing countries, through the use of the method of my own invention S.B.M. for the production of transplanting seedlings; it has a good potential and the role to alleviate the rural poors and using with intelligence the few resources available, such as empty plastic bottles, waste materials and at no cost, can easily increase and improve family horticulture activities which are indeed of primary importance in the rural India.

5.1 - Specific objectives

The aim of my research is to verify the validity of a nursery created with my S.B.M. method (Seedbed Bottle Method) in Auroville in Tamil Nadu (India) in the subtropical area, and to compare it to a traditional seedling on a plot of land which is later transplanted into black plastic polypots plant (polytene bags).

6 - Methodology

This section outlines the procedures and methods used to obtain the data necessary for the study. It includes the description of the area studied, the research project, the studied seedbed, the characteristics of the samples and the sampling techniques, the tools and the procedure of data collection and the methods of data analysis. The pilot experimentation of the "S.B.M." seedbed method at the Auroville ecovillage (India) was personally done by me at the Urban Farming Garden in City Town.

After the positive results obtained from the experimentation, the S.B.M. has been adopted as the new method for the production of transplanting plants for the Urban Farming vegetable garden and the nursery site is now used for demonstrative guided tours in order to teach the method to all Auroville residents interested in applying the method in their family gardens.

Materials used:

N. 54 empty of 2 liter CocaCola plastic bottles
N. 1 box cutter
Pen and notebook
N. 1 pair of scissors
Ruler
Magnifying glass
Camera
Shading curtain
N. 10 bags of topsoil for a total of about 0.4 mc
N. 1 10-liter watering can
N. 1 bar indexed for calculating volumes of water
N. 432 seeds of Okra esculentus
Anti-cat and anti-bird sticks
Labels
Felt tip pen
Precision balance
Electric oven for drying samples
Manual work tools (hoe, spade, pickaxe, shovel)
Sprayer for phytosanitary treatments
Plant protection products (Neem oil, sulfur and copper oxychloride)
Sower
Full container of water to free the roots of the samples from the ground

The methodology adopted for the experimentation was carried out as follows:

1) Collection and selection of 2-liter Coca Cola bottle vacuums at the "Eco-Service" Waste Management Center in Auroville.

2) Preparation of seed bottles

3) Purchase of Okra seeds and about 0.4 mc of topsoil at the Botanical Garden of Auroville

4) Purchase of the shade cloth and plant protection products in Pondicherry

5) Choice and arrangement of the experimental nursery installation site

6) Seeding

7) Daily counting and logging of germination from the growth of the first seedling to the last emergency

8) Evaluation of the daily phytosanitary status of the seedlings

9) Stripping and labeling of the first 5 seedlings of the second row of each pitch and each group of bottles

10) Collection of sample seedlings during growth (size, height from the ground, number of leaves, flower primordium)

11) Extirpation of the sample plants and cleaning of the soil from the roots

12) Analysis and measurements of the fresh extirpated samples: diameter at the collar of the seedlings, length of the stem, length and width of the root, total weight of the fresh plant and weight of the aerial part only

13) Labeling and drying of samples in an electric oven for 4 days open. at 103.8 ° C

14) Weighing dry samples with a precision scale: single plants and roots (NB: the dried roots, not individually weighable, are dried, cataloged and weighed in groups of 5 according to the groups they belong to)

6.1 - Description of the study area - Auroville

The experimental nursery was built in the Urban Farm garden in Town City, in the heart of Auroville, a short distance from the Matrimandir and the Ecovillage Administration Center.

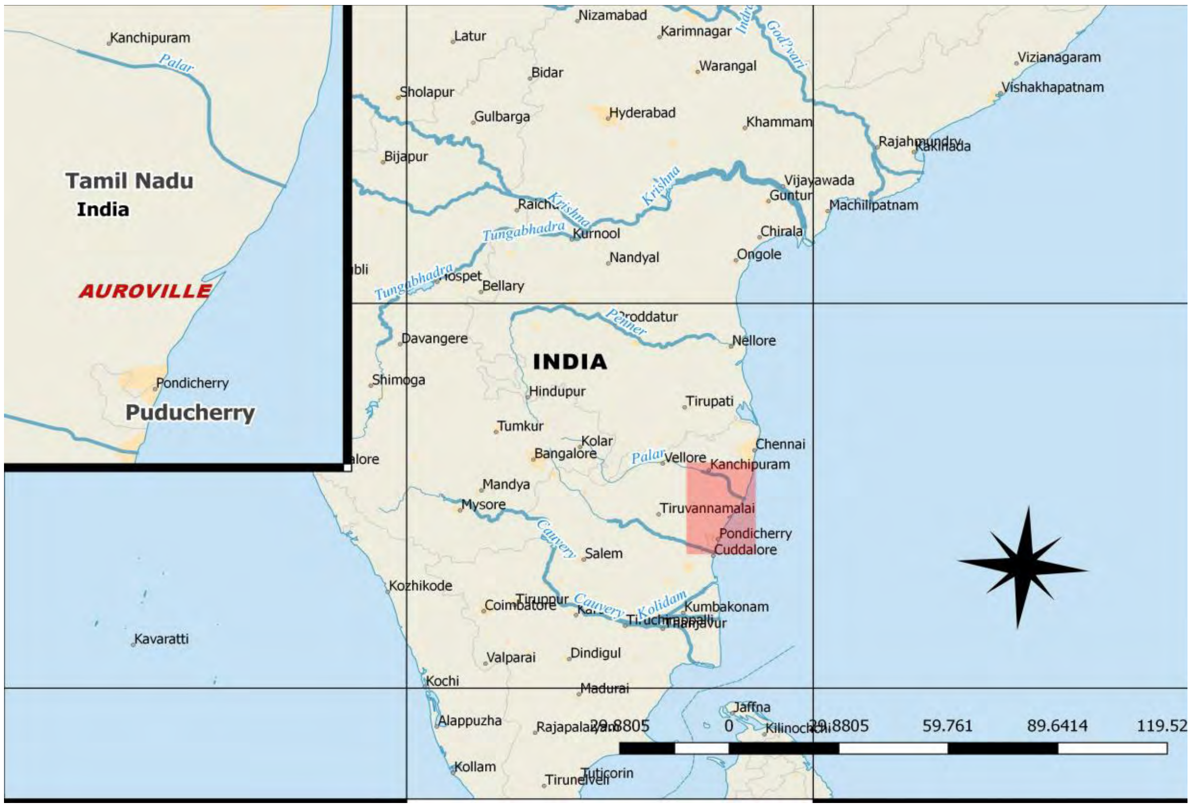


Figure 4 **– Auroville.**

Auroville's international ecovillage stands on a land that was made a desert by the indiscriminate use of timber and deforestation in the early 1960s, and today the whole site has been reforested by the activity of the volunteers in succession until today.

Auroville **(figure 4)** is located southeast of India in the state of Tamil Nadu and is made of a cluster of properties about 12 km (7.5 mi) north of Pondicherry. It can be easily reached via the East Coast Road (ECR) which connects Chennai and Pondicherry. The visitor centre and Matrimandir can be reached by travelling 6 km (3.7 mi) westwards from the signposted turnoff at the ECR Bommayapalayam. The geographical coordinates of Auroville in decimal degrees are:

- **Latitude:** 12.0054900°
- **Longitude:** 79.8088500°
- **Elevation above sea level:** 55 m = 180 ft

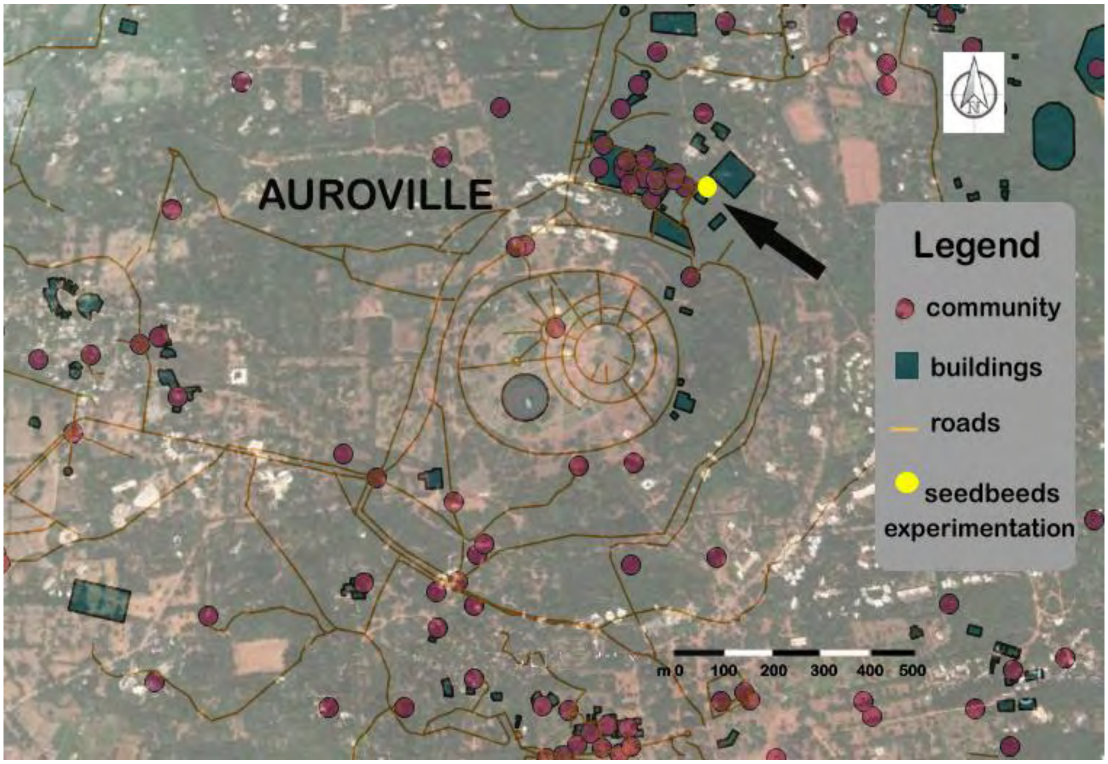
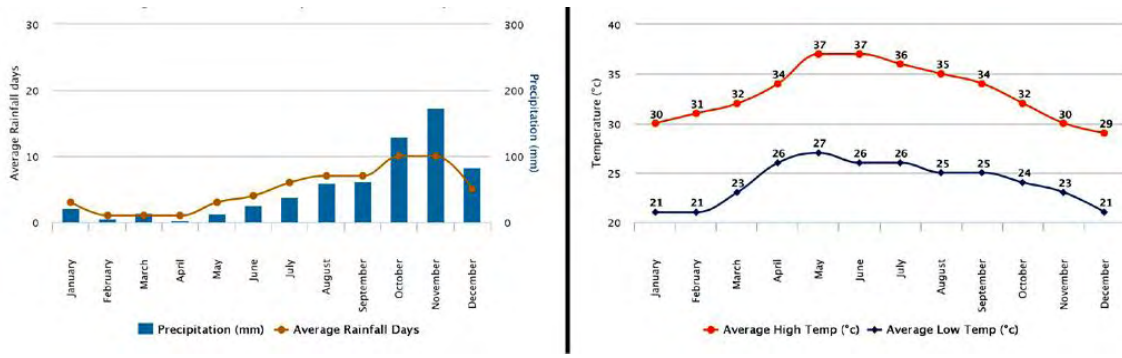


Figure 5 – **Auroville and location of the seedbed experimentation site.**

The experimental tests comparing the two types of seedbeds were carried out at the urban agriculture garden of City Town in Auroville **(figure 5).**

6.2 – Climate, soil and topography

There are not climate stations in Auroville with recorded data, and consequently the study of the climate has been based on the data available for the town of Pondicherry, located 12 km south of Auroville by the coast.



***Graph 4 – On the left:* average rainfall (mm) in Pondicherry*. On the right:* average temperature (°C) in Pondicherry**

Auroville has a tropical climate, it is part of the sub-humid tropics and is located on a plateau region with its maximum elevation of 32 m (105 ft) above sea level, in the Matrimandir area. The dry season usually lasts seven months, from January to July. May and June are the hottest months with occasional showers. The main rainy season goes from October to January. The average annual rainfall is 1,230 mm **(graph 4 - left).** The average maximum temperature is 32.2°C, and the average minimum is 20°C **(graph 4 - right).**

The prevailing wind blows from the southeast.

The central part of the designated Auroville township area is more than 50 m above mean sea level. The site slopes down from the centre to the periphery. The uncontrolled outflow appears to have been the main cause for the erosion of neighbouring land. The deeper canyons are mainly located in the east and south of the designated area. There are a few water bodies or 'eris' in and around the township, of which Irumbai eri is the largest one.

The geological structure of the area as indicated in **figure 6** reveals that the topsoil is hard laterite on a bed of clay of various depths. The soil is not suitable for productive agriculture with traditional methods.

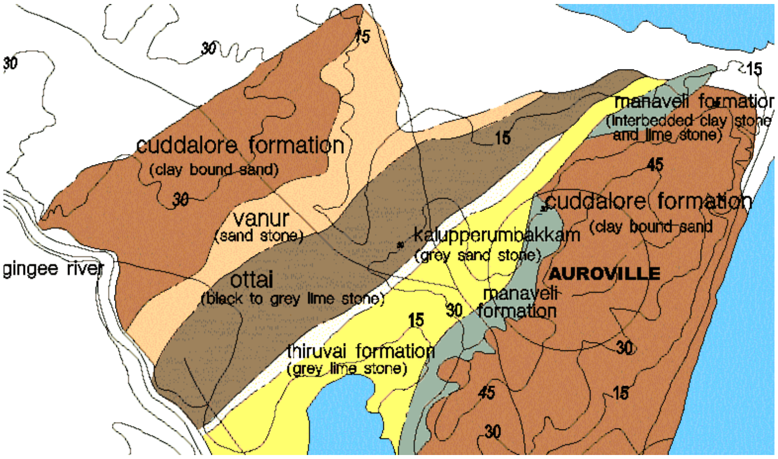


Figure 6 **– Geology of Auroville and surroundings**.

This was also confirmed by the District Officer in 1976, who concluded that "*the entire area is exposed to wind and water. If this is allowed to continue, then agriculture will be impossible…"* The area also falls in the cyclonic belt.

6.3 - Vegetation

Auroville's greatest achievement is likely to be environmental. When people arrived during the sixties, Auroville looked like the surface of Mars **(photo 11)**, because the British took all the trees with them when they left (Case Study Detail) After a massive work of replantation, today Auroville looks like a big forest with an eco-sustainable city that represents the ideal city of the future **(photo 12).**

Photo 11 **– Auroville as it appeared in the early 60s.**

In the Auroville plateau, especially in ravines and their surroundings where thirty years ago only thorn bushes and some *Gramineae species* had survived, it is now possible to observe an increasing diversity of species recolonizing the lost ground, especially in protected areas. In very degraded lands the recolonisation process can still be observed with the brave pioneers: Gramineae (*Heteropogon contortus*), Cyperaceae (*Cyperus pygmaeus*) or Boraginaceae (*Coldenia procumbens*).

Over the past ten years the grazing pressure has dramatically decreased, mostly due to the employment provided by urbanisation and because children are going to school, rather than herding goats and cattle. Gramineae protectively cover the entire ground and the thorny shrubs become erect: *Heteropogon contortus* (Gramineae), *Catunarega dumetorum* (thorny shrub). Thorny plants begin to give way to unarmed species, *Dodonaea viscosa*.

In some areas, the process of succession has been relatively fast. For example, bush clumps group around *Palmyra Borassus flabellifer* palm trees, wild *Phoenix humilis* or *Phoenix sylvestris*, harbor species of *Ficus amplissima*, *Ficus benghalensis*, *Morinda tinctoria*, *Bridelia retusa*, *Atalantia monophylla*, *Tarenna asiatica* or *Maytenus emarginata*. Birds eat the fruits of these species and spread their seeds in their feces. Thanks to this growing system, sheltered by the preceding species, it is possible to recover relics of original climax species such as *Memecylon* *umbellatum*, *Ixora arborea*, *Ochna obtusata*, *Maba buxifolia*, *Canthium diccocum*, *Syzyigium cumini*, *Buchanania angustifolia* or *Strychnos colubrina*.

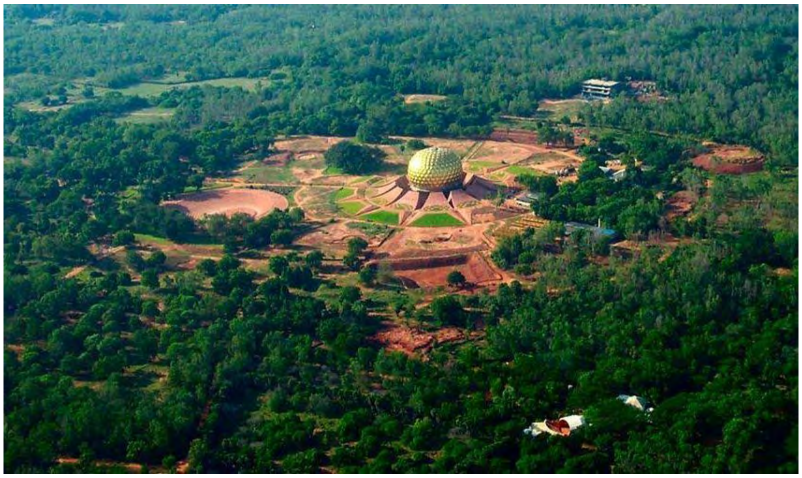


Photo 12 **– Auroville today.**

In the areas close to where the reintroduction of fruiting *Mimusops elengi* (one of the largest trees of the original climax vegetation) was carried out, plenty of wild seedlings appear in a protected environment. Where small mammals such as the civet cat and fruit bat have started to disseminate seeds of the climax species, it is now possible to find seedlings of *Caryota urens*, *Canthium dicoccum*, and *Bassia longifolia*. The areas that have had the longest protection (25 years), where older trees such as the *Azadirachta indica* (Neem) shade the ground, are now the stage of the re-establishment of the undergrowth of the climax forest with species such as *Murraya paniculata* and *Murraya koenigii*.

6.4 - Society and people

Auroville was born on the 28th of February 1968. Its founder, the Mother or Mirra Alfassa (Paris 1878 - Pondicherry 1973) read Auroville's Charter on the day of inauguration ceremony held on Wednesday 28th February 1968, which was attended by delegates of 124 nations *All India Radio* (AIR) broadcast live in 16 languages the Charter which consists of four main ideas: *"1 - Auroville belongs to nobody in particular. Auroville belongs to humanity as a whole. But, to live in Auroville, one must be a willing servitor of the divine consciousness. 2 - Auroville will be the place of an unending education, of a constant progress, and a youth that never ages. 3 - Auroville wants to be the bridge between the past and the future. Taking advantage of all discoveries from without and from within, Auroville will boldly spring towards future realisations. 4 - Auroville will be a site of material and spiritual researches for a living embodiment of an actual human unity."*

The name Auroville comes from Sri Aurobindo, or Arvind Ghosh (Kolkata 1872 -Pondicherry, 5 dicembre 1950), a revolutionary, visionary, philosopher and sage who is very well known in India and whose revolutionary endeavors against the British regime predate those of Gandhi.

Auroville is an international, intentional community—meaning that people choose to come and live in Pondicherry. There are people from all over the world, with the majority being from India and its various states. Auroville is a spiritual community, whose ethos is based on the teachings of Sri Aurobindo and his compatriot, The Mother, who founded the place in the sixties. Auroville was not meant to be a place for a new religion, or where religion is practiced. Spirituality, for them, meant something vast and ultimately indefinable, something personal that varied from one individual to the next, something that must always be renewed and expanded and reexamined, as opposed to religion, which often becomes calcified, stagnant and dogmatic. Auroville attracted many people. There are the spiritual seekers or devotees of The Mother and Sri Aurobindo; there are those who seek to find a different and new way of living, who are disillusioned from the normal flow of the society; there are those with a green vision who are interested in organic farming, alternative energy, etc, and a sustainable lifestyle.

Auroville was supposed to be a moneyless society, with everybody's needs provided for, but this did not really work out. There are some socialist elements such as an affordable and universal healthcare, as well as a common dining area where members of the community may choose to have subsidized meals. Auroville was also meant to be a rather equal society, but, as any other place, there are those who are well-off and those who struggle; there are mansions and there are shacks. Auroville receives money from the government, $200,000 a year, as well as private donors on top of the money that Aurovilians pay. The site is also protected by UNESCO since 1968 and it relies to a large extent on volunteers who come and spend some time there performing various activities such as planting trees, helping to serve food, uplifting local populations, etc.

It is like a microcosmos in the world, with people from everywhere, speaking a whole variety of languages, and bringing in many interesting and different cultural, social and personal views and understandings.

In Auroville there are 2852 residents (last census of 2018) of 56 different nationalities **(table 7)** and there are at least 5000 villagers who come to work every day for Auroville's structures, units and buildings.

Every year, especially during the winter season, thousands of tourists arrive in Auroville, tripling the population.

Summary:

Adults:	2155	F: 1080	M: 1075
Children:	697	F: 344	M: 353
Total:	2852	Nationalities:	56

Details:

Indian	1252	Austrian	13	Lithuanian	2
French	401	Brazilian	11	Ethiopian	2
German	248	South African	11	Philippines	2
Italian	153	Hungarian	8	Iceland	2
Dutch	103	Argentinian	8	Irish	2
American	94	Iranian	6	Rwandese	2
Russian	71	Slovene	6	Bulgarian	2
British	60	Nepali	6	Portuguese	2
Spanish	56	Mexican	5	Taiwan	2
Israeli	46	Latvian	4	Finnish	1
Swiss	43	Kazakh	4	Indonesian	1
Belgian	39	Colombian	4	Ecuador	1
Korean	37	Macedonian	4	Luxemburgish	1
Swedish	27	Belarusian	4	Egyptian	1
Canadian	23	Danish	3	Romania	1
Ukrainian	21	Tibetan	3	Czech	1
Australian	16	Sri Lankan	3	Polish	1
Chinese	15	Norwegian	2	Algerian	1
Japanese	13	Moldova	2		

***Table 7*– Auroville residents: breakdown by nationality (May 2018).**

6.5 - Economy

Some money comes from the Government of India, mostly for education and projects for the *"Auroville Development Scheme"*, and occasionally for road works.

More money comes from NGOs and other organisations in India and abroad, from the profits of commercial units within Auroville, from many *"Auroville International"* centres around the world, from guest houses, from cash donations made by visitors and guests, from outside well-wishers and from the families of Aurovilians, and - of course - from the Aurovilians themselves.

There is no private ownership of lands, houses or businesses in Auroville. Aurovilians are constantly investing in lands, houses and businesses owned by the collectivity. People setting up (or joining existing) commercial activities can expect, if successful, to be able to support a modest lifestyle within certain informal norms. In Auroville work is not a mean for earning a living but for serving the divine.

The community meets everybody's needs, and provides a cash allowance or 'maintenance' sufficient to live a simple life with a moderate dignity.

Nowadays Auroville is self-sufficient only for milk and some seasonal fruits. It produces only part of its total rice and grain requirements, and less than 50% of its total fruit and vegetable requirements. We are trying to improve this situation through a sustainable agriculture.

6.6 - The Urban Farming Project

In Auroville every family usually grows its vegetable garden, makes bread, recycles and reuses everything. Foreigners, fed up with the Western system, cultivate, meditate and look for a place to belong to. After two years of volunteering, you get a five-hour a day job and the rest of the time is spent on your own activities.

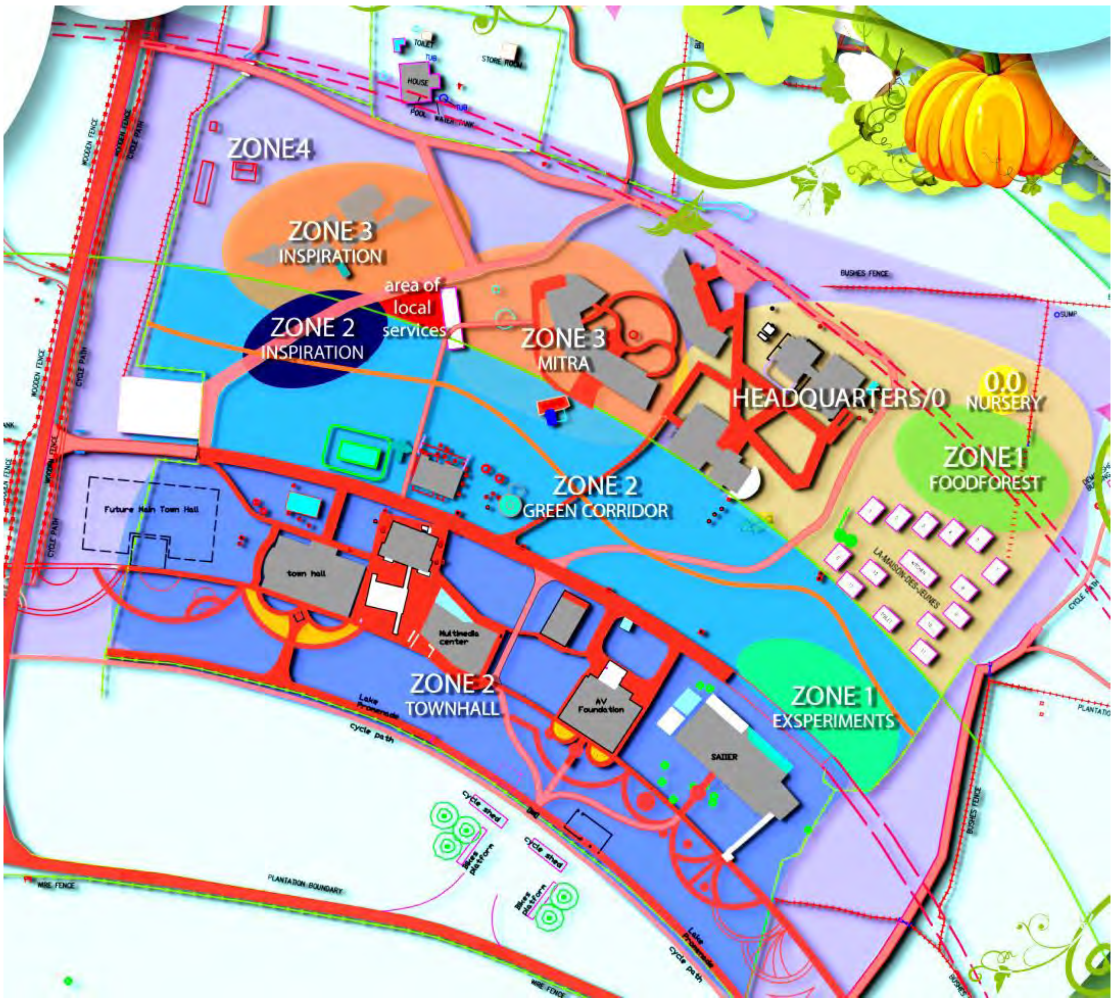


Figure 7 - **Map of the Urban Agriculture Project at Auroville.**

In 2015 though, the urban agriculture project **(figure 7)** was born in the central area of the city (City Center).

Auroville Urban Farming is a pilot project born in the City Centre for experimentations, learnings and tests for the creation of a city in a deep harmony with nature. It applies to innovative concepts like integral landscaping, rooftop gardening, agroforestry, grey-water system recycling, participation and effort of the community in the contruction processes in the attempt to address issues like Food Safety in an urbanizing context. The main goal of the project is to promote and educate the residents on self-production, to achieve the nutritional self-reliance of the Universal Township.

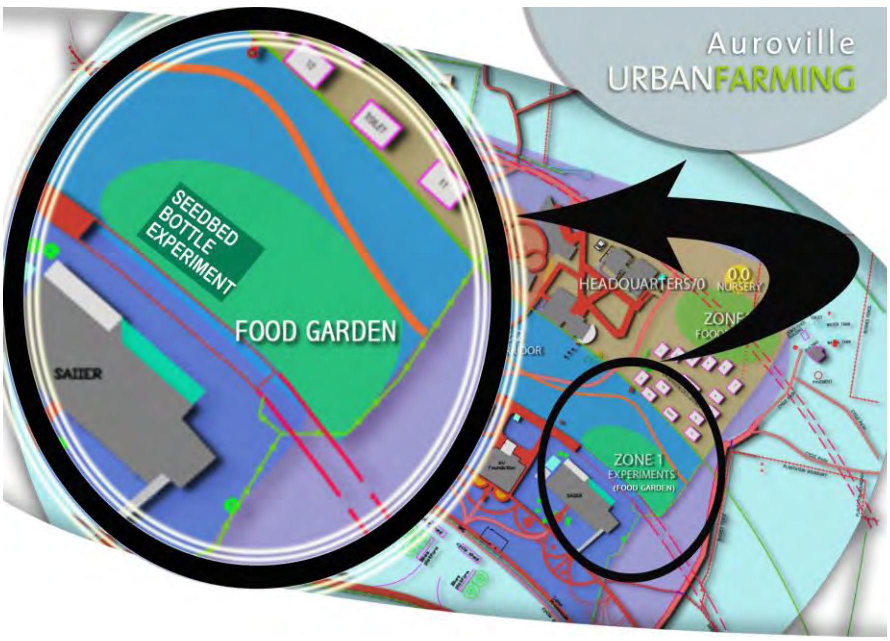


Figure 8 **– The Seedbed Bottle Experiment.**

It aims to create a stronger evenness between Nature, Human Beings and Spirit.

Inside the Urban Farming project and precisely in the vegetable garden of Zone 1 it was made possible to me to experiment the two seeding methods of my thesis **(figure 8).**

7 - Experimental design and analyzed parameters

- • **Species used:** *Okra* or *Ladies finger* (*Abelmoschus esculentus L.*);
- • **Seedbeds:** B = Bottles (in groups of 9 bottles for 6 sections labeled from S1B1 to S1B6); C = Control (listed in 6 pitches labeled S1C1-S1C6);
- • **Precision sowing in S1B1-S1B6 seedbeds bottles:** 4 seeds per bottle for a total of 54 S.B.M. (seedbeds) divided into 6 groups of 9 bottles each labeled from S1B1 to S1B6 for a total 216 *Okra* seeds;
- **Precision sowing on S1C1-S1C6 sectors:** precision sowing on the same soil surface 40 cm x 40 cm arranged in 6 rows of 6 seeds each on 6 small plot of land 15,7" x 15,7" for a total of n. 216 seeds labeled from S1C1 to S1C6.

The project consists in comparing 2 different types of seedbeds: 6 experimental seedbeds of 9

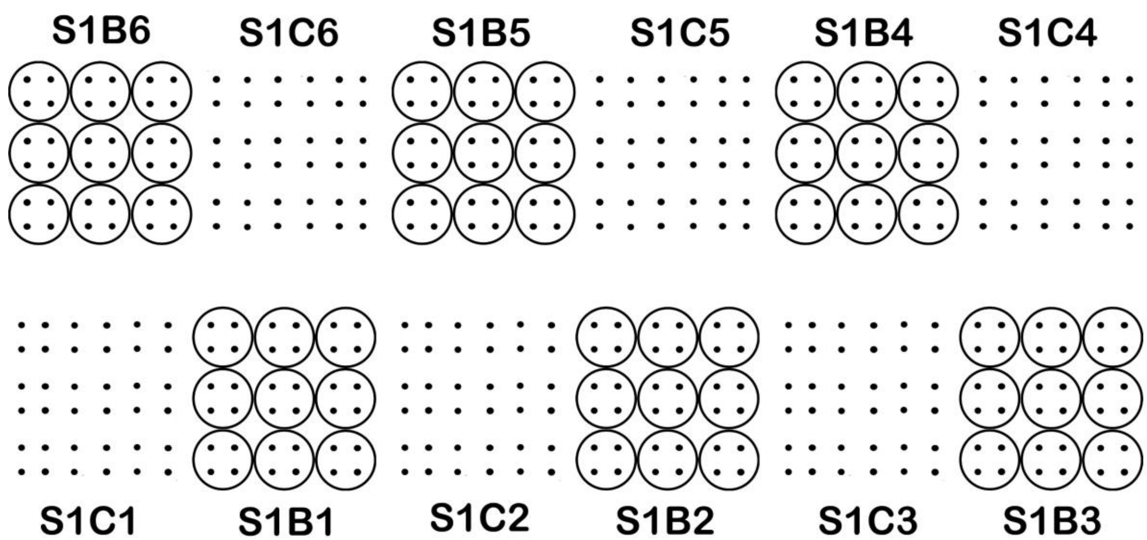


Figure 9 **– Experimental seedling scheme with alternating groups of bottles and traditional pitches:**
S1C1-S1C6 = traditional method
S1B1–S1B6 = seedbeds bottles groups.

groups of plastic bottles which alternate with the same number of traditional seedbeds in sowing sites **(figure 9 + photo 13)**

Photo 13** – **a) group of 9 seedbeds (S.B.M.). b) **traditional control pitch (15,7" x 15,7") with anti-cat and anti-bird system*. c-d)* arrangement of groups of seedbeds and traditional small plot of land for the sowing of the *Okra.***

Both types of seedbed are under the same light, temperature and water and contain the same type of soil (topsoil), purchased from the Botanical Garden of Auroville.

In order to avoid an affect on the growth of the plants, fertilizers have not been used but a simple and natural topsoil and rainwater collected in tanks. The S.B.M. (*Seedbed Bottles Method*) is made up of 6 groups of 9 seedbeds each, for a total of 54 seedbeds;

The stretch of the surface of each group of 9 bottles is equivalent to the area of a traditional pitch of 15,7" x 15,7" **(photo 13 - b).**

Precision seeding has been done and 4 seeds of Okra were sown in every bottle at a distance of 0,40" from each other, while 36 seeds arranged on 6 rows of 6 seeds each and at a distance of 0,40" from each other were sown in each pitch in order to get the same pattern and distances of the seedbeds bottles. **(photo 14).**

The seeds of Okra that have been used were 432 in total, divided as follows:

- 4 seeds for each seedbed bottle x 9 bottles x 6 groups = 36 x 6 = 216
- 36 seeds for each pitch arranged on 6 rows of 6 seeds = 216

Photo 14 **– The distance between the plants is the same both on the pitches (photo on the left) and in the seedbeds (photo on the right).**

7.1 – Project management and calendar of activities

The entire experimentation project on the tests of germination of the *Okra* in the two compared seedbeds was being held in Auroville (India) from the 26th December 2016, with the preparation of the site and the seedbeds, until the sowing on the 1st January 2017 and then the extirpation of the plants, in the middle of February, for sampling and the analysis of the samples dried in the oven for 4 days at 103.8 ° C. Along with the *Okra*, two other species (*Papaya* and *Chickoo*) had been sown for testing, but because of their slow development it was not possible to me to include them in my experimentation work due to my short stay in India.

The work phases were as follows:

1) Preparation of the nursery;

2) Collection of empty plastic bottles and preparation of the S.B.M.;

3) Seeding;

4) Labeling of the plants;

5) Management and calendar of activities;

6) Final data collection.

7.1.1 – Preparation of the nursery and collection of empty plastic bottles

It was important for the preparation of the nursery to choose the site taking into account its orientation for a maximum sun exposure. The site was then identified in the Urban Farm garden of City Town and was immediately cleaned up and the surface leveled up. **(photo 15 a-b)**.

A cover with a shade cloth was then added to protect the ground from any damage of heavy rain **(photo 17 - top)**.

Photo 15 - Site preparation for the nursery: a) **site in origin*. b)* leveled and cleaned site. *c)* sacks of topsoil *d)* topsoil (particular).**

Since the natural soil was too poor in organic substance, compact and therefore not suitable for the development of seedlings and seedlbeds, vegetal soil was purchased from the Botanical Garden in order to make the sowing ground more suitable without the addition of any soil improvers and / or fertilizers **(photo 15 c-d)**.

Photo 16- Construction of seedbeds: a-b) selection of empty plastic bottles. c) group of 9 seedbeds. d-e) detail of the bore of the cap.

The empty plastic bottles were collected from the "*Eco-Service*" Waste Management Center in Auroville, and then the 2 liters' only were selected; Coca Cola bottles were the only 2.25 liters'. (photo 16 a-b). At this stage, the bottles were first pierced with a trincet blade and then cut with a pair of scissors, so a water tank (the lower part of the bottle) and a small pot (the upper part of the bottle) filled with soil for sowing and plant growth were made from each bottle. **(photo 16 c-d)**. Afterwards, the caps **(photos 16 - e)** were holed and the bottles filled with topsoil and placed in groups of 9 seedbeds in the corresponding spaces of the nursery, alternate with the traditional pitches. **(photo 17 - bottom)**.

Photo 17 - At the top: **cover with shade cloth*****. At the bottom:*** **nursery almost ready for sowing*****.***

7.1.2 – Seeding

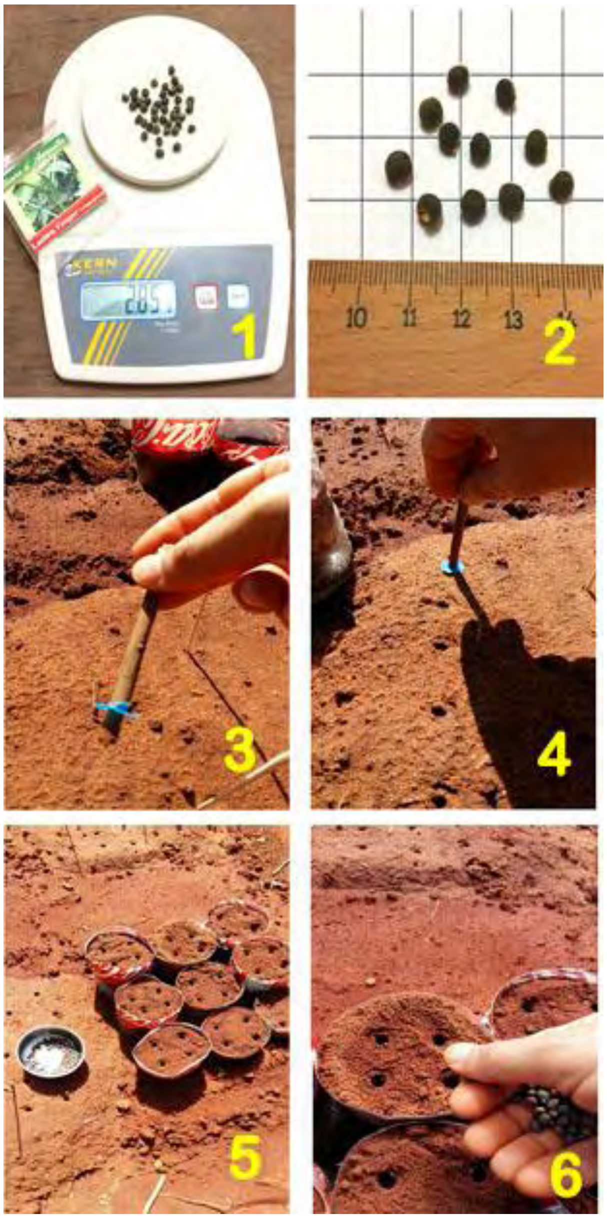


Photo 18 **- 1-2: *okra seeds.* 3-4: *Self-built seed drill.* 5-6: *okra seeding.***

The 432 seeds of *okra* (*Ledies Finger*) used for the sowing, were purchased from the Botanical Garden of Auroville in sachets of 40 selected seeds each. The net weight of each sachet was g 2.85 (**photo 18 - 1**), each seed weighed then on average 0.07 g. The *okra* seeds have a round shape with a diameter of about 5 mm (**photo 18 - 2**).

The sowing was done simultaneously on the seedbed bottle and on the traditional pitch and the previous day the first water had been given to moisten the soil.

At the time of the sowing the seeds were dry and did not undergo any pregermination pretreatment.

The constant seeding depth of about 1” was fulfilled using a simple self-built sowing tool. It was a wooden sprig of right thickness and length; into the tip was inserted a plastic hoop, cut out from a bottle cap (**photo 18 - 3-4**), which, acting as a knocker on the ground, allowed the adjustment of the depth of the hole for the sowing the seed (**photos 18 - 5-6**).

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7.1.3 – Labeling

Three types of labeling were performed and in 3 different ways:

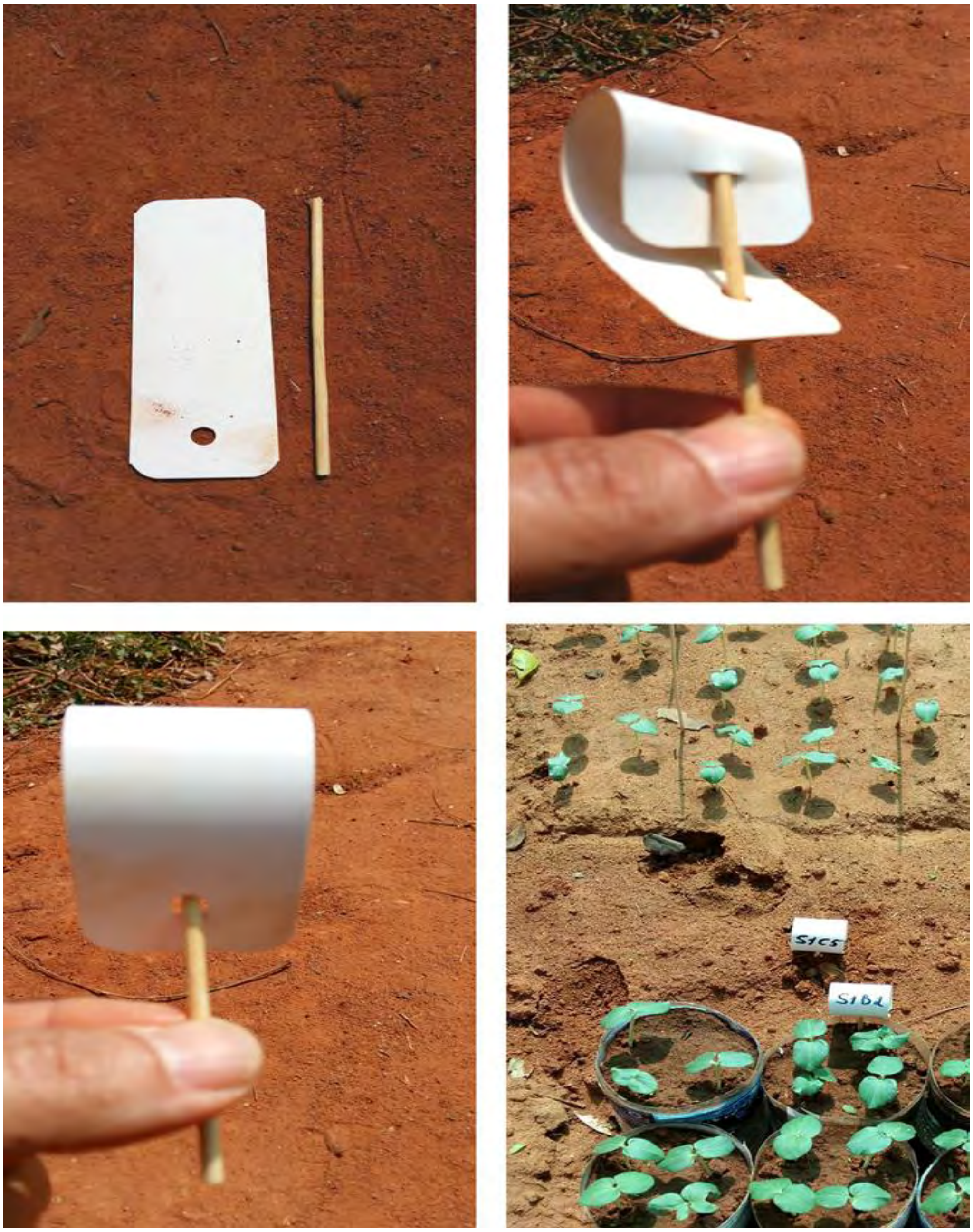


Photo 19 - **Creation of labels for seedbeds.**

• 1) **Labeling of seedbeds**: in order to number the sectors of the seedbed, a support for the labels was created using wooden sticks to be inserted into the ground **(photo 19)**.

• 2) **Repotted plant labeling**: the same rainproof plastic labels were applied interlocking on the edges of the plastic bags for the cataloging of the 5 sample plants for each sector of the seedling **(photo 20)**.

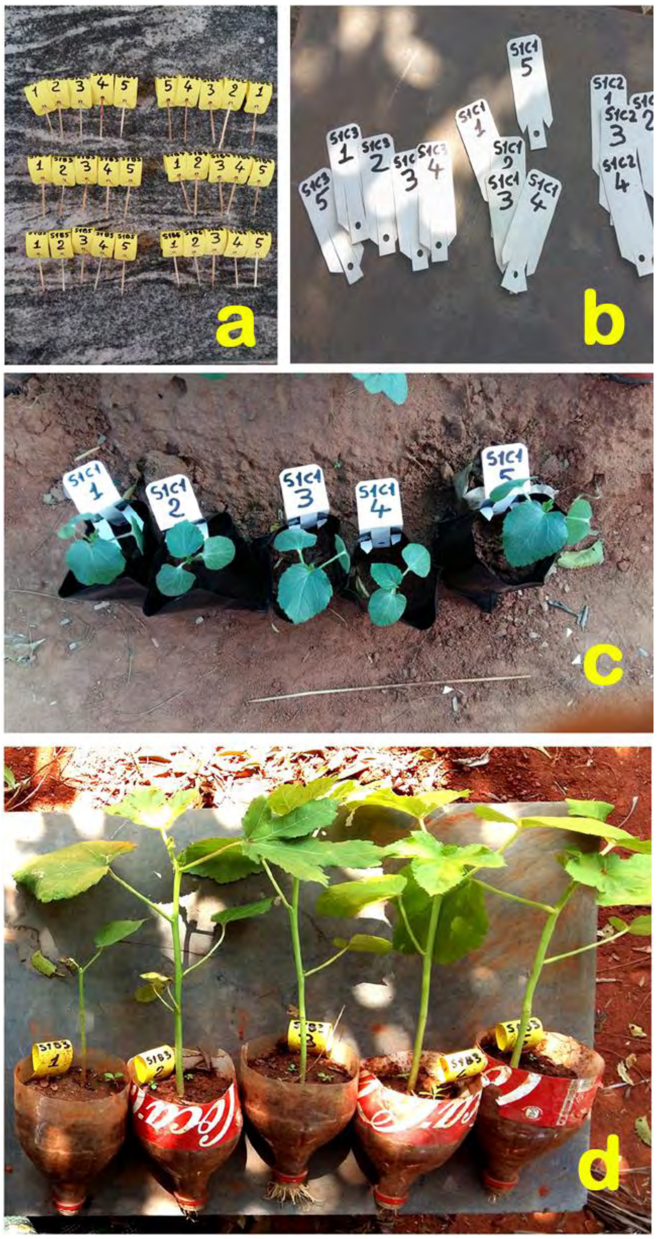


Photo 20 **- Labeling of repotted seedlings plants*****: a)*** **labels for seedbeds.** ***b)*** **labels for plastic bags.** ***c-d)*** **labeled plants.**

• 3) **Labeling of the plants to be dried**: the labels for the catalogation were also fixed to the plants before being dried in the oven (**photo 21**).

Photo 21 - **Labeling of plants to be dried.**

7.1.4 – Phytosanitary treatments

Shortly after the germination, during the first phase of the growth of the seedlings, the first damages appeared due to attacks from phytophagous parasites such as insect larvae and thrips (photo 22), and virus infections; subsequently mites (red spider mice) attacked the plants but this has fortunately been solved from the first onset by using Neem oil, a biological product with repellent action.

In order to prevent fungal infections, a sulfur-based treatment was done along with a copper oxychloride's one.

Photo 22 **- Attacks from phytophagous insects.**

7.1.5 − Repotting operations of the seedlings chosen for comparison

Similar to a traditional seedbed, which works through the sowing on a plot of land and the subsequent transfer of the seedlings into phytocells of plastic sachets, the S.B.M. is also able to fulfill every stage of the growth of the seedlings, from the germination of the seeds to the repotting of the seedlings in additional seedbed bottles, in order to have a seedling for each container.

During the phase of repotting the plants, which will subsequently become the samples to be compared, we tried not to make any preferential choice, but a random criterion was adopted by taking the first 5 seedlings from the second row of each group of bottles and of each plot of land, starting from the left side of the row (**photo 23 - top left**).

The seedlings were taken during the development phase of the third or fourth real leaf. Each of the 5 seedlings taken from the seedbeds of the second row of each sector has been potted into a seedbed bottle, likewise each of the seedlings taken from the plots of land have been repotted into a plastic bag (**photo 23 - bottom**).

Simple topsoil was used without any addition of organic or mineral fertilizers.

***Photo 23 - At the top:* picking the seedlings*. At the bottom:* sowing of the 5 plants per sector both in plastic bags and in a seedbed bottle.**

7.1.6 – Sampling and drying of plants

Before sampling, the roots were removed from the topsoil by gently manipulating the clods of soil and then soaking them into a container full of water for a better cleaning and again into another container with clean water, in order to remove all the remaining soil. (**photo 24**). Subsequently all the measurements for the sampling were taken. (**photo 25**).

Photo 24 **- Washing and cleaning of roots from the soil:**

a) Seedling in seedbed bottle
b) Seedling in a plastic bag
c-d) The two different clods of earth
e) Root washing
f) post-wash result.

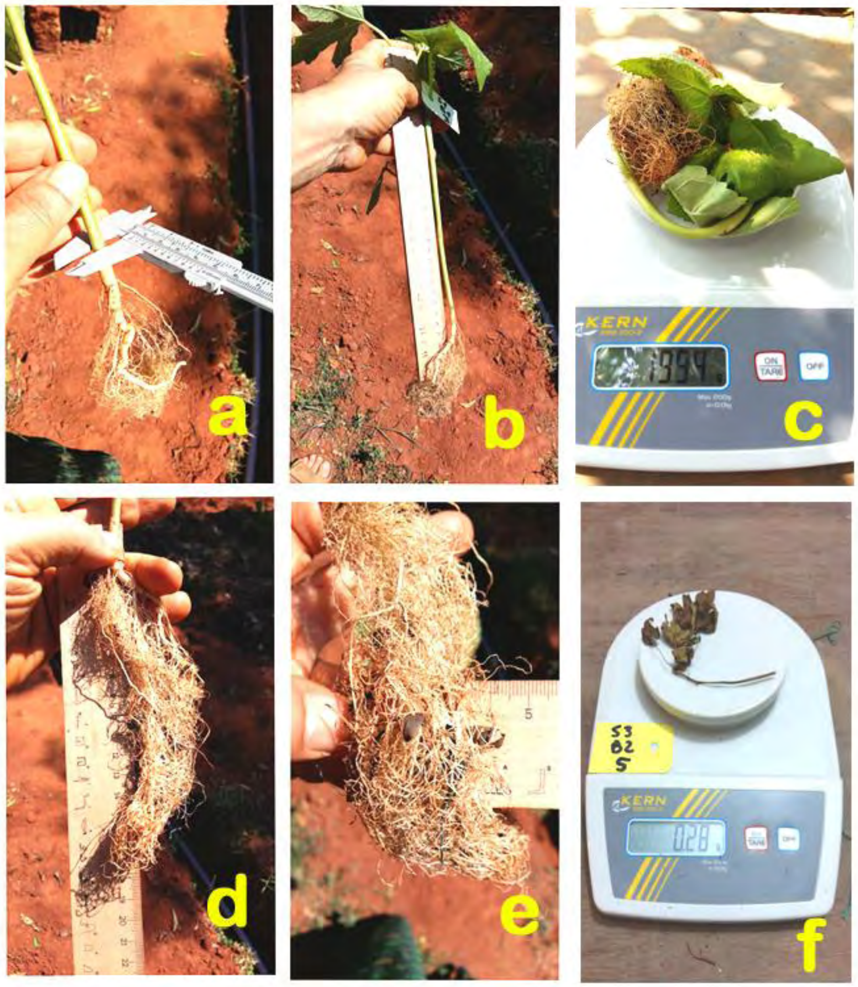


Photo 25 - Sampling of plants:

a) Stem diameter measurement at the collar
b) Seedling length measurement
c) Weighing whole plant
d) Root length measurement
e) Root width measurement
f) Weighing dried plant.

In **photo 26,** a clear view of the difference in growth between the plants grown in the seed bottle (**side b**) and those grown in pitches (**side a)**, with the same sector (S1C6-1/5)

Photo 26 **- Comparison of control seedlings S1C6_1-5 *(a)* and seedlings grown in seedling bottle S1B6_1-5 *(b).***

7.1.7 – Analyzed parameters and final data collection

- **Germination calendar**

The germination trend was noted down every day in a germination calendar (**table 8**), up to the total number of germinated seedlings. Diseased plants and those that have later died were also being watched as well as the seeds that did not germinate. The sowing took place on the 2nd January 2017 at an average temperature of 29°C and the first seedlings, both in seedbeds bottles and traditional pitches, began to spring up from the 5th January, only 3 days after sowing.

Germination	Initial number of seeds	Mean Temperature at sowing (°C)	No. of sprouted seeds												germ. (%)	Not germ.	sick plants	Death due to disease				
			d0	d1	d2	d3	d4	d5	d6	d7	d8	d9	d10	d11				d4	d5	d7	d8	d9
			Jan-5th	Jan-6th	Jan-7th	Jan-8th	Jan-9th	Jan-10th	Jan-11th	Jan-12th	Jan-13th	Jan-14th	Jan-15th	Jan-16th				Jan-8th	Jan-9th	Jan-12th	Jan-13th	Jan-14th
S1B1	36	29	2	29	31	31	31	31	31	31	31	31	31		86,11	5	1 (larva)					
S1B2	36	29	6	28	30	30	30	30	30	30	30	30	30	"	83,33	6	1 (larva)					
S1B3	36	29	7	33	33	33	33	33	33	33	33	33	33	"	91,67	3	1 (larva)					
S1B4	36	29	8	34	34	34	34	34	34	34	33	33	33	"	91,67	2	2 (larva + virus)				1	
S1B5	36	29	3	31	33	33	33	33	33	33	33	33	33	"	91,67	3	1 (larva)					
S1B6	36	29	1	28	30	30	30	30	30	30	29	29	29	"	80,56	6	4 (3 virus + 1 mycosis)				1	
S1C1	36	29	2	22	30	30	32	32	32	31	31	31	31	"	86,11	4				1 (mycosis)		
S1C2	36	29	9	23	26	28	28	29	29	29	28	28	28	"	77,78	7	3 (2 virus + 1 mycosis)				1	
S1C3	36	29	1	24	30	31	31	31	31	31	30	30	30	"	83,33	5	3 (larva))				1	
S1C4	36	29	—	23	30	29	30	30	30	30	31	31	31	"	86,11	4	6 (5 larva + 1 virus)	1				
S1C5	36	29	2	23	26	30	30	31	31	31	31	31	31	"	86,11	5	2 (virus)					
S1C6	36	29	8	27	30	30	28	29	29	29	30	28	28	"	77,78	4	9 (virus + mycosis)		2 (mycosis)			2

NOTE: The sowing was done on 02-Jan-2017 with an increasing 13% moon.

Table 8 **- Germination calendar.**

- **Parameters examined**

The parameters were the following:

- ***Quantity and quality of seeds***: N ° 432 selected seeds of the "*Fleurs d'Auroville*" series purchased from the Botanical Garden of Auroville in sealed plastic bags of 40 seeds each of the gross weight of g. 4.33 and net weight g 2.85;

- ***Germination times***: after the sowing on the 2nd January 2017, the germination began on the 5th January 2017 and lasted 10 days until the 15th January 2017 when the last seedling appeared.

- ***Temperature***: the average temperature during the sowing time was 29°C, and the average temperature during the whole cultivation timelapse up to the eradication of the plants was on average 26 ° C.

- ***Seedlings dead by disease***: 2 seedlings in S1B1-B6 and 8 seedlings in S1C1-C6 died.

- ***Non-sprouted seeds***: 25 seeds in S1B1-B6 and 29 seeds in S1C1-C6 did not germinate.

- ***Irrigation water volumes***: during the 38 days of experimentation n. 64 liters of water were dosed in S1B1-B6 for irrigation for an average of 2 liters a day, against n. 101 liters in S1C1-C6 with an average of 3 liters per day.

- **Germinability%:**

- ***Mean Germination Times (T.M.G).***

The parameters accounted in vivo from the growth stages of the seedlings of both types of seedbed under observation to the following phase of repotting, are listed in **tables 9** and **10** and are as follows:

1) ***Stem height (mm)***: the measurements were taken with the aid of a wooden ruler from the ground up to the height of the stem in 3 successive moments and exactly on the 22nd January, the 29th January and the 5th February ;

2) ***Number of true leaves***: also recorded on January the 22nd, January the 29th and February the 5th;

3) ***Primordial flowers***: only recorded on January the 29th and on February the 5th.

The average, the standard deviation and the percentage variability coefficient (CV%) of each of these parameters were measured at the end.

Growing okra seedlings (Abelmoschus esculentus L.) S1B1 - S1B6								
Plant	Height of the stem (mm)	Height of the stem (mm)	Height of the stem (mm)	True leaves (N°)	True leaves (N°)	True leaves (N°)	Floral primordium (N°)	Floral primordium (N°)
	22-gen	29-gen	05-feb	22-gen	29-gen	05-feb	29-gen	05-feb
S1B1- 1	100	140	200	1	3	4	0	2
S1B1- 2	120	200	270	2	4	4	2	1
S1B1- 3	90	150	260	2	4	4	2	4
S1B1 - 4	120	170	250	2	3	4	2	2
S1B1 - 5	110	170	220	2	3	4	2	0
Mean	108,0	166,0	240,0	1,8	3,4	4,0	1,6	1,8
St. Dev.	13,0	23,0	29,2	0,4	0,5	0,0	0,9	1,5
CV%	12,1	13,9	12,1	24,8	16,1	0,0	55,9	82,4
S1B2 - 1	100	175	250	2	3	4	1	2
S1B2 - 2	105	190	280	2	4	4	2	2
S1B2 - 3	105	180	300	2	3	4	1	1
S1B2 - 4	115	160	285	2	3	4	1	2
S1B2 - 5	130	200	290	2	4	4	1	2
Mean	111,0	181,0	281,0	2,0	3,4	4,0	1,2	1,8
St. Dev.	11,9	15,2	18,8	0,0	0,5	0,0	0,4	0,4
CV%	10,8	8,4	6,7	0,0	16,1	0,0	37,3	24,8
S1B3 - 1	100	130	135	1	2	1	0	0
S1B3 - 2	115	160	230	2	3	4	1	2
S1B3 - 3	95	150	240	2	4	4	2	2
S1B3 - 4	115	180	250	2	4	4	3	2
S1B3 - 5	95	155	215	2	4	4	3	2
Mean	104,0	155,0	214,0	1,8	3,4	3,4	1,8	1,6
St. Dev.	10,2	18,0	46,0	0,4	0,9	1,3	1,3	0,9
CV%	9,9	11,6	21,5	24,8	26,3	39,5	72,4	55,9
S1B4 - 1	105	150	200	2	4	4	1	2
S1B4 - 2	95	130	140	2	3	2	1	1
S1B4 - 3	110	160	220	2	4	4	1	2
S1B4 - 4	105	145	150	2	3	1	2	0
S1B4 - 5	80	120	120	2	3	3	0	0
Mean	99,0	141,0	166,0	2,0	3,4	2,8	1,0	1,0
St. Dev.	11,9	16,0	42,2	0,0	0,5	1,3	0,7	1,0
CV%	12,1	11,3	25,4	0,0	16,1	46,6	70,7	100,0
S1B5 - 1	100	110	120	2	2	3	2	1
S1B5 - 2	85	160	285	2	3	4	1	2
S1B5 - 3	95	145	260	2	3	4	1	2
S1B5 - 4	110	155	250	2	3	4	1	2
S1B5 - 5	90	160	200	2	3	3	2	2
Mean	96,0	146,0	223,0	2,0	2,8	3,6	1,4	1,8
St. Dev.	9,6	21,0	65,3	0,0	0,4	0,5	0,5	0,4
CV%	10,0	14,4	29,3	0,0	16,0	15,2	39,1	24,8
S1B6 - 1	105	170	260	2	4	4	2	1
S1B6 - 2	90	130	200	2	3	3	1	1
S1B6 - 3	80	130	210	2	3	4	1	1
S1B6 - 4	125	195	310	2	4	4	3	1
S1B6 - 5	120	175	170	2	3	4	2	1
Mean	104,0	160,0	230,0	2,0	3,4	3,8	1,8	1,0
St. Dev.	19,2	28,9	55,2	0,0	0,5	0,4	0,8	0,0
CV%	18,4	18,1	24,0	0,0	16,1	11,8	46,5	0,0

***Table 9* - Growth data from repotting to grubbing up:**

S1B1 ⟶ S1B6 Seedling plants S.B.M.

Media = Arithmetic mean

Dev.ST = Standard deviation

CV% = Variability coefficient%

Growing okra seedlings (Abelmoschus esculentus L.) S1C1 - S1C6								
Plant	Height of the stem (mm)	Height of the stem (mm)	Height of the stem (mm)	True leaves (N°)	True leaves (N°)	True leaves (N°)	Floral primordium (N°)	Floral primordium (N°)
	22-gen	29-gen	05-feb	22-gen	29-gen	05-feb	29-gen	05-feb
S1C1 - 1	105	130	150	2	3	3	1	1
S1C1 - 2	100	130	140	2	3	2	1	0
S1C1 - 3	100	150	210	2	3	4	1	2
S1C1 - 4	90	120	130	1	2	3	0	0
S1C1 - 5	105	130	160	2	3	4	2	1
Mean	100,0	132,0	158,0	1,8	2,8	3,2	1,0	0,8
St. Dev.	6,1	11,0	31,1	0,4	0,4	0,8	0,7	0,8
CV%	6,1	8,3	19,7	24,8	16,0	26,1	70,7	104,6
S1C2 - 1	80	80	110	1	2	3	0	0
S1C2 - 2	90	130	140	1	3	0	1	0
S1C2 - 3	95	155	235	2	3	4	2	2
S1C2 - 4	100	150	230	2	3	4	1	2
S1C2 - 5	105	125	130	2	3	4	0	0
Mean	94,0	128,0	169,0	1,6	2,8	3,0	0,8	0,8
St. Dev.	9,6	29,7	59,0	0,5	0,4	1,7	0,8	1,1
CV%	10,2	23,2	34,9	34,2	16,0	57,7	104,6	136,9
S1C3 - 1	90	110	110	2	2	2	2	2
S1C3 - 2	110	150	200	1	3	3	1	2
S1C3 - 3	95	110	150	1	2	2	0	1
S1C3 - 4	90	125	180	2	3	3	1	2
S1C3 - 5	90	110	125	2	2	3	0	0
Mean	96,3	123,8	163,8	1,5	2,5	2,8	0,5	1,3
St. Dev.	9,5	18,9	33,0	0,6	0,6	0,5	0,6	1,0
CV%	9,8	15,3	20,2	38,5	23,1	18,2	115,5	76,6
S1C4 - 1	100	120	140	2	3	1	1	0
S1C4 - 2	100	100	160	2	2	3	0	0
S1C4 - 3	50	90	115	1	3	3	0	0
S1C4 - 4	75	120	140	2	3	4	0	1
S1C4 - 5	80	120	135	2	3	3	1	1
Mean	81,0	110,0	138,0	1,8	2,8	2,8	0,4	0,4
St. Dev.	20,7	14,1	16,0	0,4	0,4	1,1	0,5	0,5
CV%	25,6	12,9	11,6	24,8	16,0	39,1	136,9	136,9
S1C5 - 1	70	95	150	2	3	4	1	2
S1C5 - 2	65	100	125	2	3	4	0	1
S1C5 - 3	75	120	150	2	4	2	0	0
S1C5 - 4	65	100	90	2	3	2	0	0
S1C5 - 5	80	125	180	2	3	4	1	2
Mean	71,0	108,0	139,0	2,0	3,2	3,2	0,4	1,0
St. Dev.	6,5	13,5	33,6	0,0	0,4	1,1	0,5	1,0
CV%	9,2	12,5	24,2	0,0	14,0	34,2	136,9	100,0
S1C6 - 1	105	145	180	2	4	4	1	2
S1C6 - 2	70	135	140	2	3	4	1	2
S1C6 - 3	85	125	150	2	3	3	2	2
S1C6 - 4	90	110	170	2	3	4	2	3
S1C6 - 5	65	115	130	2	3	2	1	0
Mean	83,0	126,0	154,0	2,0	3,2	3,4	1,4	1,8
St. Dev.	16,0	14,3	20,7	0,0	0,4	0,9	0,5	1,1
CV%	19,3	11,4	13,5	0,0	14,0	26,3	39,1	60,9

***Table 10* - Growth data of the plants from the repotting to extirpation:**

S1C1 ⟶ S1C6 Plants in plastic bags (= coming from plot of land)

Media = Arithmetic mean

Dev.ST = Standard deviation

CV% = Variability coefficient%

The parameters considered after the eradication on the 8th February 2017, 38 days after the sowing, are listed in the following **tables 11** and **12**.
Data refer to n. 60 plants, out of which 30 were of the S1B1-B6 seedbed and 30 of the S1C1-C6 seedbed; 5 plants per side were secluded from the rest of the plant groups of the nursery and were designated to be sampled.

1***) Size of the stem at the height of the collar (mm +/- 0.05)***

2) Height of the aerial part (mm)

3) Length of the radial apparatus (mm)

4) Width of the radical apparatus (mm)

5) Fresh weight of the whole plant (g)

6) Fresh weight of the aerial part (g)

7) Fresh weight of the root for differences (g)

8) Fresh total weight of the plants (aerial part + roots) (g)

On the 13th February 2017 recording the data of the biomass dried in an electric oven at 103.8 ° C for 4 days , was also made possible.

1***) Drying of the aerial part (g)***

2) Total drying of the roots (g)

3) Drying of the whole plants (g)

Analysis of Okra extirpated plants (Abelmoschus esculentus L.) S1B1 - S1B6											
Sample plant	Diameter of the stem to the collar (mm +/- 0,05)	Height of the stem (mm)	Length of the root (mm)	Width of the root (mm)	Weight of the whole fresh plant (g)	Weight of the aerial part of fresh plant (g)	Weight of the root obtained by difference (g)	Total fresh weight of plants (aerial part + roots) (g)	Drying in the oven only for the aerial part [4 days / 103.8 ° C] (g)	Drying in the oven only of the roots [4 days / 103.8 ° C] (g)	Drying in oven of the whole plant [4 days / 103.8 ° C] (g)
	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	13-feb	13-feb	13-feb
S1B1- 1	3,45	190	180	20	2,13	1,54	0,59		0,40		0,6
S1B1- 2	6,10	260	230	40	15,98	13,18	2,80		1,98		2,2
S1B1- 3	4,65	250	180	40	12,69	10,00	2,69	72,26	1,52	0,87	1,7
S1B1 - 4	6,10	245	190	65	19,94	14,08	1,90		1,83		2,0
S1B1 - 5	7,90	8,90	9,90	10,90	11,90	12,90	13,90		1,94		2,1
Mean	5,6	190,8	158,0	35,2	12,5	10,3	4,4		1,5		1,7
Dev.ST	1,7	105,3	85,3	21,0	6,6	5,2	5,4		0,7		0,7
CV%	29,8	55,2	54,0	59,6	52,9	49,8	123,3		42,9		38,6
S1B2 - 1	4,85	260	190	40	12,52	10,72	1,80		1,61		1,7
S1B2 - 2	5,55	310	280	50	14,93	11,84	3,09		1,78		1,9
S1B2 - 3	5,20	320	200	60	13,98	11,04	2,94	71,41	1,77	0,52	1,9
S1B2 - 4	5,70	325	205	60	14,05	11,25	2,80		1,69		1,8
S1B2 - 5	6,10	315	240	50	15,93	13,52	2,41		1,62		1,7
Mean	5,5	306,0	223,0	52,0	14,3	11,7	2,6		1,7		1,8
Dev.ST	0,5	26,3	37,0	8,4	1,3	1,1	0,5		0,1		0,1
CV%	8,7	8,6	16,6	16,1	8,8	9,5	19,8		4,6		4,4
S1B3 - 1	5,20	210	270	55	15,06	11,08	3,98		1,66		1,8
S1B3 - 2	4,95	295	280	55	13,05	9,80	3,25		1,67		1,8
S1B3 - 3	7,25	270	190	75	28,90	19,87	9,03	80,60	2,27	0,81	2,4
S1B3 - 4	4,20	245	230	65	11,02	6,63	4,39		0,99		1,2
S1B3 - 5	5,10	215	220	60	12,57	7,67	4,90		1,07		1,2
Mean	5,3	247,0	238,0	62,0	16,1	11,0	5,1		1,5		1,7
Dev.ST	1,1	36,2	37,0	8,4	7,3	5,3	2,3		0,5		0,5
CV%	21,3	14,6	15,6	13,5	45,2	47,7	44,5		33,9		30,7
S1B4 - 1	4,15	210	240	55	17,45	7,07	10,38		1,06		1,2
S1B4 - 2	3,55	135	190	25	3,69	1,36	2,33		0,20		0,3
S1B4 - 3	5,35	250	210	60	15,72	9,80	5,92	48,64	1,47	0,55	1,6
S1B4 - 4	4,65	155	343	30	6,86	5,61	1,25		0,90		1,0
S1B4 - 5	4,00	115	180	30	4,92	3,07	1,85		0,46		0,6
Mean	4,3	173,0	232,6	40,0	9,7	5,4	4,3		0,8		0,9
Dev.ST	0,7	55,7	65,8	16,2	6,4	3,3	3,8		0,5		0,5
CV%	15,8	32,2	28,3	40,5	65,7	61,6	88,2		60,9		53,7
S1B5 - 1	3,40	125	250	15	5,36	4,81	0,55		0,72		0,8
S1B5 - 2	5,75	345	220	70	17,27	14,05	3,22		2,11		2,2
S1B5 - 3	5,10	305	220	50	15,58	12,34	3,24	66,40	1,85	0,57	2,0
S1B5 - 4	6,65	300	310	55	21,03	16,14	4,89		2,66		2,8
S1B5 - 5	4,65	225	270	40	7,16	5,65	1,51		0,63		0,7
Mean	5,1	260,0	254,0	46,0	13,3	10,6	2,7		1,6		1,7
Dev.ST	1,2	87,0	37,8	20,4	6,7	5,1	1,7		0,9		0,9
CV%	23,8	33,5	14,9	44,4	50,7	48,0	62,9		55,7		52,0
S1B6 - 1	6,35	295	230	65	27,12	18,70	8,42		2,81		3,0
S1B6 - 2	4,15	210	245	45	12,24	6,88	5,36		1,03		1,2
S1B6 - 3	4,15	240	230	40	12,31	7,35	4,96	77,78	1,15	0,82	1,3
S1B6 - 4	5,55	345	340	50	18,85	12,55	6,30		1,88		2,0
S1B6 - 5	3,85	185	230	40	7,26	5,64	1,62		1,02		1,2
Mean	4,8	255,0	255,0	48,0	15,6	10,2	5,3		1,6		1,7
Dev.ST	1,1	64,9	48,0	10,4	7,7	5,4	2,5		0,8		0,8
CV%	22,6	25,5	18,8	21,6	49,3	53,1	46,3		49,1		44,5

***Table 11*– Analysis of the rooted plant S1B1 - S1B6.**

Analysis of Okra extirpated plants (Abelmoschus esculentus L.) S1C1 - S1C6											
Sample plant	Diameter of the stem to the collar (mm +/- 0,05)	Height of the stem (mm)	Length of the root (mm)	Width of the root (mm)	Weight of the whole fresh plant (g)	Weight of the aerial part of fresh plant (g)	Weight of the root obtained by difference (g)	Total fresh weight of plants (aerial part + roots) (g)	Drying in the oven only for the aerial part [4 days / 103.8 ° C] (g)	Drying in the oven only of the roots [4 days / 103.8 ° C] (g)	Drying in oven of the whole plant [4 days / 103.8 ° C] (g)
	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	13-feb	13-feb	13-feb
S1C1 - 1	3,35	150	230	20	5,20	4,11	1,09	32,85	0,40	0,19	0,4
S1C1 - 2	3,70	140	210	15	3,45	3,13	0,32		1,98		2,0
S1C1 - 3	4,70	230	150	35	12,20	10,84	1,36		1,52		1,6
S1C1 - 4	3,85	110	240	13	3,75	3,01	0,74		1,83		1,9
S1C1 - 5	4,10	150	210	15	8,25	7,25	1,00		1,94		2,0
Mean	3,9	156,0	208,0	19,6	6,6	5,7	0,9		1,5		1,6
Dev.ST	0,5	44,5	34,9	9,0	3,7	3,4	0,4		0,7		0,7
CV%	12,8	28,5	16,8	45,9	56,0	59,3	43,6		42,9		41,9
S1C2 - 1	3,55	115	100	20	3,47	3,23	0,24	32,14	0,48	0,20	0,5
S1C2 - 2	3,10	150	240	30	4,36	2,77	1,59		0,42		0,5
S1C2 - 3	4,15	235	270	20	9,48	7,92	1,56		1,43		1,5
S1C2 - 4	4,85	230	270	30	10,60	9,22	1,38		1,38		1,4
S1C2 - 5	3,85	130	160	25	4,23	3,69	0,54		0,55		0,6
Mean	3,9	172,0	208,0	25,0	6,4	5,4	1,1		0,9		0,9
Dev.ST	0,7	56,6	75,3	5,0	3,3	3,0	0,6		0,5		0,5
CV%	16,9	32,9	36,2	20,0	51,9	55,5	59,1		59,4		56,8
S1C3 - 1	3,15	100	160	25	2,42	1,96	0,46	25,95	0,29	0,14	0,3
S1C3 - 2	4,15	195	210	35	8,79	6,69	2,10		1,00		1,0
S1C3 - 3	3,35	135	190	20	3,74	3,06	0,68		0,46		0,5
S1C3 - 4	4,15	175	200	35	7,33	6,02	1,31		0,72		0,7
S1C3 - 5	3,85	125	225	20	3,67	3,18	0,49		0,36		0,4
Mean	3,7	146,0	197,0	27,0	5,2	4,2	1,0		0,6		0,6
Dev.ST	0,5	38,5	24,4	7,6	2,7	2,1	0,7		0,3		0,3
CV%	12,3	26,3	12,4	28,1	52,4	49,1	69,4		51,6		49,3
S1C4 - 1	3,20	140	200	25	3,52	2,52	1,00	23,68	0,31	0,13	0,3
S1C4 - 2	3,00	150	200	20	3,38	2,94	0,44		0,41		0,4
S1C4 - 3	3,10	100	230	20	3,56	2,14	1,42		0,32		0,3
S1C4 - 4	4,00	150	250	20	7,58	6,23	1,35		0,87		0,9
S1C4 - 5	3,75	140	270	25	5,64	3,62	2,02		3,77		3,8
Mean	3,4	136,0	230,0	22,0	4,7	3,5	1,2		1,1		1,2
Dev.ST	0,4	20,7	30,8	2,7	1,8	1,6	0,6		1,5		1,5
CV%	12,9	15,2	13,4	12,4	38,9	46,6	46,6		131,0		128,2
S1C5 - 1	4,60	155	180	25	7,30	6,05	1,25	31,81	1,00	0,27	1,1
S1C5 - 2	3,75	135	270	35	7,07	5,02	2,05		0,75		0,8
S1C5 - 3	3,00	155	260	30	5,56	4,32	1,24		0,65		0,7
S1C5 - 4	3,25	110	210	20	2,68	2,21	0,47		0,44		0,5
S1C5 - 5	5,20	210	230	30	9,20	7,72	1,48		1,16		1,2
Media	4,0	153,0	230,0	28,0	6,4	5,1	1,3		0,8		0,9
Dev.ST	0,9	36,8	36,7	5,7	2,4	2,0	0,6		0,3		0,3
CV%	23,3	24,1	16,0	20,4	38,2	40,4	43,7		35,4		33,2
S1C6 - 1	4,00	195	310	45	9,01	6,84	2,17	41,42	1,03	0,29	1,1
S1C6 - 2	4,90	135	220	40	9,65	4,25	5,40		0,74		0,8
S1C6 - 3	3,45	140	225	25	6,15	4,56	1,59		0,59		0,6
S1C6 - 4	4,25	185	205	30	9,49	7,70	1,79		1,16		1,2
S1C6 - 5	3,75	140	270	30	7,12	4,09	3,03		0,53		0,6
Mean	4,1	159,0	246,0	34,0	8,3	5,5	2,8		0,8		0,9
Dev.ST	0,6	28,6	43,2	8,2	1,6	1,7	1,6		0,3		0,3
CV%	13,5	18,0	17,6	24,2	18,9	30,3	55,7		33,7		31,4

***Table 12– Analysis of the rooted plant* S1C1 – S1C6.**

8 - Results and discussion

8.1 - Germinability of seeds

The speed of the germination, at the same germination power, is one of the selection criteria for the trade of seeds and for the type of seedbed to be used. Two ways can be followed to state the speed of germination. The first one is denoted from the percentage of seeds germinated after a certain number of days, corresponding to the time of the first count of germinated seeds, set by the methods of analysis; this timelapse is necessary for the germination because contemporary of the greatest number of seeds. The second is represented by the calculation of the "mean germination time".

- **Germination percentage**

It is the percentage of the number of seeds that have germinated based on the total number of seeds planted since the day of germination.

In the seedbed bottles all the seeds had already germinated on the third day of the germination while in the traditional seedlings germination and diseases continued for 8 days until the germination of the last plant in the S1C6 sector.

	Seeds planted	Germinated seeds	Germination %	St. Dev.	T.M.G.
S1B1-S1B6	216	189	87,5	4,9	1,9
S1C1-S1C6	216	179	82,9	4,1	2,2
Total	432	368	85,2 (mean)		
Difference			4,6		

Table 13 **– Analysis and comparison of germination values.**

The percentage of germination in the seedbed bottles (S.B.M.), as shown in **Table 13**, was 87.5% and 4.6% higher than the traditional method's (82.9%).

The general mean of the germinations (both in the seedbed bottles and in the pitches) was 85.2%.

A study around the germinal charactheristics of different varieties of Okra seeds (**table 14**), carried out in India by researchers Yakkala Siva Sankar and Arghya Mani and published in February 2016 in the Journal of Agriculture & Rural Development, found that the germination percentage ranged from the maximum of 92% in the Bhendi variety, followed by Shakti with

Journal of Agriculture and Technology

Table 1: Studies on Seed and Seedling Quality Parameters in Okra

Varieties	Germination (%)	1000 Seed weight (g)	Seed density (g/cm3)	Speed of germination	Electrical conductivity(dS m1)	Root length (cm)	Shoot length (cm)	Seedling length(cm)	Dry root weight(g)	Dry shoot weight(g)	Seedling dry weight(g)	Vigour index length	Vigour index mass	Seed vigour (paper piercing)
Ts-931	77.50	67.30	37.40	20.62	1.04775	8.71	21.47	31.53	0.0225	0.1925	0.2250	2443.34	17.50	55.50
Jkoh7315	79.00	67.80	29.16	20.78	1.033	8.08	24.38	31.39	0.0275	0.2075	0.2450	2479.32	19.33	68.00
Shakti	90.50	75.80	53.69	28.43	0.391	10.11	25.96	35.83	0.0325	0.2150	0.2650	3242.74	23.85	93.00
Glory	82.50	69.30	37.68	22.85	1.04425	8.34	23.25	31.94	0.0225	0.2025	0.2425	2634.68	20.23	64.00
Sivam	86.50	72.80	53.59	27.37	1.00125	9.14	25.77	34.84	0.0375	0.2525	0.2850	3013.70	24.69	90.00
Bhendi kubera	86.50	71.00	46.30	25.51	1.02625	9.54	23.15	32.77	0.0275	0.2100	0.2525	2834.15	21.84	82.50
Bhendi tender	85.00	72.50	46.17	23.42	1.0315	9.13	24.03	32.69	0.0275	0.2125	0.2450	2777.32	21.01	76.50
Bhendi anjali	92.00	72.00	46.34	31.32	0.99775	9.59	25.22	34.18	0.0300	0.2125	0.2600	3144.34	23.96	87.50
Super surekha	80.50	67.50	37.23	21.61	1.04375	8.87	21.16	29.93	0.0250	0.2100	0.2475	2409.43	19.90	55.00
Arka anamika	70.50	60.80	24.24	15.28	1.435	7.38	19.85	27.80	0.0200	0.1850	0.2125	1960.46	14.99	48.00
Mean	83.05	69.68	41.18	23.719	1.00515	8.8889	23.424	32.29	0.07	0.21	0.248	2693.948	20.73	72.00
SE (m)	4.892	0.331	0.299	1.34366	0.004	0.539	1.095	0.258	0.0031	0.0139	0.015	159.298	1.937	2.197
CDat5%	10.371	0.964	0.634	0.443	0.008	1.143	2.320	0.548	0.007	0.0294	0.031	337.711	4.107	4.658

Table 14* – Comparative study between seed characteristics and transplanting plants of some varieties of *okra (Source: Yakkala Siva Sankar e Arghya Mani "*Germination and growth of Okra seedlings (Abelmoschus esculentus L.) as influenced by organic amendments*", Journal of Agriculture & Rural Development, February 2016).

90.50% , to a minimum germination of the Arka Anamika variety with 70.50%, with an average value of 83.05%; these results are similar to those registered by Wood et al. (1997), Dronawall (1985), Gurbanovandbertri (1970).

Another study published in 2015 in *Cogent Food & Agriculture* by the Indian researchers Banashree Sarma and Nirmali Gogoi, verified the influence of different types of organic soil on the germination speed of Okra seeds and the results can be seen in **table 15.** If we consider that in the tests of germination of the two compared seedlings of this dissertation no fertilizers and no soil improvers were used, then we can compare our germination percentages with the CK values (= control not fertilized) of the study of Yakkala Siva Sankar and Arghya Mani: from this comparison of values it's clear how the seedling bottle method positively influences the germination of the

Table 2. Germination indices of Okra seed under different organic amendments

Treatments	Percent germination (%)	Emergence speed index (plants day^{-1})	Mean emergence time (day)	Coefficient of variation of germination time
CK	87.50 ± 4.17^{b}	8.92 ± 0.39^{d}	6.89 ± 0.02^{a}	14.71 ± 0.10^{c}
RDF	91.67 ± 2.40^{ab}	10.00 ± 0.03^{cd}	6.69 ± 0.03^{b}	18.38 ± 0.29^{b}
FM	97.22 ± 2.77^{a}	13.50 ± 0.24^{b}	6.48 ± 0.01^{c}	20.37 ± 0.17^{a}
VC	100.00 ± 0.00^{a}	15.17 ± 0.63^{a}	6.40 ± 0.05^{c}	20.74 ± 0.52^{a}
BC	87.50 ± 2.40^{b}	10.49 ± 0.66^{c}	6.67 ± 0.04^{b}	17.98 ± 0.44^{b}
LSD	3.83	0.642	0.047	0.484

Note: Mean (n = 3) ± SE; values followed by different superscript letters within a column differ significantly (LSD, α = 0.001).

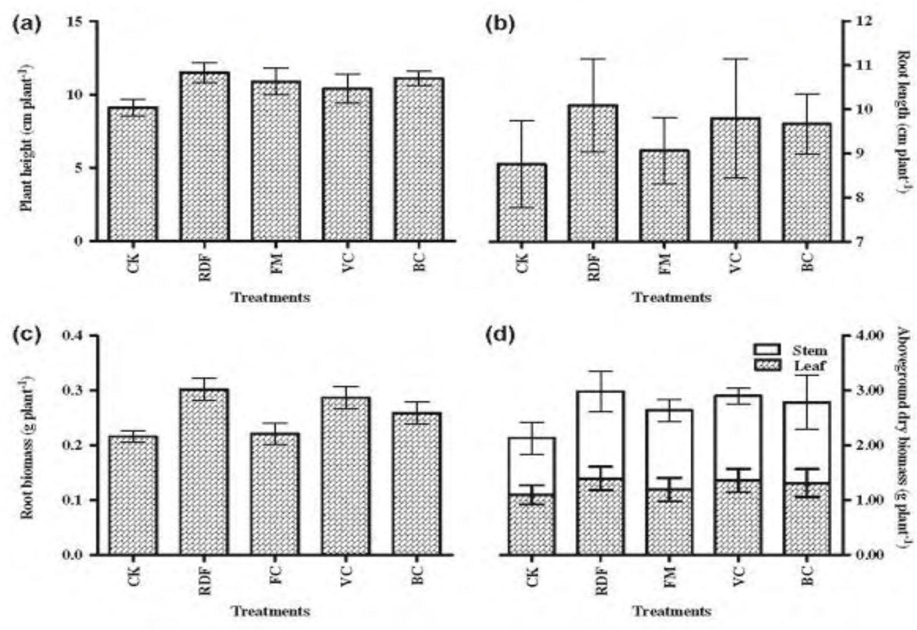


***Table 15** – Top: okra germination: comparison with the values observed by Banashree Sarma e Nirmali Gogoi nella loro ricerca "Germination and growth of Okra seedlings (Abelmoschus esculentus L.) as influenced by organic amendments, Cogent Food & Agriculture, 2015".*

(a) height of the plant; (b) root length; (c) root biomass; (d) Dry biomass in the surface of seedling of Okra

CK = unfertilized control

RDF = inorganic fertilizer N: P: K 50:50:50 kg ha-1

FM = courtyard manure at the rate of 5 t ha-1

VC = vermicompost at the rate of 5 t ha-1

BC = biochar at the rate of 5 t ha-1

seeds as it takes it to a higher level than the corresponding value of CK (= unfertilized control) of the study of the two Indian researchers.

- **Standard deviation**

Since there is a small difference on the Standard Deviation values and the results are almost similar to each other (4.9 in the seedbeds and 4.1 in the traditional method), we can deduce that both the means that we obtained are reliable.

- **Percent variability coefficient**

The coefficient of variation is a statistical indicator of relative dispersion, calculated as the ratio between the standard deviation and the mean of the distribution.

$$\boldsymbol{CV}\ \% = \frac{\boldsymbol{Standard\ deviation}}{\boldsymbol{Arithmetic\ mean}}\ \boldsymbol{x\ 100}$$

It is also referred to as the "*dispersion coefficient*" and we talk about relative dispersion indicating the variability of a phenomenon in percentage terms. It is used, for example, to compare the variability of phenomena, without taking into consideration the unit of measurement.

CALCULATION OF THE MEAN GERMINATION TIME (T.M.G.) SEEDBED BOTTLE (S.B.M.) S1B1 - S1B6				
Germination	D0 Jan-05	D1 Jan-06	D2 Jan-07	D3 Jan-08
Interval days	1	2	3	4
Tot. N. of births per day	27	183	191	191
New born	27	156	8	0
T.M.G. = (1x27) + (2x156) + (3x8) + (4x0) /191 = 1,90				

CALCULATION OF THE MEAN GERMINATION TIME (T.M.G.) TRADITIONAL METHOD S1C1 - S1C6							
Germination	D0 Jan-05	D1 Jan-06	D2 Jan-07	D3 Jan-08	D4 Jan-09	D5 Jan-10	D6 Jan-11
Interval days	1	2	3	4	5	6	7
Tot. N. of births per day	22	142	172	178	179	182	182
New born	22	120	30	6	1	3	0
T.M.G. = (1x22) + (2x120) + (3x30) + (4x6) + (5x1) + (6x3) + (7x0) /182 = 2,19							

Table 16 - **At the top:** ***calculation of the T.M.G. of S1B1-S1B6 seedling.*** **At the bottom*****: calculation of the Mean Germination Time (T.M.G.) in a traditional seedbed***

With reference to the germination of the seeds of the previous table 8 (germination calendar), we obtain, from the calculation of the respective variability coefficients % of both distributions, two fairly similar values, 5.63 for the seedbed bottles and 4.94 for the seeds germinated in the traditional system and this is a confirmation of the reliability of the average that has been found.

- **T.M.G. (Mean Germination Time)**

In order to define the Mean Germination Time (T.M.G.) **(table 16)**, germination speed has to be taken into account. The T.M.G still provides important indications for a more complete evaluation of the seed germination process.

Here the calculation of the "*mean germination time*" according to Pieper formula:

$$\boldsymbol{T.M.G.} = \frac{(\boldsymbol{n\ x\ g})}{\boldsymbol{N}}$$

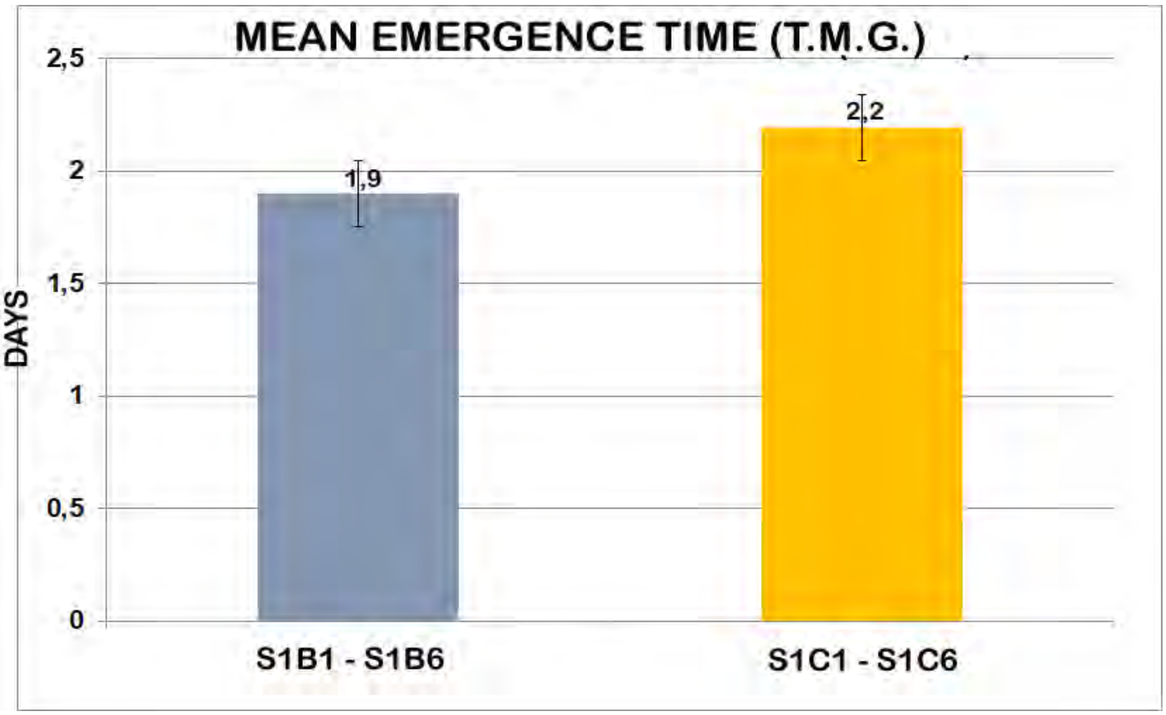
n = number of seeds germinated with normal buds on individual days;

g = number of days elapsed for each count since the start of the test;

N = total number of seeds germinated with normal buds.

Basically, it is a matter of multiplying, at each count, the number of seeds germinated by the number of days that have elapsed since the beginning of the trial, of adding the products and dividing the whole by the total number of sprouted seeds. The T.M.G. therefore represents the time required to have 50% of the germination capacity of the lot.

From the comparison of the results in table 16 (**graph 5**) we notice that the value of the T.M.G. of the seeds of the seedbed bottles is 1.90 days. and is 0.29 days less than the value of 2.19 days.



Graph 5– **Comparison of the Mean Germination Times (T.M.G.).**

of the traditional method. The reduction of the T.M.G. obviously reduces the hazards of seeds being damaged by insects, soil crust and drought. A seedbed which is therefore able to allow a quicker germination and at the highest percentage, certainly deserves more consideration from the careful farmer.

8.2 – Growing plants data processing

From the analysis of the values of the means in **table 17**, it's clearly visible how the height of

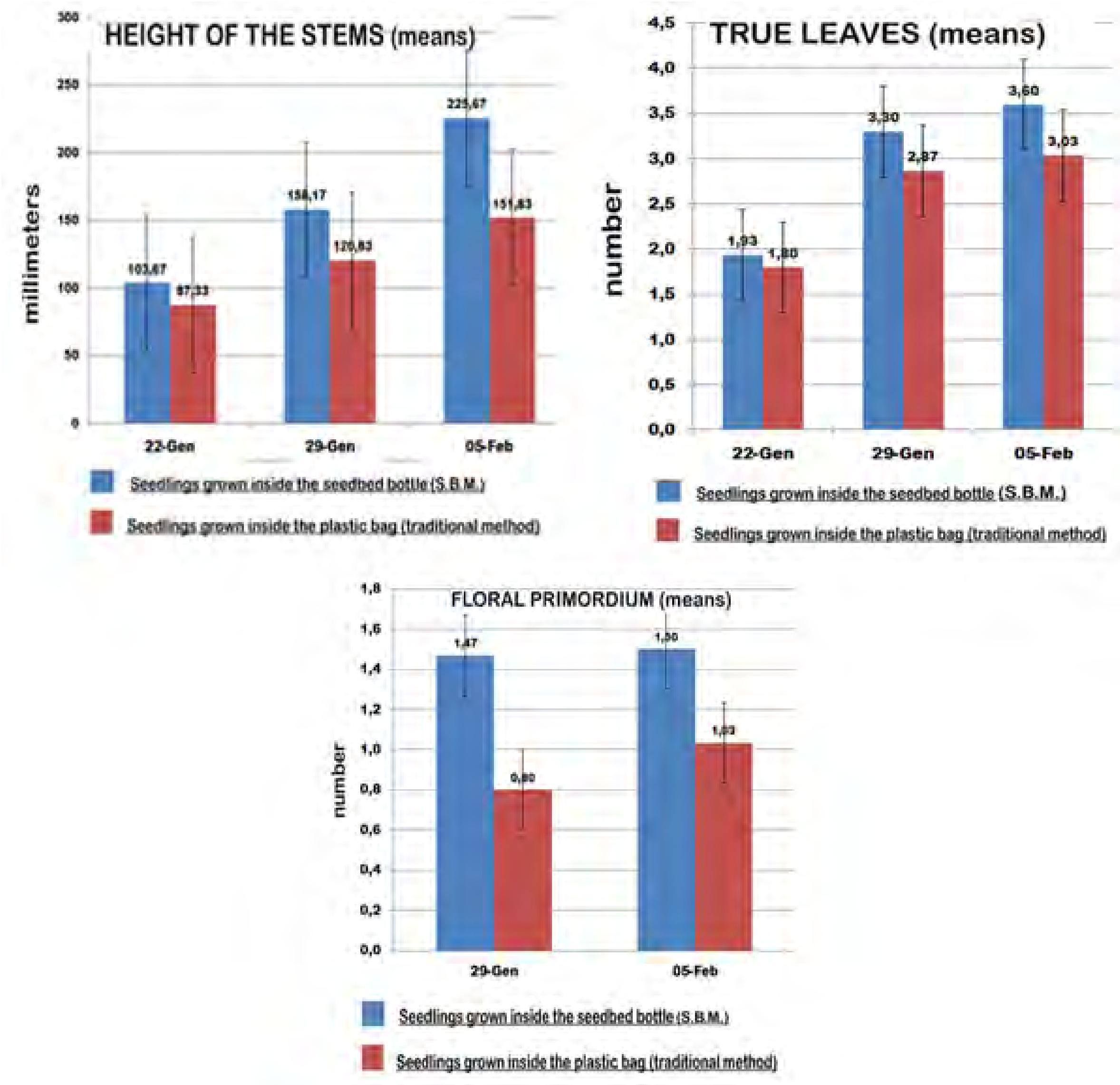
SEEDLINGS GROWN INSIDE THE SEEDBED BOTTLE (S.B.M.) S1B1 - S1B6								
	Height of the stem (mm) Jan-22th	Height of the stem (mm) Jan-29th	Height of the stem (mm) Feb-05th	True leaves (n°) Jan-22th	True leaves (n°) Jan-29th	True leaves (n°) Feb-05th	Floral primordium (n°) Jan-29th	Floral primordium (n°) Feb-05th
Mean	103,67	158,17	225,67	1,93	3,30	3,60	1,47	1,50
St. Dev.	12,93	23,25	54,02	0,25	0,60	0,86	0,82	0,86
CV%	12,47	14,70	23,94	13,12	18,06	23,75	55,86	57,40

SEEDLINGS GROWN INSIDE THE PLASTIC BAG (TRADITIONAL METHOD) S1C1 - S1C6								
	Height of the stem (mm) Jan-22th	Height of the stem (mm) Jan-29th	Height of the stem (mm) Feb-05th	True leaves (n°) Jan-22th	True leaves (n°) Jan-29th	True leaves (n°) Feb-05th	Floral primordium (n°) Jan-29th	Floral primordium (n°) Feb-05th
Mean	87,33	120,83	151,83	1,80	2,87	3,03	0,80	1,03
St. Dev.	15,18	18,57	34,30	0,41	0,51	1,03	0,71	0,96
CV%	17,39	15,37	22,59	22,60	17,70	34,07	89,30	93,32

Table 17 - At the top: **Final results of seedbed bottles (S.B.M.)*****; At the bottom:*** **final results of plastics bags (traditional pitches)**

the stem doubles in the period from the 22nd January to the 5th February, both for the plants in the seedbed bottles and for the sample plants in the plastic bags; the only difference consists on the numerical values which are higher in the seedbed bottles, perhaps a sign that the plants hugely benefit from the constant availability of water during the process of growth. The number of real leaves remains almost the same for both seedbeds, but the number of primordial flowers in the plants grown in the seedbed bottle is 50% higher than in the others. Although the number of leaves is the same for the plants of both seedbeds, at the end of the test the total biomass values are higher in the S1B1-B6 sectors.

In regard to the Standard Deviation values, they are rather valuable if we consider the parameter of the stem length, whereas the variation is minimal in reference to the number of leaves and primordial flowers.



***Graph 6– Averages of the analyzed parameters*: 1) stem height, 2) number of true leaves and 3) primordial flowers.**

The %CV, on the other hand, is much more variable in the seedlings in the pitches where it reaches for the primordial flowers higher values than in the seedbed bottles'. From the analysis of **graph 6**, related to the mean height of the stem, the increase seems to be almost proportional in the traditional method, while it is more than proportional in the plastic bottles, as a further confirmation of what has been previously observed.

8.3 – Processing of data of uprooted plants

According to the analysis of results and graphs of the comparison of all the parameters, the seedlings grown in the seedbeds bottles clearly seem to benefit more.

The caliber of the stems is an average of 14.6% higher in seedlings grown in seedbed bottles than those grown using the traditional method, as well as the fresh weight of the plant is on average greater than 36.68% (**table 18**).

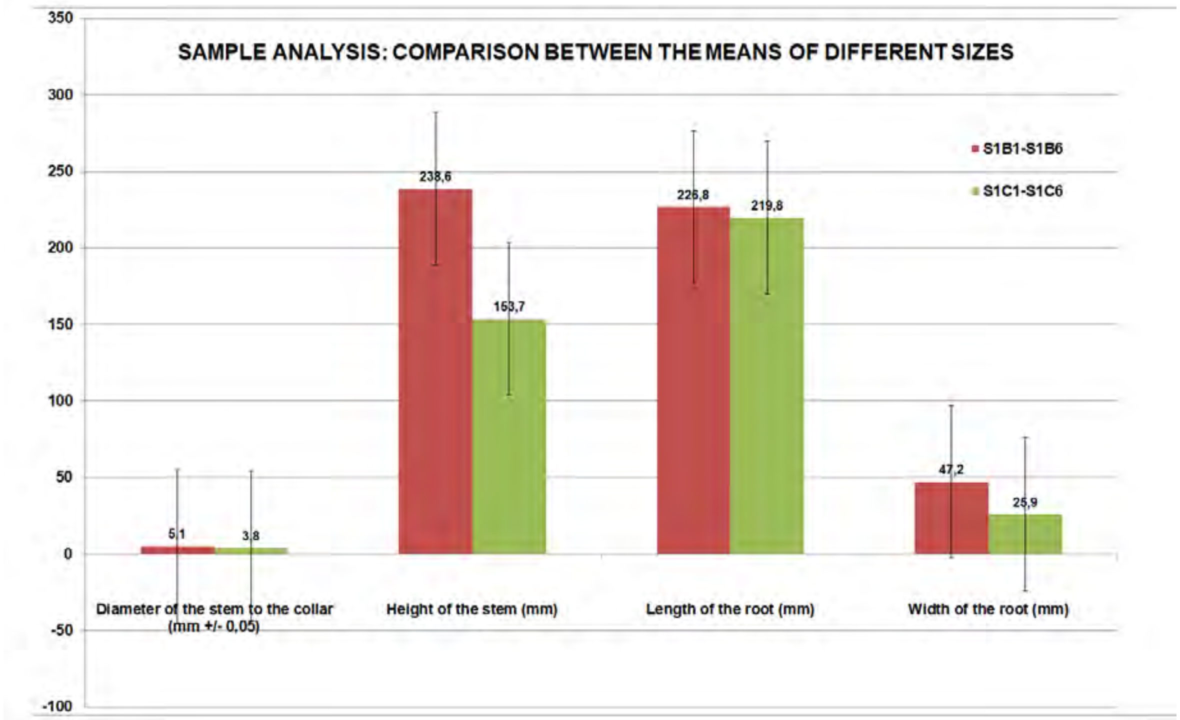
Among the most significant results, we find the one that refers to the width of the roots, whose value is on average almost double in the seedlings grown in the bottle (mm 47.2) compared to those grown in the traditional method (mm 25.9), whereas the data concerning the length of the root is not much higher (mm 226 compared to mm 219.8) (**graph 7**): in short, Okra seedlings have shown to prefer the seedbed bottle as ideal environment for growth, also because of the use of the sub-irrigation system, which allows a steady humidification of the soil. The average weight of the dry biomass is approximately double (**graphs 8 and 9**).

In relation to the process of drying in the oven for 4 days. at 103.8 ° C until the steady weight is reached, the values of the whole dried plant are g1.6 against g0.9, the values of the aerial part are on average g 1.5 g and g0.8, while the average weight of the dried roots is over tripled (g 0.7

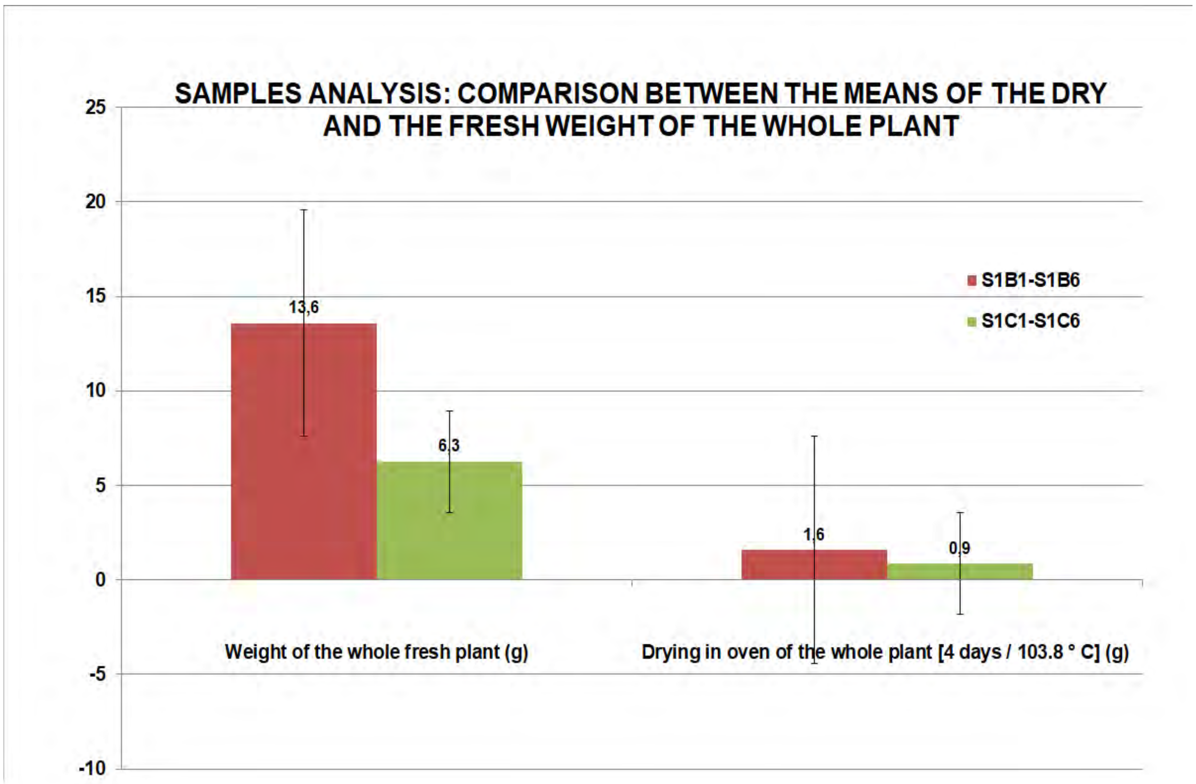
	Diameter of the stem to the collar (mm +/- 0,05)	Height of the stem (mm)	Length of the root (mm)	Width of the root (mm)	Weight of the whole fresh plant (g)	Weight of the aerial part of fresh plant (g)	weight of the root obtained by difference (g)	Total fresh weight of plants (aerial part + roots) (g)	Drying in the oven only for the aerial part [4 days / 103.8 ° C] (g)	Drying in the oven only of the roots [4 days / 103.8 ° C] (g)	Drying in oven of the whole plant [4 days / 103.8 ° C] (g)
	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	08-Feb	13-feb	13-feb	13-feb
S1B1-S1B6											
Mean	5,1	238,6	226,8	47,2	13,6	9,9	4,1	69,5	1,5	0,7	1,6
Dev.ST	1,1	76,9	60,0	16,3	6,2	4,6	3,0	11,4	0,6	0,2	0,6
CV%	21,7	32,2	26,5	34,5	45,5	46,6	74,5	16,4	44,0	22,9	40,5
S1C1-S1C6											
Mean	3,8	153,7	219,8	25,9	6,3	4,9	1,4	31,3	0,8	0,2	0,9
Dev.ST	0,6	37,5	43,6	7,7	2,7	2,3	1,0	6,2	0,7	0,1	0,7
CV%	15,6	24,4	19,8	29,7	43,4	47,3	72,2	19,8	79,4	33,2	75,7

***Table 18*– Final comparison of seedbottles and plot of lands.**

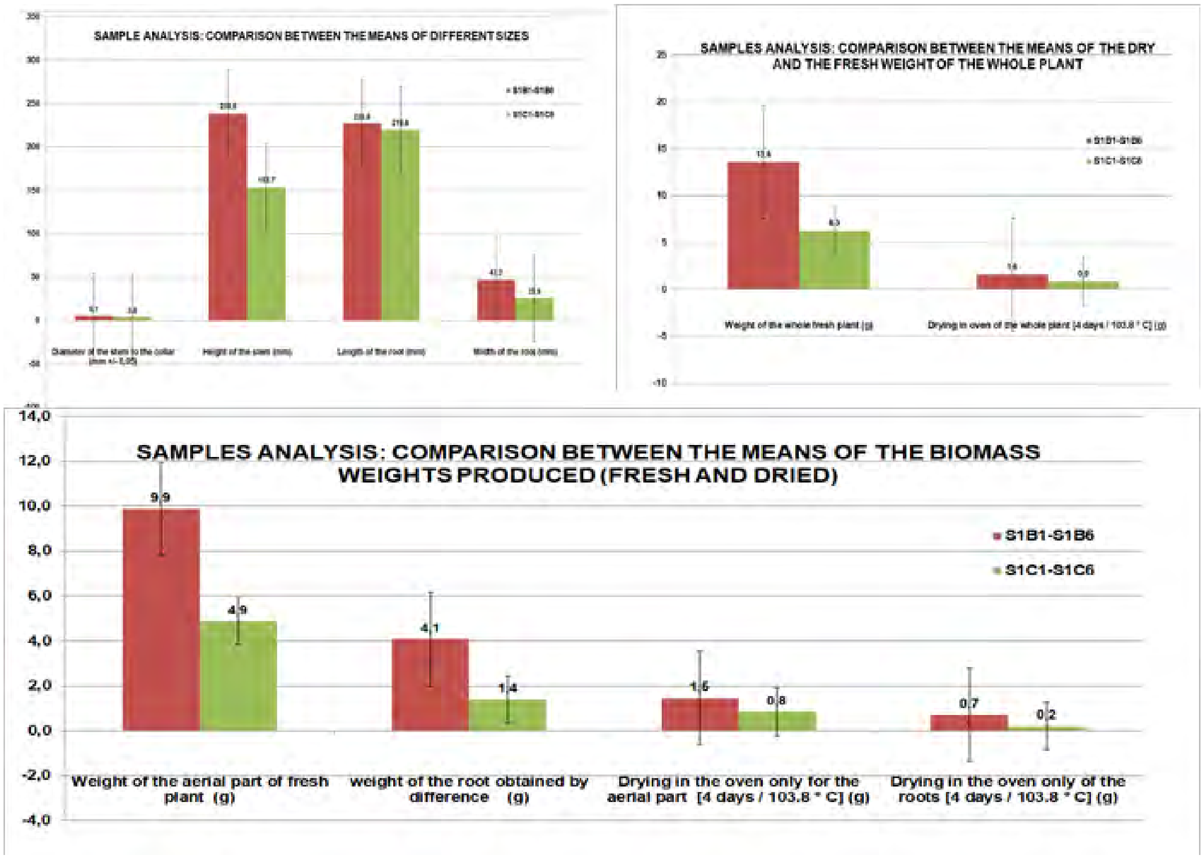
compared to 0.2 g).



***Graph 7*– Final comparison between the means of the various dimensional parameters.**



***Graph 8*– Final comparison between fresh and dried biomass of whole plants (means).**



***Graph 9*– Comparison between biomass produced only from the aerial part and the one produced from the root part (means).**

8.4 – Comparison of irrigation volumes

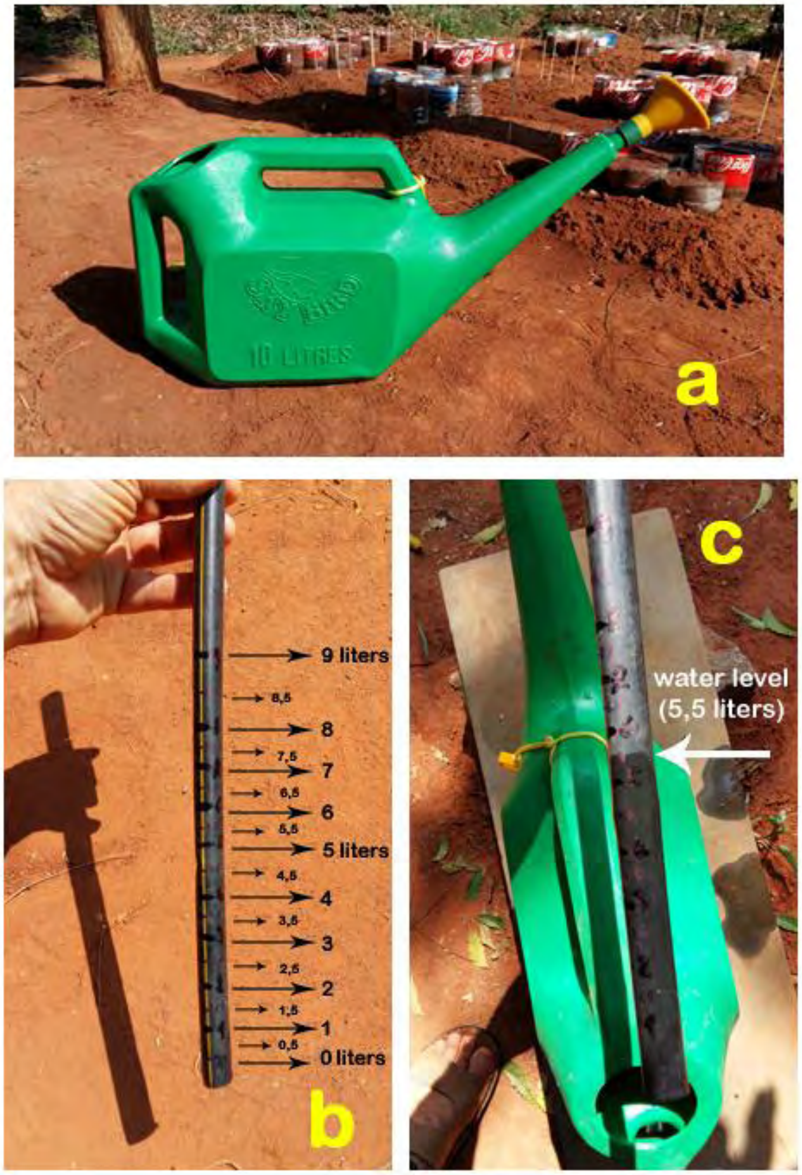


Photo 27 – **a) 10-liter watering can. b-c) Graduated bar for measuring irrigation volumes (liters).**

- **Volumes**: in order to measure the amount of water used for irrigation each time, a special graduated bar, volume measuring device, was created using a piece of plastic pipe for drip irrigation of adequate length and calibrated to liters and 0.5 liters (photo 27 - b).
The calibration of the bar was made by adding into the 10-liter watering can (photo 27 - c) 0.5 liters of water at a time and, after dipping and pulling the bar out each time, I marked with a black pen the level of wetting.
- **Doses:** in order to get the value of the amount of water that has been dosed for each irrigation, in the pitches as and in the seedbeds, I recorded the wetting levels of the bar before and after the irrigation rounding the volume down with a 0.5 liters approximation.
- **Shifts**: the irrigation water was used as often as necessary to keep the soil damp and to avoid water stress on the seedlings.

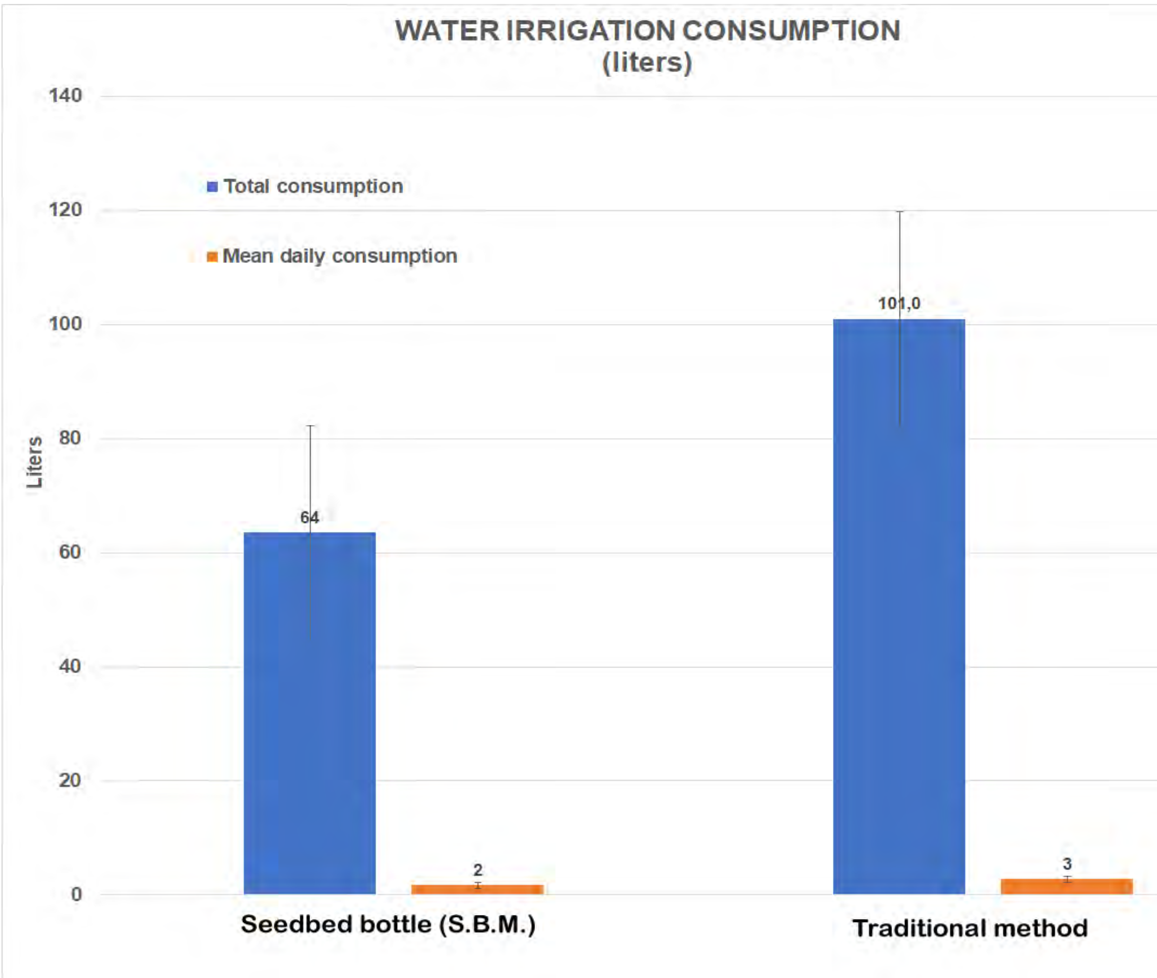
The analysis of the calendar of the volumes of water used during the experimentation (table 19) for the irrigation of the two different types of seedbeds (sub-irrigation in the seedbed bottles and sprinkling in the traditional pitches) clearly showed a saving on water of 36,64% in the seedling bottles method compared to the traditional method.

Irrigation times were not pre-arranged but set from time to time according to the needs and were aimed at maintaining the soil constantly humid in traditional pitches and at restoring the ideal level of water in the tank of the seedbed bottles.

Irrigation was done over 38 days. and the total consumption was of 64 liters in the seedbed bottles and 101 liters in the traditional pitches with an average daily consumption of 2 liters in the bottles compared to the 3 liters of the traditional pitches (chart 10).

PERIOD (Days)		MEAN T (°C)	Water volumes for irrigation (liters)	
			Seedbed bottle S1B1-S1B6	Traditional method S1C1-S1C6
PRE-SOWING D0	Jan-1st	25	37	20
SOWING D1	Jan-2nd	25,0	0	7
D2	Jan-3th	26	0	3
D3	Jan-4th	26,5	0	5
D4	Jan-5th	26	0	5
D5	Jan-6th	26	0	2
D6	Jan-7th	25,5	0	2,5
D7	Jan-8th	25	0	4
D8	Jan-9th	25,5	0	3
D9	Jan-10th	26	0	3,5
D10	Jan-11th	26	0	3,5
D11	Jan-12th	26,0	13	3,5
D12	Jan-13th	25,5	0	3,5
D13	Jan-14th	26,0	0	3,0
D14	Jan-15th	25,0	0	3,5
PRICKING OUT D15	Jan-16th	24,5	5	5,0
D16	Jan-17th	24,5	0	0,0
D17	Jan-18th	25,5	0	0,0
D18	Jan-19th	25,0	0	3,0
D19	Jan-20th	25,0	0	0,0
D20	Jan-21th	26,5	0	2,5
D21	Jan-22th	27,0	0	0,0
D22	Jan-23th	27,0	0	2,0
D23	Jan-24th	26,5	0	0,0
D24	Jan-25th	27,5	0	3,0
D25	Jan-26th	25,0	RAIN	RAIN
D26	Jan-27th	25,5	RAIN	RAIN
D27	Jan-28th	26,5	0	0,0
D28	Jan-29th	26,5	0	3,5
D29	Jan-30th	26,0	0	0,0
D30	Jan-31th	24,5	0	0,0
D31	Feb-1st	24,5	0	0,0
D32	Feb-2nd	28,0	0	4,0
D33	Feb-3th	25,0	0	0,0
D34	Feb-4th	25,0	0	0,0
D35	Feb-5th	24,5	9	4,5
D36	Feb-6th	25,0	0	0,0
D37	Feb-7th	25,5	0	2,0
ROOT OUT D38	Feb-8th	25,5	0	0,0
TOTAL			64	101,0
MEAN		26	2	3
ST.DEV.		0,9	6,5	3,5
CV%		3,4	379,4	128,0

***Table 19*– Irrigation calendar.**



Graph 10– **Comparison of irrigation volumes (means).**

Conclusion

Every minute 1 million of plastic bottles are bought worldwide and their consumption might increase by 20% by 2021, which is going to pollute even more unsustainaby the world, that is now already welcoming 20,000 new plastic bottles every second.

All over the world, the disposal of disposable plastic has become a serious problem and 22,000 tons of plastic reach the ocean every day and mould the so-called "*Great Pacific Garbage Patch*", also known as "*Pacific Trash Vortex*", a huge surface off the Pacific Ocean shaped by the convergence of waste (mostly plastic), coming from all over the world and estimated to be between 700,000 km^2 up to more than 10 million km^2, which is an ever-growing island as big as the Iberian Peninsula.

But the greatest danger in the future lies in the fact that, as a result of the disruptive action of solar radiation and sea water, these debris will tend to fragment into smaller and smaller pieces until they become extremely harmful microplastics for the life of all the marine organisms. A study by the Australian research agency CSIRO on the impact of the sea pollution on the fauna, shows that by 2050 about 95% of all the seabirds will have plastic in their body and that many of the toxins and chemicals contained in plastic are absorbed into the fish tissue, which will in turn end up on our dining tables.

Among the whole plastic garbage, bottles have a significant role: the PET which plastic bottles are made of, is a resistant material with an average shelf life estimated to be around 1000 years and can be actually considered to be non-biodegradable; reason why it is very important to reuse and dispose plastic. In 2014 12.5 billion liters of mineral water were bottled just in Italy (around 81% in PET containers and the remaining 19% in glass and polylaminate), a huge amount that required the production of about 330.000 Tons of PET, through the consumption of 650,000 tons of oil and 6 million tons (6 billion liters) of water.

But this is actually just a small part if we also consider the plastic produced for the packaging of beverages worldwide. Just in 2016 the world was the beholder of a sale of over 480 billion plastic bottles, a never-ending process that, as explained on the pages of “*The Guardian*” by *Rosemary Downey*, head of packaging at Euromonitor and one of the world's leading experts on the production of plastics, "*the increase in plastic consumption is due to the increase in* *urbanization in countries such as China, India and Indonesia and stems from a desire for well-being and the fear of drinking contaminated water* ".

Through the creation of the S.B.M. method I was simply wishing to demonstrate that reusing disposable plastic bottles can be a good opportunity for family horticulture in the production of transplanting seedlings with root balls as for the creation of a nursery at a minimal cost. Avoiding direct seeding in the field and using transplanted seedlings, the agricultural activity in the family garden will be eased and a more rational management of the garden will be reached as well as a lower consumption of water and an increase in vegetable production, compared to the conventional domestic gardens.

The S.B.M. is also easy to make and quick to be built, with a little effort and the aid of simple equipment such as a knife and a pair of scissors. It can produce seedlings on a ceaseless cycle throughout the growing season, facilitating the rotation and the association of the plants and helping in the management of pests.

Building an S.B.M. from the reuse of "*disposable*" plastic, also contributes on the development of an eco-sustainable conscience in the farmer who will begin to consider the waste as a resource and as a new opportunity for agricultural work. Reusing empty plastic bottles, an extension of the useful life of the "*disposable*" material is gained and therefore a reduction in the amount of waste because the garbage used for the S.B.M. can be reused several times before its final disposal.

In the experimental tests of the comparison between the two seedbeds, the S.B.M. has been proven to be more valid than a traditional seedbed as it favors the germination and growth of seedlings, thanks especially to the sub-irrigation system. It helps keeping the soil at a steady humidity and easing germination, it reduces the mean time of seed germination (T.M.G.) by cutting the loss of seeds for death and attacks from ants and achieving a saving on irrigation water of more than 1/3 compared to the conventional sprinkling system and, consequently, as the quantity of seed needed for cultivation gets reduced, an economic advantage is gained as well as a betterment of the whole farming activity. Since germplasm is a valuable material, using an S.B.M. would encourage farmers to reproduce their own seed while saving on seed purchase costs and fostering the development and propagation of typical local varieties. On top of that, it must be said that the S.B.M. can also be successfully used for the production of seedlings from cuttings, but this might be the topic of a new experimental research. Beyond the proven efficacy of the S.B.M. and the benefits on the growth of seedlings, I want to give a sole recommendation, discouraging the use of this method during the summer season in hot tropical countries or at least protecting the seedbed bottles from sun rays during the scorching summertime, in order to avoid excessive heat from damaging and deforming the plastic. The work of my research on the S.B.M. is aimed at the launch of the F.W.T.O.F. (*Seedbed Bottle Method - From Waste To Organic Food*) which aside from representing a valid contribution to the development of family farming in developing countries for the purpose of sustaining the family and improving food safety, an improvement on the problem of waste is achieved through the reuse of empty plastic bottles.

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