REVIEW OF LITERATURE

The literature available on the present subject has been reviewed as under:

India has made significant progress in the field of agricultural production since independence. Along with food grains, production of vegetables have also recorded commendable improvements during this period achieving more than 225% increase in such production from 39.8 m ton to 133.7 m ton in between 1979 and 2009-10 only (Anon, 2010). This success in vegetable production has brought India in the second place among the highest vegetable growing countries of the world with 14% contribution to global production (Anon, 2010). Along with this increase in such production, consumption of inorganic fertilizers has also increased rapidly in the country and in comparison to total fertilizer consumption of only 70,000 t in 1950-51 in terms on N, P₂O₅ and K₂O, such use has come up to around 28.0 m ton in 2010-11 (Anon, 2011). Of this total amount, about 40% is generally considered to be used for horticultural production including vegetable cultivation. Uses of these nutrient inputs have played significant roles in achieving the success in vegetable production in the country. However, a critical analysis of the trends of vegetable production in the country indicates this increment to be more a function of increase in total area than improvements in productivity levels. In fact, an indication of stagnation in the rate of per unit area production of vegetable crops is being observed during recent years. Although part of this behavior may be attributed towards diminishing return of increased fertilizer doses, a major reason behind such reducing response may be lesser use of organic materials in comparison to inorganic fertilizers resulting in deterioration in various physical and chemical conditions of the soils which cannot be sustained and some of which are consistently degraded with continuous application of only inorganic fertilizers. The situation may be more serious for vegetable cultivation where comparatively higher doses of fertilizers are generally recommended. In this section, an effort has been made to review the results of the studies on use of different nutrient inputs in vegetable production and also to assess the efficiency of various organic inputs, especially organic wastes in such cultivation with special emphasis on vermicomposting biotechnology.
2.1. Sustaining soil productivity under vegetable cultivation:

With the recent trends of gradual stagnation in the yields of most of the vegetable crops in India, more attention is being paid on sustenance of such productivity through appropriate land care and soil health management. Good numbers of researchers are now working on this aspect using several indicators of soil health (Chaudhury et al., 2005; Sharma et al., 2005). During the courses of these studies, it has commonly been observed that use of organic materials play a pivotal role in maintaining soil health as well as productivity (Manna et al., 2005; Mandal, 2005 and others). This importance is attributed to significant positive effects of organic matter on various physical, chemical and biological soil properties, which control the health of the soils. The beneficial roles of organic matter in sustaining soil health are well documented (Majumder et al., 2008).

Allison (1973) summarized the important contributions of organic matter in maintaining the productivity levels of soils to be as (i) it is a natural resource of inorganic plant nutrients and microbial energy (ii) it serves as chelating agent and also increases cation exchange capacity and (iii) it improves physical conditions of soils.

The arable soils of tropical and sub- tropical countries are poor in organic matter due to high temperature and intense microbiological activity (Gaur, 2006). Hence a regular and sizeable addition of organic material to soil is essential to maintain optimum organic matter status and, thereby, the health of soil. Under this context, judicious combinations of mineral fertilizers and organic manures appear to be the major option of integrated nutrient management programmes under the prevailing Indian condition (Chattopadhyay, 2005).

In spite of this widely recognized importance of using organic matter in Indian soils, large scale availability of traditional organic manures is a major problem for such countries due to other uses of organic materials (Gupta, et al, 1998). Attentions are, therefore, being paid to increase the utilization of different kinds of organic wastes after recycling them into organic manures. In view of lack of availability of sufficient amount of traditional organic manures for the vast areas of arable lands in India, more emphasis is now being given on larger uses of various kinds of organic wastes for this purpose.
2.2. Potentials of organic waste recycling:

Incorporation of organic material helps to build up humus which improves the health status of soils. Recycling of organic wastes in agriculture brings in this much needed organic matter to the soils for sustaining their health. Since most recyclable wastes are organic in nature, they directly add organic matter to the soil along with different plant nutrients contained in it. Kumazawa (1984), while elaborating this aspect, stated such applications to result in a marked increase in the humus content, cation exchange capacity and the levels of available nutrients while the bulk density is decreased and water holding capacity increased. Tandon (1995) emphasized the importance of re-using organic wastes in agriculture in establishing the natural link not only among land, plants, animals and man but also with activity of those industries, which depend on agriculture for their raw materials. Large quantities of organic wastes are produced from different agro-industries of the country, which may be utilized effectively for sustaining food, fuel and fibre production. Bhattacharya and Kumar (2009) made an assessment of the available organic nutrients in the country and calculated the potential sources to be able to supply about 12.8 million tons of NPK. It is apparent that there is considerable potential of supplying NPK and other nutrients from these resources. However, due to some socio-economic compulsions, a major portion of the crop residues in India is used as feed and fuel in rural houses. Some are also used as animal bedding and some as industrial raw materials such as paper and pulp making (Gupta et al., 1998). Despite all these uses, there is enormous scope of providing good amount of plant nutrition from different kinds of organic wastes, which are being generated in huge amount in a country like India having more than one billion population. The practice of recycling organic wastes into compost deserves significance for sustaining productivity of agricultural soils of the country as well as for abatement of environmental pollution created by these materials.

2.3. Composting of organic waste materials:

While using different wastes in agriculture, it is essential to allow adequate decomposition of the organic materials for obtaining good benefits not only by way of crop nutrition but also in terms of the improvements in soil fertility and tilth (Bhardwaj el al. 1998). Large quantities of available nitrogen may be immobilized into organic form within a short period of time when raw organic materials with wide C : N ratios are added to soils. In order to meet the emerging need of utilizing the vast resources of
organic residues, it is, therefore, necessary to compost the materials properly before they are used for any productive purpose. Goswami (1998), emphasized that the benefits from organic residue application in agriculture will depend on the ease of decomposability of all those materials to form compost. Composting has been described as a biological process for converting solid waste into a stable, humus like product which finds use as a soil conditioner (Talashilkar, 1989). Apart from providing substantial plant nutrition, these composts promote soil aggregation, improve air-water relationship, enhance cation exchange capacity, increase water retentivity, provide energy and improve several other physico-chemical properties of soils (Webber, 1978; Epstein, 1975). However, the major constraints related to wide scale adoption of composting technology have been described to be their bulk volume, long time required for composting, incomplete decomposition of resistant components, lower nutrient values as compared to mineral fertilizers and, above all, the complicated processes of composting. Enrichment of nutrient status of different compost materials through blending with phosphatic fertilizers has been done. Beneficial effects of nitrogen fixing as well as phosphate solubilising micro-organisms on improvement of the compost quality have also been explored (Gaur and Mathur, 1990). In continuation to these studies, in recent years, vermicomposting has emerged out as an efficient method for decomposing different kinds of organic wastes (Kale, 1993). This biotechnology of composting appears to be highly promising in view of its efficiency in degrading different organic components in shorter period of time, increased nutrient status of the product and simplicity of the procedure.

2.4. Concept of vermicomposting:

Importance of earthworms in maintaining fertility of soils was emphasized years back. Aristotle referred to the beneficial activities of earthworms in restoring soil fertility and described them as “Intestines of the earth”. Beneficial effects of these earthworms in improving structure, aeration, nutrient status and some other properties of the soils and, thereby, the growth of crops have been known since long. However, the knowledge about the efficiency of some groups of the earthworms in decomposing various organic materials was gathered later on and the concept of utilizing this behaviour for composting wide ranges of organic wastes was conceived during mid twentieth century (Senapati, 1993). Based on ecological niches, earthworms may be broadly grouped into three categories viz. endogeics, anecics and epigeics (Bouche, 1977). The third group known as epigeics, live on upper surface of soils feeding mainly on plant litter and other
organic debris, available on the soil surface. These earthworms are generally small in size, have uniform body colouration and while living on surface litter or dung, they can tolerate wide ranges of habitation disturbances. They have short life cycle but the reproduction and regeneration rates are high (Sharma, 2002). As these earthworms can consume a variety of organic matters, they are most suitable for converting organic wastes into useful organic manures. Since “Vermis” is the Latin word for worms, the compost prepared with the help of these earthworms has been termed as “Vermicompost” and the biotechnology has been known as vermicomposting. These epigeic earthworms being voracious feeders, can consume large quantities of different organic materials. The ingested food materials, while passing through the strong, thick walled gizzard of earthworms, are ground to very fine sizes (Edwards and Lofty, 1972), thus increasing the surface areas of these materials many fold. In comparison to their high rate of consumption, these earthworms utilize only a very small portion for their body synthesis and excrete about 90 - 95% of the ingested materials as vermicast. Since the intestines of the earthworms harbour high concentrations of various kinds of microflora (Wallwork, 1984), these vermicasts exhibit rich population of these organisms (Atlavinyte and Vanagas, 1982). The food materials ingested by the earthworms are thus subjected to more intense microbial activity in the alimentary canal not only due to these higher concentrations of different micro-organisms but also owing to increased surface area of the food particles, meshed to very fine sizes while passing through the earthworm gizzard. In addition to the activities of the microbes, occurrence of various enzymes in earthworm guts also helps such processes. In addition, existence of various hormones, antibiotics etc. have also been reported (Edwards and Lofty, 1972). All these components get mixed thoroughly with the food materials consumed by the earthworms and are released along with their excreta to be known as vermicast. These vermicasts undergo rapid aerobic decomposition in presence of different microbes. These microbial activities are accelerated by various enzymes and encouraged by occurrence of numbers of growth promoting substances. Aerobic micro-organisms being more active decomposers than the anaerobic, degradation of the vermicast takes place more rapidly than the traditional “pit composting” methods and a nutrient rich well humified organic manure is obtained in shorter period of time which is termed as “vermicompost”.

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2.5. Possibility of using vermicompost in vegetable cultivation:

Positive effects of vermicompost on growth and production of agricultural crops and also reduction in fertilizer requirement have been reported by Kale and Bano (1986), Chattopadhyay (2005) and others. However, maximum benefit of vermicompost application may probably be obtained from horticultural crops, especially vegetables. Good economic returns from such cultivation prompt the farmers to use more intensive inputs like inorganic fertilizers for achieving higher yields. Under this situation, vermicompost would be helpful not only in maintaining sustainable fertility status of the soils but also in reducing cost of cultivation by curtailing the expense towards inorganic fertilizers. However, in spite of large volume of studies on various aspects of vermicomposting, comparatively lesser works have been done on use of such compost in vegetable cultivation. Moreover, among these limited studies, most of the investigations have dealt with effect of vermicompost on production of vegetables only and systematic comparative studies using different sources of nutrients along with vermicompost are limited.

2.6. Effects of Vermicompost on Production of Vegetables:

Available information clearly shows that vermicomposts exert positive influence on yield of vegetables. However, unfortunately, systematic studies to substantiate these general observations are limited. Desai (1993) reported good yields of capsicum followed by tomato from vermicompost treated plot which was described to be of similar range as obtained with chemical fertilization. Similar trend of result was also reported by Khamkar (1993) while working on use of vermicastings on tondali (Coccinia cordifolia). Ismail (1997) communicated the results of a series of experiments on such aspect carried out in collaboration with Auroville Greenwork Resource Centre and stated that studies with vegetables like brinjal and okra have yielded encouraging results. Similar beneficial effects of vermicompost on some vegetables like onion (Jambhekar, 1992), lettuce (Seno and Koga, 1995), okra (Desai, 1993) have been reported. In addition increments in yields, some other favourable effects of vermicompost on vegetable cultivation have also been observed by different workers. Galli et al. (1994) reported a considerable increase in protein synthesis in lettuce following use of vermicasts. Again, in experiments with tomato and cabbage Szezech and Brzesk (1994) observed some plant diseases to remain suppressed due to vermicompost application. They suggested that this material may be used as a biopesticide.
2.7. Effect of Vermicompost as compared to other inputs:

With the growing awareness about the beneficial effects of vermicompost on vegetable cultivation, increasing studies are being carried out to assess the effect of vermicompost with respect to the results obtained with other resources or inputs so that specific benefits obtained from vermicompost can be identified. Madhukeswara et al. (1996) compared effects of different kinds of organic materials on growth of tomato and observed vermicompost to be superior to others. Ushakumari et al. (1996) studied the efficiency of vermicompost in producing bhendi with regard to recommended doses of inorganic fertilizers and manures. They also observed vermicompost to be efficient in increasing the production of bhendi over the recommended fertilization. Similar results were reported by Jiji et al. (1996) who observed vermicompost with full doses of inorganic fertilizers to increase the yield of bitter gourd to 21% over the treatment with FYM + inorganic fertilizers. Edwards and Burrows (1986) studied seedlings emergence of tomato, cabbage and radish with various organic wastes with and without earthworm treatment. They observed inclusion of worm cast to result in significantly better seedling emergence in each case. Possibilities of reducing use of inorganic fertilizers have been investigated by some workers also. In a study on use of vermicompost in potato cultivation Chattopadhyay et al. (2005) observed vermicompost application to reduce the requirement of inorganic fertilizers in such cultivation and reported that even about 50% reduction in the amount of recommended fertilization along with vermicompost did not result in any drop in yield of potato. Similarly, Jambhekar (1996) reported that in case of radish, spinach and green pea yields were better with vermicompost along with 50% of recommended NPK than with full dose of NPK. Bano et al. (1996) made some systematic studies on use of vermicompost in vegetable cultivation with four different vegetable crops viz. radish, carrot, brinjal and tomato using recommended doses of FYM and NPK as control and comparing the yield values with those obtained under treatments with different doses of vermicompost along with varying doses of NPK. These results also suggest that vermicompost can be used as a substitute fertilizer for vegetable crops.

2.8. Effect of vermicompost on soil quality:

Beneficial effects of organic matter on some specific properties of soils are well documented (Brady, 1974; Dash, 1993 and others). Apart from increasing nutrient status of soils, organic matter also helps to improve physical as well as chemical and also some
biological properties of soils. Vermicomposts are also supposed to help the sustenance of soils in similar manner.

However, in spite of varying natures of work done on different aspects of Vermicomposting, very little work have been done to study the changes in soil properties due to vermicompost application, especially under vegetable cultivation. Edwards and Burrows (1986) while working on nutrition to some vegetable crops through different vermicomposted and traditionally composted organic wastes observed vermicomposted organic wastes to exhibit substantially higher concentrations of N, P, K, Ca and Mg than the corresponding traditionally composted ones. Due to such high nutrient status, vermicompost application is likely to increase the nutrient content of soils in comparison to most of the organic materials. In a study on nutrient status of rice soils under treatment with vermicompost and other inorganic fertilizers, Vasanthi and Kumarswamy (1986) reported vermicompost treated soil to exhibit higher amount of N, P, K, Ca, Mg and micronutrients than the soil receiving NPK as inorganic fertilizers only. Similarly, Jambhekar (1996) while reporting effect of vermicompost on some vegetables, stated that there was considerable improvement in available N and P status in vermicompost treated soils.

A group of scientists working on use of vermicompost in red and lateritic soils have made some observations on residual quality of leafy vegetables *Ipomea* grown soils treated with vermicompost, traditional compost and inorganic fertilizer in different combinations (Anon, 1997). Use of vermicompost not only improved the fertility status of the soils with respect to N, P and K but also helped to maintain good amount of organic matter in the soil as compared to recommended fertilization schedule with traditional compost and NPK fertilizers. Moreover, even the lower doses of inorganic fertilizers exhibited higher fertility status of the soil when used alongwith vermicompost.

**2.9. Economics of using vermicompost for vegetable cultivation:**

Increase in production of different vegetables and also reduction in requirement of costly inorganic fertilizers, are likely to exert favourable impact on the economy of vermicompost application in vegetable cultivation. However, vermicompost is more expensive than traditional organic manures and this aspect sometimes tends to disturb this economy in spite of those beneficial effects. Ismail (1997) reported his studies on cost benefit of vermicompost application for growing some vegetable crops. He observed that net profit from one acre of land under brinjal cultivation with vermicompost was Rs.
18,290.50 as against Rs. 17,762.25 with traditional cultivation with inorganic fertilizers. However, as per his calculation, selling price for organically grown brinjal was Rs. 4.00 while for other treatment the said price was Rs. 3.00 per kg. For okra, he calculated vermicompost treated cultivation to yield net profit of Rs. 6803.75 and inorganic fertilizers treatment to result in profit of Rs. 6931.00. In this case also, however, price of originally grown okra was taken as Rs. 4.50 against the produce from other treatment @ Rs. 4.00 per kg. In both the cases, vermicompost treated cultivation did not appear to be much encouraging even after calculating the produces at higher rates. On the contrary, beneficial economic return of such cultivation has been reported by Desai (1993). Khamarkar (1993) compared the cost involved in tondali cultivation per acre area with vermicastings + FYM against inorganic fertilization + FYM. He showed that on the basis of cost structure of 1993, total inputs were Rs. 3675.00 and Rs. 9735.00 in these two treatments respectively.

Most of the researchers indicated that vermicomposting play an important role is providing nutrition to vegetable crops and also in maintaining sustainability of the soil health be under such cultivation. Over dependence of fossil fuel based plant nutrition has now become global concern and emphasizes are being given on integrated uses of various biological as well as organic resources. Under this context, vermicomposting process appears to be a simple, easy to perform technology with great potentials for providing plant nutrition from various kinds of organic wastes and also for maintaining sustained fertility of the soils.

2.10. Effect of vermicompost on different vegetable crops:

Bitter gourd

From findings of Rekha and Gopalakrishnan (2001), basal application of 20 tonnes of dry cow dung, 2.5 tonnes of poultry manure, fortnightly drenching of 2.5 tonnes of cow dung and a fertilizer dose of 70:25:25 kg NPK ha$^{-1}$ was found superior to all other treatments in terms of size of fruits, total and marketable yield. More or less equal fruit yield and fruit size were also recorded in another treatment, which received same manures but lacked inorganic fertilizers.

Reddy and Rao (2004) reported that application of increasing levels of vermicompost and N significantly increased the vine length, number of branches, number of fruits per vine and fruit yield/ha but flowering delayed. They concluded that
application of 13.8 t vermicompost and 34.18 kg N ha\(^{-1}\) (through urea) was found beneficial in improving the yield of bitter gourd.

Mulani et al. (2007) reported that combined application of organic manures and biofertilizers had beneficial effects on bitter gourd production. Their results showed that poultry manure (among organic N sources) was more effective than farmyard manure and neem cake at different levels and combinations. The application of 25\% nitrogen through neem cake and 75\% through poultry manure was found superior for enhancement of the growth, yield and quality parameters of bitter gourd: average vine length (5.38 m), fruit weight (84.80 g), fruit length (26.94 cm), fruit girth (3.48 cm), pulp thickness (1.03 cm), number of fruits per vine (63.11), fruit yield (263.33 kg/ha) and shelf life (7.33 days).

Meerabai et al. (2007) found poultry manure as best organic nutrient sources, in increasing number of fruits/plant, total fruit yield in bitter gourd. The fruit yield produced by poultry manure was 46.5\% higher as compared to control 1 (25 t FYM/ha+70:25:25 kg NPK/ha). They found out that basal dose of FYM at 25 t ha\(^{-1}\) and application of poultry manure to supply the recommended dose of 70 kg N ha\(^{-1}\) (on N equivalent basis) in combination with Azospirillum at 1 kg ha\(^{-1}\) was the best economic organic nutrient schedule in bitter gourd.

An investigation was carried by Kumar and Karuppaiah (2008) to find out the effect of integrated nutrient management (INM) on the performance of bitter gourd with various sources of nutrients under rice fallow condition. The biometric observations recorded by them were vine length, days taken for female flowering, number of female flowers, number of fruits, weight of fruits and yield per plant. Based on the performance, they found that the treatment combination of 75\% of NPK (60:30:20 kg ha\(^{-1}\)) + vermicompost at 5 t ha\(^{-1}\) + Azospirillum at 2 kg ha\(^{-1}\) was the best for total yield (1.33 kg/plant) followed by 75\% NPK + panchakavya at 3\% foliar spray + Azospirillum at 2 kg), which was on par with (NPK 100\% + vermicompost at 5 t ha\(^{-1}\)).

**Cabbage**

Dixit (1997) observed the effects of N (0, 40, 80, 120 or 160 kg ha\(^{-1}\)) and farmyard manure (0 or 20 t ha\(^{-1}\)) on the growth and yield of cabbage. He found increase in yield (from 136.8 to 175.1 q ha\(^{-1}\)) with increasing N rate after addition of 0 and 160 kg N ha\(^{-1}\), respectively and from 129.5 to 144 q ha\(^{-1}\) with increasing FYM rates. Addition of
FYM to N treatments further increased yield (176.1 q ha\textsuperscript{-1}) in presence of FYM + 160 kg N/ha.

Sharma and Arya (2001) found increase in marketable yield of cabbage with increasing levels of N up to 160 kg N ha\textsuperscript{-1} and FYM at 20 t ha\textsuperscript{-1} when compared with the untreated controls. They recorded significant increase in plant height, head length and head girth \textit{i.e.} up to 29, 24.42 and 46.24 cm respectively, with application of 80 kg N ha\textsuperscript{-1} which further improved by application of 20 t FYM ha\textsuperscript{-1}. They opined that the application of 120 kg N/ha and 20 FYM/ha is optimum for higher yield of cabbage under dry temperature conditions in Himachal Pradesh.

Yadav \textit{et al.} (2001) recorded maximum head weight, number of outer leaves and head yield (207.48 q ha\textsuperscript{-1}) with application of NICAST 500 + recommended NPK which was \textit{on par} with integrated use of recommended dose of FYM and NPK, and NICAST 750 + recommended dose of NPK.

Sharma (2002) studied the single and combined effects of biofertilizers, Azotobacter and Azospirillum significantly increased the number and weight of non-wrappr leaves per plant, head length and width, gross and net weight of head per plant and yield per ha over the ‘no biofertilizer’ treatment but Azospirillum treatment recorded higher values. A treatment combination of Azospirillum + 60 kg N ha\textsuperscript{-1} recorded the highest head weight per plant, head weight and yield per ha.

Anez and Espinoza (2003) determined the amount of manure needed for profitable yields of cabbages (\textit{Brassica oleracea} var. \textit{capitata} hyb. Izalco), with or without addition of chemical fertilizers. They suggested that 10 t/ha of compost or earthworm humus should be applied to the crops one month before transplanting along with 150 kg N/ha.

Chaudhary \textit{et al.} (2003) observed maximum values of soil organic carbon, available N and K in treatments VC at 100 g/plant + FYM at 500 g/plant, VC at 200 g/plant + FYM at 250 g/plant and VC at 100 g/plant + FYM at 500 g/plant respectively. They opined that application of VC at 200 g/plant along with FYM at 250 g/plant was best for obtaining sustainable yields in cabbage.

Gupta and Samnotra (2004) studied the effects of N (0, 25, 50, 75 or 100\% of the recommended rate of 120 kg ha\textsuperscript{-1}) and biofertilizers (Azospirillum and Azotobacter) on the performance of cabbage in Jammu and Kashmir, India. The application of 90 kg N +
Azospirillum resulted in the greatest plant height (25.08 cm), number of wrapper leaves (31.33), head diameter (14.63 cm), head weight (1.280 kg), yield (435.22 quintal ha$^{-1}$), and the lowest core length (5 cm). They opined that this treatment reduced the N use by 25%.

Sharma et al. (2005) recorded days to maturity, number of non-wrapped leaves, head size, shape index and head yield on cabbage crop. They revealed that application of 120 kg N + 60 kg P + 60 kg K/ha and 240 kg N + 90 kg P and 60 kg K/ha resulted into highest head yields of 413.99 and 421.15 q/ha respectively.

In Parbhani, Maharashtra, Chitrakar et al. (2007) studied the effect of combined use of organic manures and chemical fertilizer on growth, yield and quality of cabbage. They reported that the application of 25% recommended dose of fertilizer (RDF) with 75% vermicompost exhibited more root length and fresh dry weight of roots. The same treatment also produced highest yield per hectare.

Ghuge et al. (2007a and 2007b) revealed that application of 50% RDF along with 50% vermicompost at 2.5 t ha$^{-1}$ gave the maximum head weight (1232 g per head), chlorophyll content (652.1 micro g/g of leaf), and highest yield (379.87 q ha$^{-1}$).

In an experiment, conducted at Maharashtra, India; Kalabandi et al. (2007) found maximum values of studied characters viz. mean number of leaves, circumference of stem, leaf area, TSS of head and, and maximum yield per hectare, in treatment with 25% recommended NPK rate + 75% farmyard manure.

While working on integrated use of recommended dose of nitrogen (RDN) through urea, with yeast sludge (DYS) and FYM, Patil et al. (2007) recorded the highest cabbage yield (38.67 t/ha) with application of 100% RDN which was at par with 50% N of RDN (through DYS) + 50% of RDN (through urea).

Thapliyal et al. (2008) observed various important parameters of cabbage like stalk length, number and weight of non wrapper leaves, net head weight, core volume, yield per hectare, ascorbic acid content and chlorophyll content; to study the efficacy of farmyard manure and vermicompost were inoculated with biological control agents. They obtained highest yield of heads of 415.83 q ha$^{-1}$ along with more head weight, maximum ascorbic acid and chlorophyll content, in the treatment where 75% of the recommended N was supplied through FYM inoculated with P. fluorescens and 25% of balance N through urea, than other treatments under their study.
Kumar et al. (2008) studied the effects of different integrated nutrient management practices on the growth parameters (number of days taken for head formation, 1st and final harvesting, plant height and spread, and non-wrapper leaves per plant) of cabbage. They recorded highest values of these traits with application of 80:80:60 kg NPK ha\(^{-1}\) + ZnSO4 + VC and 100:80:60 kg NPK/ha + ZnSO4 + FYM.

Devi and Roy (2008) and they reported that inorganic fertilizers and organic manure (FYM) along with biofertilizer inoculation of seedlings significantly increased the yield of cabbage over inorganic fertilizer + organic manure and also over the control. The integrated treatment N: P:K (120:100:120) + FYM at 25 t ha\(^{-1}\) + Azotobacter sp. at 2 kg ha\(^{-1}\) + phosphotika at 2 kg ha\(^{-1}\) recorded maximum yielding parameters like diameter (15.37 cm and 14.69 cm for polar diameter and equatorial diameter, respectively) and consequently the yield (34.11 t ha\(^{-1}\)).

Supe and Marbhal (2008) reported that application of 50% N through organic sources was found significantly superior for average weight of head, average weight of leaves, number of leaves per plant, girth of head and days required for harvesting, over inorganic source @ 100:50:50 NPK kg/ha. Statistically similar results were obtained with combination of 50% nitrogen (through organic sources) and increased dose of NPK (125:62.5:62.5 kg/ha).

Ouda and Mahadeen (2008) studied the effect of organic and inorganic fertilizers on yield and quality of broccoli (Brassica oleracea L. var. Italica). They recorded highest yield (40.05 t ha\(^{-1}\)) with application inorganic fertilizers and organic manure at 60 kg and 60 ton per hectare respectively. Head number per plant, chlorophyll content and head diameter were recorded higher when a combination of organic and inorganic fertilizers was added, compared to using their individual addition. They did not found significant effects of different doses of fertilizers on fresh and dry weights of broccoli shoots.

Zango et al. (2009) revealed that application of FYM at 60 t/ha recorded significantly higher plant height (29.45 cm), stalk length (7.77 cm), head diameter (12.91 cm), head size (237.39 cm\(^2\)), head compactness (135.65), net head weight (1263 g) and net head yield (467.62 q/ha-1).

Wang et al. (2010) revealed that vermicompost application significantly increased the nutrient content of Chinese cabbage leaves, especially in the treatment
(proportion of vermicompost and soil, 4:7) with increases in the contents of soluble sugar, soluble protein, vitamin C, total phenols, and total flavonoids by 62%, 18%, 200%, 25%, and 17% respectively compared to the full soil treatment.

**Onion**

Mallanagouda *et al.* (1995) observed the effects of NPK and farmyard manure (FYM, 500 kg ha$^{-1}$) on the growth and yield of onions and two other crops. They obtained the highest yield of onion (4698.38 kg ha$^{-1}$) from plots treated with the recommended rate of NPK + FYM.

The highest bulb yield (27.7 t ha$^{-1}$) was obtained by Warade *et al.* (1995) with application of FYM at 40 t ha$^{-1}$ + NPK (100, 50 and 50 kg/ha, respectively), followed by 40 t FYM/ha + NPK (75, 50 and 50 kg/ha, respectively) + biofertilizer inoculation. These 2 treatments increased yield by 64.4 and 64.0%, respectively, compared with controls which received no fertilizers.

Singh *et al.* (1997) observed the effects of different organic manures (green manure, farmyard manure and vermicompost and inorganic fertilizers on the yield and quality of *Rabi* onion in Nasik, India. Highest gross and marketable yields of 292.3 and 278.8 q/ha, respectively was produced by farmyard manure (25 t/ha).

From pot experiments, Thanunathan *et al.* (1997) found coir vermicompost appears to be a very effective, recording highest bulb yield (38.05 g/plant) with application of mixture of soil, mine spoil and coir vermicompost in 1:1:1 ratio.

From a field experiment, Varu *et al.* (1997) reported that application of FYM (95 t/ha) + NPK (half rate) + Dharatidhara (2 t/ha) resulted into highest bulb diameter, weight and yield (32.70 t ha$^{-1}$).

An experiment was conducted by Yadav *et al.* (1997) at Rajasthan, India and data revealed that application of recommended dose FYM and NPK gave significantly highest bulb yield (370.37 q/ha).

Singh *et al.* (2001) observed the effects of basal application of farmyard manure (25 or 40 t/ha) combined with NPK mixture (100:50:50 kg/ha) and foliar application of micronutrients (zinc, copper and boron) on the growth, yield, quality and storage of onion. Basal and foliar treatments had no significant effects on the plant stand and neck thickness of onions. While highest bulb diameter, total soluble solids, dry matter, and
gross and marketable yield were highest with basal application of NPK and foliar application of micronutrients after 30, 45 and 60 days of planting.

Jayathilake et al. (2002) observed the integrated effect of organic manures (FYM and vermicompost), biofertilizers (Azotobacter and Azospirillum), and chemical fertilizers on growth and yield of onion (cv. N-53). They recorded highest plant height and number of leaves per plant with integrated treatment i.e. biofertilizers + 50% recommended N through organic manures + 50% N and 100% PK through chemical fertilizers. Plants treated with Azotobacter + vermicompost + chemical fertilizers gave increase of 14.25% in plant height and 30.72% in leaf number over control. Significantly higher bulb weight (60.31 g) and bulb diameter (6.46 cm) were recorded in treatment with Azospirillum + 50% recommended N through vermicompost + 50% N and 100% PK through chemical fertilizers. They obtained 22.4% increase in bulb yield with the application of Azospirillum + vermicompost + chemical fertilizers.

Khokhar et al. (2002) found maximum bulb yield of 20.0 and 34.3 t/ha during 2000-01 and 2001-02, respectively with NPK @ 100-75-50 kg/ha giving 87 and 94% increase over control.

Jayathilake et al. (2003) reported that the growth of onion in terms of plant height; number of leaves per plant; dry matter accumulation in bulb; yield and yield components such as bulb diameter, weight and quality was significantly increased with the application of biofertilizers in combination with 50% N applied through organic manure (VC or FYM) while the other 50% of recommended N and 100% P₂O₅ and K₂O were supplied through chemical fertilizer. This treatment was significantly superior to the application of 50% of recommended N through organic manure with other 50% N and 100% P₂O₅ and K₂O supplied through chemical fertilizer as well as application of chemical fertilizer alone or application of organic manure alone. They found increased yield by 22% with application of biofertilizers, organic manures and chemical fertilizers over the control.

Sharma et al. (2003) reported that an increase of 42 and 56% respectively in bulb yield over 50% NPK was registered with application of fertilizers at the rate of 100% NPK and 150% of recommended dose. Similarly, application of FYM at 10 and 20 tonnes/ha increased bulb yield by 9 and 19% over 100% NPK alone, respectively. Bulb yield recorded in the case of 100% NPK along with 20 tonnes FYM/ha (19.87 tonnes/ha)
was at par with 150% NPK alone (18.82 tonnes/ha) thereby signifying the savings of chemical fertilizers of 52 kg N, 16 kg P and 25 kg K/ha.

In a field experiment, conducted by Mondal et al. (2004) in Gangetic plains of West Bengal, India, they investigated the effect of integrated nutrient management on the productivity and quality of crops in rice-onion cropping system. In onion, application of neem seed powder, along with 75% of NPK through inorganic fertilizer gave significantly highest number of leaves per plant (13.58), bulb yield (15.25 tonnes/ha), bulb diameter and vitamin C content (8.10 mg/100 g). Significantly higher response was also found in the treatment receiving FYM and pelleted form of organic matter, along with 75% of NPK through inorganic fertilizer than the treatment receiving inorganic fertilizer only.

A study was conducted in Andhra Pradesh, India by Reddy and Reddy (2005) to determine the effects of different levels of vermicompost (0, 10, 20 and 30 t/ha) and nitrogen fertilizer (0, 50, 100, 150 and 200 kg/ha) on the growth and yield of onion (cv. N-53) and their residual effect on succeeding radish in onion-radish cropping system. They reported that significant increase in plant height, number of leaves per plant, leaf area, bulb length, diameter and weight and yield of onion was recorded with increasing levels of vermicompost (from 10 to 30 t/ha) and nitrogen fertilizer (from 50 to 200 kg/ha). Among the various treatment combinations, vermicompost at 30 t/ha + 200 kg N/ha recorded the highest plant height and number of leaves per plant but was at par with the treatment having vermicompost at 30 t/ha + 150 kg N/ha for bulb length, bulb weight and yield.

Mehla et al. (2006) recorded the highest bulb yield (141 q/ha) when inorganic fertilizer was supplemented with vermicompost, followed by that with FYM and dung cake ash. All these three sources also proved significantly better than inorganic fertilizer alone.

From findings of Ansari (2008a), the yield of onion was significantly higher in plots treated with vermiwash (1:10 v/v in water), whereas the average weight of onion bulbs was significantly greater in plots amended with vermicompost and vermiwash (1:5 v/v in water).

Ansari (2008b) studied the effect of vermicompost application on productivity of vegetable crops, spinach, potato and turnip for two years and reported that it overall was
significantly greater in plots treated with vermicompost @ 6 tonnes per ha. The reported that the requirement of vermicompost for leafy crops like spinach was lower (4 tonnes/ha), whereas higher (6 tonnes/ha) for tuber crops like potato and turnip.

From a field experiment, significantly the highest bulb weight (75.53 g) and bulb yield (202.85 q/ha) were recorded by Hari et al. (2009) in treatment with the application of VC @ 7 t/ha + 75% of recommend dose of nitrogenous fertilizers. With regards to quality, the highest TSS (%) was recorded in the same treatment followed by application of neem cake @ 20 t/ha + 75% of recommend dose of nitrogenous fertilizers.

With application of 50% NPK+50% FYM, Keniseto et al. (2009) recorded significantly higher plant height (45.45 cm), number of leaves/plant (12.67), neck thickness (2.95 cm), bulb size (5.84 cm), doubling (1.78%), bulb yield (141.47 q/ha), dry matter (12.85%) and TSS (12.11 degrees Brix) than other treatments.

Suthar (2009) studied the impact of vermicomposted and composted farmyard manure along with some combination of NPK fertilizers, on garlic (Allium stivum L.) and recorded maximum range of some plant parameters i.e. root length, shoot length, leaf length and number of leaves per plant and yield in plots treated with 15t/ha vermicompost + 50 % NPK.

Jawadagi et al. (2012) investigated the effect of different sources of nutrients on growth, yield and quality parameters of onion cv. Bellary red at Dharwad, India during rabi 2006-07 and kharif 2007-08. They recorded significantly maximum, leaf length and number of leaves noticed with the application of RDF (125:50:125 NPK kg ha-1) + FYM (30 t ha-1) followed by the application of 50% FYM (12.50t ha-1) + 50% VC (2 t ha-1) + Biofertilizers in both the seasons under investigation. The results also indicated that the same treatments recorded the highest bulb weight and bulb yield in both rabi and kharif seasons as compared to other treatments.

Radish

Mahabir et al. (1990) recorded highest plant height (70.62 cm), plant weight (395.92 g), root length (31.02 cm), root weight (215.44 g) and yield (488.8 q ha⁻¹), with the treatment consisted of 50 kg N ha⁻¹ as a basal dose of FYM + 50 kg N ha⁻¹ as a basal dose of urea.

Kalembasa and Deska (1998) investigated the influence of different forms of N (in FYM, ammonium nitrate and vermicompost applied separately or in combination on
yield and chemical composition of radishes and sweet peppers. The 1:1 mixture of vermicompost and ammonium nitrate increased sweet pepper yields but had no significant effect on radish yields.

In an experiment on onion-radish cropping system, Reddy and Reddy (2005) found significant increase in radish yield observed due to the residual effect of different levels of vermicompost and nitrogen applied to the preceding crop (onion). Among the various treatment combinations, vermicompost at 30 t ha\(^{-1}\) + 200 kg N ha\(^{-1}\) recorded the highest plant height and number of leaves per plant and yield in both crops.

Mahorkar et al. (2007) studied on the effects of organic amendments on the performance of radish in Akola, Maharashtra, India, during August-September 2005. They revealed that, at 10, 20, 30 and 40 DAS [days after sowing], vermicompost (16.67 q ha\(^{-1}\)) resulted in the greatest plant height (8.29, 14.58, 17.56 and 24.58 cm, respectively) and number of leaves (3.75, 6.75, 8.30 and 10.02). They also obtained the highest yield (322.52 q ha\(^{-1}\)) with vermicompost.

Singh et al. (2007) studied the effect of integrated nutrient management on the growth and root yield of carrot. On pooled mean analysis, they found that treatment consisted of half-strength recommended NPK + 2.5 t green leaf manure + 5.0 kg Azotobacter + 5.0 kg phosphate solubilizing bacteria ha\(^{-1}\), gave maximum plant height (61.39 cm), leaf length (45.00 cm), number of leaves per plant (12.08), fresh weight of leaves per plant (25.92 g), root length (16.37 cm), root diameter (2.85 cm) and yield (212.85 q/ha).

While observing the effects of organic and inorganic fertilizers on the performance of carrot, Sunandarani and Mallareddy (2007) reported that castor cake (4 t ha\(^{-1}\)) + 50% RDNPK and 100% RDNPK (50:30:40 kg ha\(^{-1}\), respectively) resulted in the greatest plant height (30.23 and 30.90 cm, respectively). Vermicompost (10 t ha\(^{-1}\)), neem cake (4 t ha\(^{-1}\)) and FYM (15 t ha\(^{-1}\)) combined with 50% RDNPK, as well as 100% RDNPK were superior in terms of root length (15.28, 15.93, 15.33 and 15.18 cm). Castor cake + 50% RDNPK also registered the greatest root girth (9.18 cm), fresh root weight (52.50 g per plant), dry root weight (6.80 g per plant), and net income (38 672 rupees ha\(^{-1}\)). The highest root yields were obtained with vermicompost and castor cake combined with 50% RDNPK, and 100% RDNPK (20.53, 21.98 and 20.48 t ha\(^{-1}\)). The results indicated the suitability of castor cake + 50% RDNPK for carrot on sandy loam soil.
Asghar et al. (2006) evaluated the integrated use of recycled organic waste and chemical fertilizers for improving growth and yield of radish. Enriched compost + 50% recommended nitrogen fertilizer produced significantly better results in almost all the parameters except number of leaves plant-1 and root length. Other parameters like leaf area, root girth, total biomass plant-1, and yield ha-1 were increased by 82, 68, 132.9 and 167.6%, respectively compared to control. Results revealed that enriched compost with 50% recommended nitrogen fertilizer gave almost same results as the 100% N fertilizer alone, thus saving half of the Nitrogen.

Bodkhe and Mahorkar (2010) conducted an experiment to study the effect of various organic manures on growth, yield and quality of Radish’ during Kharif season of 2005-06 at Akola (M.S.). They found the highest yield per plot as well as per hectare and the NPK content in leaves and roots of radish with application of vermicompost (16.67 q ha⁻¹).

**Tomato:**

Kalembasa and Deska (1998) studied the influence of different forms of nitrogen (in FYM, vermicompost produced from waste activated sludge and waste from a meat processing factory and ammonium nitrate) on yield and chemical composition of lettuces and tomatoes. They observed that vermicompost and FYM increased the yield of lettuces and tomatoes in comparison to the unamended control. Except at the lowest rate, ammonium nitrate decreased the yield of lettuces and tomatoes.

In Dharwad, Patil et al. (1998) observed that the highest yield and net income (18.66 t/ha and Rs. 28970/ha, respectively) were realized with the recommended rate of inorganic fertilizer (NPK at 100:75:100 kg/ha) + vermicompost at 2 t/ha tomato cv. Megha. Vermicompost at 4 t/ha + 50% of the recommended inorganic fertilizer rates gave similarly good results (18.10 t/ha and Rs 27 490/ha, respectively). The highest cost benefit ratios were also obtained with these 2 treatments (1:3.47 and 1:3.15, respectively).

Premuzic et al. (1998) evaluate the effects on Ca, Fe, K, P and vitamin C (ascorbic acid) contents of the fruits of tomato cultivar Platense grown in 2 organic and 2 inorganic media. They grew plants in a greenhouse, on sand or peat-perlite (hydroponic substrates) irrigated with a complete solution of macro and microelements, on 100% vermicompost, or on 50% vermicompost-50% soil (organic substrates) irrigated with
water. Fruits were harvested and analysed at physiological maturity. They reported that the fruits grown on organic substrates contained significantly more Ca and ascorbic acid, and less Fe than fruits grown on hydroponic media. P and K contents, they stated, did not differ between fruits from organic and hydroponic substrates.

Atiyeh et al. (1999) observed the growth of tomatoes which was measured in three kinds of horticultural potting media that were substituted with five different concentrations of vermicomposted pig manure. Tomato plants grew better in 100% vermicompost than in 100% horticultural commercial medium. Substitution of 10, 25, and 50% vermicompost for the same amounts of commercial medium stimulated plant growth, resulting in significant increases in plant height and roots and shoots biomass. Even when the plants were fertilized with all mineral nutrients needed, the growth of tomato plants in all of the potting media was enhanced significantly with the substitution of vermicompost, which suggests that factors other than nutrient availability are responsible for enhancing plant growth. They stated that for all three of the potting media used, substitution of these media with low concentrations of vermicomposts will promote plant growth.

A field experiment conducted by Kolte et al. (1999) at Rahuri with tomato crop that was applied with 75, 100 or 125% of the recommended NPK in various combinations of solid fertilizer, vermicompost and liquid fertilizer. They reported that fruit yield was highest with 100% of the recommended NPK rate applied half as liquid fertilizer and half as vermicompost.

In Orissa, Chaudhary et al. (2003) investigated the use of vermicompost (prepared using Gliricidia leaves and Eisenia fetida) in cabbage cv. S-22 and tomato cv. Golden Acre production. They obtained highest soil organic carbon with VC at 100 g/plant + FYM at 500 g/plant. They noted increase in hydraulic conductivity 7 times compare to the control in the treatment VC at 200 g/plant + FYM at 250 g/plant. The maximum available N was observed by them in VC at 200 g/plant + FYM at 250 g/plant, while maximum K was noted at VC at 100 g/plant + FYM at 500 g/plant. They concluded that VC at 200 g/plant + FYM at 250 g/plant was the best treatment for obtaining sustainable yields in both crops.

Premuzic et al. (2001) observed that total weight was larger in fruits grown with organic fertilizers with regard to hydroponic and mixed fertilizer application.
Vermicompost and hydroponic plants presented a larger number of fruits with regard to mixed fertilization. There were no significant differences for quality, and for mean and maximum weight. Vitamin C content was higher in plants with organic and mixed fertilizer while the level of sugars was significantly higher for the mixed treatment.

Renuka et al. (2001) conducted a field experiment in Bapatla, Andhra Pradesh, India to find the effect of organic manures on growth, development, yield and quality of tomato. Six kinds of organic manures, i.e. farmyard manure (FYM), vermicompost, biogass slurry, neem cake, Azospirillum and phosphobacteria, in different combinations were tested by them in comparison with inorganic fertilizer treatment as control. They deduced that vigorous growth of tomato with early flowering and high yield (46.66 tonnes) could be obtained with the application of FYM + biogass slurry, recording an increased yield of two and half times over the control (18.44 tonnes). They assumed that tomato would respond to application of organic manures either alone or in combination with FYM. Further, they noted that application of organic manures maintained the soil pH near to neutral.

Samawat et al. (2001) investigated the effects of three levels of chemical fertilizer and five levels of vermicompost on root and shoot growth, fruit weight and the number of tomato. They reported that chemical fertilizer and vermicompost had a significant effect on root and fruit weight, and number of tomatoes. They observed that in 100% vermicompost treatment, fruit weight and fruit number, and shoot and root weight were three, four, five and nine times more than the control treatment, respectively. The effect of vermicompost was higher in root growth than in shoot growth. The enriched vermicompost, combined with the highest level of chemical fertilizer, led to higher root and shoot weights. The vermicompost x fertilizer interaction had no significant effect on fruit number. However, they noted, fruit weight, as well as root and shoot growth, were significantly affected by the interaction.

In Hyderabad, Andhra Pradesh, Reddy et al. (2002) determine the effect of organic farming on tomato (cv. Marutham) production. Treatments comprised of 20 t farmyard manure (FYM)/ha (T1); 5 t vermicompost/ha (T2); 10 t FYM/ha + 2.5 t vermicompost/ha (T3); 50% N through FYM + 50% N through urea (T4); 50% N through vermicompost + 50% N through urea (T5); and recommended NPK rate (120:60:60 kg/ha) (T6). They reported that treatment T4 gave highest plant height (55.6 cm), number of branches per plant (7.4), number of fruits per plant (16.6), fruit weight
(66.7 g) and yield (30.47 t/ha), and these parameters were at par with those of T6 treatment. They observed a yield increase of 4.7% with T4 treatment, indicating that the integrated application of organic manures along with inorganic fertilizers significantly increased the yield compared to organic or inorganic fertilizer applications alone. The cost-benefit ratio was noted high (1:3.01) with the application of T4 compared to all other treatments including T6 (1:2.93).

In Parbhani, Maharashtra, Mohd-Rafi et al. (2002) observed the effect of organic and inorganic fertilizers on yield and quality of tomato (cv. Parbhani "Yashashri"). He revealed that the application of 50% recommended dose of farmyard manure (FYM) @ 12.5 t ha\(^{-1}\) along with reduced levels of recommended doses of fertilizers (50% of the recommended dose of fertilizers of 100:50:50 NPK kg ha\(^{-1}\)) resulted in the highest yield with high quality. The study also revealed that the readymade organic manures of commercial companies used in this study were inferior to traditional organic manures viz., FYM and vermicompost.

Arancon et al. (2003) revealed that the marketable tomato yields in all vermicompost-treated plots were consistently greater than yields from the inorganic fertilizer-treated plots. They assumed that improvements in plant growth and increases in fruit yields could be due partially to large increases in soil microbial biomass after vermicompost applications, leading to production of hormones or humates in the vermicomposts acting as plant-growth regulators independent of nutrient supply.

Chaudhary et al. (2003) investigated the use of vermicompost in cabbage cv. S-22 and tomato cv. Golden Acre production during a field study in Orissa. They prepared vermicompost (VC) using *Gliricidia* leaves and *Eisenia fetida*, and was applied at 100 and 200 g/plant, with or without farmyard manure (FYM) at 250 and 500 g/plant. They observed that soil bulk density decreased with the treatments and the lowest value was obtained with VC at 200 g/plant + FYM at 250 g/plant. The highest soil organic carbon was obtained with VC at 100 g/plant + FYM at 500 g/plant. Hydraulic conductivity increased 7 times compare to the control in the treatment VC at 200 g/plant + FYM at 250 g/plant. The maximum available N was observed in VC at 200 g/plant + FYM at 250 g/plant, while maximum K was at VC at 100 g/plant + FYM at 500 g/plant. They reported that application of VC at 200 g/plant + FYM at 250 g/plant was the best treatment for obtaining sustainable yields in both crops.
In Jabalpur, Madhya Pradesh Raut et al. (2003), found that the maximum plant height (45.67 cm), number of branches (12.52), number of flowers per cluster (5.56), number of flower cluster per plant (32.88), fruit weight per plant (591 g) and fruit yield (196.43 q/ha) were recorded with 100:50:50 kg NPK+20 tonnes farmyard manure (FYM). The maximum number of fruits per plant (20.96) they recorded with 20 tonnes Poultry Manure +5 kg Azospirillum+5 kg phosphate solubilizing bacteria (PSB). Ascorbic acid content in fruits was noted highest (16.5 mg/100 g) in 30 tonnes FYM+5 kg Azospirillum, which enhanced storage life. The maximum net return of Rs 33 408.00 they obtained with 100:50:50 kg NPK+20 tonnes farmyard manure (FYM), with benefit:cost ratio of 2.30.

Hashemimajd et al. (2004) observed that vermicompost is a suitable alternative for peat and other organic substrates as potting media. They reported that mixing of vermicompost to potting media decreased the bulk density and particle density but increased the water holding capacity.

In Parbhani, Maharashtra, Patil et al. (2004) observed the effects of inorganic and organic fertilizers on the fruit yield and quality of tomato cultivar Parbhani Yashshri. They found significant results with the application of 50% RFR + 50% FYM which resulted in the greatest plant height (120.70 cm), number of primary branches per plant (8.53), number of fruits per plant (52.0), average fruit weight (45.06 g), yield per plant (2.34 kg) and total soluble solid (TSS) content (6.08%). They also obtained highest number of leaves per plant with 50% RFR + 50% FYM (118.10) and 50% RFR + 50% vermicompost (116.63). Ascorbic acid content (26.76, 26.53 and 25.97 mg/100 g) and shelf life (6.91, 7.00 and 6.22 days) were highest with 50% RFR + 50% FYM, 50% RFR + 50% vermicompost and 100% organic fertilizers.

In Raichur, Karnataka, Krishna et al. (2005) evaluated the performance of tomato (cv. Pusa Ruby) under various cropping systems (sole cropping of tomato with or without the incorporation of Leucaena loppings at 5 t/ha, and alley cropping of tomato with Leucaena with or without the incorporation of Leucaena loppings) and fertilizer treatments (100% of the recommended fertilizer rates or RFR, and farmyard manure, vermicompost, VAM (vesicular arbuscular mycorrhiza) or Azospirillum + 25% RFR). They reported that alley cropping of tomato coupled with the incorporation of Leucaena loppings resulted in the highest fruit yield (27.79 t/ha), total soluble solid content (6.11%), acidity (0.93%) and lycopene content (7.64 mg/100 g of juice). FYM + 25%
RFR also registered the highest fruit yield (28.26 t/ha), total soluble solid content (5.90%), acidity (0.76%) and lycopene content (7.41 mg/100 g of juice). They also noted that in alley cropping of tomato, incorporation of *Leucaena* loppings, and application of FYM + 25% RFR gave the highest fruit yield (30.99 t/ha), total soluble solid content (0.96%), acidity (6.62%) and lycopene content (8.21 mg/100 g of juice). That particular treatment also improved the soil water holding capacity and the incorporation of lopping enhanced the soil fertility and organic carbon content, and the N, P and K contents of tomato leaves. The available P and K contents were also noticed higher by them with the alley cropping of tomato than sole cropping.

In a field experiment in Madurai, Tamil Nadu, Kannan *et al.* (2006) opined that tomato cultivar PKM1 when applied with 75% vermicompost in combination with *Azospirillum* resulted in the highest yield, titratable acidity (0.72%), ascorbic acid content (23 mg/100 g), total solids (5.4%), pH (3.9), crude protein content (1.70%) and lycopene content (3.7 mg/100 g), and lowest non reducing sugar content (0.37 g/100 g).

During a field study in Madhya Pradesh, Raut *et al.* (2006) observed the yield of tomato (*Lycopersicon esculentum*) variety Jawahar Tomato-99, as affected by different nutrient sources. They reported that the recommended NPK along with FYM gave the maximum plant height (95.67 cm), fruit weight (591.0 g/plant) and fruit yield (196.43 q/ha). They also observed maximum ascorbic acid content with the treatment of 30 tonnes FYM + 5 kg *Azospirillum* that confirm that quality of the agricultural produce improved through organic manures.

In Solan, Himachal Pradesh, Shukla *et al.* (2006), studied the effects of inorganic and organic fertilizers on the performance of tomato (*L. esculentum* cv. Naveen). He found that with the application of recommended rates of N, P and K (100, 75 and 55 kg/ha, respectively) with farmyard manure and vermicompost (250 and 12.5 quintal/ha, respectively) was superior in terms of yield per plant, yield/ha, number of fruits per plant, average fruit weight, number of fruits per cluster, and TSS content. The combined effects of N, P, K, farmyard manure and vermicompost on harvest duration and pericarp thickness were not significant. Vermicompost with N, P and K induced early flowering, whereas early picking was obtained with the application of vermicompost and P.

Gutierrez *et al.* (2007) studied the effects of earthworm-processed sheep-manure (vermicompost) on the growth, productivity and chemical characteristics of tomatoes
Lycopersicum esculentum (c.v. Rio Grande) and reported that addition of vermicompost increased plant heights significantly, but had no significant effect on the numbers of leaves or yields 85 days after transplanting. Yields of tomatoes were significantly greater when the relationship vermicompost:soil was 1:1, 1:2 or 1:3, 100 days after transplanting. Addition of sheep-manure vermicompost decreased soil pH, titratable acidity and increased soluble and insoluble solids, in tomato fruits compared to those harvested from plants cultivated in unamended soil. Sheep-manure vermicompost as a soil supplement increased tomato yields and soluble, insoluble solids and carbohydrate concentrations, they reported.

In Maharashtra, Manolikar et al. (2007) determined the effect of integrated nutrient management on the growth and yield of tomato cv. ATV-1. They reported that at 90 days after treatment, application of 100% FYM+50% RDF produced the most number of primary branches (9.55) among all treatments. Flower initiation was noted earliest with 50% vermicompost+50% RDF (27.12 days), 100% vermicompost (27.23 days) and 50% Gliricidia+50% RDF (27.42 days). The number of days to 50% flowering was noticed earliest with 100% FYM+50% RDF (32.20 days), 50% FYM+100% RDF (32.49 days) and 50% FYM+50% RDF (32.66 days). Treatment with 100% FYM+50% RDF and 50% FYM+100% RDF recorded the highest number of fruits per plant (41.86 and 40.03 per plant respectively) and fruit weight (29.549 and 29.159 g, respectively). They observed that yield per plant was highest with the 100% FYM+50% RDF and 50% FYM+100% RDF treatments application.

Rodriguez et al. (2007) determined if the vermicompost may supply partial or completely the tomato (Lycopersicon esculentum Mill.) nutritive requirements of N, P, and K for adequate growth, yield and quality. They evaluated four treatments of organic and inorganic fertilization in the Big Beef and Red Chief genotypes under greenhouse conditions. The treatments under test were T1=sand+vermicompost mixture (50:50% v:v)+chelated micronutrients; T2=sand+Vermicompost (50:50% v:v) without micronutrients, the T3=sand+inorganic fertilizers (control) and T4 sand+vermicompost extract. They reported that fresh weight, total biomass and plant height were reduced in the organic fertilizer treatments. The yield in both hybrids was noticed 20% higher in T3 than in T1, the second best treatment. The organic fertilizer treatments (T1 and T2) have higher soluble solids, fruit number, and K absorption, also flowering started 10 days
earlier, they observed. Based on the production obtained, they concluded that T2 did not supply completely the nutritive needs of these hybrid tomatoes.

Roberts et al. (2007) examined the effect of substituting commercial peat-based compost with four different vermicomposts produced by the earthworm *Dendrobaena veneta*. Their study revealed that vermicompost significantly increased germination rates (176%) and improved the marketability of fruits at 40% and 100% substitution rates due to the lower incidence of physiological disorders ('blossom end rot' and fruit cracking). Total fruit yield, marketable fruit yield, fruit number, individual fruit weight and vitamin C concentration were noticed unaffected by the presence of vermicompost. Although, they stated, vermicompost may provide a viable alternative to peat-based growth media, overall, they found little added benefit from using vermicompost. They concluded that some of the previously reported benefits of vermicompost on horticultural production may be overstated and that marketing strategies should reflect this in order to preserve consumer confidence in vermicompost products.

Sable et al. (2007a) observed the effects of various organic amendments on the performance of tomato (cv. Parbhani Yashshri) during a study in Parbhani, Maharashtra. They revealed that organic manures were generally superior to the inorganic fertilizers in the enhancement of the fruit yield and dry matter yield. The percentage of marketable fruits was noticed higher when organic amendments were applied (83-93%) than when inorganic fertilizers were used (77.5%). The fresh fruit weight was also noted lower when 100% of the N was supplied through vermicompost than when N was supplied through various combinations of neem cake and vermicompost.

In Parbhani, Maharashtra, Sable et al. (2007b) determined the impact of organic sources on uptake, quality and nutrient availability in tomato (*Lycopersicon esculentum*). They reported that nutrient uptake by tomato plants, quality of tomato fruits and availability of nutrients in soil after the harvest of tomato crop was more in treatments with organic source of nutrients through neemcake and vermicompost in variable combinations and alone. However, they noticed more TSS, vitamin C with increase shelf life in the treatments where 50% N through neemcake and 50% N through vermicompost as well as 25% N through neemcake and 75% N through vermicompost were given together. They concluded that latter treatment was more effective in increasing the nutritional value of soil after the harvest of tomato crop.
Shweta et al. (2007) observed that the fruits which were grown on organic substrates contained significantly more Ca and ascorbic acid and less Fe than did the fruits grown on inorganic media. Phosphorus and K content did not differ between the fruits grown on organic and inorganic fertilizers.

Haribhushan et al. (2008) studied the effect of different doses of vermicompost and boron on the availability of boron, yield, uptake and soil fertility in clay soil. They reported that the highest fruit yield was recorded with the combined application of 10 kg borax and 20 q vermicompost (1% N)/ha. They observed that higher application of borax decreased the fruit yield but increased the availability of boron in the soil. They noticed that the same treatment also showed increasing availability of N, P, K and organic carbon content in the soil.

Azarmi et al. (2008) evaluated the effects of vermicompost on soil chemical and physical properties in tomato (Lycopersicum esculentum var Super Beta) field. They observed that the addition of vermicompost at rate of 15 t ha-1 significantly increased contents of soil total organic carbon, total N, P, K, Ca, Zn and Mn substantially compared with control plots. The soils treated with vermicompost had significantly more EC in comparison to unamended plots. They reported that addition of vermicompost in soil resulted in decrease of soil pH. The physical properties such as bulk density and total porosity in soil amended with vermicompost were noted improved. The results of this experiment revealed that addition of vermicompost had significant positive effects on the soil chemical, physical properties.

Reddy et al. (2008) evaluated the use of organic manures in combination with inorganic fertilizers for crop response in tomato-onion cropping system. They reported that uptake of nutrients, dry matter yield, fruit/bulb yield and haulm yield of tomato and onion were significantly improved with the integrated use of organic manures (VC, PM, NC and FYM) and inorganic fertilizers compared to RDN and control. Among manures, VC recorded highest fruit/bulb and haulm yields followed by PM, NC and FYM. The nutrient uptake, dry matter, fruit and haulm yields of tomato were highest under 50% level of organic manure application in conjunction with 50% level of inorganic fertilizers. In onion, the uptake of nutrients, dry matter, bulb and haulm yields were highest with 100% level of manure application that was on par with 50 and 75% levels of manure.
Dass et al. (2008) reported the use of 50% recommended dose of fertilizers (5 t/ha) + vermicompost (20.75 t/ha) and 50% recommended dose of fertilizers (2.5 t/ha) + vermicompost (5 t/ha) + farmyard manure (19.7 t/ha) produced significantly higher fruit yield in tomato over 100% recommended dose of fertilizers (19.06 t/ha). The latter was noted statistically at par to 50% recommended dose of fertilizers + 10 t farmyard manure/ha (19.14 t/ha). Again, water use efficiency was noticed highest with 50% recommended dose of fertilizers + vermicompost (5 t/ha), followed by 50% recommended dose of fertilizers + vermicompost (2.5 t/ha) + farmyard manure (5 t/ha). These 2 treatments yielded net returns of Rs 60 025 and Rs. 57,283/ha, respectively, which, owing to the higher cost of vermicompost and farmyard manure, were 5.5 and 10.6% lower than the 100% recommended dose of fertilizers. However, soil properties such as bulk density, organic carbon, available N and available P, recorded after completion of the experiment, were significantly improved under the former treatments imparting sustainability to the soil. They suggested on-farm production of vermicompost for enhancing the net profit.

Rodge et al. (2009) conducted a field experiment with 15 treatments on 'Parbhani Yashshri' variety. They reported that the treatment 50% RDF+50% FYM (T-8) significantly increased the height of plant, number of primary branches and number of leaves at 105 days after transplanting which was followed by the treatment 50% RDF+50% vermicompost. Maximum number of fruits per plant, heaviest fruit, yield per plant and yield per plot were noted significantly more in case of treatment 50% RDF+50% FYM which was followed by the treatment 50% RDF+50% vermicompost. The fruit juice, TSS and ascorbic acid content were observed highest in the treatment 50% RDF+50% FYM and the shelf life of fruit was found maximum in the treatment 50% RDF+50% vermicompost.

Prativa and Bhattarai (2011) revealed that the integration of organic manures in combination with inorganic fertilizers was found significant in improving the overall plant growth and yield in tomato. Maximum plant height and number of leaves per plant were observed with treatment, FYM (16.66 mt/ha) + Vermicompost (8.33 mt/ha) + NPK. The earlier of days to 50% flowering was observed in treatment 20 mt/ha FYM. Highest number of fruit clusters, maximum fruit weight and fruit yield (25.74 mt/ha) were recorded in treatment 16.66 mt/ha FYM + 8.33 mt/ha Vermicompost + NPK.
Okra:

Naidu et al. (1999) evaluated the effect of manures, bio- and chemical fertilizers on the soil microbial population and growth and yield of okra using treatments: (T1) control; (T2) NPK (80:60:50)+20 tonnes farmyard manure (FYM)/ha; (T3) 55 kg N+35 kg P2O5+25 tonnes FYM/ha; (T4) 25 kg P2O5+70 kg K2O+9 tonnes poultry manure; (T5) 10 kg P2O5+3 tonnes vermicompost/ha; (T6) 12 K2O+20 tonnes FYM+4 tonnes poultry manure/ha; (T7) 20 tonnes FYM+14 tonnes vermicompost/ha; (T8) 90 kg K2O+7.5 tonnes poultry manure+1.0 tonne vermicompost/ha; (T9) 35 tonnes FYM+Azospirillum+phosphorus-solubilizing bacterium (PSB); (T10) 10 tonnes poultry manure/ha+Azospirillum+PSB; (T11) 3 tonnes vermicompost+Azospirillum+PSB; and (T12) Azospirillum+PSB. They reported that plant height, number of leaves per plant, number of nodes per plant, internodal length, number of fruits per plant, weight of fruits per plant and fruit yield were maximum under T2. On the other hand, crude protein percentage was noted highest under T8. The maximum net income was worked out Rs 19089 along with a 0.02 benefit-cost ratio under T2. They observed that application of manures and vermicompost with biofertilizers harboured significantly more microbes in soil than the control, and bacterial, fungal and actinomycetes count were all note maximum under T9.

Ushakumari et al. (1999) studied 10 fertilizer treatments with cv. Arka Anamika, in a field experiment conducted at Kerala, India to investigate whether biowastes can be used as an alternative source of organic manure and a partial substitute for costly organic fertilizers. Their study revealed that when vermicompost applied as an organic source (at 12 t/ha) + the full recommended dose of inorganic fertilizers (50 kg N, 8 kg P2O5 and 25 K2O/ha) that resulted in the highest yield (5663 kg/ha). Yields were also noted high following treatment with vermicompost (12 t/ha) + three-quarters of the recommended NPK dose (4680 kg/ha) and treatment with an NPK dose of 25:8:25 kg/ha followed 2 weeks later with vermicompost treatment in situ (by releasing *Eudrilus eugeniae* earthworms at a rate of 50 worms per m2) (4183 kg/ha). The corresponding yield for cattle manure + the recommended NPK dose was found 2763 kg/ha. Taking the production cost of vermicompost as Rs 0.5 per kg, cost-benefit analysis revealed that application of vermicompost as an organic source, or in situ application of worms, significantly reduced the cost of okra production, they stated.
In a field experiment at Tamil Nadu, India, Barani and Anburani (2004) studied the influence of different rates of farmyard manures (FYM), inorganic fertilizers and vermicompost on different growth parameters in okra cv. Arka Anamika. They reported that FYM at 25 t + 100% of the recommended NPK rate recorded the highest plant height, number of leaves per plant and internode length, while FYM at 25 t + 75% of the recommended NPK rate + 4 t vermicompost/ha recorded the highest stem girth, number of branches per plant, number of nodes and dry matter production per plant.

A study was conducted by Bodamwad et al. (2006) in Maharashtra to standardize the proper combination of organic and inorganic fertilizers for quality seed production in okra cv. Pota Parbhani Kranti. They reported that among all treatments, 50% RDF+50% neem cake was superior, recording the highest dry fruit length (20.51 cm), dry fruit circumference (5.03 cm), number of seeds per fruit (66), dry fruit weight (5.92 g), seed weight per fruit (3.01 g), 1000-seed weight (59.30 g), germination percentage (93.34%) and seed yield per plot (1.2 kg).

Bhardwaj et al. (2000) conducted an experiment to find out the effect of organic sources of nutrients, i.e. farmyard manure, neem (*Azadirachta indica*) cake and rapeseed (*Brassica campestris* var. *toria*) cake as partial or complete alternative to chemical fertilizers on yield of tomato (*Lycopersicon esculentum*), okra (*Hibiscus esculentus* [*Abelmoschus esculentus*]), cabbage (*Brassica oleracea* var. *capitata*) and cauliflower (*Brassica oleracea* var. *botrytis*), and its economic feasibility. They reported that the application of sole organic sources of nutrients recorded 11-17% lower yield in different vegetable crops. However, application of 50% recommended NPK + 50% rapeseed cake (0.72 t/ha) in tomato, 50% recommended NPK + 50% neem cake (0.72 t/ha) in okra, 33.3% recommended NPK + 33.3% farmyard manure (6.66 t/ha) + 33.3% rapeseed cake (0.48 t/ha) in cabbage, 33.3% recommended NPK + 33.3% farmyard manure (6.66 t/ha) + 33.3% neem cake (0.48 t/ha) in cauliflower recorded higher yields which were statistically at par with recommended doses of chemical fertilizers. Net returns in organic produce of different vegetables were higher as the produce received higher price in the market, they reported.

In a field experiment at Dapoli (Maharashtra) Dademal and Dongale (2004) studied the response of okra (var. Arka anamika) to the application of organic manures and varied levels of chemical fertilizers. The growth (plant height and dry matter production), yield contributing characters (number of fruits plant\(^{-1}\), fruit weight plant\(^{-1}\),...
fruit length) and fruit yield of okra were noted significantly increased with the application of FYM (farmyard manure) at 7.5 t ha\(^{-1}\) as compared to no manure and vermicompost application at 1.5 t ha\(^{-1}\). They reported that the application of varied levels of chemical fertilizers also significantly improved the above characters and fruit yield of okra. The increase in fruit yield was graded and significant even up to the highest level of fertilizer application at 150 kg N+75 kg P\(_2\)O\(_5\)+75 kg K\(_2\)O ha\(^{-1}\). The interaction effects of manures x fertilizers on fruit yield were found significant. Thus, on lateritic soil, application of FYM at 7.5 t ha\(^{-1}\) along with N, P\(_2\)O\(_5\) and K\(_2\)O at 150, 75 and 75 kg ha\(^{-1}\) respectively was found most useful for maximization of fruit yield (85.01 q ha\(^{-1}\)), they concluded. The status of available N, P and K in soil was improved significantly due to fertilizer application as compared to control, they stated.

Prakash and Bhadoria (2004) evaluated the relative efficacy of organic manures in improving productivity and pest tolerance of an okra (\textit{A. esculentus} cv. Parbani Kranti) crop in Lateritic sandy-loam soil. They assessed three commercial manures, viz., processed city waste (PCW), vermicompost (VC), and oil cake pellets (OCP), in relation to farmyard manure (FYM) alone and in combination with microbial culture (FYM + MC). Manures were supplied at rates equivalent to the recommended level of 120 kg N/ha. All were compared to chemical fertilizer (CF), which was supplied at a rate of N:P:K at 120:60:50 kg/ha. They reported that among the organic manures tested, FYM produced maximum fruit and shoot yield. The uptake of N, P, and K and micronutrients in FYM treatment were significantly superior to all other commercial manuring and CF. Increase in fruit yield with FYM application was attributed to higher retentivity of soils for water and nutrients and higher uptake of major and minor nutrients, they assumed. However, the tolerance of these crop plants to attack by pathogens and pests in terms of fruit yield was highest in the treatment with FYM, they stated. The quantity and the proportion of N, P, and K coupled with minor elements available from nutrient sources were mainly responsible for differences among nutrient sources, they concluded.

An experiment was carried out by Tripathy et al. (2004) at Mohanpur, West Bengal to study the effect of inorganic chemical fertilizers with organic/biological nutrient sources on the growth and yield of okra (\textit{Abelmoschus esculentus} Moench) cv. Utkal Gourav. They reported that integrated application of 75% recommended dose of fertilizer (RDF, 90:60:40 kg NPK/ha) + vermicompost at 5 t/ha significantly gave higher marketable fruit yield (91.75 q/ha) over the control and other treatments, but statistically
at par with 50% RDF + vermicompost at 5 t/ha (88.31 q/ha), 75% RDF + neem cake at 2.5 t/ha (86.03 q/ha) and 50% RDF + neem cake at 2.5 t/ha (78.5 q/ha). Integrated application of either 50 or 75% RDF with vermicompost at 5 t/ha or neem cake at 2.5 t/ha resulted in better vegetative (plant height, plant girth, primary branches per plant, nodes per plant, days to 50% flowering) and fruit characters (fruit length, girth and weight, fruits per plant) of okra over the control and other treatments. They suggested integrated use of inorganic and organic/biological sources of nutrient supply is than their sole application for better vegetative growth, fruit attributes and marketable yield in okra.

In Jobner, Rajasthan, Pavan et al. (2006) studied the effects of organic manures and N levels on the growth and yield of okra cv. Varsha Uphar. The treatments comprised a control (T0), recommended dose of N of 90 kg/ha (urea) (T1), 75% N (urea)+25% N (farmyard manure, FYM) (T2), 50% N (urea)+50% N (FYM) (T3), 25% N (urea)+75% N (FYM) (T4), 100% N (FYM) (T5), 75% N (urea)+25% N (poultry manure, PM) (T6), 50% N (urea)+50% N (PM) (T7), 25% N (urea)+75% N (PM) (T8), 100% N (PM) (T9), 75% N (urea)+25% N (vermicompost, VC) (T10), 50% N (urea)+50% N (VC) (T11), 25% N (urea)+75% N (VC) (T12), and 100% N (VC) (T13). They reported that plant height, node number per plant and branches per plant were increased by the application of both inorganic and organic forms of N. they reported that among the organic sources, PM stimulated better response than FYM and VC at different levels and combinations. Improved growth was noticed in plants under T7. Fruit number, length and girth, and total yield were influenced significantly by the application of PM in combination with urea than the other combinations with FYM and VC. The highest mean weight of fruits per plant was recorded under T7, with an estimated yield of 90.61 q/ha. Protein content was increased significantly by the application of different organic manures with nitrogenous fertilizers compared to the control. The highest protein content (15.61%) they obtained under T7.

In an investigation at Parbhani, Maharashtra, Bharadiya et al. (2007) determined the effect of inorganic and organic fertilizers on the growth and yield of okra. They reported that the treatment with 50% RDF+50% N through neem cake recorded the highest plant height, number of leaves per plant, days required for initiation of flowering, days to 50% flowering, number of fruits per plant, green fruit yield per plant, total yield,
weight of individual fruit, fruit length and diameter, while the least values for all the above characters were recorded in the control variant.

In a field experiment at Nadia, West Bengal, Tripathy and Maity (2009) studied the influence of Integrated Nutrient Management System on fruit quality and yield of okra (*Abelmoschus esculentus* (L.) Moench) hybrids. They reported that hybrid Sun 40 (286.04 g/plant) was poor yielder with lowest crude protein content fruits (17.34%) under INM system. Further, they reported that application of 50% RDF+BF+organic manure in the form of neem cake @ 1.25 t/ha or vermicompost @ 2.5 t/ha significantly not only increased per plant yield (408.54 and 402.08 g) but also quality of fruits such as higher ascorbic acid (18.23 and 18.25 mg/100 g) and crude protein content (20.97 and 20.93%), irrespective of hybrids.

Bairwa *et al.* (2009) observed that application of 60% recommended dose of NPK through inorganic fertilizers+neem (*Azadiracta indica*) cake at 0.6 tonnes/ha+vermicompost at 1 tonne/ha+Azotobacter+phosphate solubilizing bacteria resulted in significantly more plant height at 30, 60 and 90 days after sowing (38.80, 57.65 and 77.48 cm, respectively), stem base diameter (2.25 cm), number of primary branches (5.49), total fruit bearing nodes/plant (19.18), total chlorophyll content in the leaves at 30 and 60 days after sowing (0.311 and 0.390 mg/g fresh weight respectively), NPK per cent content in the leaves after final harvesting (2.275, 1.060 and 1.443 respectively), number of fruits (18.36/plant), fruit yield (182.50 g/plant and 13.51 tonnes/ha), fruit weight (17.65 g), length of fruits (12.26 cm), thickness of fruits (1.898 cm) and protein content 1.86 g/100 g fresh weight of fruits. They reported that fruit yield was increased 29.30% along with highest benefit:cost ratio (3.19) for this treatment.

Sharma *et al.* (2009) studied the effect of organic manures (vermicompost and farmyard manure) and inorganic fertilizers on yield and nutrient uptake by *okra* (*Abelmoschus esculentus*) - onion (*Allium cepa*) and nutrient build up in the soil. Highest yield of *okra* was recorded in the treatment comprising 100% recommended NPK + vermicompost @ 10 t ha$^{-1}$. Similarly, maximum yield of onion was observed in plots receiving 100% recommended NPK plus 25 t vermicompost ha$^{-1}$. They reported highest available NPK content (303, 28.1, 345 kg ha$^{-1}$, respectively) in treatment of 10 t vermicompost ha$^{-1}$ to *okra* and 25 t vermicompost ha$^{-1}$ to onion along with 100% NPK to these crops. Similar effect was observed on mineral composition and nutrient uptake. Furthermore, they reported that yield of *okra* obtained at 5 t vermicompost ha$^{-1}$ plus
100% NPK was at par with that under 10 t farmyard manure plus 100% NPK. Similarly, yield of onion obtained at 12.5 t vermicompost ha$^{-1}$ plus 100% NPK was at par with that under 25 t farmyard manure ha$^{-1}$ plus 100%. They concluded that vermicompost was superior to farmyard manure in okra-onion sequence.

**Vegetable amaranth:**

In field trials at Lembang, Subhan (1989) observed that leaf number and stem diameter were not affected by N application. Plant height, leaf area and fresh weight increased with increasing N application whilst root length was reduced by high N application. They reported that the highest yields were obtained with a split application of 110 kg N/ha.

Breus et al. (1992) revealed that slow release fertilizer gave lower dry matter yields in *Amaranthus sp.* than the soluble forms. Makus (1992) determined the yield response of 2 *A. tricolor* cultivars (Hinn Choy and RRC 241) to increasing levels of N, P and K in an unimproved mineral soil. They reported that both cultivars were most responsive to increasing levels of supplemental P and less responsive to increasing levels of supplemental K. Supplemental P increased leaf number per plant and the percentage of non-edible stem tissue in both cultivars. Plant water content was increased by applying K or P. It was concluded that in an unimproved mineral soil containing 59 kg N, 14 kg P and 84 kg K/ha, P was the most critical nutrient needed by both cultivars, they concluded.

Elbehri et al. (1993) studied the response of *Amaranthus spp.* to fertilizers in Minnesota. They reported that there was no response to P and K applications when initial soil tests were above 68 kg P/ha and 172 kg K/ha, respectively, but seed *Amaranthus spp.* responded linearly to applied P at one location with initial soil P tests of 11 kg/ha. They also noticed that seed yield ranged from 0.79 to 1.98 t/ha and responded to N in most environments, while forage yield ranged from 6.1 to 16.6 t/ha and was increased at higher N rates. At all locations, lodging increased with application of N. they observed that fertilizer N increased pre-flowering N accumulation but not post-flowering N accumulation. Nitrogen-use efficiency (NUE) ratio of seed yield to total soil N supply ranged from 3.48 to 7.91 kg/kg across cultivars and environments, they noted and NUE decreased with increased soil N mainly because of decreasing N-uptake efficiency (ratio of total plant N to total soil N).
In a field experiment on *Amaranthus tricolor* (cv Lal sak) Das *et al.* (1999) tested 4 levels of N (0, 40, 80 and 120 kg N/ha) in Kalyani, India. They reported that yield components and seed yield increased with increasing N, up to 120 kg/ha. They obtained highest seed yield of 0.45 t/ha with 120 kg N/ha.

In Kerala, India, Geethakumari *et al.* (2005) studied the effects of farmyard manure (FYM; 50 t/ha), poultry manure (20 t/ha), neem cake (15 t/ha), vermicompost (20 t/ha), coir pith compost (CPC; 30 t/ha), N rate (250 or 375 kg/ha, supplied as FYM and inorganic N fertilizer), and method of fertilizer application (basal or split, *i.e.* 50% of the fertilizer was applied as a basal dressing and 50% was applied as a top dressing at 2 weeks after planting) on the yield of *A. tricolor*. They reported that poultry manure gave the highest yield (43.90 t/ha) and returns (119 491 rupees/ha). The method of fertilizer application and N rate had no significant effects on the yields of the main crop and residual crop. The residual crop yield was approximately 36% of the main crop yield (averaged over the treatments). The benefit cost ratio was higher for the residual crop than for the main crop, since no cost was incurred for nutrient application in the former.

Martin *et al.* (2005) evaluated biomass production and quality of *Amaranthus mantegazzianus* cv. Don Juan with NKP and urea fertilizer application at biomass harvest cuttings and the subsequent grain yield. They reported that fertilizer application increased the leaf/petiole ratio. The other variables related to plant structure did not show significant differences between the fertilizer and control treatments, and they did not found any differences on protein and mineral contents.

Preetha *et al.* (2005) conducted a field trial on amaranth (*Amaranthus tricolor*) with different levels of vermicompost prepared using ayurvedic pharmaceutical wastes (from Oushadhi Pharmaceuticals, Thrissur, Kerala), farmyard manure (FYM) and inorganic fertilizers. They reported that five tonnes of vermicompost together with 50:50:50 N, P2O5, K2O kg ha⁻¹ gave the highest vegetative yield as well as nutrient uptake, followed by 2.5 tonnes ha⁻¹ of vermicompost + NPK, implying the synergistic effects of combined application of vermicompost and chemical fertilizers in amaranth production.

A field experiment was planned and carried out by Ananda *et al.* (2006) at Karnataka, India, to evaluate the optimum spacing and nutrient levels for rainfed grain amaranth genotypes. They reported that nutrient level of 80:80:40 kg NPK/ha produced a
significantly higher grain yield, which was 43 and 48% more compared to low (40:40:20 kg NPK/ha) and medium levels of nutrition (60:60:30 kg NPK/ha), respectively. They further reported that the highest grain yield of 1894.0 kg/ha was obtained with Suvarna at 30x15 cm spacing with application of 80:80:40 NPK/ha.

In an experiment Alam et al. (2007) evaluated the effect of vermicompost and nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) fertilizers on growth and yield of red amaranth. They revealed that application of vermicompost and NPKS significantly influenced the growth and yield of red amaranth. The vermicompost (10 t ha\(^{-1}\)) showed better growth and yield than 100% NPKS (25, 15, 20 and 9 kg ha\(^{-1}\) respectively). The highest yield (13.25 t ha\(^{-1}\)) was found with VC 10 t ha\(^{-1}\) + 50% NPKS followed by VC 10 t ha\(^{-1}\) + 100% NPKS gave 13.17 t ha\(^{-1}\) but both are statistically similar and lowest in control (no fertilization). Application of various amounts of vermicompost (2.5, 5, 10 t ha\(^{-1}\)) with NPKS fertilizers (50% and 100%) increased the vegetative growth and yield. They also suggested that vermicompost (10 t ha\(^{-1}\)) + NPKS (50%) is more favorable for vigorous production of red amaranth and maintenance of soil environment but vermicompost (5 t ha\(^{-1}\)) + NPKS (100%) can be economically and environmentally suitable.

Dhangrah et al. (2007) observed variations for chlorophyll content among twenty two genotypes of vegetable amaranth and found increasing trend of chlorophyll content at early growth stages and further decreased towards maturity.

In Brazil, Brambilla et al. (2008) studied the effect of nitrogen fertilizer application on grain amaranth yield. They reported that plant height and grain production responded quadratic. Stem diameter showed no differences. Biomass production (fresh and dry) showed linear response. Yield of amaranth grains answered positively to nitrogen fertilizer application.

Other crops:

Kirad et al. (2010) conducted field studies at Allahabad, Uttar Pradesh, India, to determine the effect of integrated nutrient management using vermicompost on the growth, crop yield and quality of carrot. They revealed that the integrated nutrient management treatments significantly affected growth, yield and qualitative characters of carrots. From the results, plant height, leaf number, leaf length, leaf fresh weight, root diameter, root length and root yield (322.66 q/ha), 75 days after sowing, were highest in
treatment comprised the half of recommended dose of fertilizers (RDF; NPK at 80:60:60 kg/ha) + half of FYM dose (10 t ha\(^{-1}\)) + rhizosphere bacteria (Azotobacter + phosphorus solubilizing bacteria, each at 5 kg/ha), followed by RDF alone, and lowest in the control (no fertilization).

Moraditochaee et al. (2011) found significant effects of vermicompost application and nitrogen usage on all studied traits viz. maturity time, fruit yield, number of fruits per plant, fruit length and plant height of egg plant. Interaction effect of vermicompost and nitrogen were also found significant on plant height, number of fruits per plant and fruit yield, but on fruit length was non-significant. Between vermicompost levels the highest fruit yield was recorded from with application of vermicompost at 33.43 t/ha. The maximum fruit yield between nitrogen fertilizer levels was found from N treatment with 35.03 t/ha. Between interaction effect levels, highest fruit yield (41.44 t/ha) was recorded with combined application of vermicompost (6 t/ha) and nitrogen fertilizer (75 kg/ha).

Mathivanan et al. (2012) studied the effect of vermicompost on plant components, growth and biochemical changes in groundnut. High amount of photosynthetic pigments such as chlorophyll-a, chlorophyll-b, Total chlorophyll and sugar (25.587, 7.847, and 4.970 mg/g fresh weight) were recorded in groundnut seedlings, grown in soil that had application of 200 g of vermicompost.

Field experiments were conducted by Kumar and Sharma (2004) for two consecutive years on cabbage-tomato sequence, to study the different integrated nutrient application strategies under mid hill conditions of Himachal Pradesh, India. They recorded highest values for growth, yield and available nutrients (NPK kg ha\(^{-1}\)) in cabbage when fertilized with FYM at 10 t ha\(^{-1}\) + NPK at 90:90:45 kg ha\(^{-1}\).

Reddy and Reddy (2005) studied the growth and yield of onion (cv. N-53) and their residual effect on succeeding radish in an onion-radish (cv. Sel-7) cropping system. They reported that the plant height, number of leaves per plant, leaf area, bulb length, diameter and weight and yield of onion increased significantly with increasing levels of vermicompost (from 10 to 30 t/ha) and nitrogen fertilizer (from 50 to 200 kg/ha). A similar increase in radish yield was also observed by them due to the residual effect of different levels of vermicompost and nitrogen applied to the preceding crop (onion).
Vermicompost at 30 t/ha + 150 or 200 kg N/ha recorded the highest bulb length, bulb weight and onion yield.

Thapa and Maity (2004) studied the effects of different levels of N (50, 100 and 150 kg/ha) and P (40 and 60 kg/ha), in West Bengal, India, on the growth and yield of Basella sp. They reported that N at 150 kg ha\(^{-1}\) and 60 kg P ha\(^{-1}\) gave the highest number of branches, number of leaves, leaf breadth, vine length, stem dry weight, leaf dry weight and crop yield.

Thapa and Maity (2007) observed declined trend of the yield and yield attributing characters in Basella sp. with decreasing levels of nitrogen and phosphorus.

Raghavendra et al. (2001) investigated the effect of vermicomposts on nodulation, nutrient uptake and dry matter yield of French bean (Phaseolus vulgaris) cv. Arka Komal. They reported that the mean number of nodules per plant significantly increased in all the treatments when compared to the control. However, with the increase in fertilizer level, the number of nodules decreased. Application of vermicomposts with or without fertilizers had significant effect on dry matter yield of French bean.

In a field experiment with at Nagpur, Maharashtra, Chaudhari et al. (2001) reported that the recommended fertilizer dose (RFD) was the best treatment for pods/plant and grain yields in French bean (Phaseolus vulgaris) cv. VL-63. However, they observed that the application of vermicompost at 2.5 t/ha + 1/2 RFD on a par with RFD treatment. Thus, 50% savings of N and P fertilizers were achieved without affecting the yield and yield components of French bean, they concluded.

2.11. Effect of vermicompost in soil fertility:

Mallanagouda et al. (1995) found highest uptake of N, P and K i.e. 186.32, 24.69 and 102.09 kg ha\(^{-1}\) respectively by onion plants from plots treated with the recommended rate of NPK + FYM.

In Mabalpur, Madhya Pradesh Naidu et al. (1999) evaluated the effect of manures, bio- and chemical fertilizers on the soil microbial population in okra field. They observed that the application of manures and vermicompost with biofertilizers harboured significantly more microbes in soil than the control.

Reddy and Reddy (1999) found that the available macro nutrients (N, P and K) were significantly increased with the integrated use of manures and fertilizers. Nutrient
availability was highest in treatments with vermicompost closely followed by poultry manure, and FYM.

Lamani et al. (2000) found that combination of green manure (sunnhemp) and poultry manure with 100 per cent RDF obtained higher organic carbon content in soil after harvest of maize (0.887%).

Sreenivas et al. (2000) studied the effect of varied levels of fertilizers and vermicompost on available nitrogen status in soil at various crop growth stages, nutrient composition and uptake by ridge gourd. They reported that soil available N content increased significantly with increasing levels of vermicompost at all the growth stages. They also indicated the superiority of vermicompost over the inorganic fertilizers in yield increase as well as maintaining the nutrient balance of the soil.

Raghavendra et al. (2001) investigated the effect of vermicomposts on nutrient uptake and dry matter yield of French bean. They reported that the application of vermicomposts with or without fertilizers significantly increased the uptake of major nutrients in all the treatments over the control.

Sharma and Arya (2001) found increase in revealed that the uptake of N, P and K (up to 18, 15 and 26 kg ha\(^{-1}\) respectively) in cabbage plants increased significantly in plants treated with application of FYM at 20t ha\(^{-1}\) and increasing N rates (from 40 to 160 kg N/ha).

Sharma et al. (2003) studied the effect of combined use of NPK and farmyard manure (FYM) on yield attributes, yield, and nutrient uptake by onion as well as on build up of available N, P, K. They reported that use of NPK fertilizers along with FYM also significantly improved the available N, P, and K status of the soil.

Chaudhary et al. (2004) reviewed that organic wastes returned to soil in form of vermicompost can maintain, enhance soil quality, fertility and productivity through favourable effect on soil properties and other processes. They concluded that application of vermicompost reduces the fertilizer requirement.

Hossain (2004) reported that addition of organic manures with NPK at 100 kg ha\(^{-1}\) respectively along with S (0.2 kg ha\(^{-1}\)) and Zn (5 kg ha\(^{-1}\)) improved nutrient uptake and bulb yield in onion. Again, Nasreen and Hossain (2004) revealed that addition of organic manure only improved nutrient uptake and bulb yield.
Preetha *et al.* (2005) reported that in amaranth highest nutrient uptake observed when five tonnes of vermicompost together with 50:50:50 N, P2O5, K2O kg ha-1 was applied, followed by 2.5 tonnes ha-1 of vermicompost with NPK, which implies the synergistic effects of combined application of vermicompost and chemical fertilizers production.

In cabbage, Ghuge *et al.* (2007a and 2007b) found maximum uptake of N, P and K nutrients (66.17, 13.22 and 34.22 kg ha-1) and more availability of N, P and K (259.45, 27.77 and 369.67 kg ha-1) with application of 50% RDF along with 50% vermicompost at 2.5 t ha-1.

While working on different vegetable crops, Ansari (2008a) and Ansari (2008b) observed significant improvement in soil qualities when treated with vermicompost.

Dass *et al.* (2008) revealed that organic carbon and available N and P status improved due to treatment with cow manure and vermicompost in cabbage and bell pepper. The data indicated that 5 Mt. ha-1 of VC can meet 50% of the fertilizer requirement of cabbage while providing higher productivity, income, and residual soil fertility. Finally, they opined from their findings that use of inorganic fertilizers alone cannot sustain high levels of productivity and cause deterioration of the soil and environment.

Meenakshi *et al.* (2008) evaluated the effect of different levels of macro and micronutrients fertigation on yield and nutrient uptake of bitter gourd. Their results revealed that the application of 100% macro and micronutrients in water soluble fertilizer form significantly increased the nutrient content and uptake of N, P, K and Fe and proved most superior over rest of the fertigation levels in case of content and uptake of N, P, K and Fe. Similarly, the same fertigation level, *viz.*, supplying 100% macronutrient in combination with micronutrients recorded the highest yield as compared to other fertigation levels and conventional method of fertilizer application.

Ouda and Mahadeen (2008) studied the effect of organic and inorganic fertilizers on yield and quality of broccoli (Brassica oleraceaL. var. Italica). They also observed increase in leaf macro-(N, P & K) and micro-nutrient (Fe, Mn & Zn) contents by application of either organic manure or inorganic fertilizer compared to control. They did not found significant effect of organic and inorganic fertilizers on Soil pH but increase in organic matter content was noted with increasing organic fertilizer doses.
Sinha et al. (2010) reviewed that wonders of earth-warms and effect of its vermicompost on farm production and stated that earth-worms restore and improve soil fertility and significantly boost crop productivity. However, with application of vermicompost the ‘organic nitrogen’ tends to be released much faster from the excreted ‘humus’ by worms and those mineralized by them and the net overall efficiency of nitrogen (N) is considerably greater than that of chemical fertilizers. Availability of phosphorus (P) is sometimes much greater. From their study, they have showed that earthworms and vermicompost could promote growth from 50 to 100% over conventional compost and 30 to 40% over chemical fertilizers besides protecting the soil and the agro-ecosystem while producing ‘nutritive and tasty food’ at a much economical cost (at least 50-75% less) as compared to the costly chemical fertilizers.

Pant et al. (2011) studied the effects of vermicompost tea (Aqueous extract) on Pak choi (Brassica rapa cv. Bonsai, Chinensis group) under three growing media. They observed variations in yield, chemical quality, N uptake and dry matter accumulation. Their findings confirmed that vermicompost tea can positively influence plant yield and quality and increase soil biological activity in multiple soil types.

Prativa and Bhattarai (2011) studied the effect of Integrated Nutrient Management (INM) on the growth, yield and soil nutrient status to tomato (Lycopersicon lycopersicum (L.) Karsten). The study revealed that the integration of organic manures in combination with inorganic fertilizers was found significant in improving the overall plant growth, yield and soil macro nutrient status than the sole application of either of these nutrients. The pH value was found near to neutral in treatment 10 mt/ha vermicompost. Similarly, the maximum organic matter percentage was also recorded in treatment 10 mt/ha vermicompost. The highest available nitrogen, phosphorus and potassium were found in treatment ½ NPK + 15 mt/ha vermicompost.

Mahmoud and Ibrahim (2012) carried out a research work to evaluate the effect of vermicompost, when used alone or in combination with water treatment residuals (WTR) at mixed ratios of 2:1 and 1:1 wet weight (Vermi: WTR), on soil chemical properties of saline sodic soils, and on barley growth (Hordeum aestivum). They revealed that organic matter and nutrients available (N, P and K) were increased as the rate of the organic materials increased.
2.12. Economics of vermicompost application:

Warade et al. (1995) revealed that the best cost-benefit ratio from onion cultivation was obtained with application of NPK only (100, 50 and 50 kg/ha, respectively) as compared to integrated use of FYM and NPK and control.

Singh et al. (1997) found increased yield of onion along with highest net return of Rs. 32,651 ha$^{-1}$ was noted with combined application of farmyard manure and 100 kg N + 25 kg P + 25 kg P/ha.

Mohanty et al. (1998) reported that application of 120 kg N + 30 kg P$_2$O$_5$ ha$^{-1}$ besides producing higher yield of cabbage gave the best return on cost of fertilizer application was 120 kg N + 30 kg P$_2$O$_5$ ha$^{-1}$.

In a study at Dharwad with tomato cv. Megha, Patil et al. (1998) noted the highest yield and net income with the recommended rate of inorganic fertilizer (NPK at 100:75:100 kg/ha) + vermicompost at 2 t/ha or Vermicompost at 4 t/ha + 50% of the recommended inorganic fertilizer rates. The highest cost benefit ratios were also obtained with these 2 treatments (1:3.47 and 1:3.15, respectively).

Yadav et al. (2001) revealed that application of NICAST 500 + recommended NPK on par with integrated use of recommended dose of FYM and NPK, and NICAST 750 + recommended dose of NPK in cabbage gave highest net return ha$^{-1}$ with the highest B : C ratio compared to the other treatments. Similarly, highest benefit-cost ratio of 2.9 was obtained by combination of Azospirillum + 60 kg N ha$^{-1}$ (Sharma, 2002).

Khokhar et al. (2002) found maximum bulb yield in onion with maximum net return (Rs. 42,609 and Rs. 48,112 respectively) and cost: benefit ratio (1:7.07 and 1:7.98 respectively) with NPK @ 100-75-50 kg/ha in two consecutive years.

On economic analysis of onion cultivation, Jayathilake et al. (2003) obtained higher net returns and benefit-cost ratios when FYM was used as an organic source replacing the 50% of the recommended dose of inorganic N.

Babatunde et al. (2004) revealed that NPK fertilizer source had the highest bulb yield of 27.43 t ha$^{-1}$ and the highest net farm income of Rs. 626,600 t ha$^{-1}$.

Gupta and Samnotra (2004) reported that application of 90 kg N (75 % of recommended dose of N) + Azospirillum in cabbage resulted in the greatest yield (435.22 quintal ha$^{-1}$), net income (79 450 rupees/ha) and benefit cost ratio (4.35).
Hossain (2004) and Nasreen and Hossain (2004) obtained maximum net return and benefit cost ratio from onion crop with application of N, P, K (100 kg ha\textsuperscript{-1} of each), S (20 kg ha\textsuperscript{-1}) and Zn (5 kg ha\textsuperscript{-1}) as compared to addition of organic manures and in control treatment i.e. no fertilization.

Geethakumari et al. (2005) reported that poultry manure (20 t ha\textsuperscript{-1}) gave the highest yield (43.90 t ha\textsuperscript{-1}) of A. tricolor and returns (1,19,491 rupees ha\textsuperscript{-1}). The benefit cost ratio was higher for the residual crop than for the main crop, since no cost was incurred for nutrient application in the former.

Sharma et al. (2005) revealed that application of 120 kg N + 60 kg P + 60 kg K/ha and 240 kg N + 90 kg P and 60 kg K/ha resulted into highest head yields (413.99 and 421.15 q/ha respectively) of cabbage with benefit-cost ratios of 2.61 and 2.53, respectively.

In Ranchi, Jharkhand, Singh et al. (2005) assessed the effect of vermicompost on cauliflower productivity and profitability considering soil health under small production systems. They found that the return per rupee spent in plots with vermicompost was Rs. 3.30 and Rs 1.98 in plots applied with chemical fertilizers. They also noted highly positive reaction of the farmers’ on the use of vermicompost because of its simplicity and compatibility with the farming system components and with the household internal resources, as well as its cost effectiveness. Moreover, they observed that the resource-rich farmers also accepted and preferred to use vermicompost in place of chemical fertilizers due to environmental considerations and to combat health hazards.

Kalabandi et al. (2007) studied the effects of organic and inorganic fertilizers on the vegetative growth yield, quality and returns of cabbage. They revealed that treatment of 25% RDF + 75 FYM recorded the highest gross income, percent increase over gross return, and net return over the control. Benefit-cost ratio was highest in treatment with 50% RDF + 50% Biomeal.

Meerabai et al. (2007) found out that basal dose of FYM at 25 t ha\textsuperscript{-1} and application of poultry manure to supply the recommended dose of 70 kg N ha\textsuperscript{-1} (on N equivalent basis) in combination with Azospirillum at 1 kg ha\textsuperscript{-1} was the best economic organic nutrient schedule in bitter gourd.

Patil et al. (2007) revealed that treatment having 100% N (through FYM) recorded the lowest gross and net returns (Rs. 53 064 and 26 086 ha\textsuperscript{-1}, respectively) with
lower B:C ratio. Treatment with 100% N (urea) recorded the highest gross return (Rs. 85 074/ha) and net return (Rs. 62 086/ha). While the B:C ratio was highest (3.71) in treatment with 50% RDN (through DYS) + 50% RDN (through urea) because of the lower cost of cultivation as DYS was available free of cost. Recommended dose of N supplied through urea showed a B:C ratio of 3.70, which was on par with the 50% RDN (through DYS) + 50% RDN (through urea).

Mandloi et al. (2008) studied the response of organic and inorganic fertilizers on the growth and yield of onion using vermicompost and other organic fertilizers. According to their findings, application of NPK (125:60:100) proved to be most beneficial yielding up to 378.61 q/ha of onion bulbs with the highest net return of Rs. 83 071 ha⁻¹ and B:C ratio of 3.72.

Mahanthesh et al. (2008) studied the cost: benefit ratio as influenced by biofertilizers along with varied levels of NPK in onion. Their results revealed that among the different treatments, the maximum net income of Rs 56 328; 82 947 and 52 135 with maximum cost:benefit ratio of 4.00 (1:4.00), 5.42 (1:5.42) and 3.94 (1:3.94) were obtained from the plants provided with Azospirillum+100% N+PK viz. Azospirillum+125:50:125 NPK kg ha⁻¹ under irrigated condition during kharif and rabi seasons and under rainfed condition during kharif season respectively. They recommended this treatment, particularly in central dry zone of Karnataka for getting maximum cost-benefit ratio under irrigated and rainfed conditions irrespective of seasons.

In onion cultivation, the highest cost-benefit ratio (7.7) was noted by Hari et al. (2009), with application of 100% of recommend dose of nitrogenous fertilizers as compared to other treatments.

Zango et al. (2009) revealed that application of FYM at 60 t/ha recorded significantly higher, net head yield (467.62 q/ha-1) of cabbage and highest net return (Rs. 1,59,810 ha⁻¹).

Jawadagi et al. (2012) recorded significantly highest yield of onion as well as net returns and B:C ratio with the application of RDF (125:50:125 NPK kg ha⁻¹) + FYM (30 t ha⁻1) in both rabi and kharif seasons as compared to other treatments.