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***Research Article***

# NUTRIENT MANAGEMENT IN ORGANIC VEGETABLE PRODUCTION

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## ABSTRACT
Vegetables are herbaceous plants and produce large amount of biomass within short period. To obtain desired yield sufficient amount of readily available essential plant nutrients need to be supplied to the plant. With the increasing awareness on ill effect of chemical faming on human health and environment, the demand for organic vegetable is increasing sharply both in domestic and international market. The supply of readily available nutrients synchronizing with crop growth stages is a challenging job for organic growers. Crop production in organic cropping systems depends heavily on using organic manures to sustain soil fertility. Utilization of organic soil amendments as nutrient source for vegetable production reduces the cost of purchased inorganic fertilizers, improves soil and environmental health, enhances quality of produce and helps to achieve sustainability in the production system. The present work compiles the potential nutrient sources for organic vegetable cultivation and their utilization in different vegetable crops. The information will increase the nutrient use efficiency of the farming system and encourage farmers to adopt large scale organic cultivation and subsequently will create more employment opportunities and higher incomes from organic vegetable cultivation.

***Keywords:*** *Vegetable Crops, Nutrient Management, Organic Nutrient Sources*

## INTRODUCTION
Organic farming is an age old practice in Indian agriculture which is based on the minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony.However in the process of modernization, particularly after green revolution the consumption of chemicals namely fertilizers, pesticides, growth regulators etc., has increased substantiallyin the production system.Excessive application of fertilizers, pesticides and synthetic hormone causing severe damage to the soil and environment as well as harvested produce. The residues of pesticides and fertilizers that persisted in the soil destroy the beneficial microorganisms, earthworms and other soil habitat.There are ample evidences to show that agrochemical based high input agriculture is not sustainable for long period due to gradual decline in factor productivity with adverse impact on soil health and quality (Stockdale *et al*., 2000). People are gradually realizing the danger of modern day production system and asking for chemical fertilizer and pesticide residue free food items and that encouraging the rapid development of organic agriculture is the country.

According to the National Organic Standards Board of the US Department of Agriculture (USDA) organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible relies upon biological system of nutrient mobilization and plant protection.Organic agriculture is therefore often termed as knowledge based rather than input based agriculture (Ramesh, 2008).

FAO defined organic agriculture as a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycle and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs. However making available all the essential nutrients for plant growth and maintaining a living soil to achieve sustainable yield is challenging task. Organic agriculture in short-term, produces lower crop yields but in the long-term it may produce higher yields (Maeder *et al*., 2002; Badgly and Perfetto, 2007). Again, it can better address the important threats of food security such as soil degradation, climate change and pest problems (Azadi *et al*., 2011).

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***Organic Vegetable Production-The Rising***

India is the land of vegetable crops and ranked second in world vegetable production. The demand for organic vegetables is increasing sharply both in domestic and international market. The growing awareness on health and environment make individual more concerned for food quality and safety leading to more focus on organic vegetable production.Consumers showing interest towards consumption of organic food with perception of being safe, healthy and hazard free besides having superior organoleptic quality. Recent study conducted by International Competence Centre for Organic Agriculture (ICCOA) estimates the accessible market potential for organic food in 2006 in top 8 metros in India out of which vegetables were at first position with Rs. 103 crores (18.33%) taking into account the current purchase patterns of consumer in modern retail format. The overall organic vegetable market potential is estimated to be around Rs. 322 crores (22.18%) among organic food (Rao *et al.*, 2006). For the first time India is included among the ten countries with most organic land, a reflection of the increasing importance of organic agriculture in this country (Helga, 2008). With sizable acreage under naturally organic/default organic cultivation, India has tremendous potentially grow crops organically and emerge as a major supplier of organic products in the world's organic market (Ramesh *et al.*, 2005).

***Importance of Nutrient Management in Organic Vegetable Production***

Vegetables are herbaceous plants that accumulate huge amounts of biomass within short duration. Thus demands readily available nutrients throughout the growth period. Nitrogen (healthy and fast growth), phosphorous (development of roots, respiration and translocation of carbohydrates) and potassium (development of fruit, increases fruit quality) are the most essential nutrients required for plants (Chandrasekaran *et al.*, 2010) besides secondary and micronutrients. Unlike cereals, any deficiency suffered by a vegetable crop in early stage is not compensated during later growth stages. Vegetable producing soils are constantly being mined of nutrients with every harvest. This massive removal must be compensated by a large volume of organic input materials, which is very difficult task in organic vegetable production. As no single source is capable of supplying the required amount of nutrients and integrated use of all available organic sources is a must to supply the required nutrients to plants. Organic manures act as a store house of plant nutrients. They played direct role in supplying macro and micro nutrients and indirectly in improving the physical, chemical and biological properties of soil (Palaniappan and Siddeswaran, 1994). Nutrient management does not mean a certain definite proportion of N, P and K or other nutrients to be added in the form of organic fertilizer, but it has to consider the availability of nutrients already present in the soil, available nutrient status of soil, crop requirement, source of the organic fertilizer and other factors like crop removal of nutrients, soil moisture regime, weed control, physical environment, microbiological condition of the soil, cropping sequence, etc. Nutrient management mainly aimed at restoring, maintaining or improving soil health from nutrient deficiencies that has been degraded by wrong and exploitative activities in the past, avoiding damage to environment, increasing farm income and crop quality. The potential nutrient sources for certified organic vegetable production are listed below (Table 1). To reap the benefits of balanced use of plant nutrients, it is important to have good quality seeds, adequate moisture and better agronomic practices with greater emphasis on timeliness and precision in field operations.

***Different Organic Sources of Nutrients***

***A. Bulky Organic Manures***

Bulky organic manures are those manures, which are generally bulk in quantities and low in plant nutrients. There are different types of agriculturally beneficial microorganisms in bulky organic manures and they have the ability to mobilise crop nutrients and even help in crop protection while they function on the root/rhizosphere of a given crop (Rupela, 2008). Application rates for these materials are commonly 11.2 – 22.4 t/ha, sometimes more (Gaskell *et al.*, 2007).

***a. Farmyard Manure (FYM)***

It is the manure produced in the farm which is made up of excreta (dung and urine) of farm animals, the bedding materials provided for them and miscellaneous farm and house hold wastes. The bedding

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material is called '*litter*' and it absorbs urine voided by animals. It is not a standardized product and its value depends on the kind of feed fed to the animal, the amount of straw used and the manner of storage.

**Table 1: The potential nutrient sources for certified organic vegetable cultivation**

| S. No. | Substance | Category |
|---|---|---|
| 1. | Farmyard and poultry manure, slurry, urine | Permitted |
| 2. | Compost and spent mushroom and vermiculate substances | Restricted |
| 3. | Compost from organic household reference | Restricted |
| 4. | Compost from plant residues | Permitted |
| 5. | Animal charcoal | Restricted |
| 6. | Blood meal, meat meal and bone meal without preservatives | Restricted |
| 7. | Fish and fish products without preservatives | Restricted |
| 8. | Guano | Restricted |
| 9. | Human excrement | Not allowed |
| 10. | Peat without synthetic additives | Prohibited for soil conditioning |
| 11. | Sawdust, wood shaving from untreated wood | Permitted |
| 12. | Seaweed and seaweed products from physical process extraction with water or aqueous acid and/or alkaline solution | Restricted |
| 13. | Sewage sludge and urban composts | Restricted |
| 14. | Sources which are monitored for contamination straw | Restricted |
| 15. | Vermicasts | Restricted |
| 16. | By products from oil palm, coconut and cocoa (including palm oil mill, effluent (pome), cocoa peat and cocoa pods) | Restricted |
| 17. | Calcareous and magnesium rock | Restricted |
| 18. | Calcified seaweed | Permitted |
| 19. | Calcium chloride | Permitted |
| 20. | Calcium carbonate of network origin (chalk, limestone, gypsum and phosphate chalk) | Permitted |
| 21. | Pulverised rock | Restricted |
| 22. | Natural phosphates (e.g. rock phosphates) | Restricted |
| 23. | Sodium chloride | Restricted |
| 24. | Trace elements (B, Fe, Mn, Mo, Zn) | Restricted |
| 25. | Wood ash from untreated wood | Restricted |
| 26. | Magnesium sulphate (Epson salt) | Permitted |
| 27. | Gypsum (calcium sulphate) | Permitted |
| 28. | Sulphur | Restricted |
| 29. | Clay (bentonite, perlite, Zeolite) | Permitted |
| 30. | Biofertilizers | Permitted |
| 31. | Biodynamic preparations | Permitted |
| 32. | Plant preparations and botanical extracts | Permitted |
| 33. | Vermiculate | Permitted |
| 34. | Peat | Permitted |

*Source: Jahanban and Davari (2012)*

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**Table 2a: Nutrient Content of the bulky organic manures**

| **Manure** | **Percentage composition of** | | |
|---|---|---|---|
| | **N** | **P** | **K** |
| FYM | 0.80 | 0.41 | 0.74 |
| Cattle dung | 0.40 | 0.20 | 0.20 |
| Cattle urine | 1.00 | – | 1.35 |
| Sheep and goat manure | 3.00 | 1.00 | 2.00 |
| Poultry manure | 3.03 | 2.63 | 1.40 |
| Horse manure | 2.00 | 1.50 | 1.50 |
| Farm litter compost | 0.50 | 0.15 | 0.50 |
| Rural compost | 1.22 | 1.08 | 1.47 |
| Water hyacinth compost | 2.00 | 1.00 | 2.30 |
| Vermicompost | 3.00 | 1.00 | 1.50 |
| Night soil | 5.50 | 4.00 | 2.00 |
| Paddy straw | 1.50 | 1.34 | 3.37 |
| Sugarcane trash | 2.73 | 1.81 | 1.31 |
| Sewage sludge | 1.5-3.5 | 0.75-4.00 | 0.3-0.6 |

*Source: Chandrasekaran et al., (2010)*

***b. Compost***

It is a manure derived from decomposed plant residues usually made by fermenting waste plant materials heaped or put in a pit usually in alternate layers with a view to bring the plant nutrients in a more readily available form. Besides macro and micronutrients vermicompost also contains humic acids, plant growth promoting substances like auxins, gibberellins, and cytokinins(Krishnamoorthy and Vajrabhiah, 1986), N-fixing and P-solubilizing bacteria, enzymes and vitamins (Ismail, 1997). The water soluble components of vermicompost such as humic acid, growth regulators, vitamins, micronutrients and beneficial microorganism increases the availability of plant nutrients, results in increased growth, higher yield and better quality produce (Atiyeh *et al*., 2002).

**Table 2b: Average secondary and micro-nutrient contents of vermicompost and FYM**

| **Nutrients** | **Vermicompost** | **FYM** |
|---|---|---|
| Ca (%) | 0.44 | 0.91 |
| Mg (%) | 0.15 | 0.91 |
| Fe (ppm) | 175.2 | 146.5 |
| Mn (ppm) | 96.51 | 69.0 |
| Zn (ppm) | 24.43 | 14.5 |
| Cu (ppm) | 4.89 | 2.6 |

*Source: FAI (2004)*

**B. *Concentrated Organic Manures***

The concentrate organics will be useful in supplying major nutrients.

**a. Oil Cakes:** Oil cake is the residue left after the oil is extracted from oil containing seed. The manurial values of oil cake lie mainly in its nitrogen contribution though it is in small quantities. The nitrogen content varies between 3% and 9% (Table 3).

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**Table 3: Nutrient content of concentrated organic manures**

| Manure | Percentage composition of | | |
|---|---|---|---|
| | **N** | **P** | **K** |
| Castor cake | 4.0-4.4 | 1.9 | 1.4 |
| Groundnut cake | 6.5-7.5 | 1.3 | 1.5 |
| Cotton seed cake (decorticated) | 6.9 | 3.1 | 1.6 |
| Cotton seed cake (un-decorticated) | 3.6 | 2.5 | 1.6 |
| Linseed cake | 5.6 | 1.4 | 1.3 |
| Coconut cake | 3.4 | 1.9 | 1.9 |
| Neem cake | 5.2-5.6 | 1.1 | 1.5 |
| Safflower cake (decorticated) | 7.9 | 2.2 | 1.9 |
| Sesamum cake | 4.7-6.2 | 2.1 | 1.3 |
| Mahua cake | 2.5 | 0.8 | 1.9 |
| Pungam cake | 4.0 | 1.0 | 1.3 |
| Raw bone meal | 4.0 | 20-25 | – |
| Steamed bone meal | 4.7 | 25-30 | – |
| Basic slag | 4.0 | 1.0 | 1.3 |
| Fish meal | 4-10 | 3-9 | 1.5 |
| Blood meal | 10-12 | 1-2 | 1.0 |
| Meat meal | 9-11 | 3.5 | – |
| Horn and hoof meal | 10-15 | 1 | – |
| Press mud | 1-1.5 | 4-5 | 2-7 |
| Guano (Peruvian bird) | 11-16 | 8-12 | 2-3 |

*Source: Chandrasekaran et al., (2010) and Gaskell et al., (2007)*

***b. Meal from Slaughter House***

These are rich in nutrients and are often used in organic farming. These are nutrient sources available for use in organic production that can be good sources of phosphorus. Bone meal is one of the earliest phosphorus sources used in agriculture. Although bone meal is often cited as an organically approved phosphorus source, it has a relatively high cost (Parnes, 1986). Available research has shown that bone meal applications can increase crop growth and crop phosphorus uptake (Meshram *et al*., 1999; Nimje and Potkile, 1997).

***c. Fish Meal and Guano***

Suitable for foliar feeding of starts and the spot treatment of transplants; is reputed to prevent stress, stimulate root growth and provide cold protection. Guano is the material obtained from the excreta and dead bodies of sea bird. One field study showed that applications of guano were the most effective of several materials evaluated in supplying supplemental N for optimal yield (Smith, 2001). Hadas and Rosenberg (1992) and Hartz and Johnstone (2006) reported that seabird guano was one of the most efficient organic sources of mineralized nitrogen based on incubation studies. Gaskell (2004) also reported relatively high nitrogen availability from feather meal and some liquid fish residue materials.

***C. Green Manures and Green Leaf Manures***

Green manuring is the act of growing of quick growing crop preferably legumes and ploughing *in situ* and incorporated into the soil at the stage of 50% flowering. Whereas green leaf manuring is incorporation of green matter into the soil transported from elsewhere. The nutrient content of some of the green/green leaf manures is given in Table 4.

**Table 4: Some important green manuring crops**

| Plant – Botanical Name | Nutrient content N (%) | P (%) | K (%) | Remarks |
|---|---|---|---|---|
| **Green manure** | | | | ❖ Most outstanding GM crop. |
| Sunn hemp – *Crotolaria juncea* | 2.30 | 0.50 | 1.30 | ❖ 15 – 25 t fresh biomass in 60 days. |
| Daincha – *Sesbania aculeata* | 3.20 | 0.60 | 1.20 | ❖ 60 days old crop produces 17 – 25 tonnes green matter/ha |
| Sesbania – *Sesbania speciosa* | 2.71 | 0.53 | 2.21 | ❖ Suitable for wetlands. ❖ Adds 2-4 t/ha green matter in 90 days |
| Wild indigo – *Tephrosia purpurea* | 3.10 | 0.52 | 1.18 | ❖ Slow growing, suitable to light soils. ❖ 3 – 4 t green matter/ ha |
| **Green Leaf manure** | | | | |
| Glyricidia – *Glyricidi asepium* | 2.76 | 0.28 | 4.60 | ❖ Can be grown in waste lands. ❖ Each plant yields 12 – 15 kg tender green succulent matter. |
| Pongamia – *Pongamia glabra* | 3.31 | 0.44 | 2.39 | ❖ Leguminous tree ❖ yields 100–120 kg green matter/year |
| Neem – *Azadiracta indica* | 2.83 | 0.28 | 0.35 | ❖ wide range of adaptability ❖ green leaves contributes 70 – 80 kg green matter per tree |
| Gulmohur – *Delonix regia* | 2.76 | 0.46 | 0.50 | |
| Peltophorum – *Peltophorum ferrugenium* | 2.63 | 0.37 | 0.50 | |

*Source: Reddy and Reddi (1997)*

Leguminous green manure plants produce root nodules and fix atmospheric nitrogen. Regular application of green manure crop may also drive long-term increases of soil organic matter and microbial biomass further improving nutrient retention and N-uptake efficiency (Goyal *et al*., 1992; Chander *et al*., 1997; Biederbeck *et al*., 1998 and Cherr*et al*., 2006). *Sesbania rostrata* produces nodules on their stem besides root, thrives well under flooded and water logged conditions and could accumulate 150 kg N/ha in 45 days. *Sesbania aculeate* and *Delonix elata* are commonly used for reclamation of sodic soils. Daincha (*Sesbania aculeata*) is highly resistant to drought and water stagnation and reclamation of saline and alkali soils. It can be grown in soils with pH 4.5 to 9.5. However, green manure based systems require critical and systematic assessment of the interactions between the crop, the environment, and management (Cherr *et al.*, 2006).

**D. *Recycling of Crop Residues***

Recycling of farm-own crop residues provides valuable organic carbon and plant nutrients. Crop residues contains high amount of carbon and have high energy value because of assimilated solar energy that can serve as potential carbon stock of the soil. Removal of crop residues from the crop field will lead to removal of essential mineral elements from the soil. Retention of crop residue will enrich the carbon stock of the soil and will help to recycle the essential plant nutrients in soil. It will also help to reduces soil, water and wind erosion of the soil. Tandon (1995) suggested that a sizeable proportion of nutrient needs for crop production can be met through appropriate recycling of a number of wastes and by-products. Gaur (1999) made a comparative study on nitrogen content and C:N ratio of vegetable crop residues and agricultural crop residues and found that tomato, cabbage, turnip residues contains 3.3, 3.6 and 2.3%

nitrogen and have 12, 12, 19 C:N ratio respectively compared to 0.5%, 0.8%, 0.3% nitrogen and 80, 50 and 110 C:N ratio in rice, maize and sugarcane respectively.

**E. *Biodynamics***

Sir Rudolf Steiner, Australian philosopher introduced Biodynamic Agriculture in 1924 (Sreenivasa, 2008). These simple, natural, homeopathic preparations are used to enhance the effects of planets and of silica and lime on the soil and the plants, and also to enhance the breaking-down process and potential life forces in the compost heaps (Yadav, 2011). Their primary purpose was not to add nutrients, but to stimulate the processes of nutrient and energy cycling (Koepf *et al*., 1976). BD 500 cow horn manure should be applied (25g/acre in 15 litres rain/pure warm water approx. 15-20°Cand stir for 1 hour) when the dew is falling (the earth breathes in) i.e. late afternoon or evening – descending Moon. It promotes root activity stimulates/increases soil micro-life, regulates lime and nitrogen, helps to release trace elements and increases germination.BD 501 Cow horn silica should be applied (dissolve 1g silica in 15 litres of warm quality water and stirring for 1 hour before sunrise)only after one or two applications of BD 500. Apply when the dew is rising (the earth breathes out) i.e. early morning 6-8 a.m. at sunrise during ascending Moon. Spray the plants using a low-pressure sprayer into the air to fall as a gentle mist over the plants. As a general rule, spray twice during the planting cycle; at the beginning and again just before harvest. This Enhances light metabolism, photosynthesis, chlorophyll, improves colour, aroma, flavour and keeping quality of plants. Biodynamically managed soils were more biologically active microbial status (Carpenter-Boggs *et al*., 2000; Mader *et al*., 1995), better soil quality (Reganold, 1995), organic matter and respiration (Goldstein, 1986; Reganold, 1994) than the soils that did not receive organic fertilization.

**F. *Biofertilizers***

Biofertilizers as the name indicates are the fertilizers of biological origin. Which, help in biological nitrogen fixation, solublization of insoluble plant nutrients, stimulating plant growth or decomposition of plant residues. Biofertilizers are broadly 3 types,

Nitrogen fixing: Nitrogen fixing microorganisms on the basis of their nitrogen fixing mechanisms may be of 2 types i.e. symbiotic nitrogen fixere.g. *Rhizobium* (for legumes) and non- symbiotic nitrogen fixer or free living e.g. *Azotobacter* and *Azospirillum* (for non-legumes).

Phosphate mobilizers: It converts the insoluble phosphorus into soluble form such microorganisms referred to as phosphate solubilizing biofertilizers (PSB). These include several hetrotrophic bacteria (*Bacillus, Pseudomonas*) and fungi (*Aspergillus, Fusarium, Pencilium*). Some fungi forms symbiotic association with plant, called, and help in the absorption of phosphorus (Kahiluoto and Vestberg, 1998), zinc, copper and iron. Among these VAM (vascular arbascularmycorrhiza) fungi is are most important that colonize various crop plants.

PGPR (plant growth promoting rhizo-bacteria): This group of microorganisms enhances the plant growth by way of secreting phytoharmones (auxins, cytokinine, gibberellic acid, indole acetic acid etc.) or suppressing deleterious microorganisms in rhizosphere. Endophytic relationships involve the PGPRs residing and growing within the host plant in the apoplastic space (Vessy, 2003). They include a wide variety of microorganisms particularly fluorescent *Pseudomonas, Bacillus, Azotobacter, Azospirillum* etc. these biofertilizers can be applied in the field either through soil application or seedling root dipping or seed treatment.

**G. *Organic Bio Stimulators/OGB (Organic Growth Boosters)***

Organic bio stimulants hold great promise for the future of organic farming. Biostimulants aid in plant growth and metabolism, increase root biomass and promote soil microorganisms. The different organic bio stimulants include panchagavvya, humic acid, seaweed and vermiwash.

**a. *Panchagavvya***

The term panchagavya used in Ayurveda to describe five important substances obtained from cow namely dung, urine, milk, ghee and curd (Sugha, 2005). Panchagavya has the potential to play the role of promoting growth and providing immunity in plant system suitably mixed and used, these have miraculous effects.300ml of panchagavvya can be diluted with 10 litres of water with proper stirring and sprayed after filtering and for soil application, dilute 1000ml in 10litres of water. Seeds are to be soaked or dipped for 20 minutes before planting with three percent of panchagavya (300 ml/10L water) solution. The photosynthetic system is activated for enhanced biological efficiency, enabling synthesis of maximum metabolites and photosynthesis. A thin oily film is formed on the leaves and stems, which helps in reducing the evaporation of water. The trunk produces side shoots, which are sturdy and capable of carrying maximum fruits to maturity. The rooting is profuse and dense. All such roots help maximum uptake of nutrients and water. Soil amended with panchagavya at a concentration of 1: 100 (panchagavya: soil v/v) increased the linear growth of both shoot and root systems of the seedlings of the pulses. Increase in linear growth of the shoots and roots was associated with a concomitant increase in the number of lateral roots produced, the number of leaves or leaflets produced, increase in leaf area, nodule formation by *Rhizobium* and a decrease in the chlorophyll a/b and C/N ratio. The effect was further enhanced when seaweed based panchagavya was used as manure at the same concentration (Sangeetha and Thevanathan, 2010).

**b.** ***Humic Acid***

Humic acid is an organic biostimulant that is the boichemically active ingredient of humus. Vermicompost originating from animal manures, sewage sludges or paper-mill sludge have been shown to contain large amounts of humic substances (Elvira *et al*., 1998). Due to the biochemical nature of humic acid, it benefits the soil and plants in many ways. Humic acids have been shown to stimulate plant growth in auxins, gibberellin and cytokinin bioassays (Phuong and Tichy, 1976). The addition of humate products increase microbial activity and root development has been noticed which will help in the uptake of iron and zinc and maintained adequate levels of other micronutrients. Humic acid application can improve fruit yield production and quality of watermelon crop (Salman *et al.*, 2005). Plant growth was increased by treatments of the plants with 50–500 mg/kg humic acids, but decreased significantly when the concentrations of humic acids in the container medium exceeded 500–1000 mg/kg (Atiyeh*et al.*, 2002).

**c.** ***Seaweeds***

The use of seaweeds as manure in farming practice is very ancient practice. In many countries seaweed and beach cast are still used in both agriculture and horticulture (Verkleij, 1992). They are used as whole or finely chopped powdered algal manure or aqueous extracts. In recent years the use of these marine macro-algae in modern agriculture has been investigated by several researchers (Rama Rao, 1990; Rama Rao, 1991; Manimala and Rengasamy, 1993; Whapham*et al.*, 1993 and Lopez-Musquera and Pazas, 1997).The carbohydrates and other organic matter present in seaweeds alter the nature of soil and improve its moisture retaining capacity (Crouch and Staden, 1993).

Seaweed liquid fertilizers (SLF) have recently gained much interest as foliar spray for inducing faster growth and yield in horticultural plants (Thivy, 1961). Their application as farmyard manure, liquid extracts obtained from seaweeds have gained importance as foliar sprays for several crops (Thivy, 1961; Metha *et al.*, 1967; Bokil *et al.*, 1974) as seaweed manure is rich in potassium (Kingman and Moore, 1982) and the extract contains growth promoting hormones (IAA, IBA, and cytokinins), trace elements (Fe, Cu, Zn, Co, Mo, Mn, Ni), vitamins, antibiotics and amino acids(Booth, 1965; Challen and Hemingway, 1965; Stephen *et al.*, 1985; Crouch and Staden, 1993).

Thirumaran *et al.*, (2009) found that the seed germination, growth and yield parameters such as shoot length, root length, number of lateral roots, number of leaves, number of fruits, weight of fruits, photosynthetic pigment concentration such as chlorophyll 'a', chlorophyll 'b', total chlorophyll and carotenoids was found to be maximum at 20% concentration of SLF with or without chemical fertilizer. Zodape *et al.,* (2008) also stated that LSF application promotes root proliferation and establishment; thereby plants were able to mine more nutrients even from distant places and deeper horizons, in balanced proportion (Singh and Chandel, 2005). Foliar application of *Kappaphycusalvarezii* sap at 5% concentration increased yield and quality of tomato fruit along with improvement in nutrient uptake, proving potential use of seaweed sap as supplemental fertilizer (Zodape *et al.*, 2011). Abdel-Mawgoud *et al.*, (2010) in an experiment concluded that applying seaweed extract can be a powerful and environmental friendly approach to improve plant growth and production with different watermelon hybrids.

**d. *Vermiwash***

Vermiwash, a liquid plant growth promoter obtained from epigeic and anecic earthworm varieties (Ismail, 2005). Earthworm body is long tubular type measure portion of this body is filled up with this celomic fluid. Celomic fluid is always secreted from the body of earthworms and always keeps the body of wet. The celomic fluid of earthworms collected by the passage of water through a column of worm activationand this is called vermiwash. It contains high amount of enzymes, vitamins and hormones like auxins, gibberellins etc along with macro and micronutrients used as foliar spray. There have been several reports on the use of vermiwash and its growth promoting effects (Fathima and Sekar, 2014). Vermiwash seems to possess an inherent property of acting not only as a fertilizer but also as a mild biocide (Pramoth, 1995).

**H. *Crop Rotation, Intercropping/mixed Cropping with Legumes***

The practice of alternating the species or families of annual and/or biennial crop grown on specific field in a planned pattern of sequence so as to break pest, disease and weed cycles and improve soil fertility and organic matter is called as crop rotation. Legume crops are beneficial in the vegetable cropping system as they can fixed atmospheric nitrogen and improved the fertility status of soil, harbor beneficial microorganism and incorporate sufficient amount of organic matter in the soil. Legumes based crop rotations have a number of effects like increased soil microbial biomass (Kucey *et al.*, 1988; Wani *et a*l., 1991), improved soil structure (Latif *et al*., 1992) and increased water-holding capacity of the soil (Wani *et al.*, 1994).Crop rotation with a non-host legume is ideal in terms of pest management and soil fertility (Prasad, 2008). Judicious crop rotation may be useful for increasing short term soil organic matter and for achieving healthy, fertile and productive soils. Requirements for other nutrients like phosphorus, sulphur and micronutrients are met with local, preferably renewable resources. Intercropping is a system for maximising productivity of the soils by efficient spatial and temporal use of resources to increase productivity, sustainability, and monetary returns (Venkateswarlu, 2008).Intercropping has been used in many production systems for various reasons, among this optimization of space, hedging with arrange of crops and management of pests (Wright, 1999).

**I. *Mulching and Cover Crops***

Mulch is a layer of material applied to the surface of an area of soil with a purpose to, conserve soil moisture, improve the fertility and health of the soil, reduce weed growth and enhance the quality of the produce. A protective covering, usually of organic matter such as leaves, straw, or peat, placed around plants to prevent the evaporation of moisture, the freezing of roots, and the growth of weeds. Cover crops fix and trap nutrients, add organic matter to soil and reduce nitrate leaching, nitrate runoff and soil erosion. Non leguminous cover crops, such as grasses and *Brassica* species, are preferred in situations where nutrient availability is high and where cover crops can trap nitrate and phosphate that would otherwise be lost by leaching or runoff (Gaskell *et al.*, 2007).Studies conducted on effect of mulches on onion during kharif, 2005 revealed that maximum yield was obtained in the of sugarcane trash mulch with 40.70% increase over the control (Patil, 2008).

***Research Achievement in Organic Vegetable Production***

***Tomato***

Samawat *et al.*, (2001) studied the effect of five levels of vermicompost and three levels of chemical fertilizer were evaluated on root and shoot growth, fruit weight and fruit number of tomato. The results showed that 100% vermicompost treatment results in three, four, five and nine times more fruit weight, fruit number, shoot weight and root weight respectively over the control. Renuka and Sankar (2001) studied the effect of organic manures on growth, yield and quality of tomato and they reported that combination of farmyard manure (FYM) and biogas slurry recorded maximum fruit yield (46.66 tonnes/ha) over control (18.44 tonnes/ha).They further reported that in addition to yield, organic manures also promoted vigorous plant growth and early flowering as well as maintained the soil pH near to neutral, besides keeping lower levels of electrical conductivity and bulk density.The experiment on organic cultivation intomato was conducted on cv. Dhanashree during 2003 in MPKV, Rahuri. The result revealed that application of organic fertilizers containing farmyard manure (20 t/ha.) plus neem cake (250 kg/ha) plus soil treatment with *Trichoderma* (6.25kg/ha) plus *Azospirillum* 2.5 kg/ha) plus phosphate solubilising bacteria (PSB) (2.5 kg/ha) with trap crop marigold and plant protection with neem seed kernel extract (NSKE) (4%), HaNPV (1 ml/litre) and *Bt* (1 g/lit) has produced comparable yields to that of recommended dose of chemicals (Patil, 2008). Gajbhiye *et al.*, (2003) also studied the effect of biofertilizers on growth and yield parameters of tomato at IARI, New Delhi. The treatments consisted of seed treatments with *Azotobacter* and phospho-bacteria along with three levels of chemical fertilizers (O; 74 kg N, 30 kg P and 60 kg K/ha; 150 kg N, 60 kg P and 60 kg K/ha). They reported that, among the biofertilizers *Azotobacter* performed good but biofertilizers in combination with chemical fertilizers (*Azotobacter* with 150 kg N, 60 kg P and 60 kg K/ha) was found to be best treatment and significantly influenced plant height, number of primary branches per plant, number of fruits per plant, weight of fruits per plant and fruit size. Arancon *et al.*, (2002) reported significantly increased growth and yields of field tomatoes (*Lycopersicon esculentum*) and peppers *(Capsicum annuum*) when vermicomposts, produced commercially from cattle manure, food waste or recycled paper, were applied to field plots at rates of 20 t/ha and 10 t/ha in the year 1999 and at rates of 10 t/ha and 5 t/ha in the year 2000 compared with those receiving equivalent amounts of inorganic fertilizers. In an experiment with vermicompost on tomato (*Lycopersicum esculentum var*. Super Beta) Azarmi *et al*., (2008) found that addition of vermicompost at rate of 15 t/ha has significantly increased the total organic carbon and physical properties of soil.

***Brinjal***

Tomar *et al.*, (1998) conducted a pot experiment to study the effect of vermicompost on production of brinjal and carrot. They observed that brinjal yield increased to 97 g/plant in pots containing soil with vermicompost compared to control pots (65 g/plant) containing soil alone. Similarly in carrot, root yield was recorded 94.9 g/pot in soil amended with vermicompost over un-amended soil (29.9 g/pot). Rao and Sankar (2001) evaluated different organic substrates like farmyard manure, neem leaves, vermicompost, *Azospirillum* and Phosphate solubalizing bacteria and neem cake along with inorganic fertilizers (100:60:60 kg NPK /ha). The results revealed that all organic nutrients have enhanced leaf number, leaf area index and dry matter production and induce early flowering in brinjal.

***Chilli***

Sajan *et al.*, (2002) conducted an experimented at Bangalore, Karnataka where treatments with sole NPK (75% and 100%) and NPK in combination with *Azotobacter*, *Azospirillum*, PSB and VAM were applied to chilli cv. *Byadagi Babba*. Better growth of chilli was observed by with the application of *Azotobacter*, *Azospirillum*, PSB and VAM in combination with 75% of the recommended rate of nitrogen and phosphorus plus 100% recommended rate of potassium.

***Okra***

Sajindranath *et al.*, (2002) reported that the efficacy of biofertilizers, *Azotobacter* plus PSB was better in improving seed germination and seedling vigour of okra var. Parbani Kranti compared with individual application of *Azotobacter* and PSB. Balemi (2003) reported that, the inoculation of efficient *Azotobacter* strain could save up to 50% nitrogen fertilizer without significantly affecting plant growth and yield and also improved soil available nitrogen and plant nitrogen under various soil types.

***Cucumber***

The experiment on organic cultivation of cucumber conducted during 2004 for two seasons revealed that the maximum yield was produced with organic manure treatment consisting of cotton seed cake (25% N i.e. 0.64 t/ha) plus poultry manure (75% N i.e. 2.5 t/ha) plus vermiphos (0.500 t/ha) plus sulphate of potash (0.105 t/ha) plus neem cake @ 200 kg/ha plus *Trichoderma viride* @ 4 g/kg plus *Azotobactor* @ 200 g/ 10 kg plus neem cake @ 200 g/10 kg plus PSB @ 200 g/10 kg plus NSKE 4% spray which was 23.4% higher during summer season and 30.01% higher during kharif than control (Patil, 2008).

***Bitter Gourd***

The experiment on organic cultivation ofbitter gourd revealed that13.40% maximum yield was produced with organic manure treatment consisted of neem cake (25% N i.e. 0.7 t/ha) plus poultry manure (75%N

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i.e. 2.47 t/ha) plus vermiphos (0.5 t/ha) plus sulphate of potash (0.2 t/ha) plus neem cake@ 200 kg/ha plus *Trichoderma viride* @ 4 g/kg plus *Azotobactor* @ 200 g/10 kg plus *Azospirillium* @ 200 g/ 10kg plus PSB @ 200g/ 10 kg plus FYM 20 t/ha plus NSKE 4% spray (Patil, 2008).

***Cole Crops***

The experiment on organic cultivation of cabbage revealed that maximum yield was produced with inorganic fertilizers but it was at par with that produced by organic package consisted of FYM @ 20 t/ha plus Neem cake @ 250 kg/ha plus soil treatment with *Trichoderma* @ 6.25 kg/ha plus *Azospirillium* @ 250 g/ 10 L water plus PSB @ 250 g/10 L water plus NSKE 4% spraying plus HaNPV @ 10 ml/10 L water plus Bt.@ 10 ml/10 L water plus *Trichoderma* @ 50g/10 L water plus trap crop of mustard in two rows in between every 25 rows of cabbage plus Fenugreek in between plants of cabbage (Patil, 2008).

In an experiment Smith (2001) stated that the timing of organic fertilizers application was an important consideration. Applications of organic nitrogen fertilizers early in the growth cycle of transplanted broccoli gave improved yields compared with later side dress applications, presumably because the early applications synchronized more effectively with crop nitrogen demand. These results indicate that growers need to carefully consider the release pattern of the fertilizer materials and how the pattern matches the demand of the crop.

***Onion***

The study on organic cultivation of onion during rabi 2005 revealed that the higher yield was obtained in FYM 30 t/ha plus neem cake 1 t/ha plus Cotton seed cake 0.8 t/ha plus NSKE 4% sprays plus *Trichoderma* sprays 0.5%. In another experiment the treatment FYM 20 t/ha plus 100% RDF plus biofertilizers plus chemical spray recorded maximum yield. Among the organic treatments FYM 20 t/ha plus 75% nitrogen (vermicompost) plus 25% N (cottonseed cake) plus neem cake plus biofertilizers gave good results (Patil, 2008). Among different substrates vermicompost produced from coir dust emerged best for the yield of onion (*Allium cepa)* (Thanunathan, 1997).

***Lettuce***

An experiment was conducted on red lettuce (*Lactuca sativa* L. cv. Veneza Roxa) in Swaziland by Masarirambi *et al.,* (2010) to assess the yield and quality of lettuce grown in river sand. Results showed that inorganic fertilizers were less suitable for lettuce production in river sand when compared to organic fertilizers and can be grown successfully using organic fertilizers.

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