2

Review of Literature

This chapter provides an overview of the general aspects of different composting techniques, composted and uncomposted organic amendments, microbial populations, Fourier-transform infrared spectroscopy (FTIR), Scanning Electron Microscopy (SEM) examination of various organic manures, biocomposting effects on biometric, biochemical and yield parameters, leghaemoglobin content, antioxidant, antibacterial activity, phytochemical and mineral composition of different crops.

2.1 Review on Composting, Microbial Populations and Physico-chemical characteristics

Rashad *et al.,* (2010) monitored the microbiological and physico-chemical parameters for 12 weeks during composting of five piles containing mainly rice straw and soybean residue and enriched with rock phosphate. Physico-chemical, changes confirmed the succession of microbial populations depending on the temperature of each phase in all treatments. Intense microbial activities led to organic matter mineralization and simultaneously narrow C/N ratios. Inoculation of composting mixtures enhanced the biodegradation of recalcitrant substances. After 84 days, all composts reached maturity as indicated by various parameters.

Sangwan *et al*., (2010a) reported that the vermicompost of sugar industry waste with cow dung resulted in a decrease in carbon and an increase in nitrogen, phosphorus and calcium concentrations. Sarma *et al.,* (2010) state that vermicompost is a rich source of macro and micro nutrients. It is mostly considered an efficient supplement of organic matter to soils and horticultural container media low in organic content. Vermicompost has enhanced plant growth-promoting effects as well as suppression of plant diseases. The role of Vermicompost in plant growth promotion is largely believed to be due to its nutrient-rich composition as well as its ability to modify soil's physical and chemical properties.

Shrimal and Khwairakpam, (2010) evaluated the best carbon: nitrogen ratio (C/N) for vermicomposting of vegetable waste blended with cow dung and saw dust. Four different reactors R1, R2, R3 and R4 with C/N ratios of 20, 30, 40, and 16.4. were tested. After 42 days the increase in TN (Total nitrogen) content varied significantly in all the reactors on all the days with a maximum increase of 73.58% in R2 as compared to 42.51% and 61.62% in R1 and *R3* while C/N ratio significantly affected the growth and reproduction of *Eisenia fetida.*

Sim and Wu, (2010) demonstrated that through vermicomposting, municipal solid wastes (MSW) such as city garbage, household and kitchen wastes, vegetable wastes, paper wastes, human faeces and others could be sustainably transformed into organic fertilizer or vermicompost that provides great benefits to agricultural soil and plants.

Das and Dkhar, (2011) identified that the application of organic fertilizers had enhanced the microbial population compared to inorganic fertilizers (NPK) and controls. The highest fungal and bacterial population was recorded in vermicompost and the least in the control plot. Application of organic fertilizers also showed an increase in rhizosphere soil physicochemical properties compared to NPK and control plots.

Othman, (2012) said that the amount of nitrogen, phosphate and potassium increased due to the varying concentration of food waste. Food waste stimulates microbial growth that generates microorganisms. The results conclude that vermicomposting has reduced the mass of the tested sample and the concentration of N, P and K in the soil is greater than the chemical fertilizer. Therefore, vermicomposting is a promising alternative treatment of food waste as it is more eco-friendly.

Pandit and Maheshwari, (2012) indicated that sugarcane wastes (especially press mud and bagasse) mixed with jeevamrutham and after partial decomposition of waste material, it works as an excellent palatable raw material for vermicomposting using *Eisenia fetida* earthworm. Desired level composition of nutrients in the vermicompost i.e., macronutrients (C, N, P, K, Na, Ca, Mg %) and micronutrients (Fe, Zn, Mn, Cu, Bo, Al ppm) was comparatively better than the control.

Punde and Ganorkar, (2012) reveal that the good-quality of biocompost was obtained in the T3 phase (Soil +cow dung+ vegetable waste (1:1 (Market waste: Cow-dung)) from T6 (Soil +cloth waste + cow dung (3:10 (cloth waste: Cow-dung)) and T7 (Soil +sugarcane waste + cow dung (1:1(sugarcane waste: Cow-dung)) in 45 days. The important characteristics such as pH, N, P, K, and C/N ratio meets the standards given in the manual on Municipal solid waste Management 2000. This process will reduce environmental damage to sustainable agriculture and wasteland development.

Velmourougane and Raphael, (2012) identified that coffee pulp could be very well used as a substrate for vermicomposting using native (*Perionyx ceylanensis*) and exotic earthworm (*Eudrilus eugeniae*) species. The chemical and microbiological properties of vermicomposted coffee pulp enhance the nutrient value and microbial quality of vermicompost and its utility as a good source of plant nutrients and soil health enhancement in coffee plantations.

Chandna *et al.*, (2013) indicated the usefulness of different nitrogen amendments and bulking agents for the improved composting process to prepare high-quality compost. The changes in organic carbon (C), total nitrogen (N), C: N ratio, phosphorus and potassium varied considerably during composting. The organic carbon decreased, whereas total nitrogen, phosphorus and potassium increased with time. A significant increase in nutrients, Na, Cu, Zn, Mg, S, Mn, Fe and Ca was noted during composting. The bacterial population was found to be maximum during the mesophilic phase, but decreased during the thermophilic phase and declined further in the cooling and maturation phase of composting. The bacterial population ranged from 10^5 to 10^9 CFU g^{-1} compost.

Gebeyehu and Kibret, (2013) postulated the microbial counts and the physicochemical parameters of compost. The aerobic mesophilic bacteria and fungi decreased while actinomycetes count increased at the last stage of composting. The electrical conductivity and pH increased throughout the composting period. Carbon, nitrogen content and carbon-nitrogen ratio decreased from the initial stage to the final stage of composting.

Ghosh *et al.*, (2013) observed that the total fungal and bacterial count per gram of sample was increased with the increasing addition of vermicompost in soil. Gopinathan and Prakash, (2013) investigated the quality of vegetable waste before and after 60 days of vermicomposting. The chemical analysis of N, P and K showed an increasing trend on 60^{th} day of composting than on the initial 0^{th} day and control sample. The total microbial population count was tremendously higher from 0 to 60^{th} days of composting.

Hanc and Pliva, (2013) investigate the effect of using pre-composted and raw kitchen waste with the addition of woodchips and paper in vermicomposting with available content of nutrients and viability of earthworms. Vermicomposting increased the total content of N, P, K, Ca and Mg and the availability of P and K. The addition of used paper into kitchen biowaste proved to be a suitable feed for earthworms. Jusoh *et al.*, (2013) reported that the application of effective microorganisms to the composting process of rice straw with goat manure and green waste increased the macro and micronutrient content.

Mahyati *et al*., (2013) revealed that degradation of lignin from corncob by using white rot fungi (*Phanerochaete chrysoporium, Lentinus edodes* and *Pleurotus octreatus*) showed maximum lignin biodegradation (96.88%). Muthurayar and Dhanarajan, (2013) observed that the highest P content of 0.47% and K content of 1.2% and the least Cellulose and Lignin contents of 22.8% and 10.03% in T1 (Coir pith + Cow dung + Vegetable market waste + Poultry waste + mixed microbial culture (*Trichoderma viridae* + *Pleurotus sajor caju*) treatment after a composting period of 12 weeks. The highest pH was observed in the treatment T3 (Coir pith + Cow dung + poultry waste + tank slit + mixed microbial culture), this was followed by T1 treatment.

Ningshen and Daniel, (2013) proved that the electrical conductivity of the coir pith subjected to decomposition using the four types of microbial consortia i.e. C1 (*Aspergillus niger* + *Pleurotus sajor caju*), C2 (*Aspergillus niger* + *Pseudomonas* spp), C3 (*Pleurotus sajor caju* + *Pseudomonas* spp) and C4 (*Aspergillus niger* + *Pleurotus sajor caju* + *Pseudomonas* spp). C1 showed steady increase in electrical conductivity and gave the highest value followed by C4, C2 and C3 (C1>C4>C2>C3). The pH steadily decreased with the increase in the number of days of decomposition. The best decrease was observed in C1 followed by C4, C2 and C3 (C1> C4 > C2 > C3).

Ananthakrishnasamy and Gunasekaran, (2014) concluded that integrated application of (800 g) vermicomposted bedding materials (Press mud and cow dung) + 250 g of vermicomposted municipal solid wastes promotes the nutrient content, organic carbon, nitrogen, phosphorus and potassium of the compost which can be utilized for organic farming.

Pal *et al.*, (2014) indicate that agricultural wastes stimulate microbial populations that are essential to the stability and resilience of the soil ecosystem as a whole. Organics also help in soil revegetation and erosion control. These wastes help to achieve sustainable high yields in food, nutritional security and environmental safety.

Shamini and Fauziah, (2014) investigate the possibility of treating selected organic wastes via vermicomposting using formulated microbial cocktail. It managed to enhance the vermicomposting combination of all three selected organic wastes in equal proportion by approximately 64% resulting in a degradation rate of 2.0 x 10^{-1} kg per day. The percentage of reduction for carbon to nitrogen ratio indicated 50% for the same combination of wastes in just 5 days. The results indicate that the microbial consortium enhances the degradation of organic wastes namely sugar cane bagasse, spent tea and banana stem in different combinations.

Song *et al.*,(2014) investigated the responses of heavy metals and nutrients to composting animal manure spiked with mushroom residues with and without earthworms. Results showed that earthworm activities accelerated organic matter mineralization and humification. The vermicomposting process could magnify the nutrient quality but relieve the heavy metals risk of agricultural organic wastes.

El-Mohamedy *et al*., (2015) stated that field application of biocompost (Compost inoculated with 25 mL/Kg spore suspension 3x10^6 spore/mL of each *Trichoderma harzianum* Th3 and *T. viride* Tv1.) enhanced the nitrogen, phosphorus, potassium, ferrous, manganese, zinc and copper contents followed by other treatments and control in potato.

Emperor and Kumar, (2015) analyzed the microbial population and activity on vermicompost of *Eudrilus eugeniae* and *Eisenia fetida* in different concentrations of tea waste with cow dung and kitchen waste mixture. In the present analysis, the microbial activity of vermicompost obtained from all the treatments T1-T4 increased and especially in T4 (600 (g) TW + 100 (g) CD + 300 (g) KW of *E. eugeniae* and *E. fetida* and T3 (500(g) TW + 100 (g) CD + 400 (g) KW of *E. eugeniae*) and *E. fetida* treatments were found to be significantly higher than T2, T1 treatments. The bacterial, fungal and actinomycetes population was found to be significantly higher in the fresh vermicast obtained from treatments T1-T4.

Oo *et al.*, (2015) observed the effectiveness of compost and vermicompost as soil conditioners in alleviating salt-affected soils and increasing maize productivity. Application of compost and vermicompost significantly increased soil organic carbon, soil N, P and K contents. Organic amendments can thus serve as a source of essential nutrients for plants as well as contribute to improved soil properties.

Sadasivuni *et al.*, (2015) suggested that recycling areca nut and cocoa wastes as vermicompost not only safe guards the soil health and environment but also improve productivity and profitability. In addition, it requires improved on-farm recycling of K to reduce the application of external K input/inorganic K and to find out alternate organic K sources. The findings of long-term field studies revealed that vermicomposting is the ideal, convenient and viable option for recycling areca nut and cocoa wastes and other component crops and improves soil fertility.

Sequeira and Chandrashekar, (2015) revealed that vermitechnolgy of municipal solid waste using *Eudrilus sp* yields a good quality vermicompost that is rich in soil quality-enhancing microorganisms. Bacteria count per gram of vermicompost obtained from waste paper is110×10^5, garden trimming leaves vermicompost is 350×10^5, mixed organic garbage vermicompost is 255×10^5 and mixed organic garbage without cow dung slurry vermicompost is 634×10^5. Fungi count per gram waste of vermicompost obtained from waste paper is 17×10^3, garden trimming leaves vermicompost is 113×10^5, mixed organic garbage vermicompost is 39×10^3 and mixed organic garbage without cow dung slurry vermicompost is $73\times10^{3.}$ The vermicomposts are made of paper and mixed organic garbage without cow dung slurry.

Aksakal *et al.,* (2016) described that vermicompost application is an effective way to improve soil's physical characteristics. Vermicompost applications in all three soils significantly increased organic matter content. When compared with control, the increasing rates in organic matter content were 14·0%, 23·8%, 42·0% and 90·2% for 0·5%, 1%, 2% and 4% vermicompost application doses, respectively.

Esakkiammal and Sornalatha, (2016) worked on the physicochemical parameters of *Eudrilus eugeniae* and *Eudrilus foetida*. Vermicompost showed a significant increase in *Eudrilus eugeniae*. The final EC of *Eudrilus* compost was 0.85 in control, 0.91 in E1, 0.96 in E2, 0.87 in E3, and 0.88 in E4. The pH of the 60th day vermicompost was increased slightly when compared to the initial stage. The micronutrients such as Ca, Mn, S, Fe, and Zn were increased when compared to the control. The total organic carbons were decreased during the experimental period. Vermicompost may attribute a significant increase and an emphatic effect on macronutrients and micronutrients on plant growth.

Hussain *et al.,* (2016a) concluded that vermicomposting is a resourceful technique to renovate vegetable market waste into a biofertilizer. It is a simple biotechnological process in which earthworms and microorganisms are employed to convert the organic waste or biological waste material into excellent biocompost. Owis *et al.,* (2016) revealed that essential elements N, P, and K represented the fertilizer value of compost increased in the produced composts. Total N content increased gradually with the progress of the composting time in all investigated heaps. Total and available forms of N, P and K were greatly increased with different plant residues composting process, while the values of pH and EC fluctuated among the different heaps and different stages of the composting process.

Rao and Mushan, (2016) proved that the vermicomposting of tendu leaf litter waste can be a viable method for converting solid waste into useful manure. The vermicompost produced from beedi waste has rich microbial flora than the decomposed tendu leaf litter.

Sakthivigneswari and Annamalai, (2016) obtained that *Pleurotus sajor-caju* and earthworm inoculated corncob samples of C1- corn cob + *Pleurotus sajor-caju* C2- predigested corn cob + *Eudrilus eugeniae,* C3- pre-digested corn cob + *Eudrilus eugeniae* + *Pleurotus sajor-caju* in which C3 found to be an efficient degrader of corncob and it showed a drastic reduction in the chemical parameter like organic carbon, cellulose and lignin content. C: N ratio was narrowed down from 112:1 to 32:1 while total nitrogen content was increased to 0.92 to 0.35% over (Raw sample) control. C3 has a higher content of micronutrients like calcium and magnesium when compared to the control.

Sivasankari and Anandharaj, (2016) found that the bacteria, fungal and actinomycetes count was higher in the midgut of *Eudrilus eugeniae* i.e in T3 (*Cassia auriculata* + *Leucaena leucocephala* + Cowdung (1:1:2) + *Eudrilus eugeniae*) on 60^{th} day compared to T1 (*Gliricidia sepium* + *L.leucocephala* + Cowdung (1:1:2) + *E.eugeniae*) bacteria (100), fungi (95.33) and actinomycetes (105.67), T2 (*G.sepium* + *L.leucocephala* + Cowdung (1:1:2) + *Eisenia fetida*) bacteria (95.33), fungi (91.00) and actinomycetes (100.67) and T4 (*C.auriculata* + *L.leucocephala* + Cowdung (1:1:2) + *E.fetida*) bacteria (100.67), fungi (95.67) and actinomycetes (106.00).

Game *et al.*, (2017) evaluated the composting efficiency of rural and urban waste in the open pit method. The bacterial and fungal population in composting pits increased gradually and the highest population was recorded in the initial phase of composting between 60 to 90 days composting in test consortium and commercial consortium treated pits, while in uninoculated control pits, it took 90 to 120 days for reaching to its maximum. Thereafter a gradual decrease in bacterial and fungal populations and an increase in actinomycetes population were recorded.

Indumathi, (2017) showed that the pH of the compost was lower and gradual increase in EC, and total potassium was recorded in all the experimental setups than their initial values. These increased levels of total potassium in the final product than the initial feed substrate indicate that the microbial flora also influences the level of available potassium. The total nitrogen content of the compost increased significantly with time in the presence of decomposing thermophilic bacteria.

Patil *et al.*, (2017) evaluated that a 20:80 combination of coir waste and cow dung was found to be the best combination from the point of macronutrient contents. Among the two species of earthworms, *Eudrilus euginae* was found superior over *Eisenia foetida*.

Patyal, (2017) stated that the application of vermicompost increased pH, electrical conductivity, temperature, bulk density, C/N ratio, N, P and K for 45 days. Pratap Singh and Prabha, (2017) reported that agricultural waste biocompost contains 45.6% of total solids, 26.7%, organic matter, 15.3% carbon and 1.36% total nitrogen which reflects that the compost is rich in the carbonaceous matter.

Sakthivigneswari and Vijayalakshmi, (2017) studied the microbial population at regular intervals of 0-30, 30-60 and 60-90 days in the composting units C_1, C_2, C_3, C_4, C_5 and C_6 during the composting period. On the 60th day remarkable bacterial (8.02×10^6) and fungal (2.16×10^4) count was obtained in C6, over the control (2.38×10^6 and 1.62×10^4). The study concluded that the combined application of coir pith, *Pleurotus sajor-caju* and *Eudrilus eugeniae* - treated compost (C_6) is microbiologically more active than other worm un-treated substrates.

Tayad *et al.*, (2017) proved that the addition of the poultry litter enriches the compost physicochemically. Set D (300 g agrowaste & 200 g poultry waste) has the highest value of C (52.70%) and organic matter (90.85%). The nitrogen content value of set B (300g agrowaste & 000 g poultry waste) is 2.87%, set C (300 g agrowaste & 150 g poultry waste) is 3.08% and set D 3.22% was higher as compared to other sets, which indicates the readily nitrogen availability to soil and the plant. The C: N ratio is high in set B (17.68).

Chander *et al.,* (2018) stated that aerobic composting (using microbial consortium culture) and vermicomposting supported a diverse microbial population of bacteria, fungi and actinomycetes. Aerobic compost has relatively higher nutrient contents (N, P, K, Ca, S and Zn) due to better decomposition as a result of higher microbial activity and both composts had a good nutrient value and high stability.

Gogoi *et al*., (2018) identified that yield of knol khol and soil health as influenced by organic inputs and microbial consortium. The results showed that T8 [RDF (80:60:60kg NPK + 10t FYM ha^{-1})] recorded the highest knob yield which was followed by under T7 (Enriched compost 5t ha^{-1}). Soil pH (5.62), N (293.82 kg ha^{-1}), P (66.91 kg ha^{-1}), K (141.22 kg ha^{-1}), bacterial population (9.11 log CFU g^{-1} soil) and fungal population (6.11 log CFU g^{-1} soil) and highest yield of Knolkhol (169.73q) were found better in treatment treated with Enriched compost 5t ha^{-1} and consortium (T7).

Mahmud *et al.,* (2018) reported that the application of vermicompost produced from fruits were significantly larger with smaller crowns, but contained slightly lower total soluble solids content (TSS). The results of soil analysis showed that the application of vermicompost had significantly increased the soil pH and was able to retain the nutrient content in the soil. The use of vermicompost produced from pineapple plants had excellent growth performance, comparable to that obtained when chemical fertilizer was used.

Nalluri and Karri, (2018) carried out a 2:1 ratio of soil to chemical fertilizer as a control and in the test, chemical fertilizer was replaced by 50, 75 and 100 % v/v of groundnut shell compost. Among the different combinations tested, a high yield was observed in 50 % (T2) and a low yield was observed in 100 % (T4) groundnut shell compost treatment. Due to high organic carbon and low total nitrogen, the C/N ratios in the groundnut shell compost treatments were much lower than that in the control. A decrease in the available phosphorus in cultivation beds was noticed with the use of groundnut shell compost and a notable aspect was the increase in potassium in the cultivation beds in proportion to the groundnut shell compost.

Nhu *et al.,* (2018) recommended that the liquid organic fertilizer prepared from fruit wastes substrate and *Klebsiella oxytoca* could enhance the growth of three vegetables, *Ipomoea aquatica*, *Brassica integrifolia* and *Brassica rapa chinensis*. Molasses liquid organic fertilizer also gave positive results for plant growth. Praveena *et al.,* (2018) experimented with the decomposting of cocoa wastes and the application of those composts in crop production had shown that promising results could be obtained from the application of compost produced by *Phanerochaete chrysosporium* and *Pleurotus sajor-caju*.

The nutrient content of N, P, and K was found to be more in the treatment with TNAU biomineralizer followed by *Phanerochaete chrysosporium* and *Pleurotus sajor-caju discusiin*.

Erana *et al*., (2019) postulated application of agroindustrial wastes compost increased soil organic carbon, pH, nitrogen and phosphorous, improved soil moisture content, and some macronutrients. Significant numbers of total soil bacteria and fungi count were achieved after compost amendment. Better onion shoot weight, shoot girth, and bulb weight were harvested when compost was applied.

Karanja *et al.,* (2019) indicate that composting of rice straw becomes more enhanced when the straw is treated with chicken manure than with donkey manure. Temperature, pH and EC among the treatments of the study revealed significant differences at a 5% level of confidence using Tukey's test. Khalil *et al.,* (2019) concluded that comparing various treatment groups, treatments having a 1:1 combination ratio (T2, T3, T4 and T5) have shown the best results in the case of pH, EC and N content of post-harvest soil. All the treatments except the control have altered the chemical status of soil to a favorable soil microbial activity and plant growth.

Meena *et al*., (2019) found that poultry manure (PM) applied @ 150% RND (Recommended Nitrogen Dose) was best which lead to higher counts of bacteria (82.45×10^3), fungi (37.82×10^3) and actinomycetes (58.23×10^3) closely followed by the treatments where poultry manure was applied with reduced rates (T8 & T7), respectively.

Usmani *et al.,* (2019) described that vermicomposting is a more effective approach for remediation of fly ash as compared to aerobic composting. The substrate mixtures were converted into rich manure by the joint interaction of *Eudrilus eugeniae* and microorganisms. The treatments E1 and E2 during vermicomposting gave good results for microbial diversity, enzymatic activity and plant hormones. The microbial population (bacteria, fungi, actinomycetes, coliform, proteolytic and cellulolytic bacteria) in the compost was lower than the vermicomposts. The level of plant hormones and microbial biomass carbon was higher in vermicompost as compared to compost. The results showed the importance of earthworms and associated microorganisms in altering the physicochemical, microbial and enzymatic activities of vermicomposted fly ash.

Zhang *et al.,* (2019) examined that hickory (*Carya cathayensis* sarg) shell could be used as a raw material for composting by adjusting the initial C/N ratio of composting with soybean meal, thus initializing the composting fermentation and heating the hickory shell. In the hickory shell composting system, bacteria played a dominant role in the initial and thermophilic phase and the lignin degradation is related to the number of fungi and actinomycetes in the composting process.

Ghinea and Leahu, (2020) experimented that three samples made with the C/N ratios of 50 (sample 1), 45 (sample 2), and 30 (sample 3) by adding apple, banana, orange, and kiwi peels waste and cabbage leaves, potato and carrot peels waste. Results showed that in the first week of composting pH is acidic and EC values are high for all three samples, and then the pH values increase during the composting process, while electrical conductivity values decrease. The N content is low in all samples and decreases during the first five weeks of the composting process, then begin to increase slightly.

Bhuyan *et al*., (2021) revealed that different organic manure combinations were having a significant influence on available nitrogen (339.89 kg ha^{-1}), phosphorus (66.62 kg ha^{-1}), potassium (266.38 kg ha^{-1}), organic carbon (1.86%) in T_{10} treatment.

2.1.1 Review on FTIR and SEM

Li *et al*., (2011) observed that SEM analysis of vermicomposted sewage sludge and cow dung, the humic acid-like fraction has been shown in the initial raw samples, humic acid-like fraction was characterized by flakes and fragments. However, in the final vermiproducts, humic acid-like fractions were close-grained, lumpy and possessed water permeability and ventilation for soil application.

Rajiv *et al.,* (2013) observed that FT-IR spectroscopy analysis of Parthenium mediated vermicompost has shown functional groups of metabolites which indicates stabilization and degradation of Parthenium weed by the vermicomposting process. The FTIR spectra of final vermicomposted mixtures revealed the absence of parthenin toxin and phenols as compared to the initial feed mixture.

Ravindran *et al.,* (2013) indicated FT-IR spectroscopy for biodegradation of fermented animal fleshing mixed with leaf litter and cow dung using earthworm *Eudrilus eugeniae.* The results revealed that the appearance of COO groups and relative reduction in

OH, CH_3 and CH_2 groups in vermicomposted mixtures indicated a decrease in aliphatic compounds and organic waste mineralization.

Zaha *et al.,* (2013) reported that pH values and EC values for the three samples (vegetable waste, Sewage sludge and Sawdust) of composts at the end of the composting process are optimal for agricultural purposes. The FTIR spectra confirm the biodegradation of complex compounds such as proteins, poly carbohydrates, amino acids, etc. into simpler compounds like carboxylic acids, alcohols, phenols, amines and their salts, amides, etc.

Bhat *et al*., (2014) studied SEM to identify surface changes in pressmud sludge mixed with cow dung in the presence of earthworm *Eisenia fetida.* The final vermicomposted samples confirmed the greater number of surface changes which indicates the mineralization of organic wastes. Fu *et al.,* (2014) reported that SEM of the vermicomposting process resulted in a more compacted structure of organic materials as compared to undigested substances. Vermicomposts processed by *Eisenia foetida* exhibited a distinct physical appearance in contrast to the substrate after the gut transit process, as evidenced by the more homogenous surface obtained. Similarly, P, K, Mg and Ca content increased in vermicomposted materials compared to controls.

Lakshmi *et al.,* (2014a) recorded the FTIR spectrum of leaf extract of *Clitoria ternatea* and confirmed the presence of phenols and alcohols with a peak at 3389.57 cm^{-1} corresponded to hydroxyl and O-H bonding frequency respectively. The peak at 2925.41cm^{-1} and 2856.66 cm^{-1} are assigned to the C-H stretching which means that some alkene compounds are present.

Lim *et al.,* (2014) studied SEM to identify texture changes in palm oil mill effluent amended with soil or rice straw in the presence of *Eudrilus eugeniae*. The SEM results revealed that the initial raw mixture was characterized by long fibers. However, the final feed mixtures were more porous and fragmented. The study indicated that the earthworms digested and fragmented rice straw leading to more surface area in the final vermicompost.

Rajpal *et al*., (2014) studied SEM during the vermicomposting of organic fractions of municipal solid waste and sewage. The results revealed that the final feed mixtures showed a different physical appearance than the initial raw waste. The initial raw waste was characterized by loosely packed fluffy and rod-shaped cells. However, spherical cell-like structure and reduction in rod-shaped cells were observed in the final feed mixtures. The final vermicompost was completely digested indicating that the complete degradation was observed in the presence of earthworms and microbes.

Kumar *et al.,* (2014) evaluated the vermicompost maturity using the SEM technique during vermicomposting of flower waste. The study observed that the vermicompost particle size was smaller than the control. The final vermicompost showed numerous surface features than the control which confirms the compost maturity.

Unuofin and Mnkeni, (2014) confirmed the extent of humification using SEM analysis in the vermicomposts of cow dung-waste paper mixtures. The well-humified products and fine-grain textures were produced by the worm stocking densities of 12.5 g worms per kilogram.

Bhat *et al.,* (2015) also applied SEM technique to identify the surface changes in the pre-and post-vermicomposted samples of sugar beet mud and pulp in the presence of *E. fetida*. The aggregates of biomass were observed in the initial feed mixtures, whereas in the final feed mixtures, the lignin and protein matrix was defragmented by earthworm *E. fetida* resulting in high-quality vermicompost with high porosity.

El Ouaqoudi *et al.,* (2015) used FTIR spectroscopy analysis for the evaluation of lignocellulose compost maturity (date palm waste). The infrared spectroscopy revealed an increase in aromaticity and polysaccharide reduction which indicates an increase in humification/ mineralization during the composting process.

Hussain *et al*., (2016b) studied SEM to identify the disaggregation of Salvinia weed during vermicomposting. The micrographs of the final vermicompost revealed strong disaggregated material as compared to that of the initial mixtures which showed contiguous structures. The SEM images reflect the mineralization of Salvinia weed.

Lim and Wu, (2016) studied FT-IR spectroscopy for vermicompost maturity of decanter cake produce from palm oil mill. The infrared spectroscopy of initial feed mixtures was characterized by a broad peak at 3282 cm^{-1} (O–H stretch), 2921 and 2852 cm^{-1} (C–H stretch), 1743 cm^{-1} (C=O stretch) and an intense peak at 1031 cm^{-1} (C–O stretch) region. After vermicomposting, the infrared spectra of final feed mixtures showed reductions in 3100–3600, 2921 and 2852 cm^{-1} regions and could be due to the mineralization of carbohydrates and aliphatic compounds.

Bhat *et al*., (2017) have reported that FT-IR spectroscopy technique is used to confirm the decomposition of polypeptides, polysaccharides, aliphatic, aromatic, carboxylic, phenolic groups and lignin during vermicomposting of organic wastes and SEM micrograph of final vermicompost reveals disaggregation of compost.

Manohara and Balagali, (2017) observed that scanning electron microscopy (SEM) on the 10th day of the composting process showed small cavities created on the surface of solid material. The size of the cavities increases further towards the 20th day and the dense solid material surface starts to become porous towards the 30th day of composting process. The porous surface starts breaking into smaller portions and the size of the solid materials goes on decreasing on the 60th (final stage) day of composting. FTIR spectra indicated intense peaks at 1500–1800 cm^{-1} and weak absorptions at 2800–3200 cm^{-1} region.

Arumugam *et al.,* (2018) proclaimed that characterization of the vermicompost prepared from paper cup with FT-IR shows high degradation of the carboxylic and aliphatic group. SEM analysis shows the disaggregation of cellulose and lignin. The increase in calcium (ranging from 50%) and sodium content (ranging from 30%) in vermicompost and 64% and 26% in vermicompost with bacterial consortium. The maximum increase of magnesium and total phosphorous was observed in vermicompost with bacterial consortium than in vermicompost. A slight increase in potassium content was recorded in vermicompost than in vermicompost with bacterial consortium.

Elango and Govindasamy, (2018) worked on the structure, morphology and composition of carbon in temple waste flowers analyzed by SEM and it has shown a greater surface area, well-developed porosity and good carbon composition.

2.2 Review of Biometric and Biochemical Parameters of Crops

Ansari and kumar, (2010) observed that great influence on plant growth parameters due to the application of organic fertilizers vermicompost and vermiwash combination when compared with control and chemical fertilizers. The average yield of Okra showed a significantly greater response in comparison with the control by 64.27%. The fruits were found to have a greater percentage of protein content when compared with those grown with chemical fertilizers by 19.86% respectively. Joshi and Vig, (2010) stated that application of vermicompost (15%) amended with soil enhanced the seed germination, growth, yield and quality of tomato plants under field conditions.

Sinha *et al.,* (2010) proved that plants grown (*Pisum* and *Cicer*) in vermicompost pre-treated soil exhibited a maximum increase in all morphological parameters such as root length, shoot length, number of stem branches, number of leaves, number of flowers, number of pods and number of root nodules in four months sampling in comparison to untreated, FYM (Farm Yard Manure treated and DAP (Diammonium phosphate) treated soils.

Goutam *et al*., (2011) suggested that the combined application of vermicompost (50%) + NPK (50%) promoted the yield (338.7 q/ha) of tomato. Khan and Ishaq, (2011) indicate that the integrated effect of all the nutrients present in vermicompost results in increased growth of *Pisum sativum* plants in a very short period. Vermicompost also played a crucial role in improving soil properties, increasing crop yield and having a tremendous effect on the growth of *Pisum sativum* as compared to pit compost and garden soil (control).

Nada *et al.,* (2011) reported that the physical and chemical properties of the soil improved with increasing application rates of vermicompost. In addition, soil treated with vermicompost showed significant increases in fresh and dry matter yields of the grass, as well as enhanced uptake of nutrients by the grass. Shadanpour *et al*., (2011) reported that the combined application of vermicompost (40%) + sand (30%) + soil (30%) enhanced the fresh weight (230.5 g) and dry weight (19.7 g) of marigold. Singh *et al,* (2011) showed that the application of N, P_2O_5, K_2O fertilizer, vermicompost, mulch of dried crop residues and 50% irrigation is the most suitable and sustainable strategy to improve plant growth, pod formation and pod yield of French bean and soil health.

Abbiramy and Ross, (2012) concluded that the vermicomposted coir pith + cow dung (1:1) enhanced the growth and physiology of *Abelmoschus esculentus.* Lenin *et al*., (2012) found that combined application of (5 t/ha) vermicompost + arbuscular mycorrhizal fungi enhanced the shoot length (34.6 cm/plant), root length (30.4 cm/plant), root nodules (404.6), chlorophyll ‘a’, chlorophyll ‘b’ and ‘total’ chlorophyll content in groundnut.

Rahman *et al.,* (2012) investigated the effects of biocompost, cow dung compost and NPK fertilizers on the growth and yield components of chili. Plant height, leaf number, primary branch, secondary branch, root number, root length and flower number were highest for biocompost (3 kg/pot) + NPK (T1) treatment and lowest in T15 (control) treatment, with a significant difference. It has been concluded that the compost produced by bacteria and kitchen waste has high nutrient values which can be used effectively as biocompost.

Upadhyay *et al*., (2012) investigated that the combined application of NPK (40: 20: 20 kg/ha) + farmyard manure (5 t/ha) + vermicompost (2 t/ha) sustained the highest fresh yield (240.5 q/ha) and quality of mint. Vanmathi and Selvakumari, (2012) revealed that vermicompost seems to maintain the soil which is ideal for the growth of the plant. The highest yield of *Hibiscus esculentus* was found in vermicompost treatment (T-1) followed by urea (T-2) and the lowest in control. Application of vermicompost increased the vegetative growth and yield of *Hibiscus esculentus*.

Vijayakumari *et al*., (2012) reported the yield obtained on 90 DAS was found to be the maximum in plants applied with panchagavya, humic acid and micro herbal fertilizer (T_3). The maximum pods (10.5), the number of seeds (25 seeds plant^{-1}), ascorbic acid (0.72 mg g^{-1}) and protein (1.37 mg g^{-1}) content of the harvested seeds were significantly increased due to the combined inoculation of panchagavya, humic acid and micro herbal fertilizer (T3). The physical characteristics and macronutrient contents of the post-harvested soil (N (88), P (8.6) and K (325) kg ha^{-1}) were higher in panchagavya, humic acid and micro herbal fertilizer treated soil compared to other treatments.

Wani and Rao, (2012) examined the vermicompost prepared from cow dung, garden waste and kitchen waste in combination were used for brinjal plants under field conditions. Plant height, number of leaves and fruit weight were higher in the vermicompost-treated field as compared to the control (without vermicompost) and no disease incidence was observed in the fruits of the vermicompost-treated plot.

Abduli *et al.*, (2013) demonstrated a significant rise in the growth of tomato plants by increasing the ratio of vermicompost combined with soil. The main stem diameter, height, number of leaves per plant, and yield of tomato plants obtained the highest rate in four tested beds after 40 days in vermicompost to soil ratios of 1:1, 2:1, 3:1, and 4:1 respectively.

Arguello *et al*., (2013) stated that vermicompost increased biomass and improved the distribution of photoassimilates and consequently, the growth of plants under treatment.Gebeyehu and Kibret, (2013) indicated that the mature organic compost improved the plant height, leaf length, leaf diameter and leaf number when compared to inorganic fertilizer.

Gopinathan and Prakash, (2013) identified the plant growth parameters Shoot length, root length and number of root nodules and yield of Black gram (*Vigna mungo* L. Hepper) was enhanced due to the application with vermicomposted vegetable waste.

Ghosh *et al.*, (2013) reported that combined use of soil at 30-40% and rest vermicompost (60-70%) as growing media can meet the crop nutrient demand throughout the growth stages for increasing yield and quality of the sweet corn through the improvement of soil physical, chemical and biological properties. Jesikha, (2013) showed that the highest leaf weight, weight of stems, and root weight were observed in *Plectranthus amboinicus*, *Morinda citrifolia* and *Jatropha curcas* in 75% concentration of vermicompost medium. 75% concentration of vermicompost promotes required nutrition to the plants compared to 50%, 25% and control. In 100% medium, the plant's growth was retarded because of the high amount of minerals in the plant medium This result identified that the plant growth also depend upon the quantity of vermicompost applied in the plant medium. Kashyap *et al.*, (2013) analyzed that continues and slow release of nutrients from vermicompost prolongs the growth and development of *Bacopa Monnieri* when compared with the MS media. In different fractions of vermicompost studied, 30% of vermicompost has given the best results.

Kavitha *et al.,* (2013) investigate that the combined application of *Azospirillum,* chemical fertilizer and vermicompost (T8) improved the shoot length, fresh and dry weight and the number of leaves. Also, it increased the protein, total carbohydrates, phosphorus and iron content of the *Amaranthus tristis* plants. Najar and Khan, (2013) stated that vermicompost at (2 t/ha, 4 t/ha and 6 t/ha) increased the germination of seeds, growth and development of *Lycopersicum esculentum*.

Pariari and Khan, (2013) revealed that the combined application of vermicompost 150% + urea 50% enhanced the number of umbel per plant (26.05), number of seeds/umbel (41.10) and seed yield (10.15 q/ha). Tatlari *et al.,* (2013) evaluate the changes induced by the different levels of vermicompost (0%, 25%, 50%, 75% and 100%). In comparison to the control samples, the increased amounts of parameters related to the growth and development including leaf fresh and dry mass and area, as well as plant height in vermicompost treated plants indicated that the application of different levels of the used vermicompost had stimulating effects on growth and development of *Dracaena marginata*.

Asgharipour and Shabankareh, (2014) concluded that vermicompost promotes the rate of germination, seedling growth, dry weight of shoot and root of okra (*Abelmoschus esculentus*). Biswas, (2014) examined that different treatments in combination with green compost and microbial bioinoculants showed positive effects. A significant increase in growth was recorded in T_1 i.e. potassium mobilizer combined with green compost. Maximum root length, shoot length, the number of leaves, fresh weight and dry weight (43.5 g) were recorded in T_1 *(Frateuria aurentia*) treated plants than control and other treatments in both 15 and 45-day-old plants. Other treatments which also influenced the growth and yield were T_2 and T_3. The combination of microbial biofertilizer along with bio manures gave maximum growth.

Dhanalakshmi *et al.*, (2014) concluded that 50% of vermicompost treated soil enhanced the root length of okra and chili 30, 60 and 90 days after planting. Gopinathan and Prakash, (2014) investigated the effect of vermicompost with biofertilizers on the growth and yield of tomato plants. Observations indicate that T4 showed significantly high performance in whole plant height, number of leaves per plant, number of branches, length of the root, number of fruits per plant, and harvest index compared to T0, T1, T2 and T3.

Kirar *et al.*, (2014) investigated the combined application of (75%) NPK + vermicompost + Azotobacter + Phosphate solubilizing bacteria enhanced plant height and the number of leaves of China aster. Kumar *et al.*, (2014) stated that the organic fractions of vermicomposted flower waste and microorganisms in the biofertilizers could be alternatives to chemical fertilizers in improving the growth and yield of groundnut. Sandeep *et al.*,(2014) determined that the combined application of vermicompost (50%) + poultry manure (50%) increased the growth and yield of radish. Olabiyi and Oladeji, (2014) experimented on *Trichoderma harzianum* incorporated into neem, cassava, sawdust and tithonia composts to have a significant effect on the plant height, number of leaves, root length, number of the pod, pod weight and number of the seed of okra.

Oyedeji *et al.*, (2014) compared the growth, yield, and proximate composition of *Amaranthus hybridus*, *Amaranthus cruentus*, and *Amaranthus deflexus*, grown with poultry manure and NPK concerning the unfertilized soil. Length, number of leaves, the order of growth parameters and yield in the three *Amaranthus* species was higher in this order NPK >PM> control. NPK-grown *Amaranthus* species had the highest protein while Poultry

Manure (PM) grown vegetables had the highest ash content. The *Amaranthus* grown with NPK and PM had better growth but differs in nutritional quality. *A. hybridus* and *A. deflexus* was recorded with maximum carbohydrate content in poultry manure.

Saraswathy and Prabhakaran, (2014) stated that application of vermicompost 30% mixed with 20% of soil enhanced the germination, shoot length, root length, number of leaves, fresh weight and dry weight in tomato. Saravanan *et al.,* (2014) revealed that vermicomposted wastes like cow dung, leaf litter, flower waste and onion garlic waste enhanced the growth and yield of cowpea.

Singh *et al*., (2014) stated that combined application of vermicompost (2.5 t/ha) + FYM (12.5 t/ha) + biofertilizer (2.5 kg/ha Azospirillum + 2.5 kg/ha phosphate solubilizing bacteria) enhanced the number of leaves (96.12), number of fruits (17.97), fresh weight of fruits (37.86 g), dry weight of fruit (18.02 g), chlorophyll 'a' (0.59 mg/g), chlorophyll 'b' (0.9 mg/g) and protein content (0.25 mg/g) of chilies. Verma *et al*., (2014) reported that the application of vermicompost (4 t/ha) enhanced the leghaemoglobin content in root nodules (1.94 mg/g) of fenugreek as compared to the control (1.07 mg/g). Zahedifard *et al*.,(2014) revealed that nitrogen (100 kg/ha) + vermicompost (15 t/ha) can be recommended and used at efficient levels to improve grain yield and oil yield of Rapeseed and to avoid the unfavorable effects of high nitrogen levels.

Badar *et al.,* (2015b) revealed that all three treatments (composted and uncomposted tea waste with bottom ash) increased root and shoot lengths of experimental plants as compared to control. Composted tea waste integrated with bottom ash showed maximum improvement in root length non-significantly and shoot length significantly. Biochemical constituents of experimental plants such as % carbohydrate (0.31), % protein (0.23) and total chlorophyll contents were also increased non-significantly by all treatments, except treatment with composted tea waste with bottom ash significantly improved total chlorophyll content of cow pea plants (2.61 mg/gm).

Badar *et al.,* (2015c**)** observed that all four treatments (composted peanut shells, uncomposted peanut shells, composted sawdust and uncomposted sawdust) increased root lengths of chickpea plants but composted sawdust significantly increased root length of experimental plants. Similarly, all treatments also promoted shoot lengths but composted peanut shells significantly increased the maximum shoot length (25 cm) of chickpea plants.

As concerned with fresh and dry weights of experimental plants both composted (2.24 and 0.52 g) and uncomposted (2.16 g and 0.49g) sawdust significantly enhanced the fresh and dry weights of chickpea plants. Composted organic materials enhanced growth as compared to uncomposted materials. Chavan *et al*., (2015) stated that application of vermicompost enhanced the number of leaves (3), number of seeds per pod (7.5), the weight of seeds (1.62 g), fresh and dry weight (0.56 g and 0.17 g) of cluster bean.

Kalaiyarasan *et al.,* (2015) recommended that seriwaste compost be practiced in mulberry to produce high-yielding and healthy leaves to improve the silk yield and also sericulture waste serves as a good source of organic nutrients. Samadhiya *et al.,* (2014) identified that shoot length and the number of leaves of plants were maximum in TR-1, TR-2 and TR-3 treatments respectively and in control. Hence it can be concluded that the effect of vermiwash and vermicompost on the growth, development of leaves and stem of brinjal plants is more significant in comparison to control (soil and dung only).

Thenmozhi, (2015) studied the effect of different ratios compared, the coir pith compost prepared in equal ratio with cow dung was significantly superior to all other treatments and recorded the maximum shoot length, shoot weight, root length, root weight, number of leaves, flowers and fruits of *Abelmoschus esculentus*. Umekwe *et al.,* (2015) found that compost improved the vegetative growth and yield of fluted pumpkin boost fluted pumpkin productivity

Alwaneen, (2016) reported that plant height and fresh biomass yield increased with the addition of cow manure vermicompost to the soil. The plant height (85 cm and 67 cm) and fresh biomass yield (123g and 89 g) of alfalfa and *vinca rosa* were increased in T5 (100% vermicompost) treatment compared with other treatments.

Chaudhari *et al*., (2016) proved the application of biocompost (2 t/ha) significantly produced the highest seed (909 kg/ha), straw yield (1771.56 kg/ha), protein content (21.44%) and protein yield (195.18 kg/ha) in green gram. Ravimycin, (2016) states that the application of 50% vermicompost and 50% soil significantly increased the morphological characters, pigment composition, protein and nutrient content of coriander plants on 90 DAS.

Sakthivigneswari and Vijayalakshmi, (2016a) reported that T6 (Raw coir pith predigested by using *Pleurotus sajor-caju* and *Eudrilus eugeniae* 5t ha^{-1}) and T3 (Raw corncob predigested by using *Pleurotus sajor-caju* and *Eudrilus eugeniae* 5t ha^{-1}) treatment of biocompost applied to soil increased vegetative growth and yield parameters of *Solanum nigrum*.

Clautilde *et al.,* (2017) found that X2 (0.5 Kg dried manure + 0.5 composted manure) treatment improved significantly the growth parameters of carrot plants compared to other treatments at 70 days after sowing. X2 treatment presented the highest height and the maximum number of leaves per plant. Dada *et al.,* (2017) revealed that the compost supplied sufficient plant nutrients needed for improving biological and economic yields of *Amaranthus cruentus*. The application of compost significantly influenced the growth, dry matter and fresh shoot yield of *A. cruentus*. Applying a combination of *Arbuscular Mycorrhiza* fungi (AMF) and compost to nutrient-limiting soil had no significant effect on yield and yield components of *A. cruentus.* The proximate composition of *A.cruentus* was significantly enhanced in pots augmented with compost better than in pots amended with the combination of AMF and compost.

Indumathi, (2017) revealed that green gram seeds was shown to be higher in the microbial inoculum added to compost. Stem length and root length were found to increase in experimental compost than in the control and the maximum plant height was observed in the microbial culture added vegetable waste compost. Reddy *et al.*, (2017) reported the effect of vermicompost, cow dung and different organic manures combination on the growth and yield characteristics of chilis (*Capsicum annuum* L.). The results indicated that plant height, number of leaves, number of primary branches increased significantly with all these treatments. Combination of vermicompost at 2.5 t ha^{-1} and FYM at 12.5 t ha^{-1} shows the maximum plant height (42.23 cm), higher number of leaves (84.22), number of primary branches/plant (12.75), compared to the untreated control (the height of plant 46.27 cm, the number of leaves 45.31, primary branches 4.78. After investigation, it was found that the application of vermicompost and farmyard manure recorded significantly higher growth and yield characters than other treatments.

Salles *et al*., (2017) used different organic composts in the production of *Eruca Miller arugula*, with improved plant growth and productivity achieved by fertilization with poultry manure, cattle manure and filter cake. Sophi and Krishnaswamy, (2017) reported that Vermicompost enhances soil biodiversity by promoting the beneficial microbes which in turn enhances the growth of *Lycopersicon esculentum.* Akoijam *et al.*, (2018) observed that amendment of flower waste leads to an overall increase in the productivity of *Solanum melongena*. Increase of 11.7cm in height, 13 leaves, 5cm in root length and 3.4 g of biomass in the flower waste amended pots.

Gupta *et al*., (2018) showed that the combination of organic fertilizers, vermicompost and vermiwash greatly influenced okra plants growth parameters when compared with control. Among the five treatments, Treatment T3 (Soil + vermicompost +1/2 recommended dose of NPK) was most effective for all growth parameters of okra. Rekha *et al.,* (2018) reported that Chilly plants grown in 50% vermicompost amended soil showed an enhanced growth rate when compared to plants treated with plant growth regulators (PGR). The results indicate that vermicompost can be exploited as a potent biofertilizer.

Chaudhary and Mishra, (2019) proved that kitchen waste compost (KWC) has good potential to improve the physical growth of tomato plants. Application of KWC 60% (T3) showed positive results followed by 20% KWC (T1) + 80% soil, 40% KWC + 60%soil (T2) and 100% soil (C).

Dey *et al.,* (2019) observed that vermicompost has a rich nutrient content of nitrogen, phosphorus, potassium, iron, zinc, manganese and copper. King Chilli plants grown in vermicompost mixed with soil shows the highest growth parameters followed by plants grown in compost and soil medium while less plant growth was found in soil. Meena *et al*., (2019) indicate that the application of 150% RND as poultry manure gave higher bulb (270.84 q ha^{-1}) and haulm yields (35.13 q ha^{-1}) in Onion than other sources and levels of organic manures.

Pandey *et al.,* (2019) revealed that plant height, no.of leaves, pod, no of branches, root nodules and yield of green gram were found maximum in T3 (75% NPK +5t FYM ha^{-1} + Biofertilizer (PSB+Rhizobium) followed by T4 (50% NPK+5t FYM ha^{-1}+ Bio-fertilizer) than T2 (100% NPK). Thus integrated application of inorganic and organic sources (Vermicompost + FYM) maximized the yield of green grams.

Purbajanti *et al.,* (2019) concluded that different doses of cow manure and NPK 16 affected the growth and physiology of peanut plants. Application of 10 ton/ha cow manure and 100 kg/ha NPK 16 fertilizer showed the highest plant height, total chlorophyll content and ANR (Activity of Nitrate Reductase). Senevirathne *et al.,* (2019) determined combined application of 25% Compost with 75% Biochar (T4) could be used instead of inorganic fertilizer to enhance growth in *Glycine max*. while T4 significantly increased the height, leaf area, nodule and chlorophyll content in *Glycine max*.

Al-Sabbagh *et al.*, (2020) observed that lettuce and Kale in the short-term potting experiment have revealed that the addition of compost generated from the dead sheep disposed of the animal using Ecodrum has proved and also provided a solution for increasing the yield of crop plants grown in container pots. Container pots with the sheep compost also showed slightly higher values concerning plant growth and biomass yield in comparison to the use of compost available in the local market.

Ashish and Kumar, (2020) reported that the application of 75% N + Full P, K + *Azotobacter* sp.+ *Bacillus* sp. + *Pseudomonas* sp. treatment had significantly increased the growth and yield attributing parameters of rice crops. Sekhar *et al.*, (2020) concluded that the application of treatment T5 [N (20Kg/ha)+K (20Kg/ha) + PSB(I)] was found to be the best treatment for obtaining higher growth and yield attributes *viz.*, plant height at 60 DAS, dry weight at 60 DAS, crop growth Rate (9.78 g m^{-1} 2 day) at 60 DAS, number of branches/plant at 60 DAS, number of nodules/plant at 45 DAS and number of pods/plant were obtained with green gram.

Sherinlincy *et al.*, (2020) evaluated biostimulants in bag culture of organic *Amaranthus tricolor* L. Among the biostimulants, humic–fulvic acid mixture @ 3% produced the highest plant height (85.83 cm), leaf length (15.08 cm), leaf width, branches per plant, fresh weight of leaves (225.85 g) and yield per plant (646.01g). Anasuyamma *et al.*,(2022) recorded that the treatment 4 Vermicompost 1t/ha + RDF(100%) – 20:40:20 NPK kg/ha significantly increase plant height (44.75 cm), number of root nodules per plant (18.89), number of branches per plant (8.33), plant dry weight (11.15 g/plant), pods per plant (36.33), seeds per pod (7.00), test weight (37.14 g), grain yield (1294 kg/ha) in Black gram. Raihing and Vijayalakshmi, (2022) have reported that vegetables and fruit waste compost increase vegetative growth and yield parameters of black gram (*Vigna mungo* L.).

Das and Bandyopadhyay, (2011) found that the application of *Rhizobium leguminosarum* and phosphate solubilizing bacteria increased the leghaemoglobin content of nodules, nodule number and fresh nodule weight of *Phaseolus vulgaris* L.

Narkhede *et al*.,(2011) concluded that the application of (20%) vermicompost in red chili enhanced the chlorophyll content (2.9%) compared to the control (2.1%). Tavarini *et al*., (2011) analyzed the effects of green compost used as a soil amendment on soil biochemical characteristics and nutritional aspects of Spinach and Lettuce. The total chlorophyll content in spinach was higher than in lettuce but it decreased with the use of green compost. The lowest value of Chlorophyll ‘a’ content was recorded in plants grown in soil amended with 50% of compost, whereas for this treatment Chlorophyll ‘b’ values were similar to plants grown in soil without compost.

Arvind, *et al*., (2012) concluded that application of vermicompost with soil mixture enhanced the chlorophyll content and yield of wheat. Kumar *et al.*, (2012) revealed that combined application of 80% effluent of painting industry + vermicompost enhanced the chlorophyll ‘a’ (0.451 mg/g), chlorophyll ‘b’ (0.293 mg/g) and ‘total’ chlorophyll content (0.103 mg/g) in *Solanum melongena* (L.).

Befrozfar *et al*., (2013) reported that application of vermicompost (5 t/ha) increased the chlorophyll ‘a’ (17.17%), chlorophyll ‘b’ (13.77%) and yield (24.84 %) of basil. Mishra and Jain, (2013) suggested that the combined application of biofertilizers (250 g) + NPK (50%) + vermicompost (5t/ha) promoted the chlorophyll and protein content in *Andrographis paniculata.* Singh and Vijayalakshmi, (2013) observed that the combined effect of composted coir pith + composted press mud + farmyard manure enhanced the leghaemoglobin content (0.0560 mg/g) in the nodules of green gram on 45 DAS.

Tak *et al.*,(2013) reported that combined application of vermicompost (5t/ha) + foliar spray of zinc increased the total chlorophyll content (1.58 mg/g) of green gram as compared to control (1.42 mg/g). Deshmukh and Jadhav, (2014) found that crude protein and carbohydrates was found higher in leaves of *Clitoria ternatea* L.

Jahanshahi *et al.,* (2014) concluded that seed sowing with vermicompost (32 t/ha) enhanced the growth and chlorophyll content of dill (*Anethum graveolens* L.). Bhardwaj, (2014) revealed that a medium of vermicompost + sand + pond soil (1:1:1) with 2 cm coco peat enhanced germination percentage in papaya seedlings. Lal *et al.*, (2014) conducted field experiment to compare the effect of phosphorus and sulfur fertilizer in chickpea and found the application of 30kg S/ha registered a higher number of nodules (26.1/plant), leghaemoglobin content (0.53 mg/g nodule) in chickpea.

Badar *et al.,* (2015a) found a significant improvement in the growth and biochemical parameters of plants as compared to control plants. JUR2 (*Bradyrhizobia* sp). with carbohydrate content up to 300% while FYM up to 135%. While PM and JUF2 (*Trichoderma* sp.) gave more or less similar results in cowpea plants up to 118%. DAP (Diammonium phosphate) also increased carbohydrate content up to 100%. PM and JUF2 significantly increased the protein content and production of nodules in cowpea plants after 30 days of growth. Therefore, biofertilizers could be a good replacement for chemical fertilizers for improving the growth and biochemical parameters of *Vigna unguiculata.*

Khan *et al.,* (2015) found that combined inoculation of cowpea with Rhizobium and PSB (phosphate solubilizing bacteria**)** coupled with vermicompost (6t/ha) improved the total nodule number and leghaemoglobin content in cowpea. Inoculation with Rhizobium and PSB increased the leghaemoglobin content significantly and their combination in the presence of vermicompost was the most effective among different treatments.

Sivakumar and Karthikeyan, (2016) reported that application of vermicomposted weed plant wastes promoted the vegetative, physical-chemical parameters, chlorophyll a, chlorophyll b and total chlorophyll, in brinjal. Baliah and Muthulakshmi, (2017) observed that the application of enriched vermicompost significantly increased the growth of *Abelmoschus esculentus* (L.) Moench and the soil amendment with different types of microbes enriched vermicompost significantly responds to the biochemical attributes such as total chlorophyll, carotenoid, protein, glucose content, and amino acid content. The effect varied with the nature of microorganisms used for the enrichment.

Vijayalakshmi and Gayathri, (2017) found that the application of different doses of vermicompost was noted significantly higher in Chlorophyll a, b, total chlorophyll, protein and carbohydrate content in chili plant on T3 (19g) treatment. Birla *et al.,* (2018) analyzed that significant improvement of protein content in seed and protein yield, N content in seed and N uptake by cowpea were noted with the application of 50% N through FYM + 50% N through vermicompost + PSB (T8).

Sakthivigneswari and Vijayalakshmi, (2018) revealed that maximum protein and carbohydrate content in leaves and seeds of Soybean was achieved in the application of T6 (Raw coirpith predigested by using *Pleurotus sajorcaju* and *Eudrilus eugeniae* (5t/ha)) treatment. Biama *et al*., (2020) Cowpea line IT97K-1042-3 and "TEXAN PINKIYE" recorded the highest amount of crude protein. IT97K-U99-35 had the highest total carbohydrates.

Ahmed *et al*., (2021) concluded that crude protein content increased with an increase in nitrogen fertilizer supplementation in *Gynura procumbens*. The increase in crude protein percentage was 62.79% when the plants were grown at 300 kg N ha^{-1} compared to no nitrogen application. Selvam and Kumar, (2022) suggest that the banana spathe compost could be used as an effective organic fertilizer for the growth of rice plants. Application of banana spathe extracts and compost increase chlorophyll, carotenoid, carbohydrate, protein, and amino acid content when compared to the untreated control plants.

2.3 Physico-chemical Status of Soil

Ansari and kumar, (2010) observed that a combined treatment of vermiwash and vermicompost was found to have a significant influence on the biochemical characteristics of the soil with marked improvement in soil micronutrients. The combined treatment was found to be better suggesting qualitative improvement in the physical and chemical properties of the soil.

Sarwar *et al*., (2010) revealed that the use of green compost at both levels (5 and 10 %) increased soil pH and EC. Organic matter, N and C % age were enhanced with a net decrease in C/N ratio. An improvement in soil chemical properties and mineral nutrient contents was increased by the addition of green compost. Thenmozhi and Paulraj, (2010) indicate that biocomposted banana pseudostem/sugarcane trash @ 750 Kg ha^{-1} with 75% of the RDF showed a profound influence on the soil available nutrient (N, P and K) status and organic carbon content at the post-harvest stage.

Romina *et al*., (2011) have observed a positive effect of vermicomposts application on soils' chemical and biological properties. Tharmaraj *et al*., (2011) suggested that the application of vermicompost alone or in combination with vermicompost and vermiwash increased the pH, electrical conductivity (EC), porosity, moisture content, water holding capacity and chemical properties like nitrogen, phosphorous, potassium, calcium and magnesium in the Samba rice cultivated soil. Macci *et al*. (2012) reported that the organic fertilizer increases the soil quality in an almond tree plantation by the improvement of the physico-chemical properties of the soil.

Selvamuthukumaran and Neelanarayan, (2012) suggested that the combination of vermicomposted poultry waste and groundnut husk (70:20:10) treated soil increased the level of total N, P, K and Na when compared to the raw poultry waste and pre-digested-poultry-waste. Vijayakumari *et al*., (2012) found that the physical characters and macronutrient contents of the post-harvested soil (N (88), P (8.6) and K (325) kg ha^{-1}) were higher in panchagavya, humic acid and micro herbal fertilizer treated soil compared to other treatments.

Oo, *et al.,* (2015) observed the effectiveness of compost and vermicompost as soil conditioners in alleviating salt-affected soils and increasing maize productivity. Application of compost and vermicompost significantly increased soil organic carbon, soil N, P and K contents. Organic amendments can thus serve as a source of essential nutrients for plants as well as contribute to improve soil properties.

Selvamurugan *et al.,* (2013) confirmed that the application of bio methanated distillery spent wash and biocompost (5t/ha) increased the electrical conductivity, available nitrogen, phosphorus and potassium content of post-harvest soil of ragi. Menon *et al*., (2014) reported that the application of farmyard manure (10 t/ha) alone induced the nitrogen content, while phosphorus and potassium were induced by the combined application of FYM (10 t/ha) + NPK (50:25:50 kg/ha). Lakshmi *et al*., (2014 b) studied that the combined application of 75% RDF + vegetable market waste compost (2.5 t/ha) to Kharif rice and 50% RDF to rabi green gram promoted the available micronutrients (nitrogen, phosphorus and potassium) in the soil.

Hiranmai, (2015) observed that applications of T10 (Composted poultry droppings at 35 g per pot) and T14 (Vermicomposted poultry droppings at 43.75 g per pot) registered the highest N content (0.57 g kg^{-1}) in the soil after harvest. The highest P content was observed in T14 and T15, N: P: K (0.12 g kg^{-1}) among the treatments. T14 recorded the highest value of 0.88 g kg^{-1} of K among the different treatments. Vermicomposted poultry droppings at 43.75 g per pot application have improved all the macronutrients of the soil.

Bhat *et al.,* (2016) stated that vermicompost is nutrient-rich manure and it acts as a soil conditioner. Vermicompost application increased the available nitrogen, potassium, phosphorus sodium, magnesium, calcium and soil fertility. Almaz *et al.* (2017) state that application of 100% PM and integrated application of 50% NPK+50% PM gave significantly higher soil pH, organic matter (OM), total N, available P, soil exchangeable K and soil CEC (soil cation exchange capacity) soil nutrient availability as compared to control and 100% NPK.

Ambadi *et al.,* (2018) analyzed the combined application of recommended FYM (3 t $ha^{-1)}$ and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1}) followed by Cotton stalks + Redgram stalks + *Glyricidia* sp. with C: N ratio of 30:1 compost @ 50 kg N equivalent at the time of sowing recorded higher major nutrients uptake, microbial biomass and soil fertility status.

Gosal *et al.,* (2018) revealed that the application of mineral NPK in combination with 50% N through compost significantly increased the organic matter content (0.36%), available phosphorus (16.50 kg/ha) and available potassium content (239.80 kg/ha) in soil. The maximum available N (225.12 kg/ha) was found by the substitution of 50% N through sewage sludge. This improvement in soil nutrient status through the combined use of organic and inorganic fertilizers.

Mahmud *et al.,* (2018) reported that the application of vermicompost produced from fruits were significantly larger with smaller crowns, but contained slightly lower total soluble solids content (TSS). The results of soil analysis showed that the application of vermicompost had significantly increased the soil pH and was able to retain the nutrient content in the soil. The use of vermicompost produced from pineapple plants have excellent growth performance. Praveena *et al.,* (2018) state that fruit waste liquid organic fertilizer improved the soil nutrient, biological properties and the number of bacteria in the soil.

Khalil *et al.,* (2019) concluded that while comparing various treatment groups, treatments having a 1:1 combination ratio (T2, T3, T4 and T5) have shown the best results in the case of pH, EC and N content of post-harvest soil. All the treatments except control have altered the chemical status of soil with favorable soil microbial activity and plant growth.

Surya *et al.,* (2019) investigate that compost with various comparisons of POME (Palm Oil Mill Effluent) 1: 1.3, 1: 1.9 and 1: 2.6 improves the chemical properties of the soil: the total N incubated for 1 month. Compost treatment with various POME 1: 2.6 comparisons give the highest results. Cahyono *et al.,* (2020) indicate that compost could improve the chemical and physical properties of soil, which were significantly different from those of the control.

Ben-Laouane *et al.*, (2021) reported that compared with the initial soil status, the compost (10 t/ha) combined with AMF (Arbuscular Mycorrhizal Fungi) and rhizobium significantly improved the organic matter, N and P content, decreased soil pH and increased electrical conductivity. Japakumar *et al.*, (2021) reported that the combination of biochar and compost gave the best results in soil organic matter (10.25%) and soil organic carbon content (5.95%) compared to other treatments.

2.4 Antibacterial and Antioxidant activity

Prabha and Vasantha, (2011) clearly showed that *Calotropis procera* flowers have powerful antioxidant activity against various antioxidant systems in vitro; moreover, these extracts can act as cytotoxic agents. Hence it can be used as an easily accessible source of natural antioxidants in pharmaceutical applications. Tavarini *et al*., (2011) analyzed the antioxidant capacity of DPPH assays and reported higher values in spinach as compared to lettuce extracts.

Mahdi-Pour *et al.*, (2012) investigate the antioxidant activity of methanolic extracts of *Lantana camara*. Results showed scavenging effects of leaves, flower, root and stem extracts on DPPH radicals were excellent, especially leaves extract of *L. camara* exhibited great potential for antioxidant activity.

Aminifard *et al.*, (2013) observed that sweet pepper fruit antioxidant activity increased with increasing compost levels, and the highest fruit antioxidant activity was obtained from 10 t ha^{-1} of compost treatment (81.7%), while the control (without compost application) had the lowest fruit antioxidant activity (73.4%).

Barman *et al.*, (2013) determined the antioxidant potential of various extracts (ethanol, acetone and aqueous) by using DPPH assay, ABTS assay and metal chelating activity assay. Among the extracts, the ethanol extract of nut showed significant scavenging activity compared with antioxidant controls, ascorbic acid and BHA respectively. The *Semecarpus anacardium* extracts prove to be a potent source of biologically active compounds that can be further subjected to the isolation of therapeutic antioxidant agents.

Lakshmi *et al.*, (2014 a) showed that the leaf and flower extracts of *Clitoria ternatea* have antioxidant activity against in vitro-generated radicals like DPPH, hydroxyl radical and hydrogen peroxide. Pramanik *et al.*, (2014) reported improvement in the DPPH radical scavenging potential of red amaranth on thermal treatment compared to the control. The activity was maximum (from 85.28 to 95.12 mM ascorbic acid equivalent/gm sample,) upon extraction at 60^{o}C. However, significant improvement was observed in the reducing power assay and maximum activity was found upon extraction at 80^{o}C (from 25.41 to 28.71 mM/gm sample) The improvement in the total phenolic content was also in consonance with the reducing power assay, where significant improvement was observed in case of all three extraction conditions. Kazimierczak *et al.*, (2016) conventionally and organically produced two varieties of (Polka and Polana) raspberry fruits that were analyzed for antioxidant activities. The organically grown varieties possess strong antioxidant activity (Vitamin C, total phenolic acids, total flavonoids and total anthocyanins) than conventionally cultivated ones.

Gbadamosi and Afolayan, (2016) studied the nitric oxide radical scavenging activity of various extracts (water and ethanol) of *Solanum nigrum* berry, leaf, stem and root. The highest activity was observed for water extract (0.36 nm) of the berry followed by the leaf (0.32 nm) and ethanolic extract of root (0.13 nm). Sereme *et al.*, (2016) reported that organic fertilizer increased the antioxidant activity (16.36 mg Trolox Equivalent (TE) /100g fresh tomato fruit) and total phenol content (6.96mg Gallic Acid Equivalent (GAE) /100g fruit) of tomatoes under mineral fertilization and the control (without fertilization).

Singh *et al.*, (2017) indicate that the flowers of *Mentha longifolia* were extracted with different solvents and studied their antioxidant activities such as total antioxidant capacity, DPPH radical scavenging and ABTS radical scavenging activities. The total antioxidant capacity noted was 7.00±0.378µmol ascorbic acid equiv/g extract, 78.915±0.353% DPPH inhibition and 8.403±0.859µmol Trolox/g ABTS radical scavenging activities.

Silva *et al*., (2018) determined that organic Lettuce had better performance as regards to phenolic compounds contents and antioxidant potential. The source of organic fertilizer is responsible for the effectiveness of antioxidant capacity and levels of phenolic compounds. Dushing and Surve, (2019) studied the antioxidant capacity of *Madhuca indica* L. flower extracted with water and investigated the efficiency of inhibiting DPPH radicals. The antioxidant capacity (DPPH radical scavenging activity) was 64.87%.

Farooq *et al*., (2019) proved that hydro-alcoholic extracts of leaves and dried fruits of *Murraya koenigii* have higher antioxidant activity as compared to the aqueous extracts of leaves of *M. koenigii* and dried fruits of *Ficus carica* L. Djeussi *et al.*, (2020) evaluated the antioxidant activity of thirteen Cameroonian plants which previously displayed antibacterial activities. Thirteen plant extracts exhibited high antioxidant activities correlated to their reducing power. They possess total reducing powers and free radical scavenging power against DPPH and Nitric Oxide (NO). Lenny and Rizky, (2020) evaluated that 15 wt % of methanolic extract of *Vigna unguiculata* (L.) Walp leaves as potential antibacterial showed a moderate diameter inhibition zone against *S. aureus* with a value of 15.5 mm. The antioxidant activity of methanolic extract has strong antioxidant activity with 66.71 mg.

Naik *et al*., (2021) investigated the antimicrobial activity of both Cinnamon leaves oils and extract by disc diffusion assay and it showed that essential oils and extracts exhibited the highest zone of inhibition (ZOI) against *Staphylococcus aureus* and *Escherichia coli*. Minimum inhibitory concentration (MIC) of both oils and extracts ranged from 0.156 mg/ml to 5mg/ml and the antioxidant properties of oils and extract of cinnamaldehyde type Cinnamon possessed the highest antioxidant activity than linalool type.

Alfarrayeh *et al*., (2022) evaluated *Inula viscos*a revealed the highest antibacterial effects against all bacterial species under examination followed by *Sarcopoterium spinosum*. Gram-positive bacteria showed higher susceptibility to the MPEs (methanolic plant extracts) than Gram-negative bacteria. Antioxidant capacity and polyphenolic content investigations revealed that *S. spinosum* and *I. viscosa* have the highest antioxidant activities and the highest amount of phenolic compounds.

2.5 Phytochemical Analysis and Mineral composition of Plants

Sharafzadeh and Ordookhani, (2011) stated that medicinal plants are very important in modern civilization to obtain natural active substances, known as secondary metabolites. The production of natural substances by plants is affected by genotype and environmental conditions, whereas continuous usage of inorganic fertilizer affects soil structure. Hence, animal and plant manures, compost and vermicompost can serve as an alternative to mineral fertilizers for improving soil structure and microbial biomass. Sajid, (2011) studied the active photo components of *Fagonia cretica* using phytochemical analysis. Phytochemical analysis showed the presence of tannins, alkaloids, flavonoids and saponins.

Padalkar *et al*., (2013) reported that phytochemical and pharmacognostic studies on *Anthocephalus cadamba* by using ethanol and distilled water extract have shown the presence of flavanoids, alkaloids, phenolic compounds, tannins and glycosides.

Parameswari and Ananthi, (2013) observed that the phytochemical analysis of *Mukia maderaspatana* L. showed the presence of various phytochemical constituents which are very useful for various treatments. Saxena *et al*., (2013) state that phytochemicals have been categorized based on their function, physical and chemical characteristics. Phytochemicals get accumulated in various parts of the plant body including the parts like leaf, flower, flower bud, root, stem, seed, fruit, etc.

Uddin *et al*., (2014) carried out a phytochemical investigation of leaf petiole of *Pterospermum acerifolium*. Methanolic extract showed the presence of tannins, saponins, steroids, terpenoids, coumarins and betacyanins.

Balabhaskar and Vijayalakshmi, (2015) reported that the Phytochemical analysis of *Bauhinia tomentosa* showed the presence of alkaloids, tannins, saponins, flavonoids, quinones, phenols, reducing sugars and calcium oxalate crystals. Santhoshkumar and kumar, (2016) observed that water, alcohol and chloroform extracts of *Annona squamosa* leaves showed the presence of glycosides, alkaloids, oils, saponins and flavonoids. Ogbonna *et al*., (2016) reported that phytochemicals act as a natural defense system for the host plants and they are responsible for the protection of such plants from environmental stress, microbial attack, insects, and other external aggression.

Yamuna *et al*., (2017) found the presence of tannins, phenols and saponins in ethanolic and aqueous extracts of *Gomphrena globosa*. *Gomphrena decumbens* showed the presence of proteins, tannins, phenols and saponins in both extracts. Tiwari *et al*., (2018) reported that *Achyranthes aspera* leaves showed the presence of alkaloids, flavonoids and coumarins. Inflorescence showed presence of alkaloids, flavonoids, saponins and coumarins, stem showed the presence of tannins, alkaloids, saponins and coumarin contents. Root showed the presence of tannins, alkaloids and coumarins.

Yadav and Saravanan, (2019) evaluated the phytochemical analysis of *Curcuma caesia* showed the presence of diterpenes and carbohydrates in chloroform, ethyl acetate, methanol and aqueous extracts and *Curcuma amada* showed the presence of proteins in all the extracts. Kousalya and Doss, (2020) observed the phytochemicals and secondary metabolites in the leaves of *Artabotrys hexapetalus.* Phytochemical screening revealed the presence of alkaloids, flavonoids, saponins, carbohydrates, proteins, amino acids, phenols, glycosides, tannins, sterols and terpenes in different extracts.

Syed *et al*., (2020) explored the phytochemicals of *Tridax procumbens* leaves. The leaves contained the phytochemicals such as alkaloids, carbohydrates, polyphenols and tannins respectively. Tiwari and Gupta, (2020) studied the preliminary phytochemical screening of bark of *Ficus religiosa*. Petroleum ether, chloroform, methanol, ethanol and water extracts revealed the presence of carbohydrates, glycosides, flavonoids, alkaloids, proteins, amino acids, phytosterol and tannins.

Abbasi and Najam-Us-Saqib, (2021) observed the presence of carbohydrates, flavonoids, phenols, tannins, glycosides, proteins, phytosterols and triterpenoids content in buds of *Bauhinia variegata.* Priya and Sharma, (2021) observed the phytochemical analysis of the root, flower and leaf of *Hibiscus rosa-sinensis*. The results revealed that methanolic and aqueous extracts showed the presence of alkaloids, carbohydrates, flavonoids, reducing sugars, polyphenols, cardiac glycosides, phlobatannins, terpenoids, saponins and tannins. Pandian and Ilango, (2022) studied the preliminary phytochemical screening of the leaf of *Huberantha senjiana.* Chloroform, ethyl acetate, n-hexane, isopropyl alcohol and methanol extracts showed the presence of alkaloids, flavonoids, proteins, carbohydrates, etc.

Theunissen *et al.,*(2010) reported that vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B, the uptake of which has a positive effect on plant nutrition, photosynthesis, the chlorophyll content of the leaves and improves the nutrient content of the different plant components (roots, shoots and the fruits).

Hunter *et al.,* (2011) compared the plant food groups such as vegetables, fruits, legumes and grains produced by organic and conventional agricultural methods for total micronutrient content. The micronutrient content of food groups was higher for organically grown vegetables and legumes compared to the conventional method. Maia *et al.,* (2013) found that the macro-and micronutrient contents in cherry tomato leaves under different doses of cattle manure compared to the chemical fertilization were influenced by the addition of the organic fertilizer to the contents of N, P, K, Ca, Mg, S, Mn and Zn.

Biswas, (2014) indicated that the treatment involving vermicompost and green compost showed the highest Ca, Mg and P, uptake. Significant variations were observed in vermicompost-treated *Rumex* plants. The highest total uptake of nutrients (Calcium, Magnesium and Phosphorus) was observed in T_2 and T_3 treatments on both 15 days and 45 days old *Rumex* plants incorporated with green compost. Dania *et al.,* (2014) obtained the nitrogen content of *Moringa oleifera* leaves being significantly improved by Poultry manure with 4.13% compared to the organic mineral fertilizer (2.01%).

Deshmukh and Jadhav, (2014) estimated that the various macronutrients in *Clitoria ternatea*, nitrogen (2.77g) was present in the highest quantity, followed by potassium (1.42g), calcium (0.66g) and phosphorus (0.57) per 100g. A sufficient amount of mineral contents, hence these plants may be useful as feed and fodder for livestock.

Saravanan *et al.,* (2013) indicated that phosphorus and iron content in the seeds were maximum in FYM+10% NPK, Tripartite association showed an increased amount of calcium, sodium and potassium in the seeds. The findings revealed that macronutrients in green gram were influenced by integrated applications of organic manure and chemical fertilizers suggesting that soil amendment with organic manure enhances the macronutrients in green gram seeds.

Kachiguma *et al.*, (2015) state that Amaranths leaves have more nutrition content than grain. The species *Amaranthus hybridus* has shown superior levels of calcium, iron and phosphorous while *Amaranthus cruentus an* amaranth genotype can make a significant nutritional contribution to recommend in human dietary intakes and consequently can contribute to the improvement of the nutritional status.

AL-Kahtani *et al.*, (2018) revealed that tomato plants grown in sandy soil amended by the combination of compost mixture and 40% sheep manure (C5) have the highest concentration of nitrogen (N), phosphorus (P), potassium (K), Ferrous (Fe), Zink (Zn) and manganese (Mn) along with fruit yield, and fruit quality. Ferreira *et al.,* (2018) indicate that the mineral composition of the leaf tissue depends on several factors, including soil and climatic conditions, genetics of the cultivar, growth stage and the bioavailability of nutrients from organic fertilizers, which may vary with the chemical composition and diversity of the material. The concentration of Zn, Mn and Cu in the leaf tissue was similar, whereas the iron content was significantly increased. This was probably due to the excess nutrient content in the organic composts.

Christophe *et al.,* (2019) reported that the mineral contents of *Moringa oleifera* was in general more elevated in all treatments than in the control. Total N content in *M. oleifera* leaves, the most significant increase was recorded when plants were treated with a mixture of fertilizers such as MF3 (4.34%) and MF2 (3.19%). Mg content were, 0.38, 0.38 and 0.37% in PM1 (0.8 kg of soil + 0.1 kg), CM1 (0.8 kg of soil + 0.1 kg of cow dung compost) and CM3 (0.8 kg soil + 0.3 kg cow dung manure compost) treatments in *M. oleifera* leaves respectively. The most elevated P content was recorded in MF3 (0.8 kg of soil + 0.032 kg each of cow dung, goat, chicken manures + 0.003 kg NPK) and PM1 treatments with 0.52% and 0.51%, respectively, compared to 0.17% in the control. Potassium was more concentrated in treatments with up to 3.87% when chemical fertilizer was applied. The organic carbon content in leaves ranged from 32.29% in the control leaves to 39.58% in PM1-treated leaves.

Obidola *et al*., (2019) identified the quantitative phytochemicals that revealed that more phenolics, alkaloids and flavonoids were present in cabbage grown with organic manure than in inorganic fertilizer. Biama, *et al*., (2020) experimented with the nutritional and technological characteristics of cowpea varieties grown in eastern Kenya. Cowpea samples recorded the highest percentage of essential amino acids, non-essential amino acids and minerals (calcium, magnesium, sodium, zinc, potassium & phosphorus).

Das and Biswas, (2020) suggested that the combined application of organic and inorganic fertilizer in sesame cultivation in red and laritic soils will exert significant nutrient uptake by sesame for its improved nutrition and improved productivity. The highest value of different nutrient uptake viz., nitrogen, phosphorus, potassium and sulphur uptake with the higher dose of fertilizer along with Azotobacter and PSB (Phosphorus Solubilizing Bacteria).