

REVIEW OF LITERATURE

The given literature pertaining to the influence of organic amendments such as composted coirpith, composted pressmud and farmyard manure on the growth, biochemical properties and yield of various crops and the influence of these manures in increasing the leghaemoglobin content, enzyme and fertility of soil as relevant to the present investigation are reviewed and presented in this chapter.

2.1 Review on composting, biometric, biochemical analysis and yield parameters

Organic farming is the background of sustainable agriculture, which improves the crops and soil health, resist pest and disease attack. It is an ecologically sound and sustainable way of growing more food (Samarta and Patro, 1996). Yau and Murphy (1998) stated that the biodegradation of coir waste was enhanced by the addition of nitrogen fertilizer and inoculation of *Chaetomium globosum*.

Pichler and Knabner (2000) reported that the compost stability is strongly related to the rate of microbial activity in compost. Increased dry matter production in black pepper (*Piper nigrum*) due to the application of composted coirpith, sand and farmyard manure was reported by Srinivasan and Hamza (2000). Burning of coirpith released high levels of carbon dioxide and smoke resulting in air pollution (Sudhira and Jacob, 2000).

Keener *et al.* (2000) reported that the composting process consisted of three steps (i) initial mesophilic phase in which sugars, amino acids, proteins are degraded (ii) thermophilic phase in which fats, cellulose, hemicellulose and some lignin are degraded and (iii) cooling phase, characterised by a decrease in temperature due to the reduction of the microbial activity which were able to degrade the remaining sugars, cellulose and hemicellulose.

Prince *et al.* (2000) studied the effects of coirpith compost on mulberry plant (*Morus alba* L.) and found that coirpith compost provides all the essential nutrients required for the growth, yield and protects the physico-chemical and biological characteristics of the soils.

According to Tolessa and Friesan (2001) the effect of growth and yield of maize were significantly increased with the application of enriched farmyard manure at 25 per cent and 50 per cent of recommended nitrogen (N) and phosphorus (P) fertilizers. Enriched farmyard manure increase the grain yield by 40 per cent when compared to conventional farmyard manure. According to Gopal and Gupta (2001) coirpith stored causes contamination of ground water due to the percolation of leachates containing residual phenol.

Mahalakshmi Priya and Vijayalakshmi (2001) concluded that sago waste and pressmud individually and in combination with bio-fertilizer increased the growth parameters of green gram. Haq *et al.* (2001) observed that the most effective treatment for *Oryza sativa* was the combination of gypsum, pressmud and farmyard manure (94 percent increase yield over control) followed by pressmud alone (60%) and farmyard manure (75%).

Pressmud can serve as a good source of organic manure (Bokhtiar *et al.*, 2001) an alternative origin of crop nutrients and soil ameliorates (Razzaq, 2001). Satyanarayana *et al.* (2002) reported that the application of farmyard manure in combination with three layers of chemical fertilizers (80: 40 : 30, 120 : 60 : 45 and 160 : 80 : 60 kg N, P₂O₅ and K₂O ha⁻¹) increase yield and production components of rice. Singh *et al.* (2002) observed significant residual effects of FYM and pressmud on the plant height, number of pods per plant and thousand grain weight of lentil crop.

Cambardella *et al.*, (2003) ascertained that the rate of inorganic N release to the soil from composted manure depended on the rate of decomposition of the organic matter and on subsequent turnover of the decomposed C and N in soil. Release of plant available N from manure in the soil was controlled by the balance of N immobilization and mineralization, which in turn was controlled, to a large extent, by the C:N ratio of the decomposing organic material. Integrated use of 75% NPK and pressmud at 1.5t ha⁻¹ recorded significantly higher grain and straw yields of sorghum (*Sorghum bicolor* L.) (Ghosh *et al.*, 2003).

Results of Parasuraman *et al.* (2003) suggested that the incorporation of composted coirpith at 12.5t ha⁻¹ along with recommended inorganic fertilizers (150: 50: 50: NPK kg ha⁻¹) resulted in highest grain yield and soil fertility status in rice .

Kumaresan *et al.* (2003) composted different organic wastes with *Pleurotus sajor – caju* and *Trichoderma viride* obtained decreased C:N ratio which increased the manurial value of the organic wastes. The findings of Kadwe *et al.* (2003) revealed that the application of $\frac{3}{4}$ recommended dose fertilizer with 5 and 4t pressmud and $\frac{1}{2}$ recommended dose fertilizer with 5t pressmud increased the biometric and yield parameters of groundnut (*Arachis hypogaea* L.).

Saraswathy *et al.* (2004) found that the application of NPK at 12.5:25:25 kg ha⁻¹ along with composted coirpith at 12.5t ha⁻¹ increased the yield attributes, dry matter, grain yield and 100 seed weight in green gram (*Vigna radiata* L.). Optimization of compost quality was directly linked to the composition and succession of microbial communities in the composting process (Taiwo and Oso, 2004). According to Annadurai *et al.* (2005) the combined application of tank silt and pressmud improves the soil by increasing the organic matter content thus enhancing the productivity of crops like sunflower, groundnut, cotton, sugarcane etc.

Shankaraiah and Murthy (2005) stated that the combined application of enriched pressmud cake at 15t ha⁻¹ and recommended NPK (250: 100: 125 kg ha⁻¹) resulted in increased cane and cane yields by 21% over chemical fertilizers alone.

Satisha and Devarajan (2005) reported that the improved quality of pressmud compost is due to the increased quantities of humic substances. Powon *et al.* (2005) stated that phosphorus and farmyard manure had significant effect on tuber dry weight, shoot dry weight and total potato tuber yield.

Ramesh *et al.* (2005) stated that under conditions of low natural productivity and low external inputs, well-managed organic farming can increase yields compared to conventional agriculture. Srinivasan *et al.* (2005) reported that the mixed effect of composted coirpith and *Azospirillum sp* increased the yield and quality of *Piper nigrum*. Mirza *et al.* (2005) revealed that both grain and straw yield of paddy were significantly improved by the application of *Sesbania* and farmyard manure.

Ramesh *et al.* (2006) reported that the coirpith mulch under drip irrigation shows significant improvement on yield attributes and yield of summer cotton. The results of

Ramesh *et al.* (2006) suggested that the application of 50% N from yeast sludge composted coirpith with ZnSO₄ and 50% inorganic N produced the highest grain yield (2185 kg ha⁻¹), which was on par with 50% N from *Pleurotus* composted coirpith with ZnSO₄ and 50% inorganic N (2103 kg ha⁻¹) in pearl millet (*Pennisetum glaucum* L.). Decomposed organic wastes having narrow C:N ratios are highly regarded for their effectiveness for improving crop yields (Ahmad *et al.*, 2006).

Mondini *et al.* (2006) stated that microbial biomass could be used as a stability parameters in lignocellulosic waste composts because it clearly reflect the transformation of organic matter during the composting process. The ATP content and the enzymatic activities were used as indicators of compost stability (Bitzer *et al.*, 2006).

The results of Shah and Ahmad (2006) suggested that the integrated use of urea and FYM performed better in improving crop and N yields of wheat. Ayoola and Adeniyani (2006) reported that nutrient from inorganic fertilizers enhances the crops, but the yield is promoted when both organic and inorganic fertilizers are used in combined form.

Salem (2006) recommended the application of 8 ton of FYM before preceding crop (wheat) with 35 kg N/fed and transplanting rice plants at plant spacing of 20x15 cm can be recommended for higher grain yield of Sakha 101 rice cultivar. Kaur and Benipal (2006) found that rice straw contains higher amount of available and water soluble K whereas farmyard manure contains considerable amount of all forms of potassium.

Soundarajan *et al.* (2007) reported that application of composted pressmud at 6t ha⁻¹ along with 75 percent NPK and *Azotobacter* increased the yield of sugarcane. The results of experiments of Balakrishnan *et al.*, (2007) showed that the application of *Suaeda* compost in combination with farmyard manure and phosphate solubilising bacteria, significantly increased the soil micro flora such as bacteria, fungi and actinomycetes and soil enzyme activities such as dehydrogenase, alkaline phosphatase, cellulose and urease in soil cultivated with *Arachis hypogaea*.

Singh *et al.* (2007) reported that pressmud application produced the longest canes (224.7 cm) with highest thickness of 2.5 cm with *Sesbania* green manuring in the planted crop. Venkatakrishnan and Ravichandran (2007) revealed that yield attributes were

significantly influenced by pressmud application which supplied good levels of essential plant nutrients to the sugarcane crop.

Sidhu *et al.* (2007) reported that farmyard manure at 50t ha⁻¹ caused substantial improvement in tuber yield (29%) and phosphorus uptake (26%) of *Solanum tuberosum* and seed yield of *Helianthus annuus* (14.7%).

Pannu *et al.* (2007) reported that the integrated effect of farmyard manure and pressmud at 2.5t ha⁻¹ along with 3 kg N and 10kg P₂O₅ ha⁻¹ enhanced the biometric and yield of *Vigna mungo*. Sushma *et al.* (2007) found that the application of coirpith based compost with pressmud and 100% recommended dose of fertilizer (RDF) increased the grain and straw yield of ragi crop.

Hufeez-ur-Rahman *et al.* (2007) reported the effect of different soil media (Farmyard manure, Saw dust, Canal silt, FYM + Sawdust, FYM + Canal silt, Sawdust + Silt and FYM + Sawdust +Silt) on seed germination and seedling growth of peach and concluded that media with farm yard manure, sawdust and canal silt is the best combination.

Rangaraj *et al.* (2007) reported that application of pressmud at the rate of 12.5 t ha⁻¹ had greater influence on soil fertility and yield of finger millet (*Eleusine coracana* L. Gaertn) followed by composted coirpith. The yield of turmeric increased four to five times with the application of farmyard manure in dark red and grey soil (Hossain and Ishimine, 2007)

Parray *et al.* (2007) noticed that the farmyard manure and neem cake independently and in combination showed significant increase in morphological and biochemical properties and yield of tomato. The results of Sanwal *et al.* (2007) revealed that the organic manure not only increased the yield of turmeric but also improved the soil fertility.

Kumar *et al.* (2007) conducted a field experiment on rice-wheat system on the combined effect of pressmud and recommended dose of fertilizer (RDF) over RDF alone and concluded that the combined effect of pressmud and RDF enhances the yield attributes over RDF alone.

Mane *et al.* (2007) selected agrowastes such as cotton stalks, groundnut haulms, soyabean straw, pigeon pea stalks and leaves and wheat straw and concluded that the bioconversion of lignocellulosic biomass by *Pleurotus sajor-caju* converts low quality biomass into an improved human food.

The results of experiments of Kumarimanimuthu (2008) indicated that application of pressmud (12.5t ha⁻¹) along with lignite flyash (5t ha⁻¹) appears to be the best in growth, yield and yield attributes of maize. This treatment gave good response when maize was intercropped with cowpea/blackgram.

Kalaivanan and Hattab (2008) concluded that the integrated application of enriched pressmud at 1.25t ha⁻¹ and inorganic fertilizers (N, P and K) enhanced the productivity of the rice. Kannan and Prasanthrajan (2008) revealed that 3.75t ha⁻¹ pressmud and recommended fertilizers registered significantly higher yield of *Lycopersicum esculentum*. Ayyasamy *et al.* (2008) reported that the leaves of maize and green gram treated with higher concentration of the sugar factory effluent (above 20%) showed lower amount of amino acid, protein and chlorophyll content due to the presence of higher concentration of magnesium and acidic pH in the effluent.

Fuchs *et al.* (2008) stated that composting of rice husk with microbial treatments improved total carbohydrate and crude protein contents which could serve as good sources of carbon and nitrogen.

The electrical conductivity (EC) reflects the salinity of an organic amendments. High salt concentration may cause phytotoxicity problems and therefore EC is a good indicator of the suitability and safety of a compost for agricultural purpose (Lazcano *et al.*, 2008). According to Quda and Mahadeen *et al.* (2008), the integrated effect of organic and inorganic fertilizers promotes the growth, yield and quality and chlorophyll content of broccoli.

Maheshbabu *et al.* (2008) observed that the application of recommended dose of fertilizer (RDF) and FYM recorded higher yield and seed quality of the soya bean. The results of Ibrahim *et al.* (2008) revealed maximum growth and yield of wheat supplemented with combined organic and inorganic fertilizers.

Mujeeb *et al.* (2008) investigated the effect of combined application of farmyard manure and diammonium phosphate on maize and found that diammonium phosphate and farmyard manure in combination enhanced yield.

The results of Premsekhar and Rajashree (2009) revealed that farmyard manure at 20t ha⁻¹ recorded the highest growth and yield of okra. The results of Muhammad and Khattak (2009) stated that incorporation of pressmud (20 mg ha⁻¹) in saline sodic soil enhance the growth and nutrient status of Indian maize.

Kanmani *et al.* (2009) reported biodegradation of coir waste with *Phanerocheate chrysosporium* and *Rhizopus stolonifer* enhanced the productivity of the crops. Dayananda and Mallesha (2009) reported that the combined inoculation of *Trichoderma harzianum*, *Azotobacter chroococcum* and *Bacillus megaterium* to mushroom spent coirpith enhanced the growth parameters of tomato.

The studies of Ofofu-Anim and Leitch (2009) showed that cowdung as the best organic manure resulted in increased plant height, chlorophyll content of leaves, dry matter accumulation and nutrient uptake in *Hordeum vulgare* L. Akparobi (2009) reported that the application of farmyard manure of 35t ha⁻¹ enhanced the biometric and yield parameters of the *Amaranthus cruentus*.

Tolanur (2009) studied the effect of different organic manures, green manuring with different levels of inorganic fertilizer and the results showed that the highest grain yield and uptake of NPK in chickpea was at 50 percent recommended dose level.

Rajarajan *et al.* (2009) reported that coirpith compost 10 kg per tree recorded the highest available nutrient in basin area and highest nut yield per tree (143 nuts per tree / year). Dash *et al.* (2010) stated that the application of nitrogen through combination of digested sludge + pressmud + carpet wastes at 40kg nitrogen h⁻¹ increased the grain and straw yield of rice (*Oryza sativa*).

Aziz *et al.* (2010) conducted a field experiment to study the effect of different sources of organic manures on soil nutrient status and growth of maize. The results of the experiment revealed that the addition of organic matter through all sources significantly improved the soil properties and maize growth.

The combination of farmyard manure (25t ha⁻¹) and recommended dose fertilizer (90: 45:35 kg ha⁻¹ of NPK ha⁻¹) along with foliar spraying of panchagavya and manchurian mushroom extract recorded highest plant height, number of leaves and number of branches in *Gymnema sylvestre* (Padmapriya *et al.*, 2010).

The rice grain and straw yield was significantly higher with integrated nutrient application (pressmud at 20t ha⁻¹+ RDF), which remain at par with pressmud at 15t ha⁻¹+ RDF or FYM at 10t ha⁻¹ +RDF (Viridia and Mehta, 2010). Sarwar *et al.* (2010) concluded that combined application of pressmud and inorganic fertilizer into the soil increased the sugar yield and cane juice quality. The results of Reghuvaran and Ravindranath (2010) indicated that the composted coirpith with nitrogen fixing bacteria is effective for the cultivation of medicinal plants.

Eifediyi *et al.* (2010) concluded that farmyard manure at 10 t ha⁻¹ increased the dry matter content of cucumber out of which Palmetto was more responsive to farmyard manure application than Ashley variety. The results of Mgbeze and Abu (2010) indicated that application of farmyard manure at 12.5% promote the growth and development of African yam bean as compared to NPK. Manikandan and Subramanian (2010) stated that the combined application of NPK (17:34:54) and biodigested pressmud (7.5t ha⁻¹) enhanced the productivity of groundnut .

Aslam *et al.* (2011) suggested that combined application of farmyard manure, poultry litter, pressmud and sewage sludge improved the growth and yield of wheat. Use of NPK at 275:112.5: 172.5 and FYM at 20t ha⁻¹ enhanced the biometric and yield parameters of *Stevia* (Navase *et al.*, 2011). The results of Rakib *et al.* (2011) in baby corn (*Zea mays* L.) revealed that the application of 75% RD + 25% N (FYM) was found to be the most productive and gainful in Kharif maize. Baranisrinivasan (2011) found positive relationship between chlorophyll and nutrient content using coir waste and cow dung in two varieties of black gram.

Mohammadi *et al.* (2011) concluded that the highest yield and best grain quality has been obtained in farmyard manure + compost + triple super phosphate treatment in chick pea (*Cicer arietinum* L.). Bhuvaneshwari *et al.* (2011) reported combined use of coirpith

based cyanobacterial biofertilizer as foliar spray (0.5%) on *Helianthus annuus* L. enhanced the biometrical, chlorophyll content and yield.

The results of Charan Kumar *et al.* (2011) in *Stevia rebaudiana* indicated maximum uptake of the nutrient, improves soil chemical properties and yield of *Stevia* due to the integrated application of nitrogen, farmyard manure, vermicompost, neem cake and biofertilizers. Application of farmyard manure at 15t ha⁻¹ enhanced the pod yield of ground nut (2890 kg ha⁻¹) (Veeramani and Subramaniyan, 2011).

Nawab *et al.* (2011) reported highest grain yield when wheat is planted after *Pigeon pea* with the combined application of farmyard manure, potassium and zinc. Combined effect of nitrogen, phosphorus, potassium and farmyard manure recorded a significantly higher tuber yield (18.7 Mg ha⁻¹) followed by lime + farmyard manure + neem cake + green manure (17.7 Mg ha⁻¹) in sweet potato (Laxminarayana *et al.*, 2011). Maunde *et al.* (2011) concluded that the application of 5t FYM ha⁻¹ increased the number of soybean, pod, sesame capsules and yield.

Ng'etich *et al.* (2012) recommended 11.5 t ha⁻¹ of farmyard manure for growing *Cleome gynandra* which enhanced chlorophyll content by 16 to 35%. Saravanan *et al.* (2012) concluded that the use of efficient biofertilizers like *Frankia azospirillum* and phosphobacterium with decomposed coirpith increased growth, biomass and nutrient content of *Casuarina equisetifolia*.

Abdissa *et al.* (2012) reported a significant tuberous root yield in sweet potato due to application of farmyard manure. Verma and Chauhan (2012) suggested that the use of farmyard manure (100kg/tree) or commercial organic manure (5-10 kg/trees) improved the yield of apple fruits in Himachal Pradesh.

Baviskar *et al.* (2012) concluded that the organic fertilizer (biocompost at 5t ha⁻¹) and sulphur (50kg ha⁻¹) increases the biometric, biochemical and yield parameters of cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.). Karanja *et al.* (2012) reported that farmyard manure application is advantageous in reducing the effect of *Alectra parasitism* on cow pea.

Dashora and Gupta (2012) revealed that the combined application of organic, inorganic fertilizer and biopesticides improves the soil fertility and increases the productivity of sugarcane and ratoon crops.

Sunil *et al.* (2012) studied the dynamics of micro organisms during composting of pressmud and indicated progressive increase in the population of actinomycetes, N – fixers and P – solubilizers upto 60 days. The results analyzed by Ainika *et al.* (2012) showed best yield of amaranth in 300 kg ha⁻¹ NPK and 5t ha⁻¹ FYM.

The results of Saravanan *et al.* (2013) indicated that the yield attributes were maximum in FYM +10 percent NPK of green gram. Suresh Kumar and Ganesh (2013) observed that the combined effect of 75% NPK along with composted coirpith (200kg) + *Pleurotus sajor-caju* (2.5 kg) + poultry manure (10 kg) enhanced the biochemical and yield parameters of groundnut VRI – 2 (*Arachis hypogaea*).

Maximum output of wheat (*Triticum aestivum* L.) was noted in application of NPK + pressmud (500 kg/acre) (Ahmad *et al.*, 2013). Thomas *et al.* (2013) revealed that the composting coirpith facilitated by poultry manure amendment brought about bioconversion of coirpith to a final product in 45 days. Sunitha Kumari *et al.* (2013a) concluded that the biological efficiency was comparatively higher in *Pleurotus florida* (16.52 %) than *Hypsizgus ulmarius* (10.00%) used for the composting of coirpith. According to Sunitha Kumari *et al.* (2013b), soil amended with composted coirpith (15t ha⁻¹) was found to be superior on the growth and yield of *Helianthus annus* L.

Pankaj *et al.*, (2013) observed the maximum uptake of nitrogen and enhanced protein content when the rice was grown under 100% N through FYM and phosphorus and potassium was maximum under 50% FYM + 50% RDF treatment. Meena *et al.* (2013) revealed that 100% of recommended dose + FYM 10t ha⁻¹ + 5t ha⁻¹ significantly enhanced the vegetative, yield and nutrient uptake of green gram.

Gangwar and Dubey (2013) supported that the combined application of vermicompost+ blue green algae+ neem cake+ farmyard manure enhanced the productivity of soil which stimulates the quality of basmati rice (*Oryza sativa* L.).

Arjumand banu *et al.* (2013) reported that farmyard manure, poultry manure and NPK can be used as a cheaper organic manure for the growth of French bean. Sahu *et al.* (2013) revealed that maximum production of the rice can be obtained by the combined application of 100% recommended dose (NPKS) , FYM (5t ha⁻¹), *Rhizobium*, phosphate solubilizing bacteria , zinc and molybdenum.

Yadav *et al.* (2013) indicated that the combined application of 50% NPK ha⁻¹ + 5t FYM + PSB + *Azotobactor* + 5 kg Zn ha⁻¹ enhanced alkaloids, yield, nutrient uptake of ashwagandha (*Withania somnifera* (L.) Dunal).

According to Sharma *et al.* (2013), substitution of 25% NPK through farmyard manure along with 5kg Zn ha⁻¹ and PSB + *Azotobactor* (58.23 q ha⁻¹) recorded significantly higher grain yield over the 100% NPK treatment (49.79 q ha⁻¹).

Sowmyamala and Nagaraju (2013) concluded that the growth, yield and quality of gaillardia (*Gaillardia pulchella* cv. D.G.S – 1) was maximum in 100% recommended dose fertilizer + pressmud at 10t ha⁻¹. Bekeko (2014) revealed that enriching FYM with inorganic fertilizers boost hybrid maize (BH-140) grain yield and harvest index significantly. The results of Mehdizadeh *et al.* (2013) indicated that the composted organic fertilizers (municipal waste compost, poultry manure, cow manure and sheep manure) at the rate of 20 t ha⁻¹ significantly increased tomato growth and yield.

Uddin *et al.* (2014) recommended the use of decomposed cocodust for strawberry production. Zahoor (2014) reported that the integrated effect of FYM (10t ha⁻¹) and nitrogen (90 kg ha⁻¹) boost up wheat production. Solaimuthu *et al.* (2014) suggested the advantages of using pressmud as a good fertilizer and can be used in combination with other raw materials to increase the efficiency of the crops. Iqbal *et al.* (2014) reported that the application of pressmud compost (10t ha⁻¹) enhanced the productivity of autumn maize (*Zea mays* L.).

Mohil and Jain (2014) revealed that the application of farmyard manure (10.0 g kg⁻¹) enhanced the root and shoot growth of *Amaranthus palmeri* as compared to NPK. Dharani and Sarojini (2014) suggested that the composting of coirpith using bacteria (*Pseudomonas*

and *Streptococci*) and fungi (*Aspergillus* and *Rhizopus*) influence the growth and productivity of sugarcane plant by 80% yield.

Rangaraj and Sultana (2014) reported that the integrated application of pressmud and spent wash (1:3.5) enhanced the physical and chemical properties of the compost leading to the formation of good quality compost. Ayoola and Makinde (2014) found that the organic based fertilizers enhanced the growth and yield parameters of green maize and vegetable cowpea along with improving the soil properties.

Reghuvaran and Ravindran (2014) reported decrease in lignin, organic carbon content and increase in nitrogen, phosphorus and potassium content when the coirpith was composted with *Pleurotus sajor-caju* (12 gm) spawn and nitrogen fixing bacteria (*Azobacter vinelandii* and *Azosprillum brasilense*) and composted coir pith can be used as effective cultivating media for all kinds of plants including ornamental, medicinal and vegetables.

2.2 Studies on leghaemoglobin content

Leghaemoglobin is a key protein in nitrogen fixation in nodules, its concentration generally correlating with nitrogen fixed (Graham and Parker, 1963). Tjepkama and Yocum (1974) gave the first positive evidence of a role for leghaemoglobin in legume nodule respiration. Ellfolk (1972) stated that the function of leghaemoglobin was facilitation of oxygen flux to the respiring *Rhizobium* bacteroids. Appleby (1974) reported that the leghaemoglobin content of most of the legume root nodules is correlated with their nitrogen fixing ability.

The leghaemoglobin showed its peak during 50th day after emergence and goes down subsequently (Zablotowicz *et al.*, 1980). The leghaemoglobin results in effective nitrogen fixation by controlling oxygen transport to the bacteroids (Uheda and Syono, 1982). According to Campo *et al.* (2000), molybdenum provides an important role in legumes to help nitrogen fixing bacteria to fix atmospheric nitrogen.

Reddy *et al.* (2000) reported that the application glyphosate of 1.12 kg ha⁻¹ for three week in glyphosate - resistant soyabean after planting did not affect nodule number or mass, 2.24kg ha⁻¹ reduced these parameters by 30-39% compared to untreated. Leghaemoglobin

content of nodules was reduced (6 to 8%) by both glyphosate rates, but effects were in consistent with rate.

Lira-Ruan *et al.* (2000) purified and characterised leghaemoglobin from the root nodules of the mimosoid (*Leucaena esculenta*) and papilionoid legumes and the leghemoglobin isolated appears to be biochemically, spectrally and structurally related. Sato *et al.* (2001) reported that the soyabean nodules consists of four leghaemoglobin components, Lba, Lbc₁, Lbc₂ and Lbc₃. Soussi *et al.* (2001) stated that the reduction of nitrogen fixation activity by salt stress is attributed to a reduction of the nodules and leghaemoglobin content.

Sharma (2001) observed that application of 10t FYM and mineral nutrients significantly increased effective number of nodules, fresh weight of nodules (gm/plant), chlorophyll a, b and total chlorophyll, leghaemoglobin (mg/gm) in cowpea crop over control.

Sharma and Bhandari (2002) reported that application of zinc sulphate (25 kg ha⁻¹), mineral nutrients and Bradyrhizobium inoculation are significantly increased the number of nodules per plant, fresh weight of nodules, leghaemoglobin content of nodules.

Krouma and Abdelly (2003) reported that iron is essential for leghaemoglobin biosynthesis that transported oxygen within cells in the nodule of soyabean. Gurumoorthi *et al.* (2003) concluded that the higher the content of leghaemoglobin in velvet bean is more efficient in fixing for atmospheric nitrogen fixation.

Nitrogen is one of the prime elements required essentially for the synthesis of enzymes, proteins, chlorophyll, DNA and RNA and hence, N plays a critical role in determining the health of living organisms including microbes and plants. For nodulating legumes, the N demand is fulfilled through symbiotic N₂ fixation (SNF) wherein atmospheric N₂ is converted to usable N (NH₃) by nitrogenase of *Rhizobia* (Shiferaw *et al.* 2004).

Ott *et al.* (2005) in *Lotus japonicas* they isolated three symbiotic leghaemoglobin, LjLb1, LjLb2 and LjLb3 two non symbiotic lehaemoglobin LjNSG1 and LjNSG2.

Puppo *et al.* (2005) revealed that reaction oxygen species are also associated in the nodule senescence process and it has been proposed that these molecules and antioxidants interact with hormones such as abscisic acid in the orchestration of the natural aging process.

Gad (2006) concluded that the addition of cobalt enhanced the N₂ fixation process in legumes and consequently increased plant N content. Roy *et al.* (2006) reported that cobalt is essential for N-fixing micro-organisms, its deficiency inhibits the formation of leghaemoglobin and hence N₂ fixation.

White *et al.* (2007) reviewed the function of the nodules and reported that for generation of energy, a high flux and low internal concentration of oxygen can be achieved with the aid of leghaemoglobin. Sharma *et al.* (2007) revealed that the synergistic effect on symbiotic parameters and grain yield of mungbean genotype, VC3890A, VCE368, VC6369 - 30 - 60, VC6173 - 10 and VC6090A showed higher nodulation and leghaemoglobin content.

Ali and Bano (2008) reported that nodule senescence have mutual relationship with the protein content as well as the sugar assimilation in the host plant which in return delay the degeneration of red bacteroid tissue of nodules and the nitrogenase activity. Oxygen availability can be regulated by O₂ binding protein leghaemoglobin (Lb) or the variable oxygen diffusion barrier (ODB) in the nodule (Minchin *et al.*, 2008).

Lopez *et al.* (2008) reported that the leghaemoglobin present in the root nodules of legumes reduces the amount of oxygen and also protect the nitrogenase enzyme. Leghaemoglobin is a red pigment protein that acts as a oxygen carrier within a bacteroid cells. Nodules lacking this important protein invariably lack nitrogenase activity and therefore lack nitrogen fixing capability (Beringer *et al.*, 2009). Marino *et al.* (2009) reported that in nodules, high respiration rates along with high concentration of leghaemoglobin and catalytic Fe enhances nodule to generate reactive oxygen species (ROS).

Sharma *et al.* (2011) found that inoculation with IRG-6 strain enhanced number of pink coloured nodules, nitrate reductase activity and leghaemoglobin content. Das and Bandyopadhyay (2011) reported that the integrated application of

Rhizobium leguminosarum and phosphate solubilizing bacteria increased the leghaemoglobin content of nodule with increase in the nodule number, fresh nodular weight and yield of fresh bean crop (*Phaseolus vulgaris* L.).

Navascues *et al.* (2012) analysed the biosynthesis of leghaemoglobin during nodule formation in soya bean (*Glycine max* L.) and reported that the modified leghaemoglobin are more abundant in senescing nodules and have aberrant O₂ binding. Singh and Kataria (2012) revealed that the increase of potassium level increases the nitrogen fixation.

Carrier *et al.* (2013) studied the reactive oxygen species (ROS) in peanut nodules (*Arachis hypogaea* L.) at three growth stage - R1 (flowering), R4 (full pod) and R6 (full seed). The results revealed that reactive oxygen species formation is not associated in the peanut nodule senescence indicating that this process would not be accompanied by an oxidative burst.

Marino *et al.* (2013) found that the biological nitrogen fixation was inhibited in nodules when exposed to cadmium which was due to leghaemoglobin / oxygen availability, affecting nitrogenase function. Tagore *et al.* (2013) studied the effect of *Rhizobium* and phosphate solubilizing bacterial inoculants on symbiotic characters, nodule leghaemoglobin and yield of chickpea genotypes and reported IG – 593 increased nodules, yield and leghaemoglobin content.

Kawashima *et al.* (2014) examined two types of leghaemoglobin genes (PSLbA and PSLbB) in pea genome which have different roles in the development of nitrogen fixation symbiosis in pea nodules.

Singh (2014) analyzed eight sub-fractional components of leghaemoglobin a₁, a₂, b, c, c₂, d₁, d₂ and d₃ which play an important role during growth phase of the nodules and correlated physiologically with development phase, longevity and supply of carbohydrate to nodules. Kucuk and Cevheri (2014) concluded that the nitrogen fixing ability of legume forage depends on temperature.

2.3 Influence of compost on dehydrogenase and urease activity

Masciandaro *et al.* (2000) studied dehydrogenase activity under the influence of organic matter amendment and stated that the enzyme activity remained unchanged during

extended period of incubation. A decrease in dehydrogenase activity was reported by Lodhi *et al.* (2000). Subhani *et al.* (2001) concluded that soil amended with organic materials (crop residues, animal faeces and their compost) increase the dehydrogenase enzyme activity with increasing microbial populations.

Aon and Colaneri (2001) stated that dehydrogenase, β – glycosidase, urease and phosphatase shows significant correlation with total organic carbon, total nitrogen, water – filled pore space and heterotrophic bacterial and fungal biomass.

Maximum dehydrogenase and invertase activity was observed for *Sesbania* and minimum in amended soil and cellulase activity was not affected strongly by organic amendments Sajjad *et al.* (2002). Murugaragavan (2002) reported that the spent wash addition increased the activity of phosphatase, dehydrogenase and urease enzymes in dry land black and red soil.

Wyszkowska and Wyszkowski (2003) demonstrated that the application of magnesium (50 to 100mg Mg kg⁻¹) to soil alleviated the negative effect of cadmium on dehydrogenase and urease activity during shoot elongation phase.

Soil enzymes are derived from soil fungi, bacteria, plant root, microbial cells, plant and animal residues, etc. and play a significant role in mediating biochemical transformations involving organic residue decomposition and nutrient cycling in soil (Cao *et al.*, 2003). Urease can be used as a good and responsive indicator of biological activities and pollution stresses in soils (Hinojosa *et al.*, 2004).

Schulz (2004) suggested that addition of farmyard manure increases microbial biomass biological activities and soil enzyme activities. Enzymes in soil, especially dehydrogenase enzymes, are highly associated with the microbial biomass (Yang and Wang, 2004), which in turn affects the decomposition of organic matter and the release of CaCO₃.

According to Liang *et al.* (2005) the incorporation of organic amendments to soil stimulated dehydrogenase activity because the added material contained intra and extracellular enzymes and also stimulated microbial activity in the soil.

Goyal *et al.*, (2005) examined the changes in enzyme activities (cellulose, xylanase and protease) of different organic waste such as a mixture of sugarcane trash, cattle dung, pressmud, poultry waste and water hyacinth biomass during composting process. The activities of cellulase, xylanase and protease were maximum between 30 and 60 days of composting in various wastes.

Tiquia (2005) studied on spent pig litter compost by analyzing total bacteria count, oxygen consumption rate, ATP content, dehydrogenase activity, microbial biomass C and N along with humification parameters [humic acid (HA), fulvic acid (FA) and HA:FA ratio] and compost temperature. Among the six microbial parameters examined, dehydrogenase activity was the most important factor affecting compost temperature and humification parameters and was selected as a suitable indicator of compost maturity.

Krishnakumar *et al.* (2005) reported that the combined application of FYM+neem cake at 90 kg N ha⁻¹ showed higher urease and dehydrogenase activity. Ralte *et al.* (2005) reported that dehydrogenase and urease activity gradually increased (0.7 µg g⁻¹ 25h⁻¹ and 31.56 µ 100 g⁻¹ 6 h⁻¹) with age of the secondary successional communities.

Yang *et al.* (2005) indicated that soil enzymatic activity was lower with increasing soil depth and to maintain soil organic matter content initial application of compost are important in organic farming.

Sylvia *et al.* (2005) reported that phosphatase and urease enzyme are produced by the micro organisms that promote the transformation of organic compounds, which are unavailable to plants in mineral form. Yang *et al.* (2006) reported urease as a soil quality indicator as it is influenced by cropping history, organic matter content, soil depth, management practices, heavy metals and environmental factors like temperature and pH.

Soil organic matter has important effects not only on soil enzyme activities (Zhang *et al.*, 2006) but also on microbial activities (Wang *et al.*, 2007). Chang *et al.* (2007) concluded that application rates of compost (1, 270 kg N ha⁻¹; 2, 540 kg N ha⁻¹ ; 3, 810 kg N ha⁻¹ ; 4, 8,080 kg N ha⁻¹) enhance the vegetable yields (spinach, lettuce, amaranth etc.), soil chemical, biological and enzymatic properties in green house cultivation.

Urease activity increases with organic fertilization and decreases with soil tillage and its activity depends on microbial community, physical and chemical properties of the soil (Corstanje *et al.*, 2007).

Balakrishnan *et al.* (2007) stated that application of *Suaeda* compost in combination with farmyard manure and phosphate solubilising bacteria, significantly increased the soil microflora and soil enzyme activities dehydrogenase, alkaline phosphatase, cellulase and urease in soil cultivated with *Arachis hypogaea*. Dilly *et al.* (2007) concluded that saccharase and urease are related to carbon and nitrogen cycles, which are the fundamental factors in forming soil fertility. Soil enzyme activities can be used as potential indicators of nutrient cycling processes and fertility management, particularly in long-term organic and conventional farming systems (Fliebbach *et al.*, 2007).

Barrena *et al.* (2008) found dehydrogenase enzyme activity to monitor the biological activity in a composting process of organic fraction of municipal solid waste. Dehydrogenase activity was proposed as a method to describe the biological activity of the thermophilic and mesophilic stage of composting. The maximum dehydrogenase activity was detected at the end of the thermophilic stage of composting, with values within $0.5 - 0.7 \text{ mg gm}^{-1} \text{ dry matter}^{-1} \text{ h}^{-1}$.

Yang *et al.* (2008) found that soil enzymatic activity (phosphatase, catalase, invertase and urease) decreased in the early growth stages of cucumber, but increased in the late ones due to the application of decomposed horse manure which enhance the yield. Shahinrokhar *et al.* (2008) found that the urease activity was controlled by organic carbon and decrease with increase pH soils.

Gu *et al.* (2009) concluded that the urease, invertase, dehydrogenase and polyphenoloxidase activities of paddy soils may be positively influenced by allelopathic rice variety through the release of allelochemicals. Kang *et al.* (2009) indicated that soil enzyme activities in a forest floor are influenced by temperature, nutrient availability and input of leaf litter.

Dehydrogenase activity in soils is very sensitive to various natural and anthropogenic factor like heavy metal combined pollution (Gao *et al.*, 2010). Kizilkaya and

Dengiz (2010) found a positive correlation between urease activities with organic matter content. Vajantha *et al.* (2010) reported highest dehydrogenase activity ($35.23 \mu\text{g TPF g}^{-1} \text{ soil d}^{-1}$) with application of 100% N through poultry manure to maize crop.

Soil enzymes include a wide spectrum of oxidoreductase, transferases, hydrolases and lyases. The dehydrogenase activity of a soil is thus the result of the activity of different dehydrogenases, which are an important component of the enzyme system of all microorganisms (Samuel, 2010).

The results of Zhang *et al.* (2010) showed that DHA and CaCO_3 positively correlated with organic matter content and DHA (soil dehydrogenase activity), OM (organic matter) and CaCO_3 (calcium carbonate) were correlated with each other in their spatial distribution, indicating that the abundant OM content contributed to the formation of the CaCO_3 .

Wolinska and Bennicelli (2010) stated that dehydrogenase are sensitive enzymes, indirectly dependent on soil aeration status. Mohammadi (2011) explained that urease is released from living and degenerated microbial cells and in the soil it can exist as an extracellular enzyme absorbed by clay particles or encapsulated in humic complexes. Vahed *et al.* (2011) reported that the relation of organic carbon with urease activity was generally quadratic correlated highly significantly with r values of 0.84^{**} and 0.77^{**} at 24°C and 16°C . Subrahmanyam *et al.* (2011) demonstrated that soil organic matter and soil moisture content, clay content and soil depth are the important determinants for dehydrogenase activity in both alluvial and estuarine soils.

Chaitanya *et al.* (2011) observed that the combined application of fertilizer (NPK 75%) and organic manure (vermicompost or poultry manure 25%) helped in sustaining soil productivity and dehydrogenase activity.

Uma Reddy and Suryanarayan Reddy (2012) indicated that the combined application of vermicompost+ poultry manure + neem cake + farmyard manure at 100 percent levels increased the dehydrogenase activity of soil in tomato-onion cropping system. Mohammadi *et al.* (2012) reported that the combined application of farmyard manure and compost enhanced the phosphatase and urease activity in the no tillage treatment compared to the conventional tillage and minimum tillage treatments.

Krzywy-Gawronska (2012) concluded that the combined application of composted municipal sewage sludge (100, 200, 300kg N ha⁻¹) and PRPSOL (150kg ha⁻¹) enhanced the dehydrogenase and urease activity by 2.04% to 21.3% and 5.17% to 34.7% in winter wheat and spring rapseed.

Punitha *et al.* (2012) reported the effect of acetamiprid on urease and phosphatase activity in selected soil of Southern Karnataka and reported that the highest urease activity was recorded in Bangalore soil (356.66 µg urea gm⁻¹ soil h⁻¹) from 20th day incubation upto 60th day incubation. According to Babita *et al.* (2012) combined application of 100% NPK +15t FYM ha⁻¹ enhanced microbial biomass C of 24%, soil microbial biomass N of 53.2%, soil dehydrogenase activity of 18.2%, urease activity of 33.9% and respiration rate of 40.5% than 100% NPK on rice productivity.

Nath *et al.* (2012) found that Integrated Nutrient Management (INM) enhanced the enzyme activities and yield of both rice and *Toria* over 100% NPK. Vandana *et al.* (2012) reported maximum soil enzymatic activities due to the increased carbon and nitrogen content in the soil.

Akmal *et al.* (2012) reported that the three enzymes (urease, alkaline phosphatase and dehydrogenase activity) have strong relation with rainfall but weak relation with atmospheric temperature. Enzyme activity was positively related with P availability but negatively related with nitrate contents in the soil. Application of N and P fertilizers significantly (P<0.05) increased the activity of all three soil enzymes.

Kumar *et al.* (2013) stated that the role of dehydrogenase enzyme in environmental science will open greater possibilities of using it as a diagnostic tool for better ecosystem assessment and amelioration.

Chinyere *et al.* (2013) found that in the altered pH cassava mill effluents dumpsites soils, acid phosphatase and urease enzyme activities were significantly higher than dehydrogenase and lipase activities.

Anju Singh and Vijayalakshmi (2013) concluded that the combined effect of composted coirpith (6.5t ha⁻¹) + composted pressmud (6.5t ha⁻¹) + farmyard manure

(6.5t ha⁻¹) increased the leghaemoglobin content of the nodules of green gram and also the enzymatic activity of the treated soil.

Bansal *et al.* (2013) significantly correlated urease activity with amount of sewage effluent and soil organic matter while negatively correlated with nitrogen fixation bacteria. Yadav *et al.* (2013) reported that the highest dehydrogenase activity was found in *Cicer arietinum* on addition of AM fungal spores i.e. 16.4 µg INTF g⁻¹ in soil.

Yang *et al.* (2013) reported that the combined application of pressmud and vinasse improved the soil microbial population, its enzymatic activities and biomass carbon, nitrogen and productivity of sugarcane. Velmourougane *et al.* (2013) reported that the maximum dehydrogenase activity was found to be in the surface horizon (0-15cm) and almost 50% dehydrogenase of the soil profile was recorded with 0-30cm soil depth.

Kussainova *et al.* (2013) found that topography influenced the macroaggregate size and dehydrogenase activity within the aggregates. Dehydrogenase activity was greater in macro aggregates of <1mm. Usha Rani *et al.* (2013) concluded that the application of 75% recommended dose of nitrogen fertilizer improves the production of spinach and the 100% organic manure results in higher dehydrogenase activity.

Chaitanya *et al.* (2013) observed that urease activity was maximum when the soil was incorporated with 75% recommended dose of nitrogen fertilizer +25% vermicompost and other enzymes were increased when supplemented with 50% vermicompost and 50% poultry manure.

Mahamuni *et al.* (2013) found that the dehydrogenase activity, available N, P, K, alkaline phosphatase and CO₂ evolution rate were increased significantly by the inoculation of fungal consortium (FC) along with agro – industrial wastes.

Frederick *et al.* (2014) studied on impact of the concentration of selected heavy metals (Mn, Si, Pb, Cu, Fe, Zn, Cd and Cr) on soil enzymatic activities. It was found that dehydrogenase has the highest activity while the lowest value was recorded for urease. This may be due to the higher sensitivity of urease due to alkaline pH of the soil.

Meena *et al.* (2014) found that the combined use of organic manure and inorganic fertilizers improved the enzymatic activities as well as microbial population of bacterial, fungal and actinomycetes.

Liang *et al.* (2014) reported that the activities of invertase, β -glucosidase, urease, acid phosphatase and dehydrogenase in bulk soil were significantly higher in the FYM treatment in all particle size fractions.

2.4 Soil status

Dikshit and Khatik (2000) reported an enhanced availability of N, P, K and S in soil with the application of FYM 10 t ha⁻¹ +50% of recommended dose of nitrogen. Singh *et al.* (2000) stated that available nitrogen and phosphorus in post – harvest soil increased significantly with the levels of sulphitation pressmud (SPM) (0, 2, 4 t ha⁻¹).

Rakkiyappan *et al.* (2001) observed that the integrated application of organic fertilizer (enriched pressmud with *Pleurotus sp* at 10t ha⁻¹) along with chemical fertilizer (50 to 70% NPK) improved the soil organic carbon and available NPK without affecting soil pH and exchangeable cation. Ouédraogo *et al.* (2001) examined increased soil pH, soil cation exchange capacity, nitrogen, phosphorus and potassium in the plots receiving 10 mg ha⁻¹ compost prepared from household refuses, animal manure, crop residues and ashes.

Nayak *et al.* (2002) reported that the applied organic fertilizer with soil colloids, results in the retention of basic cations on the exchangeable complex of the soil, thus influencing the soil pH. Nehra and Hooda (2002) stated that the application of organic manures increased the carbon content and available NPK in soil.

Krishnasamy *et al.* (2002) suggested that the application of sewage sludge alone or in combination with coirpith as mixture or pellets increased the trace metals content in soil and plant which enhanced the dry matter yield of fodder maize (*Zea mays* L.) by 22% even at the low level of 1.25t ha⁻¹ application. Brar (2003) recorded that the integrated use of organic and inorganic fertilizers improves the crop yields and soil fertility to higher level. Mathakiya and Meisheri (2003) reported that the application of pressmud increased the EC

of the soil. Choudhary *et al.* (2004) concluded that the application of pressmud at 15t ha⁻¹ + 50% gypsum requirements reduced the exchangeable sodium percentage of the soil. The importance of increased soil organic matter or soil organic carbon is its effect on improving soil physical properties, conserving water, and increasing available nutrients. These improvements ultimately lead to greater biomass and crop yield (Onemli, 2004).

Soil organic matter is a major terrestrial pool for carbon, nitrogen, phosphorus, and sulphur, and the cycling and availability of these elements are constantly being changed by microbial immobilization and mineralization (Feichtinger *et al.* 2004). Srinivasan *et al.* (2005) reported that the combined application composted coirpith (1.25 t/ha) + *Azospirillum sp.* (20g /vine) enhanced the copper content as compared to the control. According to Liang *et al.* (2005), the incorporation of organic amendments to soil stimulated dehydrogenase activity because the added material contained intra and extracellular enzymes and also stimulated microbial activity in the soil. These parameters were the most sensitive to the changes which occurred in salt affected soil and provided rapid and accurate information on changes in soil quality.

Annadurai *et al.* (2005) reported that the combined application of *Their*-soil +SP (pressmud) shows drastic reduction in pH as compared to *Their*-soil alone. Bohme *et al.* (2005) suggested that the application of farmyard manure enhanced the soil organic matter and total nitrogen as reflected by hydrolytic enzyme activities. Organic manures decompose to give humus that plays an important role in the chemical behaviour of several metals in soils through the flavonic and humic acid contents (Abou El-Magd *et al.*, 2006).

Zahid and Niazi (2006) suggested that the pressmud has considerable quantities of Ca, S, organic carbon, N, P and K which is a cheaper source of organic matter rather than gypsum, which can successfully be used for the reclamation of saline sodic soil. Kumar and Shivay (2007) reported that the application of organic manures improved the physical, chemical, biological properties of the soil.

Mohan and Chandaragiri (2007) reported the post harvest soil sample, available N, P, K and soil organic carbon were found to be higher in organic manure treatment. Anil and Singh (2007) observed that application of pressmud for 10 years increased the electrical conductivity of the soil under pearl millets-wheat cropping system.

Influence of farmyard manure along with chemical fertilizers (NPK) to increase the soil organic carbon (SOC) content and to improve the physical properties of soil (Bhattacharya *et al.*, 2007). Iqbal *et al.* (2008) determined that a major benefit attributed to the green manure and organic fertilizer is the increased organic matter of the soil.

Mahmoud *et al.* (2009) reported that application of 100% animal compost promotes the electrical conductivity and pH of the soil during the two successive summer seasons of 2007 and 2008. The results of Walia and Kler (2010) emphasized that the application of organic manures alone or in combination with inorganic fertilizers increased the yield and availability of nutrients in soil.

Gulam *et al.* (2010) concluded that the application of pressmud at 15 to 20 t ha⁻¹ would be the most suitable dose for improving the physico-chemical properties of calcareous soil. Lakhdar *et al.*, (2010) reported that the Municipal Solid Waste (MSW) compost supplied at 13.3 g kg⁻¹ seemed to be a useful strategy to enhance biologic activities of salt – affected soil.

Kumar *et al.* (2011) concluded that the combined application of 100% recommended dose of nutrients through inorganic source and FYM (10t ha⁻¹) promote the yield attributes and grain yield of rice. Ondieki *et al.* (2011) during their study on the effect of fortified manure on the yield of African nightshade observed that the increase in the total yield may be due to the effects of organic fertilizers soil aggregation, soil aeration and increasing water holding capacity and offers good environmental conditions for the root system of spider plants.

Rajanna *et al.* (2012) reported that the application of FYM (10t /ha) enhanced the available nitrogen, phosphorus and potassium in soil after harvest of rice. Aruna *et al.* (2012) estimated that the application of 100% nitrogen through neem leaf manure promote the post harvest nutrient status of soil. Sridevi and Venkata Ramana (2012) revealed that organic treatments (FYM + biofertilizer) improves the soil physical properties thus increasing the enzymatic activity of the soil by improving the yield parameters of the crop when compared to the inorganic treatments and integrated nutrient management.

Vimera *et al.* (2012) concluded that the integrated application of 50% NPK+ 50% FYM+ biofertilizers (*Azotobacter* and *Phosphotica*) enhanced the available nitrogen, phosphorus, potassium, organic carbon and pH of after harvest of king chilli in an acid alfisol soil. The results of Law-Ogbomo *et al.* (2012) showed maximum biometric growth supplied with organic manure at 40t ha⁻¹ and relative agronomic efficacy were maximized at that level due to its cumulative and complementary effect on nutrient availability.

Shah *et al.* (2013) reported reduction in pH and EC with the application of FYM (20t ha⁻¹) + 100% gypsum in alkali soils. Meena *et al.* (2013) revealed that the combined application of FYM (10t ha⁻¹) + sewage sludge (2.5t ha⁻¹) along with recommended NPK fertilizer promote the soil organic carbon, available nitrogen, phosphorus and potassium in the surface soil. Chesti *et al.* (2013) stated that the integrated application of 100% NPK + FYM 10t ha⁻¹ promote the yield and fertility level of the soil in the intermediate zone of Jammu and Kashmir. Sanjeeva Rayudu *et al.* (2013) stated that pressmud improves the biological characteristics (Bacteria -1700000, Fungi -3000000) and electrical conductivity (4.17 m Mhos/cm) of the alkaline soil.

Tadesse *et al.* (2013) examined that the integrated application of farmyard manure (15 t ha⁻¹), nitrogen (120 kg ha⁻¹) and P₂O₅ improved the soil physico-chemical properties and yield of rain – fed rice in Fogera plains of North Western Ethiopia. Datt *et al.* (2013) determined maximum organic carbon with the application of FYM (10t ha⁻¹) nitrogen fixer – A, phosphate solubilizer and chopped crop residues in an acid alfisol soil.

Awotoye *et al.* (2014) observed that six weeks incubated ashed coconut husk at 10t ha⁻¹ gave the highest cation exchangeable capacity (CEC) to the soil. Patil *et al.* (2014) stated that 50% recommended dose of nitrogen + 25% FYM+ 25% castor cake +*Azospirillum*+ PSB enhanced the straw and grain yields, protein content of pearl millet and post harvest nutrient status of soil.

Menon *et al.* (2014) reported that the application of farmyard manure (10t ha⁻¹) alone induced the nitrogen content, while phosphorus and potassium were induced by the combined application of FYM (10ha⁻¹)+ NPK (50:25:50kg ha⁻¹). Chang *et al.* (2014) observed maximum soil EC with the application of compost +2/3 N (applying compost

complemented with 66% of the chemical Nitrogen fertilizer of the chemical – N treatment) as compared to the CK (without fertilizer).

Dotaniya *et al.* (2014) investigated the effect of organic residues on phosphorus fraction, mainly Al-P, Ca- P, and available phosphorus in soil during a one year incubation period. Application of organic residue was found to reduce the phosphorus fraction while available P in soil increased with the higher levels of organic residue as well as increasing incubation time. Parmar (2014) reported that the combined application of 100% NPKB + FYM improve the soil health by promoting the available nitrogen, phosphorus and potassium in mid – hill zone of Himachal Pradesh.

Rama Laxmi *et al.* (2014) stated that the combined application of 75% RDF + vegetable market waste compost at 2.5 t ha⁻¹ to kharif rice and 50% RDF to rabi green gram promote the available micronutrients status (nitrogen, phosphorus and potassium). Patel *et al.* (2014) reported that the combined application of 50% RDN through FYM + *Rhizobium* enhanced the available nitrogen. The highest available phosphorus and potassium were recorded with the combined application of 50% RDN through castor cake + *Rhizobium* + PBS inoculation in the post harvest soil fertility.