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REVIEW OF LITERATURE

The literature pertaining to the present investigation on the effect of composted sugarcane trash and sugarcane bagasse on physico-chemical composition, microbial population, vegetative parameters, biochemical properties, yield parameters of selected crops, soil analysis, soil microbial population, antibacterial activity and antioxidant activity is presented in this chapter.

2.1 REVIEW ON COMPOSTING, PHYSICO-CHEMICAL AND MICROBIAL POPULATION

Organic farming is the low cost and eco-friendly technology used to improve the yield and quality of the crop. Composting is a process where the large particles are broken down into smaller ones by the action of soil micro and macro fauna. Composting application helps in controlling soil erosion increase water holding capacity. Organic manures not only supply nutrients to crops and improve the soil texture in dry lands but also act as good mulching agent. They protect crops against adverse temperature effects, improves seed germination, increase water retention capacity of the soil and create the right micro-climate for the growth of beneficial soil microbes.

Pichler and Knabner, (2000) stated that the compost stability is strongly related to the rate of microbial activity in compost. Ansari and Ismail, (2001) experimented with bio composted paddy straw waste along with cattle dung and three species of earthworm. *Perionys excavates, lampito mauritii* and *Eugenia foetida* reported that the vermicompost has slightly alkali pH scale (7.72).

Nirmalnath *et al.,* (2001) studied the vermicompost microflora as influenced by different crop residues, to enumerate microbial load such as bacteria, fungi, *Azotobacter* and phosphate solubilizing microorganisms in vermicompost obtained from different kinds of crop residues. Among the different crop residues, vermicompost obtained from sunflower crop residue harbored more bacteria ($48x10^5$), actinomycetes ($98.60x10^4$) and phosphate solubilizing microorganisms ($25x10^4$), while vermicompost from sugarcane trash was found to have more number of *Azotobacter* ($40x10^4$) and fungi ($16x10^3$). Tolessa and Frieson, (2001) found that application of enriched farm yard manure at (25%) and (50%) of recommended nitrogen(N) and phosphorous (P) fertilizers significantly enhanced the grain yield (40%) as compared to the conventional farm yard manure.

Rampal and Sharma, (2002) stated that combined application of vermicompost lowering the level of C: N ratio. Kumaresan *et al*., (2003) composted different organic wastes with *Pleurotus sajor-caju* and *Trichoderma viride* and obtained decreased C: N ratio which increased the manurial value of the organic wastes. Nagavallema *et al*., (2006) observed that the enumeration of bacteria $54x10^{-6}$ (CFU), $8x10^{-4}$ (CFU) and actinomycetes $1x10^{-4}$ (CFU) from vermicomposted organic wastes.

Abdelaziz, (2007) observed combination of compost and microorganisms increased the nitrogen, phosphorous and potassium fertilizers in rosemary plant. Alam *et al*., (2007) concluded that the integrated application of vermicompost (10/ha) + nitrogen, phosphorous, potassium, sulphur (NPK 100%) sustains the growth and yield of potato in barind soils of Bangladesh. Chandramohan and Chandragiri, (2007) conducted experiments with two inorganic and five organic manure treatments and observed that 50% of nitrogen from sun hemp and 50% of nitrogen from vermicompost was found to be superior to other treatments. In the post-harvest soil organic sample available N, P, K and soil organic carbon contents were found to be higher in organic manure treatment.

Lazcano *et al*., (2008) stated that high salt concentration may cause phytotoxicity problems and therefore EC is good indicator of the suitability and safety of a compost for agriculture purpose. The electrical conductivity reflects the salinity of an organic amendments.

Pritam *et al*., (2008) studied the feasibility of utilization of horse dung spiked sugar mill filter cake in vermicomposters using exotic earthworm *Eisenia foetida*. Maximum growth was recorded in 90% horse dung + 10% sugar mill filter cake feed mixture containing vermicomposter. Earthworm biomass gains and reproduction was favorable up to 50% horse dung + 50% sugar mill filter cake feed composition. A significant decrease in C: N ratio and increase in total Kjeldahl nitrogen, total available phosphorus and calcium contents was recorded.

Suthar and Singh, (2008) stated that the nutrient status of vermicompost depends on the nature of organic substrate used as food material for earthworm. He also found reduced C: N ratio in vermicompost treatment. Meenatchi *et al.*, (2009) revealed that the best substrate- earthworm combination with respect to beneficial microflora such as bacteria, fungi and actinomycetes population in vermicompost was kitchen waste + *Perionyx excavatus* (Perrier) ($65x10^7$ CFU g^{-1}), check + *P. excavatus* (10x103 CFU g-1), check + *P. excavatus* (15 x 10^4 CFU g^{-1}) respectively. Whereas, vermiwash obtained from Paddy straw + *P. excavatus* recorded maximum bacterial population (67 x 10^7 CFU ml^{-1}) and check + *p. excavatus* recorded maximum fungal population (10 x 10^3 CFU ml^{-1}). Vermiwash obtained from soybean harvest waste + *Eudrilus eugeniae* (Kinberg) recorded maximum actinomycetes population (14 x 10^3 CFU ml^{-1}).

Pant *et al*., (2009) reported that active bacteria and fungi population was significantly higher in vermicompost than chemical fertilizers at 100 and 150ml concentration. Radhakrishnan, (2009) studied that the application of vermiwash prepared using tea organic wastes showed good nutritive values which comprised of major and secondary nutrients like N, P, K, Ca, Mg, Zn and Fe in varying proportions. Nutrient contents of vermicompost are always higher than that of vermiwash. The study revealed that both contained appreciable count of beneficial microorganisms like *Azospirillum*, phosphate solubilizing bacteria, *Pseudomonas*, yeast, moulds and actinomycetes.

Patil *et al.*, (2010) studied the effect of nutrient management and biofertilizer on quality, NPK content and uptake of blackgram in medium black soil. The experiment comprised of twelve treatment combinations of three levels of recommended dose of fertilizer (A0-0% RDF, A1-50% RDF and A2-100% RDF) and two levels each of Farmyard manure (F0-No FYM, F1-FYM 6 t ha-1). 100% RDF+FYM 6 t ha^{-1} and biofertilizers inoculation with *Rhizobium spp* + *Pseudomonas striata* significantly enhanced protein, nitrogen, phosphorus and potassium content and uptake by black gram as compared to rest of treatments.

Reghuvaran and Ravindranath, (2010) reported that the application of composted coirpith with nitrogen fixing bacteria is an effective potting medium for cultivation of medicinal plants like *Phyllanthus amaranthus*, *Andrographis paniculata, Bacopa moneiri* and *Piper longum.* According to Sangwan *et al*., (2010) vermicomposted sugar industry waste and cow dung resulted in decrease in carbon, increased in nitrogen, phosphorus and calcium concentrations.

Swati and Reddy, (2010) studied the nutrient status of vermicompost of vegetable market waste and floral waste processed by three species of earthworms *Eudrilus eugeniae*, *Eisenia foetida*, and *Perionyx excavatus*. Nitrogen, phosphorus, potassium, calcium and magnesium increased in the vermicompost and compost while the organic carbon, C/N and C/P ratios decreased as the composting process progressed from 0 to 15, 30, 45 and 60 days.

John de Britto *et al*., (2011) studied the municipal solid waste vermicomposting with an epigeic earthworm, *Perionyx ceylanensis* Mich. The C/N ratio was reduced from 41.8 to 17.6 and 38.8 to 15.4 in municipal solid waste + cow dung (10:1) and cow dung, respectively. NPK showed significantly ($p < 0.05$) higher contents in vermicompost than worm-unworked composts. The bacterial, fungal and actinomycetes population in vermicompost was significantly higher than in the compost.

Meena and Ajay, (2011) studied vermicomposting of vegetable wastes amended with cattle manure. Three different earthworm species *Eisenia foetida, Eudrilus eugeniae* and *Perionyx excavatus* in individual (Monocultures) and combinations (Polycultures) were utilized. The results showed that vegetable waste amended with cattle manure produced high quality stable compost free from pathogens but the waste is not ideal for the growth and reproduction of earthworms.

Pradeepa *et al*., (2011) measured the physico-chemical and biological variables such as pH, EC, NPK and colony forming unit of bacteria, fungi and actinomycetes. Nitrogen fixing bacteria, *Rhizobium spp,* phosphate solubilizing bacteria and *Pseudomonas spp,* mixed in 1:1 ratio was added to vermicompost at a load of 108 cells g^{-1}. The results showed that enriching the vermicompost with biofertilizers is essential to enhance crop production of *Vigna unguiculata* (L) Walp.

Raphael and Velmourougane, (2011) studied the efficiency of an exotic (*Eudrilus eugeniae*) and a native earthworm (*Perionyx ceylanesis*) from coffee farm for decomposition of coffee pulp into valuable vermicompost. The percentage of nitrogen, phosphorous, potassium, calcium and magnesium in vermicompost was found to increase while C: N ratio, pH and total organic carbon declined as a function of the vermicomposting. Vermicompost and vermicasts from native earthworms recorded significantly higher functional microbial group's (Bacteria, fungi, yeast and actinomycetes) population as compared to the exotic worms.

Garg *et al*., (2012) studied the management of food industry waste employing vermicomposting technology. After 15 weeks significant increase in total nitrogen (60 – 214%), total available phosphorous (35.8–69.6%), total sodium (39–95%), and total potassium (43.7–74.1%), while decrease in pH (8.45–19.7%), total organic carbon (28.4 –36.1%) and C: N ratio (61.2–77.8%) was recorded. The results indicated that food industry spiked waste may be converted into good quality manure by vermicomposting if spiked with other organic wastes in appropriate quantities.

Mahyati *et al*., (2013) revealed that degradation of lignin from corncob by using white rot fungi (*Phanerochaete chrysosporium, Lentinus edodes* and *Pleurotus octreatus*) showed maximum lignin biodegradation (96.88%).

Naveen *et al*., (2013) combined application of NPK (78.06 kg/ha nitrogen), (15.28 kg/ha phosphate), (101.67 kg/ha potassium) with *Azospirillum brasilense* + *Bacillus megasterrum* + vermicompost promoted the growth and nutrient uptake of rice. Selvamurugan *et al.*, (2013) stated that biocompost (5t/ ha) application enhanced bacteria ($25x10^{6}$ CFU g^{-1}), fungi ($14x10^{4}$ CFU g^{-1}), actinomycetes ($8x10^{3}$ CFU g^{-1}) as compared to the biomethanated distillery spent wash.

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

El-Mohamedy *et al.,* (2015) stated that field application biocompost (compost inoculated with 25 ml/kg spore suspension $3x10^{6}$ spore/mL of each *T. harzianum* Th3 and *T. viride* Tv1.) enhanced the nitrogen (1.54%), phosphorus (0.37%), potassium (2.59%), ferrous (303.66 ppm), manganese (53.33 ppm), zinc (50 ppm) and copper (13.97 ppm) contents followed by other treatments and control in potato.

Viji and Neelanarayanan, (2015a) stated that vermicompost obtained from mixed leaves litter treated with cow dung in 1:2 ratio significantly enhanced the chemical parameters like nitrogen, phosphorus, potassium and biological parameters like bacteria, fungi and actinomycetes followed by mixed leaves litter treated with cowdung and goat dung in 1:1:1 ratio and mixed leaves litter treated with goat dung in 1:2 ratio.

Viji and Neelanarayanan, (2015b) recommended that the combination of three lignocellulolytic fungi *Rhizopus oryzae*, *Aspergillus oryzae*, *Aspergillus fumigates* degraded the paddy straw waste and produced good quality compost containing higher amount of total nitrogen (1.55 ± 0.03%), total potassium (1.57 ± 0.01%) and total phosphorus (1.48 ± 0.17%) content.

Physico-chemical analysis showed decreased content of total organic carbon, C: N ratio and increased nitrogen, phosphorus and potassium content of the vermicompost compared to initial agricultural waste paddy straw (Jaybhaye and Satish, 2016). Sridevi *et al*., (2016) stated that water hyacinth compost integrated with cow dung (1 : 3) increased the microbial flora like bacteria (93.07 x 10^6 CFU g), fungi (118 x 10^{-2} CFU g^{-1}), actinomycetes (77.52 x 10^{-3} CFU g^{-1}) and physico-chemical parameters like nitrogen (2.85%), phosphorus (2.10%) and potassium (3.05%). Villar *et al.*, (2016) reported that physico-chemical properties of vermicompost enhanced the pH and total nitrogen in sewage sludge.

Amman and Subramanian, (2017) recommended that the combined application of organic manure and biofertilizers on soil microbial count increase in bacteria (96.76), fungi (52.46) and actinomycetes (94.66) in black nightshade (*Solanum nigrum* L.). Malinska *et al.,* (2017) stated that, sewage sludge vermicompost enhanced the micro and macro elements of compost.

Usmani *et al*., (2019) concluded that the application of vermicomposted fly ash improved the physico-chemical properties, pH, organic carbon, electrical conductivity, total nitrogen, available phosphorous and microbial population up to 90 days after sowing of seeds in tomato (*Lycopersicum esculentum* Mill.) and brinjal (*Solanum melongena* L.).

Hassan *et al*., (2022) reported that the application of vermicompost showed maximum pH (7.2), EC (2.4), organic carbon (32.1%), c:n ratio (29.1) N (1.80), P (0.55) and K (1.2) in banana plants. Rehman *et al.*, (2023) this review aims to provide key insights into the potential of vermicompost to boost crop production and protect crops from biotic and abiotic stresses without harming the environment. The value of vermicompost is its promotion of plant growth based on its enrichment with all essential nutrients, beneficial microbes and plant growth hormones.

2.2 REVIEW ON FT-IR

Dai *et al*., (2013) point out that 1000 cm^{-1} band was due to C-O of alcohols derived from intact cellulose and hemicellulose. These functional groups may form part of the cellulose, partially mineralized. The increase of the oxygen-based functional groups was in line with the values of the H/O ratio which confirm the increase of oxygen base groups due to the composting process. OH stretching was observed at 3685 cm^{-1} and 3306 cm^{-1} that signifies a strong bond that represents mainly phenolic compounds (Hussain *et al*., 2015).

Hussain *et al*., (2016) studied Fourier transform infrared (FTIR) spectroscopy and revealed that the phenols, the sesquiterpene lactones that are responsible for the negative allelopathic impact of parthenium was reduced during vermicomposting.

Bhat *et al*., (2017) stated that the FT-IR spectroscopy technique is used to confirm the decomposition of polypeptides, polysaccharides, aliphatic, aromatic, carboxylic, phenolic groups and lignin during vermicomposting process. The spectrum of initial and final vermicomposted samples are generally obtained in the mid-infrared area range of 4000-400 cm^{-1}. It is one of the most reliable techniques for determination of vermicompost maturity and different peaks/values show the presence or decomposition of their group in the sample.

Arumugam *et al*., (2018) studied the FT-IR spectra comparison of cellulose (C), paper cup (PC), vermicompost (VC) and Vermicompost with bacterial consortium (VCB) and the stretch of vibration of region around 3100-3600 cm^{-1} indicates the VC cowdung + paper cup waste + earthworm (*Eudrilus eugeniae*) and VCB – cowdung + paper cup waste + earthworm (*Eudrilus eugeniae*) + microbial consortia when compared to paper cup (PC).

Chavez-Garcia *et al*., (2020) investigated the FT-IR spectra of biochars and reported to have few OH groups (3600 cm-1) in the composition. The 1600 cm-1 band, which corresponds to the aromatic C=C and to the COO-carboxylates are present in great intensity in the composted biochar and the band 1700 which corresponds to the COOH region was absent.

Kauser and Khwairakpam, (2022) investigated the FT-IR spectra of vermicompost using earthworm species and without earthworm. The peaks in VrEF (Vermicompost with

Esenia fetida) reactor are shallower than in the other reactors after treatment, owing to degradation by various types of enzymes found in the earthworm gut and microflora which show a significant reduction during the vermicomposting process.

2.3 REVIEW ON BIOMETRIC CHARACTERS, BIOCHEMICAL ANALYSIS AND YIELD PARAMETERS

Atiyeh *et al.*, (2000) noted that combined application of chicken manure compost and vermicomposted pig waste (20%) increased the growth of marigold and tomato seedlings. Rajkhowa *et al.*, (2000) stated that application of nitrogen (75%) and vermicompost (5 t/ha) enhanced the number of nodule and dry weight in green gram.

Chinnamuthu and Venkatakrishnan, (2001) observed enhancement in the growth parameters like plant height and head diameter in the vermicomposted and Vesicular-arbuscular mycorrhiza (VAM) treatments as compared to the chemical fertilizer in sunflower.

Renuka and Ravishankar, (2001) conducted an experiment with combined application of biogas slurry + farm yard manure, vermicompost + farm yard manure, vermicompost alone treatment and recorded increased diameter of fruit, highest number of fruit / plants as compared to inorganic fertilizer treatment (NPK) in tomato crop.

Manonmani and Anand, (2002) observed an increase in biochemical constituents like carbohydrate in leaf tissue of lady's finger up to 60 DAS by the application of vermicompost. The effect of earthworm processed pig manure (vermicompost) on the growth and productivity of French marigold (*Tagetes patula*) plants were evaluated under glasshouse conditions. (Atiyeh *et al.*, 2001)

Agarwal *et al.*, (2003) reported that combination of vermicompost, farmyard manure and chemical fertilizer enhanced the biomass production and highest yield of wheat (*Triticum aestivum* L. var. HD- 2643) over control. According to Kumar *et al*., (2003) application of vermicompost (5 t / ha) promoted the grain yield (16.5%) when compared to FYM in mung bean.

Arancon *et al.*, (2004) stated that peppers grown in potting mixtures containing (40%) vermicomposted food waste and Metro-Mix 360 (60%) enhanced the fruit weight (45%) and number of fruits (17%) than the control.

Arshad *et al*., (2004) revealed that the application of compost enriched with nitrogen and L-tryptophan in combination with (50%) additional dose of nitrogen fertilizer increased the growth and yield of hybrid maize. Youssef *et al*., (2004) stated that the use of biological fertilizers containing the bacteria *Azotobacter* and *Azospirillum* in medicinal plant Salvia (*Salvia officinalis*) increased plant height and shoot dry weight.

Abira, (2005) reported that combined application of vermicomposted fruit waste (75 g) + biofertilizer increased chlorophyll 'a' (0.2600 mg/g), chlorophyll 'b' (0.4316 mg/g) and total chlorophyll (0.4249 mg/g) in soybean. Srinivasan *et al*., (2005) concluded that the mixed effect of composted coirpith and *Azospirillum* sp. enhanced the yield and quality of *Piper nigrum*. Mirza *et al*., (2005) reported that both grain and straw yield of paddy were significantly improved by the application of *Sesbania* and farm yard manure.

Elham, (2006) observed enhancement is the yield and quality of sugar beet due to the application of biofertilizer and compost in combination. The findings of Jat and Ahlawat, (2006) revealed that application of vermicompost (3 t/ha) boost up the dry matter accumulation, grain yield, dry fodder yield and grain protein content in chickpea.

Kannan *et al.*, (2006) investigated the effects of farmyard manure, vermicompost and coirpith, applied at 50, 75 and 100% combined with *Azospirillum* (2kg/ha) increased the yield, nutrient uptake and crop quality of tomato cv. PKM1. They also found that the application of 75% vermicompost in combination with *Azospirillum* increased protein content (1.70%) and lycopene content (3.7 mg/100g).

Lourduraj, (2006) identified the optimum dose of vermicompost for maize under different levels of fertilization. He found that optimum dose of vermicompost application to maize in addition to recommended fertilizer was (5 t/ha) which recorded similar growth and yield (5560 kg/ha) as that of vermicompost application at the rate of (7.5 t/ha).

Ramesh *et al.*, (2006) concluded that combined application of vermicompost (3 t/ ha), cattle dung (4 t/ha) and poultry manure (2 t/ha) increased the protein content (21.25%) of pigeon pea.

Hakeem *et al.*, (2007) studied the effect of different levels of neem cake and biofertilizers on soil properties, growth, yield and nutrient uptake in black gram

(*Vigna mungo*). Hameeda *et al.,* (2007) reported that the application of rice straw vermicompost (2.5 t/ha) promoted the shoot length (1-12%), leaf area (20-34%), plant biomass (9-27%) and root volume in sorghum plant.

Sidhu *et al*., (2007) stated farm yard manure at 50 t / ha caused substantial improvement in tuber yield (29%) and phosphorus uptake (26%) of *Solanum tuberosum* and seed yield of *Helianthus annuus* (14.7%). Sushma *et al*., (2007) found that the combined application of coir pith based compost with pressmud and 100 per cent recommended dose of fertilizer (RDF) significantly increased the grain and straw yield of ragi crop.

Azizi, (2008) concluded that the organic fertilizers significantly improved the vegetative growth, early flowering and increased diameter receptacle in German chamomile. Ibrahim *et al*., (2008) revealed that combination of organic and inorganic fertilizers significantly promoted the growth and yield of wheat.

Karmegam and Daniel, (2008) observed application of vermicompost (2.5 t/ha) using (*Perionyx ceylansis* and *Perionyx longifolia*) + 1/2 dose NPK increased the total chlorophyll content (1.83 mg/g) in leaf and fruit length (8.46 cm) of hyacinth bean (*Lablab purpureus* L.). According to Maheshbabu *et al*., (2008), application of recommended dose of fertilizer (RDF) and FYM enhanced the yield and seed quality of soybean crop.

Padmavathiamma *et al.,* (2008) reported the usage of *Eudrilus eugeniae* as a bioinoculant enhanced the root growth and yield of cowpea, banana and cassava. Prajapati *et al.,* (2008) investigated the combined inoculation of *Azotobacter chroococcum* and *Piriformospora indica* with vermicompost increased the shoot length (37.38 cm), root length (17.08 cm), fresh and dry weight of shoot (1.74 g and 0.66 g) in rice. Ouda and Mahadeen *et al*., (2008) suggested that combined application of organic and inorganic fertilizers enhanced the growth, yield and chlorophyll content of broccoli.

Ofosu-Anim and Leitch, (2009) confirmed cow dung as the best organic manure resulted in increased plant height, chlorophyll content of leaves, dry matter accumulation and nutrient uptake of *Hordeum vulgare* L. Dayananda and Mallesha, (2009) reported that the combined inoculation of *Trichoderma harzianum, Azotobacter chroococcum* and *Bacillus megaterium* to mushroom spent coir pith promoted the growth parameters of tomato.

Manivannan *et al.,* (2009) stated that application of 50% vermicompost+ 50% NPK (5 t/ha) significantly enhanced shoot length (40.3 cm), root length (11.5 cm) and shoot dry weight (1.97g) of beans in clay loam soil. Singh and Chauhan, (2009) reported that application of vermicompost (4kg/bed) enhanced the growth and yield of French bean. Uthayakumar and Bakthavathsalam, (2009) conducted the experimental analysis of vermicompost of vegetable market waste and its effect on the growth and yield of black gram.

Dash *et al*., (2010) stated that combined application of digested sludge + press mud + carpet waste compost increased the grain and straw yield of rice (*Oryza sativa*). Joshi and Vig, (2010) stated that application of vermicompost (15%) amended with soil enhanced the growth, yield and quality of tomato plants under field conditions.

Lavanya and Ganapathy, (2010) studied the effect of diammonium phosphate and naphthalene acetic acid spray along with biofertilizers for black gram and revealed that applications 2 % diammonium phosphate + *Rhizobium* + Phosphobacteria recorded the highest growth and yield of black gram crop.

Kumar *et al.,* (2010) studied the response of *Rhizobium* and different levels of molybdenum on growth, nodulation and yield black gram and reported that seed inoculation with *Rhizobium* and application of molybdenum at 1.0 kg ha^{-1} recorded significantly increase in plant height, branches dry matter accumulation and yield.

Baranisrinivasan, (2011) studied the effect of coir waste and cow dung which positively enhanced the chlorophyll and nutrient content of black gram. Bhuvaneshwari *et al*., (2011) reported that combined use of coir pith based cyanobacterial biofertilizer as foliar spray (0.5%) enhanced the biometrical, chlorophyll content and yield of *Helianthus annuus* L. According to Charan Kumar *et al*., (2011) combined application of nitrogen, farm yard manure, vermicompost, neem cake and biofertilizer enhanced the yield and soil properties in stevia.

Hussain *et al.,* (2011) studied the response of biofertilizers on growth and yield attributes of Black gram (*Vigna mungo* L.). The treatments consisted of combination of three levels of biofertilizers viz., *Rhizobium*, phosphate solubilizing bacteria and *Rhizobium* + phosphate solubilizing bacteria, replicated three times in randomized block design.

Shadanpour *et al*., (2011) stated that combined application of vermicompost (40%) + sand (30%) + soil (30%) and reported enhanced the fresh weight (230.5 g) and dry weight (19.7 g) of marigold. Mohamadi *et al*., (2011) revealed that application of farm yard manure + compost + triple super phosphate increased the yield and grain quality of chick pea (*Cicer arietinum* L.). Narkhede *et al.,* (2011) concluded that application of (20%) vermicompost in red chilies enhanced the chlorophyll content (2.9%) compared to the control (2.1%).

Baviskar *et al*., (2012) revealed that application of biocompost (5 t / ha) and sulphur (50 kg / ha) increased the biometric, biochemical and yield parameters of cluster bean (*Cyamopsis tetragonoloba* (L.) Taub). According to Gandhi and Sundari, (2020) combination of *Azolla* and vermicompost enhanced the number of leaves per plant (6.05, 18.12 and 28.32) in egg plant on 20, 40 and 80 days after sowing.

Lallawmsanga *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.). According to Lenin *et al*., (2012) 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.

Mathivanan *et al*., (2012) reported that application of 200g vermicompost in 10kg of soil increased chlorophyll ‘a’ (0.764 mg/g), chlorophyll ‘b’ (0.544 mg/g), ‘total’ chlorophyll (1.313 mg/g) and carotenoid (1.570 mg/g) content in groundnut seedlings. Neral *et al*., (2012) concluded that application of vermicompost with soil mixture enhanced the chlorophyll content (1.996 mg/g) and yield (42.416 q/ha) of wheat.

Saravanan *et al*., (2012) concluded that application of coir pith compost and biofertilizer (*Frankia* + *Azospirillum* + *Phosphobacterium*) increased the root length (23.7 cm), shoot length (45.87 cm), number of nodules (6.62) and colour diameter (3.35 mm) of *Casuarina equisetifolia* seedlings at 180 days after inoculation.

Selvakumar *et al.*, (2012) studied the response of biofertilizers on growth, yield attributes and associated protein profiling changes of black gram (*Vigna mungo* (L).

Hepper). The treatments consisted of biofertilizers alone or combination treatment viz., control (without any microbial inoculation), *Azotobacter*, *Azospirillum*, Phosphobacteria, *Rhizobium, Rhizobium* + *Azotobacter*, *Rhizobium* + *Azospirillum* and *Rhizobium* + Phosphobacteria replicated three times in randomized block design.

Suresh Kumar and Ganesh, (2012) stated that highest yield and increased biochemical content has been obtained due to the application of (75% NPK along with composted coir pith (200 kg) + *Pleurotus sajor - caju* (2.5 kg) + poultry manure (10 kg) in groundnut VRI-2 (*Arachis hypogaea*). Upadhyay *et al*., (2012) investigated that 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 (*Mentha arvensis* L.)

Arjumand Banu *et al.,* (2013) stated that farm yard manure, poultry manure and NPK can be used as cheaper organic manure for the growth of French bean. Arguello *et al*., (2013) stated that vermicompost increased biomass and improved the distribution of photo assimilates and consequently, the growth of plants under treatment.

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 (*Ocimum basilicum* L.). Mishra and Jain, (2013) suggested that combined application of biofertilizers (250 g) + NPK (50%) + vermicompost (5t/ha) promoted chlorophyll (5.9 mg/g) and protein (7.2 mg/g) content in *Andrographis paniculata*.

Ranjan *et al*., (2013) reported that combined application of vermicompost (1.92 kg / bed) + Biospirillum (10 ml / kg of seed) + Biophos (10 ml / kg of seed) + Biopotash (10 ml / kg of seed) increased yield (18.57 q / ha), chlorophyll ‘a’ (3.055 mg / g), chlorophyll ‘b’ (0.556 mg / g) and ‘total’ chlorophyll (3.627 mg / g) of baby corn under the north – west Himalayan conditions.

Swarnam and Velmurugan, (2013) confirmed that application of poultry manure (3.79 t / ha) and vermicompost (3.73 t / ha) increased the yield of maize better than the *Gliricidia* and coconut husk compost. Tak *et al*., (2013) reported that combined application of vermicompost (5 t/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).

Asgharipour and Shahankareh, (2014) concluded that vermicompost promote the rate of germination, seedling growth, dry weight of shoot and root of okra (*Abelmoschus esculentus*). Dhanalakshmi *et al*., (2014) concluded that the 50% of vermicompost treated soil enhanced the root length of okra (7.07, 9.13, 13.03 cm) and chili (5.80, 7.60, 10.90cm) on 30, 60 and 90 days after planting. Jahanshahi *et al.*, (2014) concluded that seed sowing in early April along with vermicompost (32 t/ha) enhanced the growth and chlorophyll content of dill (*Anethum graveolens* L.).

Kapare *et al*., (2014) reported that foliar sprays of humic acid vermicompost and NAA increased growth, plant height, number of branches and yield in chickpea. Kirar *et al*., (2014) investigated that combined application of (75%) NPK + vermicompost + *Azotobacter* + Phosphate solubilizing bacteria enhanced plant height (51.57 cm) and number of leaves (1.54-22) of China aster. Kumar *et al*., (2014) determined that combined application of vermicompost (50%) + poultry manure (50%) increased the growth and yield of radish.

Saraswathy and Prabhakaran, (2014) reported that application of vermicompost 30 per cent mixed with 20 per cent of soil improved the germination (90.8%), shoot length (9.19 cm), root length (2.95 cm), number of leaves (20.5), fresh weight (0.352 g) and dry weight (0.154 g) of tomato. Sardoei, (2014) concluded that application of vermicompost (50%) enhanced the chlorophyll ‘a’ (9.39 μg / ml^{-1} fresh weight), chlorophyll ‘b’ (6.25 μg / ml^{-1} fresh weight) and ‘total’ chlorophyll content (15.74 μg / ml^{-1} fresh weight) in marigold.

Saravanan *et al*., (2014) revealed that vermicompost prepared from cow dung, leaf litter, flower waste and onion garlic waste enhanced the growth and yield of cow pea. Senthilkumar *et al*., (2014) stated that the organic fractions of vermicomposted flower waste and microorganism in the biofertilizers could be alternative to chemical fertilizers in improving the growth and yield of groundnut.

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 chillies.

Chavan *et al.,* (2015) stated that application of vermicompost enhanced the number of leaves (3), fresh and dry weight (0.56 g and 0.17 g) of cluster bean. Biocompost application enhanced the protein and carbohydrate content in potato tuber as compared to the other treatments and control (El-Mohamedy *et al.*, 2015). Gopinathan and Prakash, (2015) concluded that application of vermicompost increased shoot length, root length and yield of green gram. Rekha *et al.*, (2015) concluded that 50% vermicompost significantly increased the shoot length (15.20 cm), number of leaves (22.50) and number of branches (8.16) in *Vigna mungo*.

Chaudhari *et al.,* (2016) In a field experiment conducted during 2013-14 at college Farm, Navsari Agricultural University, Navsari, (Gujarat) application of biocompost (2 t/ha) significantly produced highest seed yield (909 kg/ha), straw yield (1771.56 kg/ha), protein content (21.44%) and protein yield (195.18 kg/ha) in green gram.

Sakthivigneswari and Vijayalakshmi, (2016) reported that the biocompost prepared from the partially decomposed coirpith with *Pleurotus sajor-caju* and vermicompost prepared by using *Eudrilus eugeniae* enhanced the root length (60.1 cm) and shoot length (90.47 cm) on 75 DAS in *Solanum nigrum.*

Sivakumar and Karthikeyan, (2016) reported that application of vermicomposted weed plants waste promoted the vegetative, physico chemical parameters, chlorophyll a, chlorophyll b, total chlorophyll, carotenoids and anthocyanin in brinjal.

Tensingh Baliah and Muthulakshmi, (2017) stated that application of vermicompost promote the rate of germination, seedling vigour index, shoot length, root length, plant fresh weight and plant dry weight of okra (*Abelmoschus esculentus* L. Moench). Vijayalakshmi and Gayathri, (2017) concluded that vermicompost significantly increased the protein, carbohydrates and chlorophyll content in chilli plant (*capsicum annum* L.). According to Kumar and Gupta, (2018) application of vermicompost enhanced the plant height (50.00 cm), stem diameter (1.40 cm), weight of the fruit (152.30 g), number of fruits per plant (44.38) and dry matter yield (41.36 g) in *Raphanus sativus*.

Suganya and Vijayalakshmi, (2018) reported that 20g of composted corncob increased the shoot length, root length, number of leaves, fresh weight, dry weight, protein, carbohydrate and chlorophyll content on 15, 25, 35 and 45 days of green gram and black gram. According to Rajasri and Vijayalakshmi, (2019) application of vermicomposted groundnut shell + vegetable waste (75g) increased the shoot length, root length, number of leaves, fresh weight, dry weight, protein, carbohydrate and chlorophyll content on 15, 35, 55 and 75 days in pigeon pea.

Jjagwe *et al*., (2020) stated that the application of organic fertilizers enhanced plant height and number of leaves in maize (*zea mays* L.). Vegetative and reproductive growth parameters in plant height, number of leaves, number of branches, days 50% flowering, number of fruits per plant, single fruit length and fruit yield per hectare were recorded in hot pepper. (Berhe *et al*., 2022).

Dey *et al*., (2022) stated that the application of vermicompost and different organic media enhanced the plant height, number of branches per plant, yield / plant, fruit length, fruit diameter, fruit weight and edible pulp weight in dragon fruit (*Hylocereus costaricensis* L.).

Hassan *et al*., (2022) reported that the application of vermicompost combined with vermiculture and sand (33.3 % each) enhanced the vegetative parameters plant height, root length, number of leaves, shoot fresh weight, shoot dry weight, root fresh weight and root dry weight in banana plants.

Mostofa Amin *et al*., (2022) observed that the application of organic manure enhanced the shoot length and root length and manure application effectively conserved soil water throughout the vegetative stage of maize. Al-Hadithi *et al*., (2023) stated that the application of different fertilizers increases in plant height, fresh weight, dry weight, protein and chlorophyll content in fenugreek (*Trigonella foenum-graecum* L.).

2.4 REVIEW ON SOIL ANALYSIS

Soil plays a key role in completing the cycling of major demands required by biological systems decomposing organic wastes and detoxifying certain hazardous compounds. Singh *et al*., (2000) stated that available nitrogen and phosphorus in post-harvest soil increased significantly with the levels of sulfidation press mud (SPM) (0, 2, 4 t / ha).

Atiyeh *et al.,* (2001) reported that, EC content increased in soil with the combined application of pig manure vermicompost and Metro-mix 360. Bhattacharjee *et al*., (2001) reported that application of vermicompost reduces the loss of nutrients through leaching from the soil by changing the soil's physico-chemical properties in paddy crop. Khatik and Dikshit, (2001) reported an enhanced availability of N, P, K and S in soil with the application of FYM 10 t ha^{-1} + 50 per cent of recommended dose of nitrogen.

Ouedraogo *et al*., (2001) reported increased soil pH, soil cation exchange capacity, nitrogen, phosphorus and potassium in the plots receiving 10 mg/ha compost prepared from household refuses, animal manure, crop residues and ashes.

Rakkiyappan *et al*., (2001) observed that the integrated application of organic fertilizer enriched press mud with *Pleurotus* sp. At 10 t / ha along with chemical fertilizer (50 to 70 per cent NPK) improved the soil organic carbon and available NPK without affecting soil pH and exchangeable cation.

Krishnasamy *et al*., (2002) stated that the application of sewage sludge alone or in combination with coir pith as mixture or pellets increased the trace metal content in soil and plant. It also enhanced the dry matter yield of fodder maize (*Zea mays* L.) by 22% even at the low level of 1.25t ha-1 application.

Nayak *et al*., (2002) reported 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 application of organic manures increased the carbon content and available NPK in soil. Brar (2003) recorded that the integrated use of organic and inorganic fertilizers improves the crop yields and soil fertility to higher level.

Chaoui *et al.*, (2003) observed combination of vermicompost and NPK treated soil enhanced the nitrogen, phosphorus and potassium content in post-harvest soil of rice, ragi and cowpea. Mathakiya and Meisheri, (2003) investigated that the application of press mud increased the electrical conductivity of the soil.

Choudhary *et al*., (2004) stated that the combination of press mud (15t/ ha) + 50% gypsum requirements reduced the percentage of sodium in the soil.

Soil organic matter is a major terrestrial pool for carbon, nitrogen, phosphorus and sulphur. The cycling and availability of these elements are constantly being changed by microbial immobilization and mineralization (Feichtinger *et al*., 2004). The importance of increased soil organic carbon is its effect on improving soil physical properties, conserving water and increasing available nutrients. This enhancement ultimately lead to greater biomass and yield (Onemli, 2004).

Bohme *et al*., (2005) reported application of farm yard manure enhanced the soil organic matter and total nitrogen as reflected by hydrolytic enzyme activities. Seldon *et al.,* (2005) reported that vermicompost is the microbial composting of organic waste through earthworm activity to form organic fertilizer which increase the organic matter, organic carbon, nitrogen, phosphorus, potassium, micronutrients, microbial and enzymatic activities of soil.

Arancon *et al.,* (2006) observed that application of vermicompost treated soil had significantly increased the nutrient contents and microbial population in the strawberry grown soil when compared to the control. Organic manures decompose to give humus that plays an important role in the chemical behavior of several metals in soils through the flavonic and humic acid contents (Abou El-Magd *et al*., 2006).

Kumar and Shivay, (2007) reported application of organic manures improved the physical, chemical, biological properties of the soil. Rangaraj *et al*., (2007) observed that the agro-industrial waste pressmud and composted coir pith (12.5 t / ha) favorably improved the soil organic matter, pH, EC, microbial population, nitrogen, phosphorus and potassium in finger millet.

Azarmi *et al.,* (2008) examined vermicompost application increased contents of soil total organic carbon, total N, P, K, Ca, Zn and Mn and electrical conductivity in the plots receiving 15t/ha in the tomato grown soil.

Manivannan *et al*., (2009) stated that recommended dose of vermicompost (5 t / ha) enhanced the organic matter, pH, EC, nitrogen, phosphorus, potassium, calcium, magnesium, sodium, manganese and zinc in the post-harvest soil of *Phaseolus vulgaris*.

Ondieki *et al*., (2011) during their study on the effect of organic manure on the yield of African nightshade observed increase in the total yield which may be due to increased soil aggregation, soil aeration, water holding capacity and good environmental conditions for the root system of spider plants.

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 increased the soil quality by the improvement of physico-chemical properties of soil in almond tree plantation field. Selvamuthukumaran and Neelanarayanan. (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.

Selvamurugan *et al*., (2013) confirmed that application of biomethanated distillery spent wash and bio compost (5 t/ha) increased the electrical conductivity, available nitrogen (139 kg/ha), phosphorus (23.66 kg/ha) and potassium (320 kg/ha) content of post-harvest soil of ragi.

Menon *et al*., (2014) reported that the application of farm yard 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).

Rama Lakshmi *et al*., (2014) stated combined application of 75 per cent RDF + vegetable market waste compost (2.5 t/ha) to kharif rice and 50 per cent RDF to rabi green gram promoted the available micro nutrients (nitrogen, phosphorus and potassium) in the soil.

Bhatti *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.

Suganya and Vijayalakshmi, (2018) reported that the post harvested soil analysis of black gram and green gram showed increased N, P and K in T_5 treatment (20 g of composted corncob). According to Rajasri and Vijayalakshmi, (2019) application of vermicomposted groundnut shell + vegetable waste (75g) increased nitrogen, phosphorus and potassium in post harvested soil analysis of pigeon pea. Kumari *et al*., (2020) reported maximum pH, electrical conductivity, total nitrogen, total phosphorus and total potassium due to the application of vermicompost crop residue and cow dung. According to Hoque *et al*., (2022) who found that the application of vermicompost showed significant pH, nitrogen, phosphorus and potassium content in rice crop. Kumar *et al.,* (2023) found that increase pH, phosphorus and potassium due to the application of vermicompost waste with vermicomposting technology.

2.5 REVIEW ON SOIL MICROBIAL POPULATION

Islam and wright, (2004) suggested that the microbial communities of soil organisms ranging in size from 0.5 to 5.0 µm consists predominantly of bacteria, fungus and actinomycetes. Kang *et al*., (2005) who stated that the application of soil microbial population bacteria count (2.88) was increased in FYM + GM and compared to the control (1.45).

Bhattarai *et al*., (2015) reported that the application of soil microbial population maximum in bacteria, actinomycetes and fungi in different soil horizons. Meena *et al*., (2015) indicated the higher value of soil microbial population in bacteria, fungi and actinomycetes were observed in farmyard manure by organic manure in popcorn (*Zeamays* L. var.everta).

Akande and Adekaryode, (2019) investigated microbes from different land use and soil depths. The highest microbial population and fungi population was recorded from surface soil layer of the cassava land (0-15). Umadevi *et al*., (2019) stated that the application of organic and inorganic manure increased bacteria, fungi and actinomycetes in soil with poultry manure in cowpea. Zhao *et al*., (2021) observed that the application of soil microbial community increased bacteria, fungi and actinomycetes in Eurasian Steppe (Inner Mongolia, China). Dinca *et al*., (2022) revealed that the application of soil microbial community and fertilization maximum in bacteria and fungi.

Gonzales *et al.,* (2023) who reported that the application of soil microbial population in the rhizosphere that can be beneficial to the growth of cacao trees was also improved after inoculation of the proposed biofertilizer technology the Arbuscular mycorrhiza (AMF) population was improved with the inoculation of bamboo biochar while Nitrogen-fixing bacterial (NFB) counts were the amendment of bamboo biochar alone and with the combination of Mykorich (MR) + 15% Bamboo biochar (BB).

2.6 REVIEW ON ANTIOXIDANT AND ANTIBACTERIAL ACTIVITY

Duthie *et al.,* (2000) reported that natural antioxidants such as flavonoids, tannins, coumarins, curcuminoids, xanthons, phenolics and terpenoids in various plant products from fruits, leaves and seeds. They were effective as synthetic antioxidants in model systems. Premuzic *et al.,* (2001) stated that combined application of organic and mineral fertilizer promoted the powerful antioxidant vitamin C content in cherry tomato than mineral fertilizer alone. Plants contain different types of natural antioxidant which have a remarkable role in the traditional medicine in different countries (Virgili *et al.,* 2001). Worthington (2001) stated that organically grown crops contained significantly more vitamin C, iron, magnesium and phosphorus, less nitrates and lower amounts of heavy metals than conventional crops.

Carbonaro *et al.,* (2002) studied the effect of antioxidant activity of organic and conventionally grown plant species of *Prunus persica* and *Pyrus communis.* The highest concentration of polyphenol and polyphenoloxidase activity was shown in both fruits as compared to conventional ones. Antioxidant rich foods used to help the human body in reducing oxidative damage by free radical and active oxygen (Gulcin *et al.,* 2002).

Asami *et al.,* (2003) indicated consistently higher level of total phenolics in organically grown crops (dried-marionberry, strawberry and corn) compared with those produced by conventional agricultural practices. Antibacterial activity of *Caesalpinia digyna* was evaluated on some human pathogenic microorganism like *Staphylococcus aureus*, *Salmonella typhimurium*, *Escherichia coli* and *Pseudomonas aeruginosa*. The fruit extract showed broad spectrum of antibacterial properties (Elizabeth, 2003).

The reports by Jin and Sato, (2003) showed that aqueous extracts of the tissue of succulent young shoots of the pear *Pyrus spp* exhibited strong antibacterial activity against the bacterium *Erwinia amylovora*.

Raju *et al.,* (2003) carried out the antibacterial studies of *Glycosmis pentaphylla* against six human pathogenic bacteria. Among the tested bacteria, the maximum inhibition activity was found against *Proteus vulgaris* and *Escherichia coli.*

Son *et al.,* (2003) stated that the ethanolic extract of the ripe fruits of *Solanum nigrum* inhibits potent antioxidant activity at a concentration of 50 µl. The extract also inhibits the tumor cell growth at a concentration of 5µg/ml.

The planting medium (100% compost) and 50% soil + 50% compost significantly enhanced the level of hydrogen peroxide, hydroxyl radical and singlet oxygen absorbance capacity in fruit of two strawberry cultivars, Allstar and Honeoye (Wang and Lin, 2003).

Caris-veyrot *et al.,* (2004) reported that organic tomatoes had higher vitamin C, carotenoids and polyphenol contents than conventionally grown tomatoes. Veberic *et al.,* (2005) studied the antioxidant activity in eleven apple cultivars by using organic and integrated fertilizer. The promising antioxidant activity was achieved by organically grown apple cultivars as compared to the integrated production.

Tarozzi *et al.,* (2006) reported that organic red oranges have a higher phyto-chemical content (phenolics, anthocyanins and ascorbic acid), total antioxidant activity and *in vitro* bioactivity, in terms of protective effect against oxidative damage at cellular level, than nonorganic red oranges.

Dani *et al.,* (2007) studied the antioxidant activity of different colors of grapes (white and purple) cultivated by organic and conventional farming. They obtained highest total polyphenol and invitro antioxidant was shown in organic grape juice as compared to the conventional grape juice.

Malencic *et al.,* (2007) screened the total phenol and total antioxidant properties in the aqueous acetone extract in different genotypes of soybean seeds. The highest content of total phenolics were found in Serbian cultivar 1511 and Chinese cultivar LN92-7369 which also displayed the highest total antioxidant activity. Perez- Lopez *et al.,* (2007) confirmed significant higher content of total carotenoids in organically grown sweet peppers than integrated and conventionally cultivated peppers.

Ghosh *et al.,* (2008) investigated antibacterial activity of hot aqueous and methanolic leaf extracts of *Polyalthia longifolia* against six different bacteria. Highest antibacterial activity was noted against *Klebsiella pneumoniae* in both the leaf extracts followed by *E. coli* in hot aqueous extract and *B. subtilis* in methanol extract as evident from MIC values. Wang *et al.,* (2008) studied the antioxidant activity of blueberry grown from organic culture yielded significant amount of total phenolics, total anthocyanins and antioxidant activity.

Deore *et al*., (2009) evaluated the DPPH free radical scavenging assay, reducing power ability and hydrogen peroxide scavenging activity in *Lagenaria siceraria* fruits and reported that ethanolic extracts of *Lagenaria siceraria* fruits showed effective antioxidant activity in all assay techniques.

Kannabiran *et al.,* (2009) reported that aqueous extracts of *Centella asiatica* and *Solanum xanthocarpum* had highest antibacterial activity than the solvent extracts against gram positive bacteria *Klebsiella pneumoniae* (20mm and 11mm) and *Escherichia coli* (17mm and 11mm).

Parthasarathy *et al.,* (2009) studied DPPH radical scavenging activity of various extracts (aqueous, alkaloid and methanol) of *Mitragyna speciosa* leaves. Methanol extract of *Mitragyna speciosa* leaves (37.08 µg/mL) showed strong inhibitory potential. It could act as potent source of antioxidants. They reported positive correlation between the total phenolic content and the antioxidant activity of extracts.

Stracke *et al.,* (2009) estimated the polyphenol content and antioxidant capacity of golden apples grown under organic and conventional conditions for three years (2004-2006). In 2005 and 2006 the antioxidant capacity was significantly higher (15%) in organically produced apples than in conventionally produced fruits.

Loganayaki *et al*., (2010) reported the ferric reducing scavenging effect of DPPH, ABTS, iron chelation and antihemolytic activity of the different extracts (chloroform, acetone and methanol extracts) of *Solanum torvum* and *Solanum nigrum* leaves and fruit. Among the selected assays, chloroform (leaf and fruit) extract was highly effective as free radical scavengers and antioxidant assay followed by acetone and methanol.

Maria *et al.,* (2010) evaluated the antioxidant activity of medicinal plants containing polyphenol compounds and recommended to use more than one extraction system for better assessment of the antioxidant activity of natural products.

Philips *et al*., (2010) analyzed the DPPH radical, ABTS radical, nitric oxide radical and hydroxyl radical scavenging activity of leaves of *Indigofera aspalathoides* using two different solvents ethanol and chloroform. The chloroform extract showed highest scavenging activity in *Indigofera aspalathoides* leaves. Raigon *et al.*, (2010) detected lower antioxidant activity in conventionally grown egg plant due to application of high concentration of chemicals.

The *Aegle marmelos* hot methanol extract showed highest antibacterial activity (inhibition zone 14-29 mm) than the cold methanol extract (18-27 mm) against gram positive and gram-negative bacteria was reported by Saradha and Rao, (2010).

Sheeba, (2010) stated that *Solanum surratense* is used for various disease. The antibacterial activity was detected against *Staphylococcus aureus*, *Streptococcus spp, Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Shigella dysenteriae* and *Vibrio cholerae.* The highest antibacterial activity was observed in ethanolic leaf extracts at 500 μg concentration against all selected bacteria except *Shigella dysenteriae.*

An experiment was carried out under plastic house conditions to compare the effect of four fermented organic matter sources (cattle, poultry and sheep manure) 1:1:1 ratio showed increased vitamin C, total phenolics and anthocyanin content of bell pepper fruit and garden peas (Abu-Zahra, 2011). Despande *et al.*, (2011) reported that the methanolic extract of *Coccinia grandis* fruit showed significant reducing power and free radical scavenging activities.

John de Britto, (2011) analyzed antibacterial activity of the five medicinal plant species (*Solanum nigrum*, *Solanum torvum, Solanum trilobatum*, *Solanum surattense* and *Solanum melongena*) from Solanaceae family. Antibacterial activity was performed by disc diffusion method against two gram negative bacteria *Xanthomonas campestris* and *Aeromonas hydrophila.* It was found that the methanol extracts of all the plant samples showed significant activity against the two tested bacteria. The methanol extracts of *S. nigrum, S. torvum* and *S. surattense* exhibited clear zone of inhibition against the tested microorganisms.

Shahat *et al.,* (2011) grew three fennel cultivars under organic farming condition for essential oil purpose. They were tested for the antimicrobial activity against two gram negative bacteria *Escherichia coli* and *Pseudomonas aeruginosa* and gram positive bacteria *Staphylococcus aureus* and *Bacillus subtilis.* All three cultivars showed highest zone of inhibition against gram positive bacteria.

Subramanian *et al.,* (2011) investigated antioxidant activity of *Cassia fistula* seeds. Methanolic seed extract of *C. fistula* showed strong DPPH radical scavenging activity (59.587%). Suneetha *et al.,* (2011) analyzed the antioxidant activity during vermicomposting at different time intervals (15, 30 and 45 days). There was a significant increase in the antioxidant activity (0.397) at 45 days of vermicompost followed by 30 and 15 days.

Alam *et al.,* (2012) screened the antioxidant status of different parts of *Solanum nigrum* and found the total antioxidants, flavonoid content and free radical scavenging activities were significantly higher in ethanolic leaf extract followed by the fruit extract. Chauhan *et al.,* (2012) reported that methanol and ethanol extracts of *Solanum nigrum* dry fruits possess potent antioxidant, free radical scavenging activity and cytotoxic activity.

Chand *et al*., (2012) stated that aqueous seed extract of *Cucumis callosus* had maximum DPPH (94.71 μg/ml) and hydroxyl radical scavenging activity (143.45 μg/ml). Hassan *et al.,* (2012) reported that the organic compost increased the antioxidant activity in *Cosmos caudatus* leaf extracts compared to inorganic fertilizer. Organic based fertilizer application reduced the nitrate content than inorganic fertilizer.

Jayachitra and Krithika, (2012) analyzed the total antioxidant activity in the different leaf extracts (petroleum ether, chloroform and ethanol) of *Clitoria ternatea, Solanum nigrum* and *Aloe vera*. The results indicated that all the extracts of *Solanum nigrum* leaf possess good antioxidant activity compared to *Clitoria ternatea* and *Aloe vera.*

Kapusta-Duch *et al.,* (2012) studied the comparison of antioxidant activity of three species of cruciferous vegetables (white cabbage, red cabbage and Brussels sprouts) grown under conventional and organic condition for three consecutive years. Among the three selected species organically grown vegetables shown highest antioxidant activity in methanol extracts.

Kestwal *et al.,* (2012) screened phenolic content and antioxidant status of sprouts (6 day old) and dry seeds of *Vigna aconitifolia.* The phenolic content of the sprouts was approximately 27% higher than dry seeds.

Thangaraj *et al.*, (2012) tested the hydrogen peroxide radical scavenging activity, reducing power assay, superoxide radical scavenging assay in the aqueous and hydro alcoholic extracts of leaf, stem and fruit of *Solanum nigrum*. Leaves and fruits of *Solanum nigrum* showed significant antioxidant activity compared to stem.

Aminifard *et al.,* (2013) indicated that the application of compost (10t/ha) significantly enhanced the antioxidant components in the pepper fruit. Aires *et al.,* (2013) evaluated the phytochemical composition and antioxidant properties of watercress (*Nasturtium officinale*) cultivated under organic production system. They identified two major classes of healthier secondary plant metabolites (phenolics and glucosinolates) and higher antioxidant capacity.

Borguini *et al.,* (2013) reported alcohol and aqueous extract from organic tomatoes showed highest DPPH free radical scavenging activity (25.43 and 14.28%) than conventional grown tomatoes (19.52 and 11.33%).

DPPH radical scavenging activity, hydroxyl radical scavenging, nitric oxide radical scavenging activities of various extracts (n- hexane, chloroform, ethyl acetate and methanol) of *Lepidium sativum* seeds were estimated by Indumathy and Aruna, (2013) and reported that all the assays showed good antioxidant activity in the methanolic extracts of *Lepidium sativum* seeds.

Free radical scavenging activity of the methanolic extract of *Nelumbo nucifera* flowers found to possess comparatively higher antioxidant potential in terms of reducing power and DPPH radical scavenging capacity. (Kirithika *et al*., 2013). Wu *et al.,* (2013) reported highest antioxidant activity of 5.5 mmol TE/100g from fresh jujubes (*Ziziphus jujube* Mill.) under organic fertilization and 4 mmol TE/100g from fresh jujubes under mineral fertilization.

Antioxidant activity was analyzed in the organic and conventionally grown culinary herbs namely *Origanum vulgare, Origanum heracleoticum* and *Mentha spicata.* Among the three plants organically grown oregano and Greekoregano (fresh and dry herb) showed highest DPPH scavenging activity than conventionally grown plants (Kourimska *et al.*, 2014). Romero *et al*., (2014) analyzed the superoxide dismutase, high total phenolics, flavonoids and vitamin C content in the hydroalcoholic extract of dry soybean. It showed potent phenolic content and they suggested that dry soybean sprouts could also be used as a cheap natural antioxidant source for meat and meat products.

Seasotia *et al.,* (2014) reported that the ethyl acetate extract of *Trigonella foenum graecum* seeds having highest inhibitory potential. There was a positive correlation between the total phenolic content and the antioxidant activity of extracts. These findings suggest that the fenugreek extracts could act as potent source of antioxidants. According to Yadav *et al.,* (2014) *Solanum surattense* has the potential to serve as the source of alternative natural antioxidants and can be used as a medicine against the diseases caused by free radicals.

Doncean *et al*., (2015) reported that different compost mixture (green leaves, fresh chicken manure, cow manure) in combination with 75% soil achieved highest antioxidant activity (FRAP) in tomato. Among the organically grown both the varieties possess strong antioxidant activity (Vitamin C, total phenolic acids, total flavonoids and total anthocyanins) than conventionally cultivated ones (Kazimierczak *et al.,* 2015).

Mary and Nithiya, (2015) supported that the application of organic fertilizer increased the DPPH free radical scavenging activity and reducing power activity in leaf extract of *Solanum nigrum*. Perumal *et al.,* (2015) conducted a field experiment using different types of organic fertilizers using the test crop *Mentha spicata* and found combined application of farmyard manure + vermicompost + *Azospirillum* showed highest enzymatic and non-enzymatic antioxidant activity in the methanolic leaf extracts of mentha on 60th day followed by other treatments and control.

Zambrano-Moreno *et al.,* (2015) tested the antioxidant activity between conventional and organically cultivated egg plant. Antioxidant capacities were greater in organically grown egg plant as compared to the conventionally grown egg plant. Conventionally and organically produced two varieties of (Polka and Polana) raspberry fruits were analyzed for antioxidant activities.

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).

Mohamed *et al.,* (2016) screened *Solanum dubium* seeds extracted by using 96% ethanol, methanol, water and combination with honey. The water extracts of the seeds and honey combination showed the highest DPPH radical scavenging activity (91±0.04).

Ngereza and Pawelzik, (2016) stated that ascorbic acid content was significantly higher in organically produced mango and pineapple than conventional farming at different locations. Antioxidant capacity was higher by 22% in organically grown mango. The total carotenoids content was 17% in mango and 21% in pineapple under cultivated organic farming system as compared to the conventional farming.

Sereme *et al.,* (2016) reported that organic fertilizer increased the antioxidant activity (16.36 ± 0.07mg Trolox Equivalent (TE) /100g fresh tomato fruit) and total phenol content (6.96± 0.63mg Gallic Acid Equivalent (GAE) /100g fruit) than tomatoes under mineral fertilization and the control (without fertilization).

Ghaghelestany *et al*., (2022) analysed the DPPH anitioxidant activity of aqueous and methanolic extracts of weeds (*Acroptilon repens, Amaranthus retroflexus, Chenopodium album* and *Convolvulus arvensis*). The results indicated that free radical DPPH of aqueous and methanolic extracts of *Amaranthus retroflexus* was significantly lower than other weed extracts.

Narayanankutty *et al*., (2022) carried out the antibacterial activity of *Citrus limetta* on some microorganism like *Staphylococcus aureus*, *Salmonella typhimurium*, *Escherichia coli* and *Pseudomonas aeruginosa* and reported Highest activity against *Staphylococcus aureus.*

Cimen, *et al*., (2023) supported that the application of vermicompost increase the free radical scavenging activity in summer snowflake (*Leucojum aestivum* L.).