ORGANIC VEGETABLES ISSUES AND STRATEGIES
- A REVIEW

Lily Varghese
National Research Centre for Citrus. Shankar Nagar. Nagpur-440 010, India

ABSTRACT

A variety of vegetable crops viz., Brassica oleracea, Brassica parachinensis, Brassica Chinesis, Brassica oleracea (Botrytis), Cucumis melo, Cucumis sativus, Pisum sativum, Lycopersicon esculentum, Phaseolus vulgaris, Solanum tuberosum, Ipomoea batatas, Abelmoschus esculentus, Lactuca sativa, Solanum melongena, Allium cepa, Allium sativum, Allium ameloprasum, Raphanus sativus, Capsicum annum, Vicia faba, Daucus carota and Asparagus officinalis hold promise under organic farming. The different components of growing vegetables organically comprising over crops vis-a-vis tillage affect, soil health, control on weed emergence and disease incidence; microbial fertilizers versus crop nutrition; role of mycorrhiza in nutrient mobilization, better resistance towards biological crop protection besides improvement in yield and quality; agronomic importance of vermicompost and its role in soil aggregate stability; the influence of other organic substrates in crop quantitative and qualitative improvements have been thoroughly envisaged.

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 imparting better resistance against various biotic and abiotic stresses. Renewed efforts are in vogue during the last 10-15 years in the pursuit of growing vegetables organically world over. The immediate elimination of all chemical fertilizers and pesticides in organic vegetable cultivation would be a difficult venture for many of the vegetable growers. In transition from purely chemical based production to a more environmentally benign one, economics may dictate the use of pesticide to save the crop (Mc Grady, 1992). Organic wastes, mechanical cultivation, mineral bearing rocks and aspects of biological pest control to maintain the soil and its tillage to supply plant nutrients and to control insects and weeds (Oelhaf, 1978; U.S. Deptt. Agriculture, 1980) are equally important during the transition from chemical based cultivation to organic one. Huang et al. (1993) advocated the use of organics plus limited input of chemical fertilizers and pesticides as the first stage of transition from conventional to organic farming. Similar studies by Dimitrov (1997) in Bulgaria suggested that organic farming could be easily applied during transition period taking into account the limited resources of the country and irrigated vegetables should be the priority on organic farm.

The opinions vary greatly about the organic farming as part of sustainable agriculture. It has been called organic farming which is a system of production that largely avoids the use of chemical fertilizers, pesticides and plant growth regulators (U.S. Deptt. Agriculture, 1980). The success of organic farming strategies would depend on long term whole farm systems involving all aspects of crop production that will maintain soil productivity and reduce dependence on off farm inputs (Pathak, 1992). Many studies from time to time have revealed resounding success of organic vegetable cultivation in India (Abu Sakha, 1992; Mallanouda et al., 1995; Wange, 1995; Shankaram, 1996), USA (Mc Grady et al., 1991; Maynard, 1991; 1997; Zehnder et al., 1997), Germany (Schnitzler and Michalsky, 1996), Spain (Ruiz-Lozano et al., 1996), Poland (Kolota et al., 1993), Morocco (Ibijbien et al., 1996), Australia (Asirifi et al., 1994; Line 1994), New Zealand (Mahimairaya et al., 1995), Brazil (Miranda and Harris, 1994), China (Wang, 1993; Huang et al., 1993; Hseih and Hsu, 1993), Nigeria (Sagiv et al., 1994), Switzerland (Leisn, 1993), Japan (Ito et al., 1991; Matsubara et al., 1994) and Canada (Wen et al., 1996; Warman and Harwad, 1998). Taking clues from the successes of organic vegetable farming from these countries, and reviewing the chronological developments towards the art available with regard to organic vegetable production, the evasive issues and
consequent upon them, the strategies could precisely be streamlined which otherwise would continue to impair the sustainability besides ensuring the soil health and ecological sustainability.

**Organic Farming defined**

Organic farming was defined as production systems, which avoid or largely exclude the use of synthetically compounded fertilizers, pesticides, growth regulators and rely upon crop rotations, crop residues, animal manures, green manures, off farm organic wastes, mechanical cultivation, mineral bearing rocks and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests (U.S. Deptt. of Agriculture 1980). The recently formulated federal definition of organic, scheduled to supersede all others in 1993, specifies the food labeled as organic "shall have been produced without the use of synthetic chemicals - not on land to which prohibited substances including synthetic chemicals have been applied during the 3 years immediately preceding the harvest - in compliance with an organic plan (Congressional Record, 1990). Organic farming and low input sustainable agriculture (LISA) program are both part of an alternative agricultural movement that promotes the use of biological interactions and cultural practices over agricultural chemicals. LISA is meant to "lessen the farmer's dependence on the purchased inputs especially synthetic chemical fertilizers and pesticides by greater use of crop rotations, crop and livestock diversification, soil and water conservation practices, greater use of animal and green manures, biological pest controls and mechanical cultivation wherever appropriate (U.S. Deptt. of Agriculture, 1991). Many of the alternative practices promoted by LISA are also frequently found on organic farms. However, the use of synthetic nutrients and pesticides is largely avoided by organic producers while LISA allows the wise and limited use of such inputs.

**Nutrient value of organics**

The nutritive value of biogenic waste compost for vegetable production indicated that it can be used successfully directly or in combination with chopped bark in various fields of plant production (Vogtmann and Fricke, 1989). In India, the various sources of organic wastes such as crop residues, animal wastes, municipal wastes, sewage wastes have the current total plant nutrient figures to the tunes of 3.32, 12.40, 0.09 and 0.18 x 10^6 tonnes in 1991 which would be 5.79, 21.64, 0.07 and 0.32 x 10^6 tonnes, respectively in another 25 years (Bhardwaj, 1995). Such vast potential of nutrients through various available organic sources exists in other countries also where agriculture contributes a significant share to their national economy. Out of various organic sources, materials derived from animals and oil cakes are richer in nutrient content than those derived from excreta, crop residues, refuse etc. Among crop residues, those of legumes are richer in N than the residues of cereals (Table 1).

**Components of organic vegetable - use of cover crop**

**Tillage effect**: Historically, the primary purpose of cover crops was to provide supplemental N for subsequent crop by the use of leguminous species as green manures. The incorporation of cover crop biomass into soils also provides an additional organic matter inputs into the system which in turn can lead to improved soil organic matter content, physical properties and water infiltration characteristics (Patrick et al., 1957; Smith et al., 1997). Cover crops have become important in conservation tillage practices because they control soil erosion and help increase in soil tilth (Pieters, 1927). This is especially true where soils are coarse textured having low fertility and organic matter. Stewart et al. (1975) showed that the dense vegetative cover and rooting of crops resulted in negligible soil loss. Pre and post pre-plant tillage are still considered important for weed control in vegetables (Putnam, 1990). Pathak (1987) suggested conservation tillage for vegetable production only where it has proved consistently successful. The residual mulch improved infiltration, and soil did not erode for several years thereafter. The use of mulches in commercial vegetable production is limited due
### Table 1: Nutrient content of some organic waste materials, FYM, compost, cakes and residues (Gaur 1992).

<table>
<thead>
<tr>
<th>Category</th>
<th>Source</th>
<th>Nutrient content (%)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
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<tr>
<td>Animal Wastes</td>
<td>Cattle dung</td>
<td>0.3-0.4</td>
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<td></td>
<td>Cattle urine</td>
<td>0.80</td>
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<td></td>
<td>Sheep and goat dung (mixed)</td>
<td>0.65</td>
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<td></td>
<td>Night soil</td>
<td>1.2-1.5</td>
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<td></td>
<td>Human urine</td>
<td>1.0-1.2</td>
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<td></td>
<td>Leather waste</td>
<td>7.0</td>
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<tr>
<td></td>
<td>Hair and wool waste</td>
<td>12.3</td>
</tr>
<tr>
<td>FYM &amp; Composts</td>
<td>Farmyard manure</td>
<td>0.5-1.0</td>
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<td></td>
<td>Poultry manure</td>
<td>2.87</td>
</tr>
<tr>
<td></td>
<td>Town compost</td>
<td>1.5-2.0</td>
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<td></td>
<td>Rural compost</td>
<td>0.5-1.0</td>
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<td></td>
<td>Water hyacinth compost</td>
<td>2.0</td>
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<tr>
<td>Oil Cakes</td>
<td>Castor</td>
<td>5.5-5.3</td>
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<td></td>
<td>Coconut</td>
<td>3.0-3.2</td>
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<tr>
<td></td>
<td>Cotton seed</td>
<td>3.9 (6.5)&lt;sup&gt;*&lt;/sup&gt;</td>
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<td></td>
<td>Groundnut</td>
<td>4.5 (7.8)&lt;sup&gt;*&lt;/sup&gt;</td>
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<td></td>
<td>Karanj (Pongamia pinnata)</td>
<td>3.9-4.0</td>
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<td></td>
<td>Neem (Azadirachta indica)</td>
<td>5.2</td>
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<td></td>
<td>Niger</td>
<td>4.8</td>
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<td></td>
<td>Mahua Butter tree (Bassia latifolia)</td>
<td>2.5-2.6</td>
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<td></td>
<td>Rapseseed</td>
<td>5.1</td>
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<td></td>
<td>Linseed</td>
<td>5.5</td>
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<tr>
<td></td>
<td>Safflower</td>
<td>4.8 (7.8)&lt;sup&gt;*&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>Sesame</td>
<td>6.2</td>
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<tr>
<td>Animal Meals</td>
<td>Blood meal</td>
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<td></td>
<td>Meat meal</td>
<td>10.5</td>
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<td></td>
<td>Horn and hoof</td>
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<tr>
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<td>Raw bone</td>
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<td></td>
<td>Steamed bone</td>
<td>1-2</td>
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<td></td>
<td>Fish</td>
<td>4-10</td>
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*Figures in ( ) are for decorticated material.

To several factors. Beste (1973) observed no stand reduction or crop injury in no till cucumbers (*Cucumis sativus* L.), tomatoes or lima beans (*Phaseolus lunatus* L.) the seeding and transplanting vegetables directly into killed mulches may be mechanically difficult, possibly require alterations to machinery (Shelby et al., 1988). Wallace and Bellinder (1989) found that potato stands were reduced by 16% when grown in rye stubble when perennial weed control and pre-emergence herbicides were used in no till cabbage (*Brassica oleracea* var. capitata), weed control and crop yields were equivalent to those of conventional tillage (Bellinder et al., 1984). Following a period of bare fallow with a cover crop, had the potential to reduce leaching losses of mobile nutrients such as nitrate, and thus minimized ground water contamination (Muller et al., 1987).

**Soil health:** The ability of certain crops to improve soil fertility or physical conditions has long been recognized. As early as Chow dynasty (1134-247 B.C.) in China, there were reports whose value for soil
improvement was greater than silkworm excrement (Pieters, 1927). The studies on response of sewage sludge application (20-60 tons per ha) revealed best improvement in yield of spinach, cabbage, turnip in summer and onion in winter. Using 60 tons per ha sewage sludge, a rapid mineralization of N led to excess ammonia accumulation which inhibited the growth. A correlation was observed between the amount of sewage sludge applied and soil organic carbon, available N, P and Zn content (Ito et al., 1991). Hsieh and Hsu (1993) observed increase in soil pH, organic matter, available P, exchangeable K and Mg, extractable Mn, Zn and Cu and decreased soil salinity and extractable Fe due to application of composted pig manure, cattle manure and chicken manure using soybean and sweetcorn as test crops. Hooda and Alloway (1996) reported that liming the soils previously treated with sewage sludge to pH 7.0 prior to sowing significantly reduced metal concentrations in carrots and spinach, although the reduction appeared to be greater for Cd, Ni and Zn than for Cu and Pb. Increased soil organic matter content is not universally observed in systems that included cover crops in their rotations, e.g. Vander Linden et al., (1987) observed little change in soil organic matter content following 20 years of green manure application, but significant changes in soil physical and biological properties was observed in the absence of large changes in organic carbon levels.

**Weed suppression**: Organic farming methods applied to weed control are categorized as: preventive (e.g. soil cultivation, farmyard manure, composting, under sowing) mechanical (use of special hoeing, harrowing and other types of cultivation), flaming and mulching (Geier, 1991). The concept of a “living mulch” has been suggested to manage weeds in vegetable production (Lanini et al., 1989). Geier (1991) observed flame cultivation method for weed control in carrots which eventually improved the yield and reduced the time spent on manual weeding. Addition of *Brassica hirta* to the soil at the rate of 20 g per 100 g soil reduced the emergence of shepherd’s purse (*Capsellabursa pastoris*), Kochia (*Kochia scoparia*) and green foxtail (*Setaria viridis*) by 97, 54 and 49% respectively (Al-Khatib et al., 1997).

**Insect pests and control**: There is little information on the effect of cropping sequences and cover crops on beneficial and pest insect populations. Bugg et al. (1990: 1991) found that when summer vegetables were planted amid “dying mulches” of cold season cover crops, some insects moved onto the vegetables. The studies by Zehnder et al. (1997) demonstrated that the application of organic materials (*Javelin-Bacillus thuringiensis* subsp. *Kurstaki*), biological insecticide, garlic barrier and *Capsicum* can provide equivalent or better control of cabbage worms than Karate (Lambdacynalthrin), a synthetic insecticide by reducing the larval feeding damage.

Use of cultivars resistant to nematodes (Sasser and Kirby, 1979), rotating with non-host crops and planting antagonistic crops (e.g. marigold, hairy indigo, showy crotalaria, sunhemp, velvetbean, castorbean etc.) were observed very effective for killing nematodes and application of chitin would be helpful in nematode infested areas (Leonard, 1991). Chindo and Khan (1990) in a studies on poultry manure application (0-4 tons per ha) on the severity of *Meloidogyne incognita* race attack on tomato cv. Enterpriser in Nigeria, observed a drastic reduction in nematode population in soil (root gall index) due to toxic substances produced during decomposition of poultry manure in soil. Gul et al. (1990) observed depression in root knot causing nematodes population with neemseed oil cake plus mustard oil cake. The other studies by Mukhtar et al. (1994) showed maximum control of *Meloidogyne incognita* root knot causing disease of tomato using combination of neem leaf cake and sawdust both applied at the rate of 25 g/Kg of soil.

The studies by Marull et al. (1997) on the efficacy of olive (*Olea europaea*) pomace, chicken litter and municipal compost residues as soil amendments for control of *Meloidogyne javanica* using pepper (*Capsicum annuum*) as test crop demonstrated that the residues of olive
pomace had lower number of *M. javanica* in the roots than those grown in unamended soil. Akhtar and Mahmood (1997) observed that application of poultry and cattle manures, inorganic fertilizer in form of urea, neem based urea coated agent and neem based nematicide “Suneem G” significantly reduced populations of *Meloidogyne incognita* and other plant parasitic nematodes and their symptoms on the plant and increased the populations of microbivorous nematodes. Vawdrey and Stirling (1997) in a studies on suppressive effects of sawdust (150 m³ per ha), molasses (375 litres per ha per week for 14 weeks), a velvet bean (*Mocana pruriens* var Utilis), green manure crops and fenamiphos (10 Kg a.i. per ha) in field grown tomatoes found best effects of molasses on root knot nematode population in soil. The sawdust amended soil was almost free of galls and had the lowest populations of root knot nematode.

**Disease control**: Soil borne pathogenic fungi are limiting factors in production of vegetables organically. *Rhizoctonia solani* Kuhn, *Pythium myriotylum* Drechs, *P. aphaniidermatum* (Edison) Fitzp, and *P. irregularare* Buiss are the most virulent pathogenic fungi and cause pre- and post-emergence damping off on cucumber and snap bean (Sumner *et al.*, 1983; 1988), *Sclerotium rolfsii* Sace. causes root, hypocotyl, and stem rot in cucumber and snap bean (Sumner *et al.*, 1986; Sumner *et al.*, 1988). In green house tests, the fusarium yellows disease of *Phaseolus vulgaris* caused by *F. oxysporum* F. sp. *Phaseoli* was effectively controlled by amendments of coffee halls and farm yard manure but not by rice husks. Coffee hall affected the host by causing N deficiency symptoms through application of high levels of amendments (Mutitu *et al.*, 1989).

Dickerson (1996) reported that plants treated with compost (20 tons per acre) recorded lowest number of plants with *Phytophthora* causing root rot of chilli. The studies by Sreenivasa (1997) and Silveira and Maia (1996) showed least sclerotium bodies in three varieties of chilli and bacterial, fungal and viral diseases in tomato (*Lycopersicon esculentum* Milli). respectively. Akiew *et al.* (1996) observed reduction in bacterial wilt of tomatoes caused by *Pseudomonas solanacearum* (*Ralstonia solanacearum*) by the application of residues of Indian mustard, rape and tobacco both under greenhouse and field trials.

**Microbial fertilizers**

Biofertilizers have for long been witnessed shifting fortunes in agriculture and their use in vegetables farming is no exception possibly due to lack of redefined application technique. The studies by Sundaravehi and Muthukrishnan (1993) also showed similar response of Azospirillum in Radish (cv. Japanese White). The effect of bio-fertilization in production of okra (*Abelmoschus esculentus* L.) showed best response with Azospirillum inoculation in acidic clay loam soil which increased green fruit yield by 195% compared to untreated and by 54.5% compared to 50% NPK treatment only (Mishra and Pat Joshi, 1995). Zeenot Rizvi and Sharma (1994) observed a good response on the vegetable growth of potted tomato seedlings to application of algal culture (*Aubosira fertilissino* as N₂ fixing and *spirulina subsch* as non N₂ fixing). Kshiragar *et al.* (1994) observed highest P uptake following inoculation with both Azobacter and *Glomus fasiculatum* and application of 50% of recommended P rate. Omran *et al.* (1995) observed that increasing farmyard manure rates 25 to 100 m³ per feddan (1 feddan = 0.2 ha) increased the fruit weight of pepper besides better nutrient composition.

The response of biofertilizers obtained from cow dung on onion (*Allium cepa* L.) showed highest value for fresh bulb yield (22.26 tons per ha) with 750 ml liquid etnile per meter from an anaerobic digestor combined with 60 kg N and 40 kg P per ha which was also associated with reduced incidence of insect pests (Serrano *et al.*, 1995). The other study by Warade *et al.* (1996) indicated highest bulb yield of onion (22.7 tons per ha) with 40 tons farmyard manure plus NPK (100, 50 and 50 Kg per ha, respectively), followed by plus biofertilizer inoculation in clay soil. Wange *et al.* (1996) observed 15.20% higher yield of cabbage by inoculating with cultures of Azobacter and Azospirillum compared to uninoculated controls in medium black soil. The
studies on response of vegetables to biofertilizers showed highest yield of cabbage (cv. Golden Acre) and seeds of other vegetables with 60 Kg N per ha plus Azotobacter treatment (Verma et al. 1997). Wang (1996) observed that the use of 45 Kg N per ha in combination with Azotobacter and Azospirillum increased carrot yield by 50% over that observed at the recommended N dose of 60 Kg N per ha. El-Anshoury et al. (1989) observed that inoculation of tomato with A. chroococcum enhanced root infection by G. fasiculatum, stimulated the growth and resulted in an increased shoot N, Ca, Mg and K compared with other treatments and root N, P, Na, Ca and Fe compared with uninoculated plants displaying the synergistic effect of A. Chroococcum with G. fasiculatum.

Role of Mycorrhizae

Mycorrhizae have been shown to improve the nutrition of the host plants for nutrients that are diffusion limited such as P, An, Cu and Fe (Tinker 1982), on account of their ability to dissolve and absorb these elements (Englander, 1981). Mycorrhizae have also been found to liberate organic acids and solubilize otherwise insoluble phosphorus in the rhizosphere which is taken and transferred to plant by VAM fungi (Krishnaraj and Sreenivasa, 1992). Afek et al. (1991) observed VAM colonization of roots of onion and pepper was maximum (59% and 63%, respectively) at 3-5 weeks after planting in non-fumigated plots by soil solarisation plus trap coverage. Studies by Singh et al. (1990) indicated that out of the Glomus mosseae, Glomus fasiculatum and Glomus sp. inoculated with onions at transplanting in sterile soil, Glomus fasiculatum recorded maximum increase in plant height, number of leaves, number of extra matrical chlamydospores per 50 ml soil and percentage root infection (34.89cm, 22.56, 273.33 and 91.67%, respectively) compared to uninoculated control (28.00 cm, 13.22, 48.33 and 40.13%). Nevertheless, Glomus deserticola was the most efficient fungus and exhibited the highest level of mycorrhizal colonization as well as the greater stimulation of physiological parameters (Ruiz-Lozano et al., 1995).

There is little information available on either role of enzymes in the symbiosis between arbuscular mycorrhizal fungi and plants, or about the response at the biochemical level of the mycorrhizal symbiosis to drought stress. Higher superoxide dismutase activity (Ruiz-Lozano et al., 1996), nitrite reductase activity (Ruiz-Lozano and Azcon, 1996) and glutamine synthetase (Azcon and Tober, 1998) in mycorrhizal inoculated plants under stress conditions were observed in addition to salt tolerance (Ruiz-Lozano et al., 1996).

Biometric response: Miranda and Harris (1994) observed improvement in vegetative growth of leek seedlings due to soil inoculation of arbuscular mycorrhiza in Brazilian Oxisol. The yield improvement in tomatoes was observed as result of inoculation with Glomus sp. which recorded 33.6 Kg per plant compared to only 30.9 Kg per plant from uninoculated plants. Gurubatham et al. (1989) observed higher onion bulb yield ranging from 15.9 tons per ha in unfertilized control which was increased 29.5 tons per ha with Azospirillum (100 g/Kg seeds) and mycorrhizal inoculation.

The studies by Matsubara et al. (1994) showed enhancement in growth by vasicular arbascular mycorrhizal fungus (VAMF) inoculation to roots in welsh onion cv. Green Negi, asparagus cv. Hokushi, pea cv Senzyuichi Kinuseyaendi, celery cv Kernel No. 619 and cucumber cv Hokushiu Kyuri, the response of which varied with host-fungus combination. Sreenivasa (1994) recorded improvement in growth and yield of chilli as a result of inoculation of Glomus macrocarpum in conjunction with worm casts having narrow C:N ratio in red soils of Tamil Nadu, India.

The growth rates of primary yield components (stem dry weight, leaf dry weight and leaf area) cucumber infected with Glomus mosseae, Glomus dimorphicum and Glomus intraradices were greater than non infected plants at all levels of phosphorus nutrition. It was suggested that in relative to non-infected plants, higher concentration of soluble carbohydrates in roots of VAM infected
cucumber plants indicated an increased sink demand to support the symbiosis (Trimble and Knowles 1995a). Later, studies by Trimble and Knowles (1995b) showed that infection of cucumber plants with Glomus intraradices stimulated early flowering and fruit production. The studies by Zhao and Li (1994) and Matsubara et al. (1995c) showed that inoculation of Glomus epigalum and Glomus mosseae to Capsicum annum improved plant height, number of leaves per plant, stem diameter and plant dry weight besides bringing forward the time of flowering improving cold resistance and prolonging the growing period.

Nutrient mobilization: A varying responses were observed on the nutrient uptake depending upon differences in genotype which were further dependent upon the length of time required for vesicular arbuscular mycorrhiza (VAM) colonization, the effect of root age and the position of VAM inoculum with respect to root system (Afek et al., 1990). The studies on short term effects of phosphorus and VA mycorrhizal fungi (Glomus deserticola and VA mycorrhizal fungi (Glomus deserticola) on nutrition, growth and development of Capsicum annum L. showed increase in leaf tissue P concentration and reduced molybdenum concentration with no effect on K and N content (Davies and Linderman, 1991). Sasai (1991) observed that phosphorus application decreased the mycorrhizal infection rate in tomato, soybean, carrot and Arctium leppa with the result P uptake also reduced. The higher efficiency of mycorrhizal infection was obtained in P deficient soils. Tawaraya and Saito (1994) observed higher concentration of total amino acids in roots of onion and white clover as result of mycorrhizal inoculation when compared with uninoculated plants. Sreeramulu et al. (1996) observed significantly higher P uptake by shoot and root of Glomus fasciculatum inoculated Amaranthus viridis and trigonella foenum-graecum in a sandy loam soil of Karnataka. The studies by Dhinakaran and Savithri (1997) in a red calcareous soil showed increased uptake of P at 100 Kg P₂O₅ per ha which was higher with the use of VAM fungal inoculation through P³² use in tomato crop. Kim et al. (1998) recorded higher total N and P uptake with Enterobacter agglomerans and Glomus etunicatum compared to untreated tomato plants due to synergistic interaction.

Qualitative response: In a study where Xanthine tobacco and Tapaz F1 onions were inoculated with either Glomus mosseae, G. intraradices or G. fasciculatum and Mycorrhizal roots were observed to contain more soluble protein than non-mycorrhizal roots showing better quality of onions inoculated with mycorrhiza (Dumas et al., 1990). Mathur and Vyas (1995) observed increased levels of proteins (>2folds) and sugars (>50%) in pods of Cyamopsis tetragonoloba as a result of inoculation with Glomus fasciculatum compared to uninoculated plants. Subbiah (1994) reported increase in yield of chilli pods (Capsicum Sp.) and onion bulbs as a result of inoculation of seed with Azospirillum brasiliense (50-100 g per 100 g) and VAM fungi Glomus Fasiculatum (1 Kg per m³).

Role of vermicompost
Various research groups have been working on variegated role of vermicompost to devise ways and means with the objectivity of adopting natural farming with eco-friendly soil fauna. One of the such alternatives has been the production and utilization of composted organic wastes which can be achieved by earthworms. The resultant product known as vermicompost is rich in both macro and micronutrients, vital plant promoting substances, nitrogen fixers and humus forming microorganisms (Gavilov, 1962; Bano et al. 1987).

Stability in soil properties and yield response: The stability of soil aggregates is of great physical importance for improved soil-water-nutrient-plant relationship. Bhendari et al. (1967) reported that earthworms formed water stable soil aggregates which reduced soil erosion. The soil particles in worni'Gast were found stabilized by polysaccharidé gums produced by bacteria present in the intestine of earthworms, thereby enhancing the entry of water into the soil. Kale et al. (1987) reported a significant improvement in water holding capacity and aeration when mixes of wools
wastes (eucalypt) with seaster wastes in ratio (v/v) of 3:1 (bark:seaster) or 4:1 (sawdust:seaster) were composted for two months using earthworms (Line, 1994). The crop yield in relation to earthworm was quantified for the first time by Hopp and Slater (1949) who attributed improved yield of crops on account of increased levels of readily available nitrogen in the presence of either dead or live worms. Improved growth in pastures and other crops was observed by Nielson (1965) due to growth promoting ability of earth worms fauna, chemical exudates and microbes associated with earthworms besides presence of allied compounds of IAA in earthworms tissues. An improvement in growth and yield of radish, tomato, carrot and Brinjal (Kale et al., 1991) were reported following the application of vermicompost. On the contrary, adverse effect on plant growth and yield were also reported by Agrawal et al. (1958) and Patel and Patel (1959).

**Response of other organic substrates**

Different kinds of organic substrates are in practice for providing momentum to the vegetable production organically out of which some organic substrates may be unconventional, thereby may solve the problem of garbage disposal. Recent studies by Kropise (1992), Maynard (1991), Chanda et al. (1996) and Ranganna et al. (1991) showed good response of organic substrates such as composted pine bark, farmyard manure, spent mushroom compost amended chicken manure, poultry manure, compost and spent sludge in vegetables like cabbage, onion, carrot, eggplant, pepper, tomatoes broccoli, cauliflowers, spinach and garlic. The formulation containing 88% powdered poultry manure, 4% urea, 4% KCl and 4% boron sulphate produced best growth for vegetables when applied at the rate of 337.5 Kg per m² to autumn cabbage cucumber and white guard (Wang et al., 1996). The trials in China testing monocropping with intercropping and organic with inorganic fertilizer demonstrated higher mean crop yield of autumn sweetcorn, winter potatoes, spring soybean and winter garlic by 19.3, 6.5, 36.9 and 5.0%, respectively with legume and organic manure compared to monocropping using inorganic fertilizer (Wang, 1993).

**Agronomic importance:** The agronomic value of an organic material is evaluated on the basis of its capacity to improve the crop yield derived from its application. The studies by Ozares-Hampton et al. (1998) on the use of composted wastes on Florida vegetables crops showed that waste materials like yard trimmings, household trash (municipal solid waste) or bio solids (waste water sludge) have the potential to increase water and fertilizer conservation and reduce leaching of inorganic fertilizers in Florida sandy soils in addition to improving the growth and yield of vegetables. Ning et al. (1997) observed their applying organic nitrogen fertilizer retarded growth and flowering and reduced yields but produced heavier pumpkins fruits. Ranganna (1991) observed increase in garlic yield by 246.5% by application of 10 tons per ha biogas spent sludge due to higher concentration of N, P₂O₅, K₂O and organic carbon to that of farmyard manure. Chui et al. (1992) found 79.1% increase in yield of *Brassica chinensis* with 200 Mg sludge per ha compared to control in a sandy soil having pH 6.5 Buchanan (1993) observed necessity of considering the residual effect and disposal of organic substrates such as composted pine bark, farmyard manure, spent mushroom compost amended chicken manure, poultry manure, compost and spent sludge in vegetables like cabbage, onion, carrot, eggplant, pepper, tomatoes broccoli, cauliflowers, spinach and garlic. The formulation containing 88% powdered poultry manure, 4% urea, 4% KCl and 4% boron sulphate produced best growth for vegetables when applied at the rate of 337.5 Kg per m² to autumn cabbage cucumber and white guard (Wang et al., 1996). The trials in China testing monocropping with intercropping and organic with inorganic fertilizer demonstrated higher mean crop yield of autumn sweetcorn, winter potatoes, spring soybean and winter garlic by 19.3, 6.5, 36.9 and 5.0%, respectively with legume and organic manure compared to monocropping using inorganic fertilizer (Wang, 1993).
evaluated on a lakeland fine sandy soil which showed that first cabbage marketable yield responded quadratically to increasing rates of poultry manure with the maximum yield as 28.4 tons per ha obtained (Hochmuth et al., 1993). Mallangonda et al. (1995) observed highest fruit yield (2099.8 Kg per ha fresh weight and 577.8 Kg per ha dry weight) was observed in C. annuum plus garlic system treated with the recommended dose of NPK + FYM which was also associated with highest K uptake (37.28 Kg per ha). The studies conducted by Dixit (1997) showed increase in yield of onion (Allium cepa) by 42.8% compared to control when farmyard manure was applied at the rate of 20 tons per ha along with 120 Kg N per ha in hill region of Himachal Pradesh. Kumar et al. (1997) observed increased yield related traits of tomato (Lycopersicon esculentum Mill.) with neem cake, karanj (Pongamia pinnata) cake and mustard cake alone or in combination with foliar sprays of streptocycline (200 ppm) at flower initiation stage compared to untreated plants.

**Qualitative improvement :** Many studies in the recent past have demonstrated the better quality of organic vegetables than inorganic vegetables (Montagu and Goh, 1990; Heclerc et al. 1991; Lacic et al., 1992; Krospise, 1992; Silva Junior, 1992; Huang et al., 1993; Leiser, 1993) such as carrots having better β-carotene (>12%), vitamin C content (>11%), less nitrate in celeriac, excellent flavour, aroma, colour and betanin in beetroot besides improved yield. Studies on effects of 2 organic (blood and bone compost) and 2 inorganic KNO₃ and (NH₄)₂SO₄ at the rate of 0, 150, 300 and 600 Kg per ha based on bulk density on the quality indices of tomato cv. Potentate grown in peaty loam soil showed increased fruit colour with blood and bone whereas compost showed no effect. Increasing N rate produced significant negative linear trend with vitamin C concentration decreasing by 18-28% depending on the form applied (Montagu and Goh 1990). Warman and Havard (1998) in a study on the comparison of vitamin C content of potato grown organically versus conventionally, observed higher vitamin C content in organically grown potato (Solanum tuberosum cv. Superior) in a sandy loam soil near Truro, Nova Scotia, Canada. Tam and Wong (1995) found beneficial effect of spent pig litter from pig pen in sandy soil on the tissue concentration of N, P and K application in leafy vegetables. Brassica parachinensis.

**Issues and strategies**

As suggested by Kelly (1990) and Wien (1990), large, scale, long term, multidisciplinary studies are essential to follow nutrient cycling and seasonal soil microbial activity in traditional mono crop system (Jackson 1991), farming systems comparisons (Mc Grady et al., 1991; Shennan et al., 1990) and evaluation crop rotations and cultural techniques during transition (Peters 1991). 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 vegetables organically. These organic farming practices have to be tuned to the change in traditional concept of farming. The following issues and their viable strategies are suggested to make organic vegetables production more vibrant, dynamic and responsive to changing consumer demand both locally and globally as well:

- Involvement of multidisciplinary research in a holistic manner with long term evaluation of different organic substrates.
- Identification of suitable cover crop and smother crop in a given cropping strategy, living and drying mulches, relay cropping, companion cropping, crop rotations, green manuring and composting including the techniques of shelf life improvement of bacterial biofertilizers, monitoring of changes in groundwater quality with reference to heavy metal toxicity besides nitrate pollution and identification of soil improving crops under major agro-climatic zones assumes foremost importance.
- Evaluation of soil conservation practices of disease management, change in habitat for beneficial insects and suitability of trap crops in organic culture and identification of nematode repellant cover crops especially
from various vegetables of Liliaceae family should be given a due emphasis.

- Optimum management in terms of cover crop planting incorporation and tillage methods before establishment of subsequent crops.
- Development of techniques for modifying fertilizer recommendations for new crop rotations using different cover crops and fool proof technology for transformation of traditionally used chemicals inputs farm into a successful organic farm.
- Biophysical interaction studies between different components of organic farm including socio-economic dimensions and techniques of elimination of constraints on conservation of natural resources through studies on crop-environment compatibility and integration of traditional practices of insect pests and disease control along with use of ecofriendly third generation pesticides and botanicals.

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