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ORGANIC FARMING IN VEGETABLES

ICAR - Indian Institute of Vegetable Research
Post Bag No. 1, Post-Jakhini (Shahanshahpur)
Varanasi - 221 305, Uttar Pradesh

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PREFACE

Vegetables are important constituents of Indian diet as they are rich source of carbohydrate, proteins, vitamins, minerals, glucosinolates, antioxidants and fiber etc. Vegetables and fruits are consumed for nutrition, maintenance of health and many for their therapeutic values and prevention of diseases. The indiscriminate use of chemical inputs in agriculture fears/concerns the contamination of foods with agrochemicals and also the pollution of environment, soil and water and therefore made us to think about alternate form of agriculture to produce food free of contaminants. Besides in the present era of global warming and climate change, the face of agriculture has to be more environments friendly, hence the main emphasis should be for development of production technologies which are sustainable in long run. Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment and restricts the use of synthetic inputs. The primarily goal of organic vegetable production is to optimize the health and productivity of interdependent communities of soil, plants, animals and people. With the increasing awareness about the safety and quality of foods, long term sustainability of the system and accumulating evidences of being equally productive, the organic farming has emerged as an attractive source of income and also ensures a profitable livelihood option. India with its varied climate and variety of soils has an enormous potential for organic production of vegetables and generate revenue through export.

Organic farming systems rely on the management of soil organic matter to enhance the chemical, biological and physical properties of the soil. One of the basic principles of soil fertility management in organic systems is that plant nutrition depends on 'biologically-derived nutrients' instead of using readily soluble forms of nutrients; less available forms of nutrients such as those in bulky organic materials are used. This requires release of nutrients to the plant via the activity of soil microbes and soil animals. Improved soil biological activity is also known to play a key role in suppressing weeds, pests and diseases. Under conditions of soil constraints and climate vagaries, organic inputs use has proved more profitable compared to agrochemicals. Animal dung, crop residues, green manure, bio fertilizers and bio-solids from agro-industries and food processing wastes are some of the potential sources of nutrients of organic farming. While animal dung has competitive uses as fuel, it is extensively used in the form of farmyard manure. Development of several compost production technologies like Vermi composting, Microbe Mediated, Phospho composting, N-enriched Phospho composting, etc. improves the quality of composts through enrichment with nutrient-bearing minerals and other additives. These manures have the capacity to fulfil nutrient demand of crops adequately and promote the activity of beneficial macro-and micro-flora in the soil. In addition, use of liquid manures prepared through fermentation of green leafy materials, cattle urine and other locally available resources can be done. The differences in quality of manures used are probably the reason for wide difference reported in crop yields under organic and conventional system of crop production. There is however a need to scientifically evaluate the nutrient supply methods in organic *vs* conventional systems. Their efficient use is an area of future research investigation .The basic requirement in organic farming is to increase input use efficiency at each step of the farm operations.

An effort has been made to compile the information generated at this institute and other national institutions and are presented in this bulletin entitled "Organic farming in vegetables". The bulletin includes information on effect of different sources of nutrition on vegetable productivity, quality and soil health.

The help rendered by the scientists of this division is thankfully acknowledged.

Authors

Content

1. INTRODUCTION

India is an agrarian economy and the agriculture sector in India contributes about 17 percent of country's GDP and provides employment to approximately two third of the population (United Nation Development Programme Fact sheet 2011). India with its varied agro-climatic zones is amenable to grow a wide variety of vegetable crops. India, with production level of 176.2 million metric tonnes of vegetables, is the second largest vegetable producer country after China, in the world, accounting for 14% of the total world vegetable production. Vegetables are important constituents of Indian diet as they are rich source of carbohydrate, proteins, vitamins, minerals, glucosinolates, antioxidants, fibre, etc. Vegetables and fruits are consumed for nutrition, maintenance of health and many for their therapeutic values and prevention of diseases. The indiscriminate use of chemical inputs in agriculture fears/concerns the contamination of foods with agrochemicals. The consumers are concerned about the vegetables they eat. Both the international and domestic communities are becoming more and more conscious on issues like residues of poisonous agrochemicals in vegetables and their associated health and environmental hazards. This therefore made us to think about alternate form of agriculture to produce food devoid of contaminants. Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment and restricts the use of synthetic inputs.

India is the second most populous country in the world. With the increasing population, the cultivable land resource is shrinking day by day. To meet the food, fibre, fuel, fodder and other needs of the growing population, the productivity of agricultural land and soil health needs to be improved. Green Revolution ushered through use of modern agriculture technologies such as greater use of synthetic agrochemicals like fertilizers and pesticides, adoption of nutrient-responsive, high-yielding varieties of crops, greater exploitation of irrigation potentials, etc., undoubtedly has increased production and labour efficiency in the post-independence era and made our countries self-sufficient in food production. But indiscriminate and excessive use of chemicals during this period has put forth a question mark on sustainability of agriculture in the long run and concerns have been raised time and again over its adverse effects on soil productivity and environment. Some of the adverse effects are soil erosion, depletion of organic matter in soil, nutrient deficiencies, low water availability, salinization, fertilizer and pesticide contamination of food and water bodies and erosion of bio-diversity calling attention for sustainable production technology which will address soil health, human health and environmental health and eco-friendly agriculture. Besides in the present era of global warming and climate change, the face of agriculture has to be more environments friendly, hence the main emphasis should be for development of production technologies which are sustainable in long run. Therefore, in sustaining agricultural production against the finite natural resource base, the demands has shifted from the "resource degrading" chemical agriculture to a "resource protective" biological or organic agriculture. Organic farming appears to be one of the options for sustainability. As a result, there is a resurgence of interest in organic farming globally, which holds sustainability of natural resources and environment supreme along with natural taste and nutritional quality of the produce. During the last two decades, 'Organic Agriculture' has emerged as a dynamic 'Alternate Farming System'. There has been a paradigm shift and interest to adopt organic vegetable production systems, which are ecologically and economically viable and socially just. Organic farming of vegetables production favours maximum use of organic materials and discourages use of synthetic agro-inputs to ensure conservation of natural resources and healthy environment. The primarily goal of organic vegetable production is to optimize the health and productivity of interdependent communities of soil, plants, animals and people.

In view of growing awareness of health and environment issues, organic farming especially of vegetables is gaining momentum across the world and emerging fast as an attractive source of rural income generation. Organic products are increasingly preferred in developed countries and in major urban centers in India. There is high demand for organic food in domestic and international market which is growing around 20-25 percent annually; as a result the area under organic farming has been increasing consistently. India with its varied climate and variety of soils has an enormous potential for organic vegetable production. The wide product base, high volume of production round the year, strategic geographic location, high international demand, abundant sunlight and availability of labour at comparatively low cost make India an apt location for organic vegetable production.

Under organic farming nutrient management is of utmost importance as the soil fertility has to be not only maintained but also to be improved. All synthetic fertilizers are prohibited in organic farming. A healthy biologically active soil is the source of crop nutrition. A live, healthy soil with proper management and effective crop rotation can sustain optimum productivity over the years, without any loss in fertility. The sustenance of crop yields is linked to the capacity of cycling and manipulation of essential nutrients. The capacity to produce usable biomass depends upon the adequacy and balance of macro and micro nutrients in the plant. Organic sources of nutrition contain all the essential nutrients. The application of appropriate quantity of organic manures can not only sustain the yield of vegetable crops but can also enhance it. The basic idea of nutrient supplementation in organic farming is to replenish the requirement of nutrients through the use of permitted inputs. There are a number of organic sources of nutrients and among them green manures, compost, vermicompost, organic cakes, biofertilizers and biodynamic preparations are important. In organic farming, efforts are made to minimize losses of nutrients and maximize the input use efficiency. It has been estimated that in India every year 280 million tonnes, cattle dung, 273 million tonnes, crop residues, 285 million tonnes compost and 6351 million cubic meter domestic wastes are produced which can be reused and recycled effectively in order to promote organic farming in India. Organic farming of vegetables is still in its infancy in India and there is not much work done in this field.

2. BASIC CONCEPT AND PRINCIPLES OF ORGANIC FARMING

The concept of organic farming is not clear to many concerns (Palaniappan and Annadurai, 1999). Many people consider that traditional agriculture, sustainable agriculture, Jaivik Krishi etc, as organic farming. Some people are of the idea that the use of organic manures and natural methods of plant protection instead of using synthetic fertilisers/ pesticides is organic farming. But this is not true. Organic farming in real sense envisages comprehensive management approach to improve the health of underlying productivity of the soil (Palaniappan and Annadurai, 1999). Above all, the success of organic farming depends to a great extent on the efficiency of agronomic management adopted to stimulate and augment the underlying productivity of the soil resources. All the management practices followed in organic farming are governed by the principles of ecology and are within the ecological means.

The basic concepts behind Organic farming are:

- It concentrates on building up the biological fertility of the soil so that the crops take the nutrients they need from the steady turnover within the soil nutrients produced in this way are released in harmony with the needs of the plants.
- Control of pests, diseases, and weeds is achieved largely by the development of an ecological balance within the system and by the use of bio-pesticides and various cultural techniques such as crop rotation, mixed cropping, and cultivation.
- Organic farmers recycle all wastes and manures within a farm but the export of the products from the farm results in a steady drain of nutrients.
- In a situation, where conservation of energy and resources is considered to be important, community or country would make every effort to recycles to all urban and industrial wastes back to agriculture and thus the system would be only being small inputs of new resources to “top up” soil fertility.

The International Federation of Organic Agriculture Movements (IFOAM) states that “Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.” According to *Codex Alimentarius* (FAO/WHO), organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking in to account that regional conditions require locally adapted system. This is accomplished by using where possible, agronomic, biological and mechanical methods, as opposed to using synthetic materials, to full fill any specific function within the system. Organic agriculture relies on a number of farming practices that take full advantage of ecological cycles. According to IFOAM, organic agriculture is guided by following four principles:

Principle of health: Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible. This principle points out that the health of individuals and communities cannot be separated from the health of ecosystems - healthy soils produce healthy crops that foster the health of animals and people.

Principle of ecology: Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them. This principle roots organic agriculture within living ecological systems. It states that production is to be based on ecological processes, and recycling. Nourishment and well-being are achieved through the ecology of the specific production environment.

Principle of fairness: Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities. Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings.

Principle of care: Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. Organic agriculture is a living and dynamic system that responds to internal and external demands and conditions. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being.

These principles of organic farming encourage:

i. To work as much as possible within a closed system, and draw upon local resources:
ii. ii)To maintain the long-term fertility of soils.
iii. To avoid all forms of pollution that may result from agricultural techniques.
iv. To produce foodstuffs of high nutritional quality and sufficient quantity.
v. To reduce the use of fossil energy in agricultural practice to a minimum.
vi. To give livestock conditions of life that confirm to their physiological need.
vii. To make it possible for agricultural producers to earn a living through their work and develop their potentialities as human being.

3. APPROACHES TO PRODUCE ORGANIC VEGETABLES

Varieties of concern and problems of modern agriculture gave birth to various new concepts of farming such as organic farming, biodynamic agriculture, natural farming, eco-farming, etc. The essential concept of these practices remains the same, *i.e.*, back to nature, where the philosophy is to feed the soil rather than the crops to maintain soil health and it is a means of giving back to the nature what has been taken from it (Funtilana, 1990). The organic agriculture is called in different names by different people, however, the basic concept and philosophy remains the same. A number of terminologies are available as mentioned below:

i. Organic farming

It is a holistic production management system that avoids the use of synthetic fertilizers and pesticides, minimizes pollution of air, soil and water, and optimizes the health and productivity of independent communities of life, plants, animals and people. It uses the organic amendments to supply nutrition to the soil and crop.

i Bulky organic manures (viz. FYM, vermicopost etc.)

ii Green manure (viz. dhaincha, sunnhemp etc.)

iii Concentrated organic manures (viz. groundnut cakes, neem cake etc.).

ii. Natural farming

It was developed in Japan during 1930 by Mokichi Okada who later formed the "Mokichi Okada Association (MOA)". Natural farming is *at par* with organic farming in many ways but gives special emphasis on soil health through composts and use of microbial preparations.

iii. Ecological agriculture

It is labour intensive system which is based on techniques of crop cultivation. It involves all attention to promote renewable source of energy (draught animal power), electric energy from garbage disposal and biogas from organic wastes. It also involves water use efficiency through conjunctive use of rain, tank, underground well and river water. Practices which improve crop productivity (genetic and agronomic) i.e. hybrid vigour, gene pyramiding, multiple cropping, Integrated Plant Nutrient Management (IPNM) and Integrated Pest Management (IPM) are the essential components of ecological farming.

iv. Agnihotra

Agnihotra is a process of purification of the atmosphere as a cumulative effect of various scientific principles harnessed to give rise to an unparalleled purifying and healing phenomenon. The process of *Agnihotra* consists of making two offerings to the fire exactly at the time of sunrise and sunset along with the chanting of two small Sanskrit mantras. *Agnihotra* balances the cycle of nature and nourishes the human life. It cleanses the negative effects of pollution.

v. Rishi Krishi (Rishi Kheti)

This system was evolved by Mr. Mohan Shankar Deshpande in Maharashtra and is being promoted by large number of farmers in Maharashtra and Madhya Pradesh. In this system, the following aids are used to maintain soil fertility and crop yield.

a) Angara: *Bhomi Sanskar* is being performed to make the soil fertile wherein 15 kg rhizosphere soil of banyan tree (*Ficus benghalensis*) is broadcasted over an acre of land. It has lot of earthworms and other beneficial microbes, which improves the soil fertility.

b) Amrit Pani: *Amrit Pani* is prepared by mixing 20 kg cow dung, ½ kg honey, ¼ kg ghee. All ingredients are mixed and kept overnight. This is used to treat the seeds field and plants(*Beej Sanskar, Jala Sanskar* and *Vanaspati Sanskar*).

c) Panchya Gavya: It basically consists of five products from cow i.e. dung (5 kg), urine (5 litres), milk (3 litres), curd (3 litres) and ghee (1 kg). These are mixed with sugarcane juice, tender coconut water, ripe banana and toddy and incubated for 15 days. The mixture is stirred daily for proper mixing and fermentation. Mixture is diluted in 1:10 ratio with water, filtered and sprayed on the crop.

vi. Homeopathy farming

It is a kind of farming with homeopathic aids *i.e.* Homeo nutrients and Homeopathic plant protection measures.

vii. Biodynamic agriculture or Vedic Kheti

Biodynamic farming is defined as working with energies, which create and maintain life. It involves certain principles and practices for healthy soil, healthy plant and healthful food for human beings and feed for animals. In the system, energies from cosmos, earth, cow and plants are systematically and synergistically harnessed. It is based on the knowledge that soil, plants, animals and men work together in one agricultural cycle.

Biodynamic preparations

Steiner prescribed nine different preparations to aid fertilization, and described how these were to be prepared. Steiner believed that these preparations mediated terrestrial and cosmic forces into the soil. The prepared substances are numbered 500 through 508, where the first two are used for preparing fields whereas the latter seven are used for making compost.

BD 500: It is a humus mixture prepared by filling the horn of a cow with cow manure and burying it in the ground (40–60 cm below the surface) in the autumn. It is left to decompose during the winter and recovered for use the following spring.

BD 501: It is prepared by stuffing crushed and powdered quartz into a horn of a cow and buried into the ground in spring and taken out in autumn. It can be mixed with 500 but usually prepared on its own (mixture of 1 tablespoon of quartz powder to 250 liters of water) The mixture is sprayed under very low pressure over the crop during the wet season, in an attempt to prevent fungal diseases. It should be sprayed on an overcast day or early in the morning to prevent burning of the leaves.

Both 500 and 501 are used on fields by stirring about one teaspoon of the contents of a horn in 40–60 liters of water for an hour, creating vortexes in alternate directions.

BD 502: Yarrow blossoms (*Achillea millefolium*) are stuffed into urinary bladders from Red Deer (*Cervus elaphus*), placed in the sun during summer, buried in earth during winter and retrieved in the spring.

BD 503: Chamomile blossoms (*Matricaria recutita*) are stuffed into small intestines from cattle buried in humus-rich earth in the autumn and retrieved in the spring.

BD 504: Stinging nettle (*Urtica dioica*) plants in full bloom are stuffed together underground surrounded on all sides by peat for a year.

BD 505: Oak bark (*Quercus robur*) is chopped in small pieces, placed inside the skull of a domesticated animal, surrounded by peat and buried in earth in a place where lots of rain water runs past.

BD 506: Dandelion flowers (*Taraxacum officinale*) are stuffed into the mesentery of a cow and buried in earth during winter and retrieved in the spring.

BD 507: Valerian flowers (*Valeriana officinalis*) are extracted into water.

BD 508: Horsetail (*Equisetum*)

One to three grams of each preparation is added to a dung heap by digging 50 cm deep holes with a distance of 2 meters from each other, except for the 507 preparation, which is stirred into 5 liters of water and sprayed over the entire compost surface. All preparations are thus used in homeopathic quantities. Each compost preparation is designed to guide a particular decomposition process in the composting mass.

Astronomical planting calendar

In biodynamic farming, it is considers that there are astronomical influences on soil and plant development, for example, what phase of the moon is most appropriate for planting, cultivating or harvesting various kinds of crops. This aspect of biodynamics has been termed “astrological” in nature.

4. ORGANIC FARMING IN INDIA

4.1 Historical perspective and background

Although the term 'organic farming' is getting popularity in recent times, but Organic farming is not a recent origin in India. It was initiated 10000 years back when ancient farmers started cultivation depending on natural sources only. There is brief mention of several organic inputs in our ancient literatures like Rigveda, Ramayana, Mahabharata, Kautilya Arthasashthra, etc. In Rigveda, the use of animal dung as manure was emphasized. Atharvaveda indicated the importance of green manure, which was practiced before 1000 BC (Bhattacharya and Chakra borty, 2005; Bisoyi, 2003). Kautilaya's Arthashastra recorded manure like oil cakes, excreta of animals, etc. In fact, organic agriculture has its roots in traditional agricultural practices that evolved in countless villages and farming communities over the millennium.

India has traditionally practiced organic agriculture, and farmers were following organic cultivation till the advent of chemical fertilizer and pesticides in the middle of the last century (1950) that dramatically changed the face of agriculture. The process of modernization, particularly the green revolution technologies, has led to the increased use of chemicals. However, continuous use of these high energy inputs indiscriminately, now leads to decline in production and productivity of various crops as well as deterioration of soil health and environments. The realization has now dawned that it is essential to make another turnaround if severe environmental damage is to be stemmed. However, the approach is not to return *per se* to traditional methods but to integrate modern knowledge to develop a sustainable system.

In the modern era, as per the documented evidence, the organic farming in India started long back in 1900 by Sir Albert Howard, British Agronomist in a local village in North India. Development of Indore Method of aerobic compost (Howard, 1929), Bangalore method of anaerobic compost (Acharya, 1934), NADEP Compost (ND Pandari Panda, Yeotmal,1980) initiated organic agriculture in India.

4.2 Scope of organic farming in India

India is bestowed with lot of potential to produce all varieties of organic products due to its various agro-climatic regions. India is endowed with various types of naturally available organic form of nutrients in different parts of the country and it will help for organic cultivation of crops substantially. In several parts of the country, the inherited tradition of organic farming is an added advantage. There is diversity in climates100-10,000 mm rainfall, hill, desert, strong traditional farming system-crop-tree animal, innovative farmers, vast dry lands (60% agricultre land), least use of chemicals. In India, only 40% of total cultivable area is covered with fertilizers where irrigation facilities are available and in the remaining 60% of arable land, which is mainly rain-fed, negligible amount of fertilizers is being used. Farmer's in these areas often use organic manure as a source of nutrients that are readily available either in their own farm or in their locality. The North-Eastern region of India provides considerable opportunity for organic farming due to least utilization of chemical inputs. It is estimated that 18 million hectares of such land is available in the NE, which can be exploited for organic production. Infact, the rainfed, tribal, north east and hilly regions, of the country where negligible chemicals are used practicing subsistent agriculture for a long period, these areas are organic by default. With the sizable acreage under naturally organic/default organic cultivation, India has tremendous potential to grow crops organically and emerge as a major supplier of organic products in the world's organic market. This hold promises for the organic producers to tap the market which is growing steadily in the domestic market and to the export market. India is an exporting country and does not import any organic products. The main market for exported products is the European Union, USA, Far east and Gulf countries. The report of the Task Force on Organic Farming appointed by the Government of India also observed that in vast areas of the country, where limited amount of chemicals issued and have low productivity, could be exploited as potential areas for organic agriculture (Anonymous, 2001).

As regards the availability of major organic nutritional inputs (NPK) in India, it is estimated that around 700 mt of agricultural wastes available in the country every year, but most of it is not properly used. This implies a theoretical availability of 5 tonnes of organic manure/hectare arable land/year, which is equivalent to about 100 kg NPK/ha/yr. (Tondon, 1997). The estimate of National Centre of Organic Farming, Ghaziabad (Bhattacharya and Kumar 2005) is as follows: a) Crop residue = 3.865million tonnes b) Animal dung = 3.854 million tonnes c) Green manure = 0.223 million tonnes d) Biofertilizer = 0.370 million tonnes. There are several alternatives for supply of soil nutrients from organic sources like compost, FYM, Crop residues, vermicompost, biofertilizers, etc. Technologies have been developed to produce large quantities of nutrient-rich manure/compost. There are specific biofertilizers for cereals, millets, pulses and oilseeds that offer a great scope to further reduce the gap between nutrient demand and supply. Besides, there is enough scope of using biodynamic preparation, Amrit Pani , Jeeva Amrit, etc. on on-farm production basis.

5. ORGANIC FARMING IN VEGETABLE CROPS

Vegetables in addition to being a source of highly digestible carbohydrate and nutritionally complete protein, are also an excellent source of essential nutrients, glucosinolates, antioxidants, fibre and vitamins, particularly niacin, riboflavin, Thiamin and vitamins A and C, etc. Green leafy Vegetables such as amaranth, bathua and spinach etc., are cheaper source of folic acid. Vegetables are the best resource for overcoming micronutrient deficiencies. Judicious mix of vegetables can provide the recommended daily allowance for vitamin, folate as well as significant amounts of other essential mineral nutrients required for human health. Moreover, most of the vegetables, being short duration crops, fit very well in the different multiple and inter-cropping system and are capable of giving very high yields and very high economic returns to the growers in a short period of time, besides generating on farm and off farm employment as a result, in recent years major emphasis is given for commercial exploitation of vegetable crops. Organics added in its cultivation will lead to more value addition providing better income and a sustainable production.

According to the United Nations Food and Agricultural Organization report about 17% of Indians are too undernourished to lead a productive life. Main issue is the lack of balanced nutrition in the diet. Around 51% men and 48% women have high fat diets. Almost three in five men and an equal number of women have low intake of fruit and vegetables. This emphasizes the need for balanced nutrition in the diet. Vegetables being nutritionally rich, thus, offer vast potential for ensuring food and nutritional security and eradicating malnutrition for millions of people of our country. Most of the fruits and vegetables are consumed in fresh conditions. The indiscriminate use of chemical inputs in agriculture fears/concerns the contamination of foods with agrochemicals and may lead to various kinds of health hazards. Hence there is need to produce food free of contaminants. Organic vegetable production, besides feeding the burgeoning population of the country, increases the farmers' income providing them economic security. India has an enormous potential for organic production of vegetables and generate revenue through export.

India grows the largest number of vegetables from temperate to humid tropics and from sea-level to snowline. More than 70 types of vegetables are grown in our country, which generate high income and employment, for small farmers particularly in peri urban areas. Major vegetables grown in India are potato, onion, tomato, cauliflower, cabbage, bean, egg plant, cucumber and gherkhins, frozen peas, garlic and okra. The country has exported 6, 99,600.34 MT of Fresh Vegetables other than Onion to the world for the worth of

Rs. 2119.50 crores during the year 2015-16. The major destinations for Indian fruits and vegetables are UAE, Bangladesh, Malaysia, Netherland, Sri Lanka, Nepal, UK, Saudi Arabia, Pakistan and Qatar.

Vegetable consumption of an average Indian per capita per day (252g) is far less than recommended (300 g). Our demand by 2020 will be around 250 million tonnes of vegetables. Thus in order to feed the population, the only solution is the vertical expansion or by increasing the productivity per unit area per unit time as the potential available land and water resources is going to be limited. Our strategy should be to produce more vegetables from less land, less water with less pesticides and with less detrimental to soil and environment as well. Organic vegetable cultivation offers one of the most sustainable farming systems with recurring benefits to not only long-term soil health but provides a lasting stability in production by importing better resistance against various biotic and abiotic stresses. Organic vegetables fetch a premium price of 10-50 % over conventional products. There is high demand for organic food in domestic and international market. Market of organic products is growing at faster rate (20-25%) as compared to conventional ones (5%) annually. This growth rate is highest in Japan, USA, Australia and EU. Export preference of organic vegetables offers a great scope to a country like India, which has inculcated the skill of growing organically since time immemorial.

5.1 Characteristics of Organic Farming Systems in vegetables

Management of Organic farming is focussed on the whole farm system and its interactions with climate, environment, social as well as economic conditions, rather than considering the farm as comprises of individual enterprises. The key characteristics of Organic Farming include:

- Protecting the long-term fertility of soils by maintaining organic matter levels, soil biological activity and careful mechanical intervention.
- Nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, as well as effective recycling of organic materials, including crop residues and livestock wastes.
- Weed, disease and pests control relying primarily on crop rotation, natural predators, crop diversity, organic manuring, use of resistant varieties and limited thermal, biological and chemical intervention.
- Supplementing crop nutrients, where necessary, by using nutrient sources which are made available to the plants indirectly but the action of soil micro organisms and chemical reactions of the soil.
- The extensive management of livestock, paying full regards to their evolutionary adaptations behavioural needs, and animal welfare issues with respect to nutrition, housing, health, breading and rearing.
- Careful attention to the impact of the farming system on the wider

environment and the conservation of wildlife and natural habitats (Padel and Lampkin, 1994).

5.2 Objectives of Organic Farming in Vegetable crops

The primary goal of organic vegetable production is to optimize the health and productivity of interdependent communities of soil, plant, animal and people

- To produce food of high nutritional quality in sufficient quantity
- To encourage biological cycles within farming systems by involving the use of microorganisms, soil flora & fauna, plants and animals
- To maintain and increase the long-term fertility of soil and biodiversity
- To use renewable resources in locally organized production systems
- To work as much as possible within a close system with regard to organic matter and nutrient elements and draw up on local resources
- To avoid all forms of pollution that may results from Agricultural techniques
- To reduce the use of fossil energy in agricultural practice to the minimum

6. NUTRIENT MANAGEMENT OPTIONS FOR ORGANIC VEGETABLES

The intensification of agriculture, excess and indiscriminate/imbalance use of inorganic fertilizer and agrochemicals has deteriorated soil health badly with deficiency of macro and micronutrient. Depleting soil organic carbon status, decreasing soil fertility and reduced factor productivity, increase in the cost of production and deteriorating environmental quality are other issues of concern (Yadav et al., 2016). Existing and emerging widespread deficiencies of nutrients are threatening the sustainable agricultural productivity, nutritional quality as well animal and human health as most of the nutrients that are required for human health come from the soil through either plants or animal products consumed by humans. These indicate the weakening of natural resource base. If we continue to exploit the natural resources at the current level, productivity and sustainability is bound to suffer. Besides in the present era of global warming and climate changes, efforts must be focused on reversing the trend in soil degradation by adopting efficient organic agriculture practices, to achieve sustainable higher productivity.

Conventional agriculture is based on concept of fertilising the crop while in organic agriculture, it is for 'fertilising the soil'. A living soil is the basis of organic farming. The organic farming system takes local soil fertility as a key to successful production. Plant uses nutrients from organic sources through mineralisation and billions of microorganisms are available in soil for this job. Under present agricultural situation of inorganic conventional farming practices, due to loss of organic matter maintenance of optimum soil microbial load is a major problem. Under organic farming practices, regular addition of organic fertiliser improves the soil quality. The loss of nutrient in organic manure is also less due to its slow release. It is always better to use on farm inputs.

Nutrient management is the key factor for all farming systems. In organic farming systems there is no place for synthetic chemicals therefore use of chemical fertilizers is abandoned, In organic farming, nutrient management depends on biologically derived nutrients through recycling of on- farm inputs. As a strategy, the quantity of biomass removed for human food and fiber, cattle feed or firewood from an organic farm should be replaced with any other bio-waste on the farm. Use of organics in vegetable production should be practiced. It does not involve the use of any particular organic source of material or the use of a single organic farming practice. The various types of organic farming (natural farming, ley farming, non-chemical farming, etc.) can be followed by adopting variety of methods of organic farming. Depending upon the resource base of an ecosystem and time/cost factors, some methods may attain predominance in a given situation. Sometimes, a particular requirement such as pest control may get pre-dominance over other aspects of organic farming (for instance, control of boll worm in hybrid cotton is of utmost importance than other factors to increase the cotton yields). A particular method of organic farming to control pests may be emphasized. Thus, each eco-system and each crop may require different set of methods of organic farming based on priority. Sometimes, a mixture of many methods may have to be developed based on critical analysis of resources available at hand, cost of materials, convenience of their use and favourable situation for decomposition.

6.1 NUTRIENT SOURCE

6.1.1 Green manures

Green manuring refers to incorporation of live biomass into the soil in order to supply plant nutrients. When green and succulent tissues are used, decomposition of incorporated biomass is faster, thus the practice attained a name called 'green manuring'. The crops grown to be incorporated are called green manuring crops. Ideally, a green manure crop should be a fast growing, non-woody and short duration crop so that the practice of green manuring is practically feasible in a given cropping system. A large number of fast growing nitrogen fixing crops like dhaincha (*Sesbania* sp.), sunhemp and cowpea may be used as green manure which can fix atmospheric nitrogen to the extent of 60-100 kg/ha. Generally, dhaincha (*Sesbania esculenta, S. rostrata*) and sunhemp (*Crotolaria juncia*) are ploughed in the soil after about 6 to 8 weeks of sowing when adequate vegetative growth is attained. Use of green manure is highly beneficial for organic production and maintaining soil health Besides adding nutrients into the soil, green manures also improve the physical and microbial properties of the soil. The benefits arising out of green manuring practice are limited by factors such as:

- Quantity of green matter incorporated and actual nutrients contained in them
- Time taken for decomposition
- Favourable factors available in soil for decomposition
- Stage of incorporation
- Release pattern of nutrients

Green manuring can be done either through in-situ growing of leguminous crops(Dhaincha, sun hemp and cowpea)or through ex-situ addition of green lopping from pongamia or gliricidia trees and other plants grown on bunds, Major nutrients content of some of the green manure crops has been presented in Table 1 a and b.

Table 1(a): Productivity and nitrogen content (fresh wt. basis) in some green manure crops

Crop	Green biomass (t/ ha)	Nitrogen %
Subabul	09-11	0.80
Sunhemp	12-13	0.43
Dhaincha	20-22	0.43
Cowpea	15-16	0.49
Clusterbean	20-22	0.34
Berseem	15-16	0.43
Green Gram	08-09	0.53

Table 1(b): Nutrient content (dry wt. basis) in some green manure crops

Crop	Nutrient content (% on dry weight basis)		
Green manure	N	P	K
Sesbania aculeatea	3.3	0.7	1.3
Sesbania speciosa	2.7	0.5	2.2
Crotalaria juncea	2.6	0.6	2.0
Tephrosia purpurea	2.4	0.3	0.8
Phaseolus trilobus	2.1	0.5	-
Green gram	2.0	0.44	2.5
Balck gram	2.0	0.40	2.0
Green leaf manure			
Pongamia glabra	3.2	0.3	1.3
Glyricidia maculeata	2.9	0.5	2.8
Azadirachta indica	2.8	0.3	0.4
Calatropis gigantea	2.1	0.7	3.6

6.1.2 Farm yard manure

The term 'farm yard manure' is an expression to signify any manure prepared in the backyard using the farm waste, cattle urine and dung. Since very early ages, its use is prevalent in agriculture. Although very little scientific attention was paid till 1970's to scientifically study the method of preparing FYM and possibility of improving the quality of decomposition. Three principal methods of preparing FYM are standardized on scientific lines in the last 15 to 20 years.

1.	Open pit method	Allowing semi-aerobic decomposition of farm wastes in underground pit. This method gradually requires turning of the decomposition material frequently
2.	Sealed pit method	Allowing anaerobic decomposition of farm wastes in underground pit. This requires sealing the surface of the pit with dung slurry
3.	Japanese method (vat method)	Allowing aerobic decomposition of farm wastes in an above ground structures of stones/bricks or thatched walls upto height of 1 meter

The benefits derived by application of FYM are reported ever since the documentation on experimental results started. Farm yard manure application can result into chain of effects in soil besides increasing the crop yield. The response to applied FYM could be studied in four groups:

1. Improved crop yields
2. Improved physical properties of soil
3. Improved microbial activity
4. Residual benefits to succeeding crop

The willingness to associate with FYM preparation is lacking in the rural community and not the shortage of dung or crop residues. There is no other reason why FYM is not available in adequate quantity, when quantity of dung and crop residues has substantially increased in the past 25 to 30 years. Consumption of crop residues by cattle does not create a dearth of biomass for manure preparation. If the dung and urine from cattle are effectively collected, nearly 70 to 80 per cent of energy fed to as crop residues can be recovered back. As much as 80 to 90 per cent of N, 60 to 70 per cent of P and 60 to 75 per cent of K contained in the crop residues fed to cattle are excreted by them in the form of dung and urine. In case of milch cows, 70 to 79 per cent of N, 50 to 59 per cent of P and 61 to 65 per cent of K are excreted (Gaur *et al*., 1990). In this perspective, dung and urine from cattle are efficiently converted energy from crop residues. It is ridiculous to allow such huge resource of nutrients from the Indian cattle population, which is one of the largest, to go to waste.

6.1.3 Enriched Compost

Composting of organic residues is the traditional source of nutrients for crops. Though the concentration of nutrients is quite low in compost, its special merit lies in its capacity to supply almost all the essential micronutrients in addition to NPK, which are becoming deficient in the intensively cultivated areas. The supply of micronutrients particularly satisfies the hidden hunger in plants and safeguards against toxicity/injury. Besides the supply of nutrients, compost improves the physical, chemical and biological health of the soil. The compost can be further enriched by incorporation of biofertilizers, microbial inoculants, and rock phosphates etc.

6.1.4 Vermicompost

Vermiculture technology is an aspect involving the use of earthworms as versatile natural bioreactors for effective recycling of non-toxic organic wastes to the soil. They effectively harness the beneficial soil micro flora, destroy soil pathogens, and convert organic wastes into valuable products such as bio-fertilizers, bio-pesticides, vitamins, enzymes, antibiotics, and growth hormones. The term vermicompost refers to manure prepared out of large scale rearing of earthworms in an artificial or natural pit. Earthworms can be used in specifically designed pits or in any ordinary FYM pits. Frequently, a term vermiculture is also used to denote a culture of young earthworms which are let in any undigested compost pit or in an agricultural field directly. They reproduce and grow in number. The fecal waste from large number of earthworm is available as manure. Generally, this method is adopted when soil has large undecomposed organic matter. The establishment of required population of earthworms may take more time to contribute sizeable manure.

Table 2: Average nutrient content of organic manures

Amendment	**Percentage content (dry wt)**		
	Nitrogen	**Phosphoric acid (P_2O_2)**	**Potash (K_2O)**
Bulky organic manures			
Farmyard manure	0.95	0.62	2.20
Rural compost	0.75	0.63	1.05
Urban compost	1.35	0.62	1.43
Sewage sludge	2.75	0.75	0.35
Sewage sludge activated.	5.41	3.15	0.62
Vermicompost	1.80	0.22	0.40

6.1.5 Concentrated organic manures (Oil cakes)

Use of oil cakes as manures for increasing the crop yields is one of the conventional form of organic farming. Before the use of fertilizers, the oil cakes were applied in granulated formulations to agricultural lands, so that the nutrients contained in them were made available to crops. This added large amounts of organic carbon to the soil, which helped in enhancing microbial activity. At present in the Indian scenario, use of oil cakes as a source of nutrients is largely limited because:

- Most of the edible oil cakes are fed to the cattle as concentrates.
- Oil cakes usually supply limited amount of nutrients because of better oil extraction methods like solvent extraction as compared to traditional methods.
- The extraction process is performed in oil industries which is located away from the agricultural fields thus increasing the cost of transportation per kg of nutrient in the oil cake.

Nevertheless, the potentiality of oil cakes for being used as manures is evident in non- edible cakes (castor cake, linseed cake and neem cake) and oil bearing trees (*Terminalia chebula, Madhuca indica*, *Jatropha cucras*)

Table 3: Nutrient content of some oil cakes

Oil cake	Nutrient composition (%)		
	N	P_2O_5	K_2O
Castor cake	4.3	1.8	1.3
Neem cake	3.9	1.8	1.6
Linseed	4.9	1.4	1.3
Safflower cake	5.2	1.0	1.4
Ground net cake	7.3	1.5	1.3

6.1.6 Crop residue

Use of crop residues is essential in organic vegetable production, which increases the soil organic matter content, maintains soil fertility status, and in turn increases the crop yield. Recyclable nutrients (N, P, K, S, Zn, Mn, Fe and Cu) from plant wastes can be used through scientific composting. The technology for converting waste into compost has been developed but it needs refinement as per the location and situation specific adaptation. This step would help in organic farming, reducing the cost of cultivation and improving the soil health. Vegetable crops generate a large amount of crop residues after harvesting of economic part. The embedded nutrients in the residues can be potential source of organic nutrition. These huge amounts of otherwise unused vegetable waste can be effectively recycled to produce valuable vermicompost and NADEP compost as per the principles of organic farming. In a study conducted on production of NADEP compost and vermicompost through recycling of crop residues at IIVR, Varanasi, revealed that vegetable residues are excellent source for production of organic manures. The efficacy of these composts was evaluated in field experiments in organic vegetable production. The hardy plant residues (such as brinjal, okra and cowpea) were subjected to NADEP compost preparation. The study demonstrated that vermicompost produced from the combining mixture of non-legume and legume vegetable waste in 1:1 ratio with cow dung (40-50%) will provide the major nutrients in more balanced proportion compared to vermicompost from sole /individual family waste.

Table 4: Quality and recover of vermicompost produced from vegetable wastes

Vegetable residues	C:N ratio	Nutrient content (%)			Dry matter content (%)	Recovery of VC(%)
		N	P	K		
Waste of Solanaceae (brinjal, tomato) + Leguminosae (Garden pea, French bean , Indian bean) in 1:1 ratio	25.17	1.72	0.74	1.32	46.45	46.24
Waste of Cruciferae (Cabbage, cauliflower)+ Leguminosae in 1:1 ratio	26.20	1.73	0.75	1.34	45.62	42.54
Waste of Cucurbitaceae (bottle gourd, pumpkin, spong gourd, bitter gourd) + Leguminosae in 1:1 ratio	27.32	1.62	0.69	1.31	45.12	45.86
Leguminosae +Cow dung only	22.14	1.74	0.81	1.36	38.27	48.56
Cow dung only	26.84	1.54	0.76	1.20	40.23	51.20

Table 5: Quality and recover of NADEP compost produced from vegetable wastes

Vegetable residues	C: N ratio	Nutrient content (%)			Dry matter content (%)	Recovery of C(%)
		N	P	K		
Brinjal	36.14	0.69	0.32	0.67	72.51	65.32
Cucurbits	32.52	0.61	0.24	0.54	74.31	64.27
Cowpea	25.42	1.11	0.46	0.72	76.12	66.4
crucifers	34.21	0.71	0.31	0.74	68.23	61.12

In a study at IIVR, Varanasi, it was observed that the vermicompost and NADEP compost prepared from vegetable residues improved the yield of brinjal, cabbage and Pea (Table 6) under organic farming system by 12.0, 53.8 and 25.9 percent respectively due to application of vermicompost @ 10t/ha, FYM@ 10t/ha+ NADEP compost @10 t/ha and. NADEP compost @ 25t/ha. (IIVR annual report, 2017). Chatterjee *et al* (2014) reported that vermicompost prepared from mixture of non-legume and legume wastes at 2:1 emerged best considering the nutrient contents. Use of such vermicompost recorded highest root length, root volume, root weight and root yield of carrot.

Table 6: Yield of Brinjal, Pea and cabbage cultivation under organic system

Treatment	CabbageYield (t/ha)	Pea Yield (t/ha)	Brinjal Yield (t/ha)
FYM@25 t/ha	38.64	6.35	27.6
NADEP compost @25 t/ha	40.1	7.26	27.78
Vermicompost @ 10 t/ha	39.91	7.1	29.28
FYM + Vermicompost (10t+2.5t/ha)	39.63	9.4	28.51
NADEP + Vermicompost (10t+2.5t / ha)	37.82	10.6	28.84
FYM+NADEP compost (10t+10 t/ha)	40.83	9.9	29.06
Inorganic RDF	32.43	6.89	26.14
CD(P=0.05)	12.5	1.75	3.12

A number of studies conducted by many workers have demonstrated the viability of composting technology for utilization of fruit and vegetable wastes for production of vermicompost. Avinash Chauhan *et al.* (2010) reported increase in Nitrogen, Phosphorous and Potassium content of the vermicompost prepared from wastes of green peas, brinjal, French beans, cabbages, tomatoes, parts of cauliflower and carrot collected from markets by *Eisenia foetida*. Similarly Khwairakpam and Kalamdhad (2011) reported that vegetable waste amended with cattle manure produced high quality stable compost free from pathogens. The findings can be promoted as a sound vegetable wastes recycling technology to conserve natural resources for organic production of vegetables. In another studies conducted by Upadhyay and Sharma (2000) reported that application of five group of crop residues like bhang (*Cannabis sativus*) leaves, parthenium weeds, gulmohar and peepal leaves to the soil @ 15t/ha each before raising cowpea crop in a cowpea-potato-cucumber rotation and subsequently the crop residues of cowpea, potato (haulms) and cucumber were added in succession after harvest of each crop and before sowing of succeeding crop resulted a positive effect on the yield of crops and enriched the soil with organic matter.

Table 7: Nutrient content of some of the crop residues

Crop Residue	Nitrogen (%)	Phosphoric acid (%)	Potash (%)
Groundnut husks.	1.6-1.8	0.3-0.5 1	1-1.7
Banana, dry	0.61	0.12	1.00
Cotton	0.44	0.10	0.66
Maize	0.42	1.57	1.65
Paddy	0.36	0.08	0.71
Tobacco	1.12	0.84	0.80
Pigeon pea	1.10	0.58	1.28
Wheat	0.53	0.10	1.10
Sugarcane trash	0.35	0.10	0.60
Tobacco dust	1.10	0.31	0.93

6.1.7 Liquid manures:

Application of liquid manure (for soil enrichment) is essential to maintain the activity of microorganisms and other life forms in the soil. 3-4 applications of liquid manure is essential for all types of crops. Liquid manures such as Jivamrutha, vermiwash , cow urine , Panchgavya compost tea and Biosol etc are excellent growth promoters when used as foliar spray

***Vermi-wash*:** Vermi-wash is prepared from the heavy population of earthworms reared in earthen pots or plastic drums. The extract contains major micronutrients, vitamins (such as B_{12}) and hormones (gibberellins) secreted by the earthworms. Earthworms produce bacteriostatic substances found in the vermi-wash can protect the bacterial infections. Vermi-wash can be sprayed on crops and trees for better growth, yield and quality.

Jeevaamrit : Jeevamrit popularized by Shri Subhash Palekar, is considered to be a panacea for the prosperity of small farmers. It is important to provide a congenial environment to microorganisms that help in making available the essential nutrients for plant growth viz., nitrogen, phosphorus and potassium, to the plants. Application of Jeevamrutha to soil improves the soil considerably. It also encourages microbial activity in the soil.

Preparation method: Jeevamrit is prepared by mixing 10 kg local cow dung with 10 litres cow urine, add 2 kg local jaggery, 2 kg pulse flour and handful of garden soil and the volume made upto 200 litres. Keep the drum in shade covering with wet gunny bag and stir the mixture clockwise thrice a day and incubate.

Application: Apply the mixture when the ground is wet for the plants. This seems to work wonders for the plants due to increased microbial activity by 3rd and 4th day. This is an excellent culture for enabling the exponential increase of beneficial microbes. The microbes are added through 2-3 handful of local soil.

Panchgavya: It is a cow excreta based indigenous nutrient solution. Panchagavya consists of products viz. cow dung, cow urine, milk, curd, jaggery, ghee, banana, tender coconut and water. When suitably mixed and used, these have miraculous effects.

Preparation Method: 1. 7 kg. cow dung and 1 kg. cow ghee is mixed thoroughly and kept for 3 days. After 3 days, 10 lt. cow urine and 10 lt. water is added, mixed and kept for 15 days with regular mixing both in morning and evening hours.. After 15 days the following ingredients are added and mixed Cow milk - 3 liters , Cow curd - 2 liters, Tender coconut water - 3 liters, Jaggery - 3 kg , Well ripened banana – 12 nos. Panchagavya is ready after 30 days .In the investigation, 3% solution was found to be most effective compared to the higher and lower concentrations. 3 litres of Panchagavya to every 100 litres of water is ideal for all crops.

6.1.8 Bio-fertilizers

A new class of fertilizers known as 'biological fertilizers' or 'bio-fertilizers' has come to forefront as a means of supplying nutrients to the crops. They neither refer to synthetic source of nutrient(inorganic chemical fertilizers) nor to organic sources of nutrients (manures, residues, etc.). Biofertilizers either refer to a culture of micro-organism applied to the soil/seed in order to encourage fixation of N or release of P or they include biomass of certain plants which contain large quantities of N as a result of their association with N fixing organism. Thus, bio-fertilizers are cultures of appropriate species of microbes that have the capability of fixing atmospheric nitrogen such as *Rhizobium* species in leguminous crops and *Azotobacter* and *Azospirillum* in non-leguminous crops. The phosphate solubilizing bacteria (PSB) and phosphate mobilizing fungi (VAM) have been found very effective in making unavailable soil phosphorus available to plants. The legume – *Rhizobium* association can fix nitrogen in the range of 40-120 kg/ha under optimum conditions

- Symbiotic N-fixing bacteria-*Rhizobium*
- Asymbiotic N- fixing bacteria-*Azotobacter, Azospirillium*
- P-solubilizing fungi-mycorrhizae-Vescicular Arbuscular Mycorrhizae (VAM)
- P-solubilizing bacteria
- Anabaena-Azolla association

Biofertilizers viz: *Rhizobium, Azotobacter, Azospirillum,* PSB Azolla**,** VAM and *Pseudomonas,* etc. have been found to be very effective tools of fertility management and biological nutrient mobilization. Recently customized consortia of such biofertilizer organisms, better adapted to local climatic conditions have also been developed and are available commercially. Efficiency of such microbial formulations is much higher under no-chemical use situations, therefore application of such inputs need to be ensured under all cropping situations.

Besides this, bio-fertilizers like *Azotobacter, Azospirillum,* PSM, and phosphorus mobilize have antifungal activities without any residual or toxic effect resulting in the sustainable quality vegetable production. Crop inoculated with mycorrhizal fungi exhibits increase resistance to *Rhizoctonia solani* and *Fusarium oxysporum*. Damping off of tomato caused by *Pythium* could be considerably prevented. Mycorrhized tomato plants were found more resistant to nematode infection. Application of microbes in agriculture is one of the best options for organic agriculture. Soil contains 10^4 to 10^5 microbes/g of soil to perform various functions and can act as Plant growth promoter and Enhancement of nutrients availability.

6.1.9 Agro industrial wastes

Large numbers of agro-based industries were established in our country during the past 40-45 years. As they handle organic plant products, they invariably produce large quantities of organic decomposable wastes. Although industries regard them as value less wastes, they are rich in plant nutrients. Wasting such vast resources can only be stopped if the industries are made aware of their huge manurial potential and handle them efficiently. The industries themselves can establish commercial manure unit to produce manure and sale, giving additional income and resolve problems related to disposal.

List of industries with potentiality to produce large quantities of organic wastes

- Sugar industry
- Rice industry
- Cotton industry
- Tea/tobacco industries

- Silk industry
- Paper industry
- Fruit processing industry
- Coconut based industries
- Areca based industries
- Coffee pulping industry
- Jute industry
- Vegetable market waste compost

6.1.10 Bio conversion of under-utilized sources

(a) ***By-products of Slaughter Houses***

(i) Bone meal

An estimated quantity of 4.5 lakh tons of animal bones are available in our country, annually out of which nearly 1.4 lakh tons are collected and crushed. Remaining quantities of bones are yet to be utilized.

(ii) Meat meal

Slaughter houses produce large quantity of meat not normally used as food. It is estimated that nearly 1.2 lakh tons of decomposable animal wastes are generated from slaughter houses.

(iii) Leather wastes

Although major part of arable leather reaches leather industry for processing, sizeable leather wastes are generated from slaughter houses estimating to about 5000 tons annually.

(b) ***Bio-Gas Slurry***

An estimated number of 20 lakh bio-gas plants are working in India. Bio-gas plants being a digester to convert crop residues and animal dung into combustible gas-generates large quantities of bio slurry. It is rich in plant nutrients. On an average it contains 1.4 per cent N, 0.8 per cent P_2O_5 and 0.6 per cent K_2O.

(C) ***Poultry Manure***

Each poultry bird on an average produce 0.025 kg litter (excreta) per day on dry weight basis, 2.8 million tons of poultry manure is produced annually in our country. The average manorial value of this poultry manure works out to 27,553 tons of N, 36,772 tons of P_2O_5 and 21,941 tons of K_2O. Use of poultry manure will open newer options in the field of agriculture.

6.1.11 Minerals

The mineral based materials like rock phosphate, gypsum, lime stone, calcium chloride, Sodium chloride Magnesium rock and chalk etc can be applied in limited quantities when there is absolute necessity. The product such as Saw dust, wood shaving from untreated wood and plant preparation and extracts products are permitted for use in manuring/soil conditioning in organic field.

6.2 CULTURAL METHODS

Organic sources of nutrients augmented with different cultural methods are more effective. There is no involvement of additional materials but a mere shift in method of cultivation or pattern or system of cropping. These methods have been part of our agriculture since a long time and some have been introduced lately. These methods contribute to increasing nutrient concentration. Important cultural methods include:

- Effective and useful rotation of crops
- Ideal intercropping with complimentary interactions
- Alley cropping with N-fixing trees
- Practice of homestead farming
- Soil and water conservation practices
- Fallowing
- Establishment of vegetative bunds

6.2.1 Crop Rotation and crop diversification

Growing of legumes as main or inter or companion crops with vegetable/cereal crop improves the organic load of the soil. Changing crop rotations and multiple crops ensure better utilization of resources. Legume crop like beans, peas, cowpea etc is to be included in the crop rotation to improve the soil fertility by fixing atmospheric nitrogen. Inoculation of legume crop specific rhizobium strains can further improve their N- fixing ability. The quantity of N fixed by different crops is given in the Table. 8

Table 8. Quantity of N fixed by legumes

Crop	N fixed (kg/ha)
Cowpea	80-85
Cluster bean	37-196
Fenugreek	44
Pea	52-57
Black gram	50-55
Chick pea	85-100
Pigeon pea	168-200

(Source: Palaniappan and Annaduari, 1999)

6.2.2 Weed management

The effect of weedicides on soil health has been totally ignored which is causing serious changes in soil ecology. Application of weedicides is not permitted in organic farming. Weed management is becoming ineffective due to emerging herbicide resistance in weeds. Scientists have come out with the technology, which reduces the weed density and increases the crop competition with weeds. Control of weeds including Phalaris minor can be done to a larger extent through changing the crop dynamics and timely sowing. Mechanical weeding is highly beneficial for crop establishment. Cultivation practices may be devised in such a way that help the crops in capturing the resources easily and grow vigorously in comparison to weeds. Biological control of weeds can be highly effective. However, under Indian conditions; the approach has to be evolved. Use of locally available mulching materials or polythene sheets to reduce weed growth moisture conservation can be effectively employed in vegetable cultivation

Novel preparations such as biodynamic formulations etc can be used in appropriate quantity. Use of Biodynamic preparations, such as BD-500 and BD-501 as foliar spray has also been found to be effective in growth promotion

7. RESPONSE OF VEGETABLES TO ORGANIC FARMING

7.1 Vegetable productivity under Organic farming

The study conducted on organic farming in vegetable crops at IIVR, Varanasi, revealed that the productivity of vegetables crop in organic farming was less in initial years but the yields increased progressively under organic farming equating the yields under conventional inorganic farming in 4-5 yea (Singh *et al*, 2016; Bhattacharya and Chakroborty, 2005). Tomato and cabbage grown during winter season and okra and cowpea grown during summer season, the comparable yield under organic cultivation to conventional system were achieved during fourth year (Table 9). However, in rainy season cowpea and pea during winter season, the comparable yield was recorded only in third year of consecutive organic farming.

Table 9: Yield of different vegetable under organic farming

	Cabbage	Tomato	Okra (S)	Cowpea (S)	Cowpea (K)	pea
Conventional yield (t/ha)	41.00	37.5	9.26	8.00	10.26	7.3
Organic farming						
first year yield (t/ha)	25.42	23.63	5.27	4.64	7.5	4.964
second year	29.54	27.75	6.57	5.76	8.97	6.278
third year	34.75	33	8.23	7.04	9.4	7.154
fourth year	38.83	36.84	9.16	7.84		

After practicing 5-6 years of organic farming with the soil fertility sufficiently restored, the yield realized in organic farming of vegetable is either comparable or more than that realized in conventional farming. Huang *et. al.,* (1993) and Ramesh *et. al.,* (2008) have also reported that in irrigated areas, organic agriculture has shown the potential to increase the yield. A long-term experiment as conducted by ICRISAT also sustains the view that yield of different crops in low cost sustainable system, the annual productivity (rainy + post rainy season yields), in particular, is comparable to that in the conventional system (Rupela *et al* 2004). Similarly Rajendran *et al* (1999) has also reported that the productivity of organic farming may be less in initial years, but the yields increased progressively under organic farming equating the yields under inorganic farming by sixth year) (Table 10)

Table 10: Yields of organic farming vis -a-vis conventional farming

year	status	Yield (q/ha)
conventional		10
First year	Year of conversion	5
Second year	Year of conversion	5.75
Third year	organic	6.25
Fourt year	organic	7.5
Fifth	organic	8.75
Sixth	organic	10.0
Source; Rajendran et al 1999		

Indian Council of Agricultural Research took up a research programme on organic farming during 10th Five-Year Plan, by establishing a 'Network Project on Organic Farming (NPOF)', to study some agronomic aspects of organic farming and develop package of practices in arable crops at 13 centres. Further, seven new centres were approved in XII plan to cover additional crops (seed spices and tuber crops) and areas (hilly and rainfed regions). Analysis of research data from various centres revealed the following.

- Yield advantage (after 8th cycle across the locations): garlic, cauliflower, tomato (4-6 %) & onion, chilli, cabbage, turmeric (7-14 %)-
- Yield reduction (after 8th cycle across the locations):, potato, French bean (5-8 %)
- Soil organic carbon increased by 22 % under organic production over inorganic in 6 years
- Increase in soil microbes (fungi, bacteria, actinomycetes) was observed in all locations

Table 11: Mean yield of vegetable crops tested in cropping systems under organic input management and yield trend over the years

Crop	No. of observations	Mean yield (kg/ha) under organic input management	Yield trend under organic system over the years (% increase (+) or decrease (-) over inorganic input management)						
			1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
Cauliflower	12	10683	-8	-8	4	2	-	-	-
Tomato	11	20577	-13	-13	-30	-28	35	26	20

The studies conducted in Central Indo-Gangetic alluvial plains on potato have revealed that in succeeding years, the organic tuber yield increased consistently (70-80%) in all cultivars, when raised on same plot each year (Fig. 1), indicating trend towards yield stabilization. (Singh and Upadhyay, 2011)

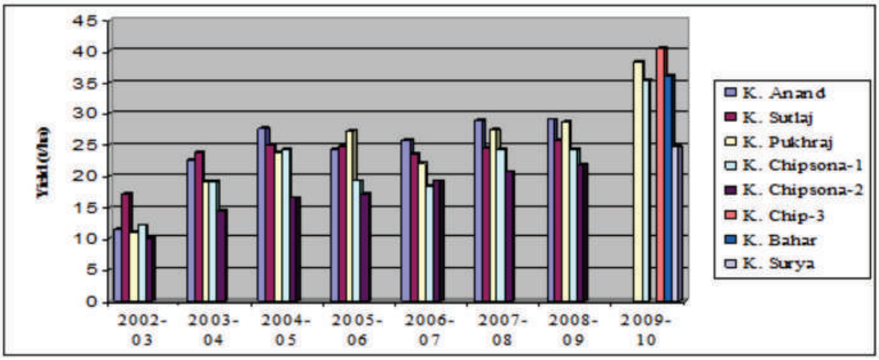

Fig 1 Improvement in organic tuber yield in successive years from FYM

Thamburaj,(1994) found that application of oil cakes of margosa, castor, and groundnut (@0.2% W/W) is found to reduce the intensity of root gall development in tomato. Organically grown plants were taller with more number of branches. They yielded 28.18 t/ha, which was at par with the recommended dose of FYM and NPK (120:100:100 kg/ha). It was reported that highest yield of brinjal was recorded with 50 kg N/ha as poultry manure and 50 kg N/ha in the form of FYM (Jose *et al*, 1988). By application of neem cake higher yield was obtained in brinjal (Som *et al*, 1992). Under organic farming production of vegetables at IIVR, Varanasi, it was found that integrated application of FYM@ 25t/ha + Biofertilizer (PSB + *Azotobacter / Rhizobium*) increased the yield of okra, cowpea and bottle gourd during summer by 27.5, 40.1 and 8.33 percent while in rabi season integrated application of NADEP compost @ 25t/ha + Biofertilizer (PSB+Azotobacter/rhizobium) increased the yield of cabbage and pea by 12.8 and 23.5 percent respectively over conventional inorganic system.

Okra responded to poultry manure @ 20 kg N/ha (Abusaleha and Shanmugavelu, 1989). There was increase in protein and mineral content of okra crop by application of FYM as compared to commercial manures (Bhadoria *et al*, 2002). Higher yield was also recorded by application of neem cake (Raj and Geetha Kumari, 2001). Application of bio-fertilizers with chemical fertilizers increases the availability of NPK in soil and fruit in okra (Subhiah, 1991). Singh and Mishra (1975) obtained highest returns of cauliflower by mulching with mango leaves.

7.2 Efficiency of different sources on vegetable productivity

The studies were also conducted on the relative efficacies of different organic sources in vegetable production. At IIVR, Varanasi, it was found that application of 20-30 t/ha FYM/NADEP compost or 7.5-10 t/ha vermicompost or poultry manure @ 7.5-10 t/ha along with the bio inoculation of *azatobacter* and PSB can ensure 20-35 % higher yield as compared to conventional system. Even mixture of different organic sources such as FYM @ 10t/ha + vermicompost @ 3.5t/ha or FYM @ 10t/ha + poultry manure @ 2.5t/ha or NADEP Compost@ 10t/ha + vermicompost @3.5 t/ha along with the bio inoculation of *Azatobacter* and PSB were equally effective and produced yield comparable to conventional inorganic system in cabbage, brinjal, broccoli, cauliflower, pea, bottle gourd (Fig 2), tomato, cowpea and okra crop etc. However, it was observed that different organic sources performed differentially on different vegetable crops during different seasons. Yield relative to comparable conventional systems are variable between crops and individual crops over time. (Stockdale. E., 2000)

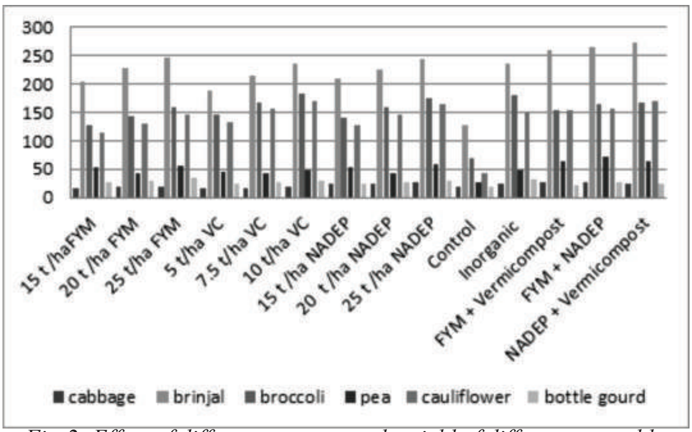

Fig-2: Effect of different sources on the yield of different vegetables

The long-term field experiment for seven years at Jalandhar (Sharma *et al*, 1988) revealed that FYM was more effective in increasing tuber yield than green manuring with dhaincha. Grewal and Jaiswal (1990) reported that the yield increase due to increased nutrients by increasing organic matter. From studies in different places, it was found that FYM to supply 100 kg P_2O_5.ha (about 30t/ha) not only met P and K needs of the crop but also kept the potato yield level at a higher than the combined use of P and K fertilizers (Sud and Grewal, 1990). Role of green manures in economizing P and K for potato has been evaluated in the field experiments at Jalandhar (Sharma et al, 1988; Sharma and Sharma, 1990). The studies conducted in Central Indo-Gangetic alluvial plains on potato have revealed that vermicompost is a better source of organic manure than FYM (Singh and Upadhaya, 2011). The reasons could be presence of enzymes, hormones, growth regulators along plant nutrients in vermicompost (Kumara Swamy, 2002). Network Project on Organic Farming (NPOF) has identified nutrient management package for different vegetable cropping systems for various locations as given in Table 13 and time of application of panchagavya for various crops are given in Table 14.

Table 13: Identified nutrient packages for various locations

Location	Cropping System (s)	Sources
Coimbatore (TN)	Chillies-sunflower-GM	FYM + NEOC @ ½ N each + Panchagavya (PG)
Calicut (Kerala)	Ginger-fallow	FYM + Neem Cake (NC) + 2VC + PG + biodynamic + Rock phosphate(RP)
Dharwad (Karnataka)	Chilli +onion	EC + VC + Green leaf manure (GLM) + biodynamic spray @ 12 g/ha with PG spray
Karjat (Maharashtra)	Rice-red pumpkin Rice-cucumber	FYM + rice straw + gliricidia @ 1/3rd each of N during kharif and FYM + NC + VC @ 1/3 each of N during rabi along with spray of PG
Pantnagar (Uttarakhand)	Basmati rice-vegetable pea	FYM + VC + NC + EC @ ¼ N each + BD + PG
Ranchi (Jharkhand	Rice-potato	VC+ Karanj cake (KC) + BD+ PG

Note: VC-Vermicompost, NEOC-Non edible oil cakes

Table 14: Time of application of Panchagavya for different crops

Crop	Time schedule
Bhendi	30, 45, 60 and 75 DAS
Moringa	Before flowering and during pod formation
Tomato	Nursery and 40 DAT: seed treatment with 1 % for 12 hrs
Onion	0, 45 and 60 DAT
Rose	At the time of pruning and budding
Jasmine	Bud initiation and setting

Note: DAT- Days after transplanting, DAS- days after sowing, DAF- days after flowering

The bio fertilizers and bio-agents application in agriculture have greater impact on organic agriculture and also on the control of environmental pollution, soil health improvement and reduction in input use. Inoculation by improved *Azotobacter* strains in addition to package of practices enhanced the productivity of wheat, cotton and paddy significantly. High ammonia extracting mutant of *Azospirillum* increased nitrogen uptake in wheat and it may help in reducing the dose of nitrogenous fertilizers. Use of PSB helps in increased availability of phosphorous. Application of bio-fertilizer is of great significance in organic farming as they play a nutritional stimulatory and the therapeutic role in improving growth, yield and quality of vegetable crops. Inoculations of vegetable crops with different bio-fertilizers have depicted an encouraging response both in terms of increasing yield, quality and soil fertility. The field response of rhizobium is encouraging as reported by a number of research workers. *Azotobacter* and *Azospirillum* depicted a significant influence on vegetable crops, resulting in nitrogen economy of 25-50% and increase in yield from 1-42 % (Table no.15a). Similarly, phosphorus solubilizers can also save in general 40% phosphorus fertilizers and can enhance the crop yields from 4.7-51% (Table no. 15b)

Studies have shown that common combination of lower input costs and favorable price premiums can offset reduced yield and make organic farming equally and often more profitable than conventional farms. (Peterson *et. al.,* 1999, Reganold *et. al.,* 2001 and Hanson *et. al.,* 1997) There was reduction in the average cost of cultivation in organic system due to use of farm derived inputs. In India where 85 percent farmers are either small or marginal, any reduction/saving in cost of cultivation will go a long way in ensuring the sustainability of the system.

Table 15(a) Response of Vegetable crops to Bio-fertilizer inoculations (for nitrogen)

Bio-fertilizer	Crop	Increase in yield (%)	Nitrogen economy (%)	References
Rhizobium	Cowpea	4.09		Mishra & Solanki (1996)
	Pea	13.38		Kanaujia *et al* (1999)
	Pea	5.10		Choudhury *et al* (1982)
Azotobacter	Cabbage	24.30	25	Verma *et al* (1997)
	Cabbage	26.45-	-	Lehri & Malhotra (1972)
	Garlic	14.23	25	Anonymous (2003)
	Garlic	14.80)	25	Wange (1995)
	Knol khol	9.60	25	Chatto *et al* (1997)
	Onion	18.00)	-	Joi & Shinda (1976)
	Tomato	13.60	50	Kumaraswamy (1990)
Azospirillum	Cabbage	7.00	25	Jeeva Jothi *et al* (1993)
	Cabbage	11.87	25	Verma *et al* (1997)
	Capsicum	9.98	25	Anonymous (2002)
	Chili	26.70	25	Paramguru & Natrajan (1993)
	Chili	15.10	25	Deka *et al* (1996)
	Knol khol	14.90	25	Chatto *et al* (1997)
	Onion	9.60	25	Thiiackavathy & Ramaswamy (1999)
	Onion	6.20	25	Gurubatham *et al* (1989)
	Onion	21.68	25	Anonymous (2002)
	Garlic	6.42	25	Anonymous (2003)
	Okra	9.00	25	Subbiah (1991)
	Radish	9.00	-	Sundaravelu & Mutukrishna (1993)
	Sweet potato	8.50	-	Desmond *et al* (1990)

Table 15(b) Response of Vegetable crops to Bio-fertilizer inoculations (for phosphorus)

Bio-fertilizer	Crop	Increase in yield (%)	Phosphorus economy (%)	References
PSM	Garlic	14.23	25	Anonymous (2003)
	Onion	9.60*	25	Thiiakavathy & Ramaswamy (1999)
	Potato	30.50*	-	Gaur (1985)
	Pumpkin	51.00*	25	Karuthamani *et al* (1995)
VAM	Chilli	14.29*	-	Biswas et al (1994)
	Onion	4.70*	25	Gurubatham *et al* (1989)
	Potato	20.00*	-	Biswas *et al* (1994)

7.3 Soil fertility status

Organic carbon build up was noticed in organically fertilized fields in vegetable crops. Regular addition of organic manure improves soil fertility and quality. On an average in organic field there was 39% increase in organic carbon and 22.3% increase in soil carbon stock of the soil as compared to conventional system over a period of only three years (IIVR annual Report, 2016). The carbon sequestration was 301.1 kg/ha/year under organic farming while it was only 42.6kg/ha/year under conventional system in cabbage. Organic carbon is a good indicator of soil quality because it improves soil physical and biological properties and also acts as reservoir for nutrients.

In a study at IIVR it was found that the organic carbon content of the soil improved by 16.23 and 20.42 percent respectively due to application of NADEP compost @ 25t/ha and FYM@ 25t/ha over inorganic system. Similarly, Singh and Upadhyay (2011) reported that treatments receiving organic amendments showed higher stock of C as well as C sequestration rate in potato based cropping systems. The organic approach of potato production increased the soil organic carbon content significantly. In addition, the available phosphorus and potassium status of soil showed marked improvement (Upadhayay *et al*. 2004). Manjunath *et al* (2016) and Mohamed Amanalluah (2008) also reported higher build-up of organic carbon and better nutrient uptake under FYM treated plots under organic farming.

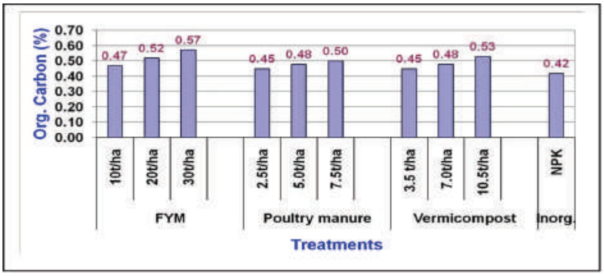

Fig 3: organic carbon status of soil after 3 years in cabbage under organic farming

The loss of nutrient in organic manure is less due to its slow release. Higher P use efficiency was noted in organic soils due to the slow rate of release and fixation of phosphate ion in organic soils. (Ramesh *et al* 2010) Application of animal compost (cattle manures and chicken manure) to soil for production of cabbage crop was effective in reducing the leaching out of mineral nutrients. The total carbon content was increased with the application of compost prepared with cattle manure. Nitrate content in the soil water increased with the amount of chemical fertilizers applied but remained low when only compost was applied (Nishiwaki and Noue, 1996).

Regular addition of organic fertiliser improves the soil quality (Table 16). The bulk density of the soil in the organic field was lower than the conventional system. The bulk density is less in organic field soil, which is a sign of better soil aggregation and soil physical condition. (Regnold et al.,1993) Improvement in soil organic matter decreased the bulk density as humus is lighter than soil particles. Similarly, Singh and Upadhaya, (2011) have also reported that the physical viz soil aggregation, Bulk density, water holding capacity and biological properties of soil were also improved, where organic potato was grown continuously for 2-3 years (Table 17)

Table16: Mean value of aggregated soil data from 16 pairs of farms each with organic (bio) conventional (Con) farming.

Soil property	All “bio”	All “con”
Bulk density(Mgm^{-3})	1.07	1.15
Penetration resistance (0-390 cm)(Mpa)	2.84*	3.18
Carbon (%)	4.84 *	4.27
Respiration(	73.7*	55.4
Mineralizable N(mg kg^{-1})	140.0*	105.9
Ratio of mineralizable N to carbon(mg kg^{-1})	2.99*	2.59
CEC (cmol kg^{-1})**	21.5*	19.6
*= Significantly different at p<0.01; **= cation exchange capacity in centimole of cation charge(=) per kilogram of soil.		

Source: Regnold *et al*.(1993)

Table-17: BD (CC), MBC (µg kg^{-1}) and dehydrogenase activity as influenced by organic and inorganic nutrient management options

Treatment	**BD (CC)**	**MBC (µg kg-1)**	**Dehydrogenase activity (µg TPF g-1 24h-1**
Initial	1.58	119.3	74.8
100% NPK	1.52 ± 0.08	130.2 ±0.10	82.9 ± 2.5
100% organic	1.32 ±0.11	161.9 ±0.14	113.2 ± 3.1

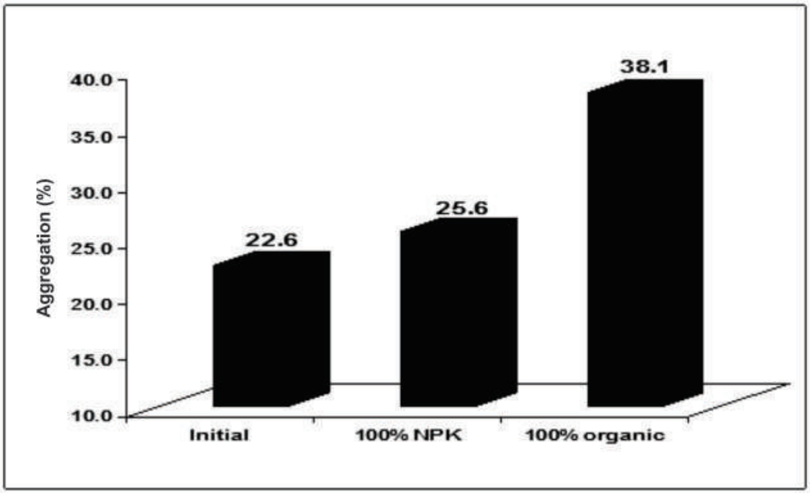

Fig-4: Improvement in aggregation due to addition of organic manure (after 3 years)

Table 18: Water holing capacity as influenced by organic and inorganic nutrient management options

Water content (% by wt)	**Initial**	**100% NPK**	**100 % organic**
Saturation	27.8	30.2 ± 1.2	40.2 ± 1.6
-0.2 bars metric potential	25.1	26.4 ± 1.4	33.8 ±1.5
-1.5 bars matric potential	22.0	23.9 ± 0.9	28.7 ±1.2
-15 bars matric potential	16.0	16.7 ±1.3	19.8 ±1.4

Continuous addition of organic manure assures a regular supply of micronutrients. A steady increase in positive balance of Zn, Cu, Fe and Mn was recorded in organic plots as compared to conventional system. It is well documented that there is a significant positive co-relation between organic matter and micronutrient availability. Similar Increase in soil health by addition of organic manures in organic farming has been reported by Ramesh *et al* (2008, 2009). Manjunath *et al* (2016) observed that higher yield of rice under organic farming with application of FYM could be ascribed to its beneficial effect including availability of micronutrients

7.4 Influence on soil microbial population

The increased organic matter content, which supports the soil micro, meso and macro fauna, makes the soil a living body. At IIVR Varanasi, microbial activity measured in terms of Dehydrogenase activity, alkaline phosphatase and microbial biomass carbon were higher in organic soils by 32, 26.8 and 22.4 % respectively compared to conventional system in cabbage and tomato crop. The higher microbial activity in organically fertilized plots helps in nutrient transformation and increased availability of these nutrients to the plants. In general increase in microbial biomass carbon in organic manure added soils was due to increased availability of substrate carbon that stimulates microbial growth but a direct effect from microorganism added through the compost is also possible (Powlson *et al* 1987). Similarly, Manjunath *et al* (2016) observed that vermicompost application influenced relatively higher build-up of both bacterial and actinomycetes growth in soil as compared to its earlier population. Higher fungal population was observed both in FYM and vermicompost treated plots as compared to their earlier levels. The higher microbial growth under FYM and vermicompost may be attributed to the sufficient quantity of organic matter through them that might have served as better substrate for the microbial growth and favourable soil environment. Singh *et al* (2007) and Kumari Niru *et al* (2013) also observed enhanced microbial population owing to the application of organic amendments compared to recommended dose of fertilizer application. Singh *et al* (2011) observed increased microbial population with organic source of nutrition with noticeable enhancement in the dehydrogenase activity. Organic farming, thus, help in restoring effective microorganisms in the soil improves soil fertility and health.

7.5 Produce quality under Organic farming

Organic produce contains more vitamins, minerals, enzymes, trace elements and even cancer fighting antioxidants than conventionally grown food.(Bhattacharya and Chakraborty, 2005) The quality, taste and flavour improves in organically produced vegetables mainly through increased dry matter, vitamin C, protein content and quality, decreased free nitrates in vegetables, decreases storage losses and disease. (IIVR vision 2050) The studies conducted at IIVR revealed that in organically grown cabbage, tomato and cowpea, the Vitamin C content increased by 17, 35 and 36 percent respectively and the protein content in cowpea improved by 30 percent while lycopene content in tomato improved by 39 percent. Similarly, the total phenolic compounds and peroxidase activity also improved by 44 and 38 percent respectively in organically produced cabbage. Organic farming also improved the physical attributes of vegetables. The ascorbic acid, total phenol and anti-oxidant content in pea increased by 31.8, 48.8 and 4.96 percent respectively over inorganic system. The organically produced cowpea, okra, cabbage, and tomato had better colour, lusture and texture. Singh and Upadhyay (2011) reported that the organic potatoes have more shining surface than conventionally raised tubers from fertilizers.

Studies conducted at Modipuram (Meerut), have revealed that compared to inorganic treatment (100% NPK through fertilizers), The organic production of potato also improved the tuber dry matter, specific gravity and chip colour in both processing and non- processing potato varieties.

A scientific study conducted by Smith (1993) clearly indicated that that organic food is more nutritious. It was observed that organically grown apples, potatoes, pears, wheat and sweet corn averaged 63% higher in calcium, 73% higher in iron, 118% higher in magnesium, 178% higher in molybdenum, 91% higher in phosphorus, 125% higher in potassium and 60% higher in zinc. The organic food averaged 29% lower in mercury than the conventionally raised food. Research work also showed that organically grown vegetables have higher vitamin C, total carotenoids, higher mineral levels and higher phytonutrients, which can be effective against cancer (Worthington 2001, Bahadur *et al*., 2003, 2006a, 2006b, 2009). A detailed scientific analysis of organic fruits and vegetables (Baker *et al*., 2002) showed that organic foods have significantly less pesticide residues than conventionally grown foods. Due to continuous use of nitrogenous fertilizers, problems of high nitrates content in food arise. Nitrates in foods are harmful for human. It is well known that the nitrate content of organically grown crops is significantly lower than in conventionally grown products (Worthington, 2001).

Table 19: Quality of organically grown produce

Vegetables	Percent increase (+) or decrease (-) in nutrients in organic over conventional			
	Vitamin C	Iron	Magnesium	Phosphorus
Lettuce	+17	+17	+29	+14
Spinach	+52	+25	-13	+14
Carrot	-6	+12	+69	+13
Potato	+22	+21	+5	0
Cabbage	+43	+41	+40	+22

Singh *et al* (2011) observed significant enhancement in uptake of iron, zinc and manganese in the rice grain due to application of different organic source of nutrients. It has been demonstrated that organically produced foods have lower levels of pesticides and medicinal and hormonal residues and in many cases lower nitrate contents. Nitrates are significant contaminants of foods, generally associated with intensive use of nitrogen fertilizers. Studies that compared nitrate contents of organic and conventional products found significantly higher nitrates in conventional products. Thus, organic farming offers an opportunity to achieve the twin objectives of nutritional security and environmental sustainability.

7.6 Climate change mitigation through organic farming

In the present era, global warming and climate change is a reality. Climatic changes will influence the severity of environmental stress imposed on vegetable crops. Vegetables are generally sensitive to environmental extremes. Under climate change scenario, increasing temperatures, reduced irrigation water availability, flooding, and salinity will be major limiting factors in sustaining and increasing vegetable productivity. The tropical vegetable production environment is a mixture of conditions that varies with season and region. Farmers in our country are usually small-holders, have fewer options and must rely heavily on resources available in their farms or within their communities. Thus, technologies that are simple, affordable, and accessible must be used to increase the resilience of farmers under climate change.

Organic farms have greater diversity due to mandatory crop rotations and preference for crop varieties with high tolerance to complex abiotic and biotic factors such as climate extremes, pests and diseases. Diversity is an economic strategy to control pests and diseases. Through intercropping and other practices, organic farms establish systems of functional biodiversity that stabilize the agro-ecosystem. Resiliency to climate disasters is closely linked to farm biodiversity; practices that enhance biodiversity allow farms to mimic natural ecological processes, enabling them to better respond to change and reduce risk. In organic farming, maintenance of biodiversity through crop diversification and different micro fauna due to organic matter addition is an integral part. By increasing resilience within the agro-ecosystem, organic agriculture increases its ability to continue functioning when faced with unexpected events such as climate change (Borron, 2006). Thus, organic agriculture suffers less damage compared to conventional farmers planting monocultures (Borron, 2006; Ensor, 2009; Niggli *et al*., 2008). Organic farming practices preserve soil fertility and maintain or increase organic matter can reduce the negative effects of drought while increasing productivity (ITC and FiBL, 2007; Niggli *et al.,* 2008). Water-holding capacity of soil is enhanced in organic farming, helping farmers withstand drought (Borron, 2006). Other practices such as crop residue retention, mulching and agro-forestry, conserve soil moisture and protect crops against microclimate extremes. Conversely, organic matter also enhances water capture in soils, significantly reducing the risk of floods (ITC and FiBL, 2007; Niggli *et al*., 2008). Organic farming systems contribute to reduced consumption of fossil fuel energy, reduced carbon dioxide and nitrous dioxide emissions, reduced soil erosion and increased carbon stocks. Energy consumption in organic systems has been found to be reduced by 10 to 70 percent in European countries and 28 to 32 percent in the USA as compared to high-input systems, except for crops such as potatoes and apples where energy use is equal or even higher. Greenhouse warming potential in organic systems is 29 to 37 percent lower because of omission of synthetic fertilizers and pesticides as well as less use of high energy feed. Carbon sequestration efficiency of organic systems in temperate climates is almost double (575- 700 kg carbon per ha per year) as compared to conventional soils. Thus, Organic farming, can potentially contribute to mitigate threats from climate change on vegetable production.

8. RESEARCH ISSUES

The following issues needs to be addressed and their viable strategies developed to make organic vegetable production more vibrant, dynamic, and responsive to changing consumer demand both locally and globally as well**.**

- The research for Organic farming in vegetable crops must be on a system basis. It must be integrated one and must not be looking at in isolation.
- Suitable packages of technologies are to be developed for organically grown vegetables
- Development of techniques for modifying fertilizer recommendations for new crop rotations using different cover crops and full proof technology for transformation of traditionally used chemicals inputs farm into a successful organic farm.
- Efforts should be made to select suitable cropping systems or more precisely, farming systems specific to those agro climatic zones having higher productivity under Organic Farming
- The research should be in a holistic manner with long-term evaluation of different organic substrates
- Large scale multiplication of bio-fertilizers, vermicompost, bio-control agents and distribution to the farmers at reasonable rates
- Finding the right combination of sources are essential to meet the demand.
- Mismatch between time of nutrient release from organic materials and crop nutrient demand (Mineralization of N from VC is high in first 30 days) in most of the cases affects the yield. Hence, split application of enriched manures for various crops and systems needs to be standardized
- Standardization of frequency and quantity of application of manures are essential to develop of practices in a system mode.
- Identification of suitable cover crop and smother crop in a given cropping system
- Identification of soil improving crops under major agro-climatic zone
- Developing suitable varieties or hybrids for organic cultivation
- There should be strategy for monitoring of changes in groundwater quality with references to heavy metal toxicity, besides nitrate pollution.
- suitability of trap crops in organic culture and identification of nematode repellent cover crops especially for various vegetable crops should be given due emphasis
- The research for organic farming should be focused on developing technologies which may attract the vegetable growers to adopt them, keeping in view of the requirements of small holdings of resource poor small and marginal farmers

- The Government should provide them adequate infrastructure facilities to make the organic farming, a profitable enterprise.
- There should be incentives to the growers who produce organic vegetables
- There is need for marketing research for organically produce for export potential. There should be proper planning for marketing of organically grown fruits, vegetables and food grains that should help farmers to get a better price for their produce. This, in turn, should motivate them to invest more in Organic Farming.

9. CONCLUSION

It is estimated that by the year 2020, the global population will reach the 8 billion marks. The galloping explosion of population made during last 5-6 decades requires not only food security but also nutritional security. Food and nutritional security is therefore a serious global concern. The role of vegetables in nutritional security is immense, hence the production of vegetables need to be increased. Under the present scenario of global warming and climate change the Organic Farming has the twin objective of the system sustainability and environmental protection.

It has been proved by various experiments that by application of nutrients through various organic sources are capable of sustaining higher crop productivity, improving soil quality and soil productivity, besides supplying N, P and K, these organic sources also helps in alleviating the increasing incidence of deficiencies of secondary and micronutrients. Therefore, these organic resources should be used in integration to narrow down the gap between addition and removal of nutrients by crops as well as sustain the quality of soil and achieve higher crop productivity.

Organic farming, especially of vegetables is gaining momentum worldwide due to increasing awareness and concern on adverse effects of indiscriminate use of chemical fertilizers and pesticides and machinery on food quality, soil health, human health and environment. Studies revealed that organic agriculture system has strong potential for building resilient food system in the face of uncertainties through farm diversification and building soil fertility with organic residues. Certified organic vegetable products offer high income options for farmers and therefore can serve as promoters for eco-friendly farming practice worldwide. The future success of organic vegetable production would largely depend upon size of the farm and supplies of non-chemical inputs, which have to be thoroughly backed up by well proven package of practices addressing to the objectives of producing vegetable organically. These organic farming practices have to be turn to change in traditional concept of farming.

In order to harvest a good yield of vegetable crop under organic farming selection of suitable varieties is one of the most important pre-requisites. The use of varieties that are better adapted to local biotic conditions (e.g. biological control of pests and diseases, climatic stress) shall be promoted. All the best varieties/land races of the conventional farming may not be suitable for organic cultivation. Conventional plant breeding is known to be slow, therefore marker aided selection can accelerate the development of varieties suitable for organic farming. Similarly, additional genes conferring resistance to vegetable crop against disease and insect-pests need to be introduced. Improved nutrient use efficiency is required for better utilization of nutrients that will in turn, result in production of higher biomass, partitioned efficiency to improve the harvest index/economic yield. Vegetable crop varieties with a long period of nutrients uptake can make better use of slow, but prolonged release of available nutrients. The possibilities to supply nutrients particularly nitrogen and suppression of diseases through periodic spray of vermiwash should be investigated. Similarly, studies on use of biopesticides to minimize yield loss in vegetable production due to insects and pests should be given due attention.

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