4

RESULTS AND DISCUSSION

The current chapter describes the results and discussion of microbial population during bio-composting, physico-chemical parameters, FT-IR, XRD and SEM characteristics of raw and composted groundnut shell and toddy palm shell and their efficacy on biometric, yield parameters, biochemical characteristics and pre & post harvest soil of selected test crops Bhendi (*Abelmoschus esculentus* (L.) Moench Var. Co 4), Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1), Coriander (*Coriandrum sativum* L. Var. Co 4) and Fenugreek (*Trigonella foenum-graecum* L. Var. Co 2). The results of the current research on "**Harnessing the benefits of groundnut and toddy palm shell biocompost on selected crops**" are discussed under the following heading in four phases of experimental studies as previously mentioned in the chapter 3 (Materials and Methods). The current chapter provides the significantly outcomes of this research (Table 1-45 & Figure I - XV).

PHASE I

Composting

4.1 Microbial population

Six different types of biocomposts were prepared by using groundnut shell and toddy palm shell wastes with different combinations of *Trichoderma asperelloides,* microbial consortium and *Eisenia fetida*. Composting treatments such as C – Control, C_1 – (Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida*), C_2 – (Groundnut shell + Microbial consortium), C_3 – (Groundnut shell + Microbial consortium + *Eisenia fetida*), C_4 – (Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida*), C_5 – (Toddy palm shell + Microbial consortium) and C_6 – (Toddy palm shell + Microbial consortium + *Eisenia fetida*). During the decomposition of the groundnut shell and toddy palm shell at regular intervals of 30, 60 and 90 days the microbial population was analyzed. Maximum number of colonies were observed on 60 days of the composting due to the presence of thermophilic microorganisms promotes a highest number of colonies.

4.1.1 Bacterial population

During the mesophilic phase (initial stage) the maximum number of bacterial colonies were observed from C_6 (1.92×10^6 CFU g^{-1}) followed by C_3 (1.76×10^6 CFU g^{-1}) over the control (1.12×10^6 CFU g^{-1}) on 30th day. On 60th day of composting the thermophilic bacteria occupied remarkable count in all the treatments. The highest number of colonies were observed in toddy palm shell composted with the help of microbial consortium and *Eisenia fetida* (2.48×10^6 CFU g^{-1}) followed by C_5 (2.32×10^6 CFU g^{-1}), C_3 (2.24×10^6 CFU g^{-1}) than C (1.62×10^6 CFU g^{-1}) as shown in Fig I a, Plate 9. The final stage (on 90th day) the bacterial count was slightly decreased than initial and middle phase of composting with the highest count of C_3 (1.60×10^6 CFU g^{-1}) followed by C_2 (1.56×10^6 CFU g^{-1}), C_6 (1.44×10^6 CFU g^{-1}), C_5 (1.36×10^6 CFU g^{-1}), C_1 (1.24×10^6 CFU g^{-1}), C_4 (1.12×10^6 CFU g^{-1}) and C (0.88×10^6 CFU g^{-1}) respectively.

4.1.2 Fungal population

The highest number of fungal colonies were found in the combined application of toddy palm shell composed with microbial consortium and earthworms (0.85×10^4 CFU g^{-1}) followed by C_3 (0.74×10^4 CFU g^{-1}), C_2 (0.64×10^4 CFU g^{-1}), C_5 (0.58×10^4 CFU g^{-1}) compared to the C (0.26×10^4 CFU g^{-1}) on 30th day of groundnut shell and toddy palm shell composting. A peak fungal population was obtained from C_3 (0.96×10^4 CFU g^{-1}) followed by C_6 (0.90×10^4 CFU g^{-1}) than control (0.42×10^4 CFU g^{-1}) on 60th day of bio-compost during the middle phase (Fig. I b, Plate 9). On 90th day the fungal count was slightly decline than 30th and 60th day and the maximum count was found in C_6 (0.66×10^4 CFU g^{-1}) and minimum in C (0.21×10^4 CFU g^{-1}) respectively.

4.1.3 Actinobacteria population

The maximum actinobacteria colonies were observed from groundnut shell + microbial consortium + *Eisenia fetida* (0.77×10^4 CFU g^{-1}) followed by toddy palm shell + microbial consortium + *Eisenia fetida* (0.69×10^4 CFU g^{-1}) than control (0.48×10^4 CFU g^{-1}) on 30 days respectively. On 60th day of decomposition a significantly increased actinobacteria colonies were found in C_6 (0.90×10^4 CFU g^{-1}) followed by C_3 (0.85×10^4 CFU g^{-1}), C_5 (0.80×10^4 CFU g^{-1}), C_2 (0.77×10^4 CFU g^{-1}), C_4 (0.74×10^4 CFU g^{-1}), C_1 (0.69×10^4 CFU g^{-1}) and C (0.58×10^4 CFU g^{-1}) as shown in Fig I c, Plate 9. During the maturation or cooling phase, the actinobacteria colonies were considerably reduced than initial and middle phase. And the groundnut shell treated with microbial consortium and earthworms enhanced the number of colonies in C_3 (0.58×10^4 CFU g^{-1}) and lowest in C (0.26×10^4 CFU g^{-1}) on 90^{th} day respectively.

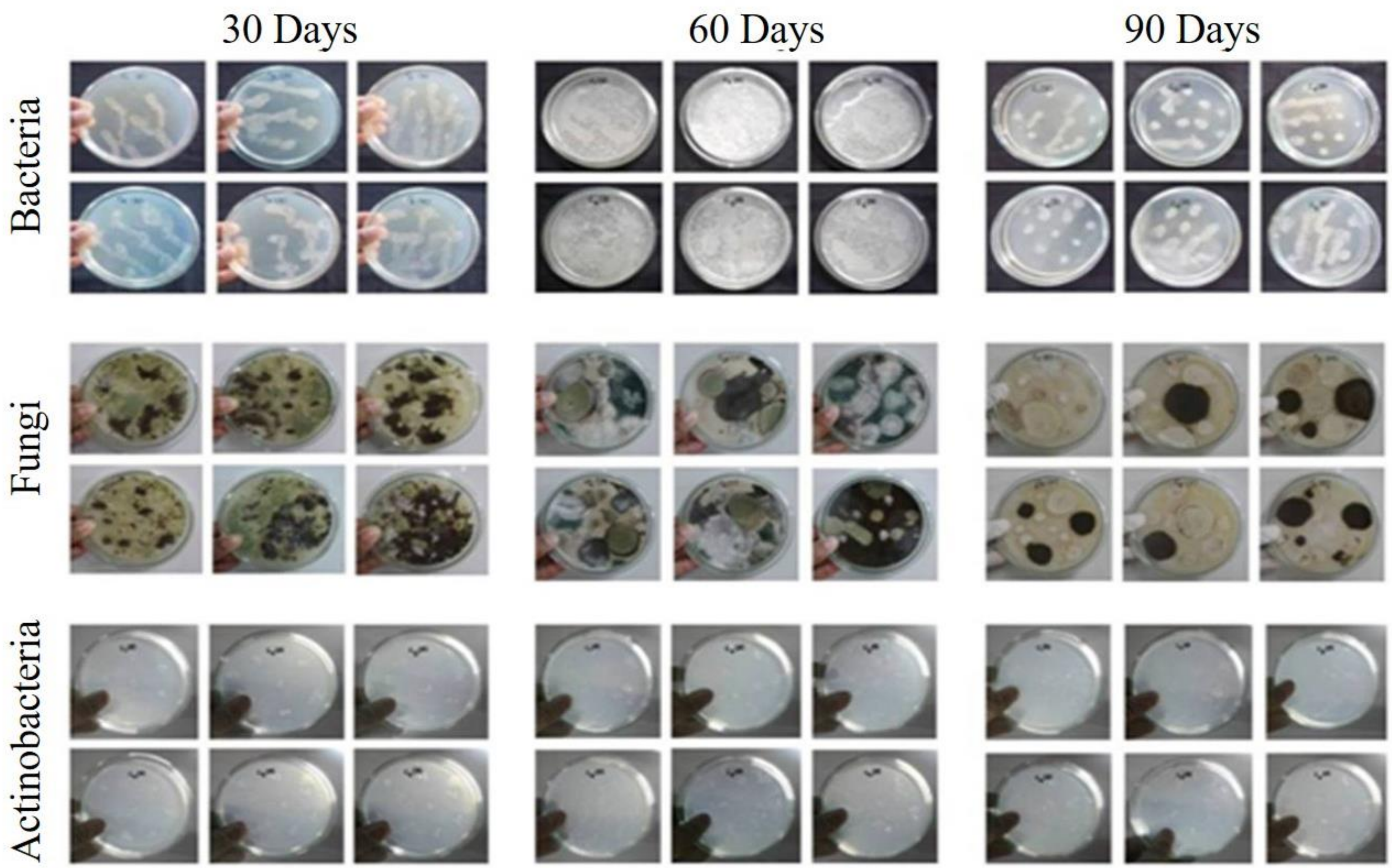
Composting is a biological decomposition process that converts organic matter into stabilized nutrient rich products by microbial activities. The growth of microorganisms depends on the physical and chemical factors such as temperature, moisture, pH and oxygen level. During the early stage of composting the carbon and nitrogen in the organic material was breakdown by microorganisms. The microbes consume oxygen while feeding the carbon rich material (organic matter) and break it down in a simple compound rich in NPK. The presence of lignocellulolytic microorganisms in the consortium of microorganisms has the ability to decompose organic materials by secreting lignocellulolytic enzymes. In this stage, mostly mesophilic microorganisms initiate the degradation process.

Afterwards, these microorganisms completely disappears and thermophilic microorganisms started to raise. A peak microbial load was obtained on 60^{th} day of composting due to the population of thermophilic microorganisms which are generated in high temperature about > 40°C. Increase in microbial populations might be due to the existing environmental conditions as well as availability of nutrients from the gut of earthworms. Likewise in the present study the highest microbial load was obtained from C_6 (Toddy palm shell + microbial consortium + *Eisenia fetida*) and C_3 (Groundnut shell + microbial consortium + *Eisenia fetida*) composts which had good degradation rate by microbial consortium and the energy provided from the gut of earthworms.

The study was par with the result of Premalatha *et al.* (2017) who reported that the influence of leaf litter composted with the help of microbial consortium increased the maximum bacterial population (42×10^6 cfu g^{-1} dry of compost) on 60 days. The present finding coincides with the result of Sivakumar and Karthikeyan (2016) reported that influence of weed plant waste vermicompost promotes maximum number of colonies of bacteria (185), fungi (15) and actinomycetes (207) compared with commercial compost (60, 9 and 103). Barghouth *et al.* (2023) reported that the application of bovin compost tea significantly improved the number of total bacteria (170×10^5) and the sea manure improved the number of total fungi (31×10^4) than other composts.

Plate – 9

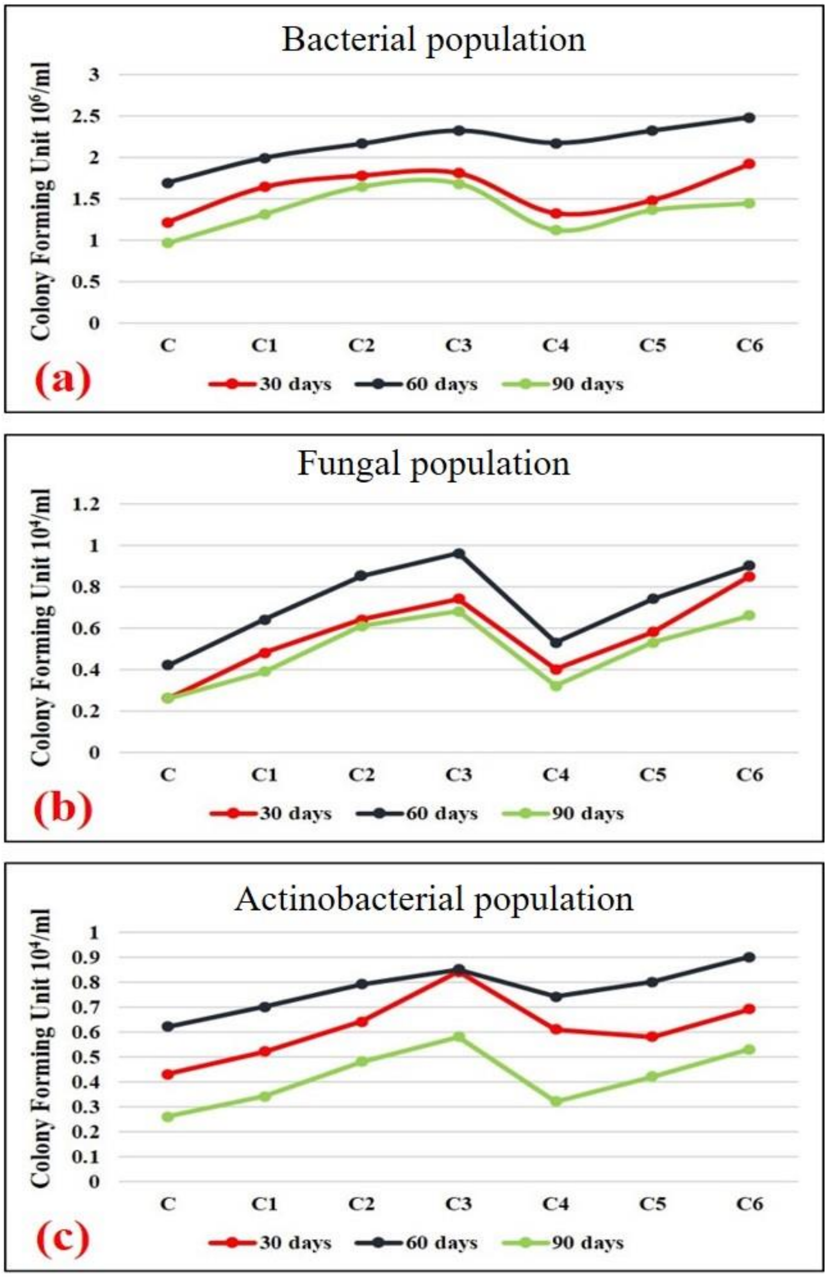
Microbial Population during Composting and Vermicomposting of Groundnut Shell and Toddy Palm Shell



C_1 – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida*, **C_2** – Groundnut shell + microbial consortium, **C_3** – Groundnut shell + microbial consortium + *Eisenia fetida*, **C_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida*, **C_5** – Toddy palm shell + microbial consortium and **C_6** – Toddy palm shell + microbial consortium + *Eisenia fetida*

Figure – I

Microbial Population during Composting and Vermicomposting of Groundnut Shell and Toddy Palm Shell



C – Control, $\mathbf{C_1}$ – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida*, $\mathbf{C_2}$ – Groundnut shell + microbial consortium, $\mathbf{C_3}$ – Groundnut shell + microbial consortium + *Eisenia fetida*, $\mathbf{C_4}$ – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida*, $\mathbf{C_5}$ – Toddy palm shell + microbial consortium and $\mathbf{C_6}$ – Toddy palm shell + microbial consortium + *Eisenia fetida*.

The groundnut shell and toddy palm shell vermicomposted by using *Eisenia fetida* improves the degradation rate and population of microorganisms. The result has coincided with the findings of Aira *et al.* (2006) who reported that degradation of cellulose due to the activity of *Eisenia fetida* promotes fungal growth during the vermicomposting process. The increasing population of microbes may be due to the source of nutrients available from the earthworm gut was also reported by Senapati and Dash (1984).

4.2 Physical and chemical composition of raw and composted groundnut shell and toddy palm shell

The physico-chemical parameters (pH, electrical conductivity, organic carbon, C:N ratio, total nitrogen, total phosphorus, total potassium, calcium, magnesium, lignin and cellulose) were analyzed in raw and composted groundnut shell and toddy palm shell to assess the maturity of compost as shown in the Table 1 respectively.

4.2.1 pH

The value of pH is an indicator for the decomposition and stabilization of composting process. The pH value of raw groundnut shell and toddy palm shell is 5.97 and 6.02 respectively. After the bio-degradation process a gradually increased pH value was observed in all composted samples like C_1 (6.01), C_2 (6.31), C_3 (6.25), C_4 (6.32), C_5 (6.37) and C_6 (6.40) as presented in the Table 1.

An increasing value of pH mainly due to the breakdown and mineralization of organic materials by microorganisms was reported by Tognetti *et al.* (2007) and Sharma *et al.* (2023). In the current study maximum degradation was observed in the combined application of microbial consortium and earthworm. Among the treatments, the highest pH value was observed in C_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) which accelerates the decomposition process faster. The presence of consortium of microorganisms accelerates the decomposition of organic materials. Hence the level of pH increased in composted samples. Similar result was also reported by Arumugam *et al.* (2018) who stated that increased level of pH was noted in papercup waste vermicomposted by bacterial consortium within 12 weeks.

The present result coincides with the result of Prakash and Hemalatha (2013) who observed an increased value of pH from 7.12 to 7.65 in pressmud vermicompost using *Eisenia* *fetida* on 60 days and composted paddy straw enhanced the pH value (6.97) than raw material (6.35) reported by Jaybhaye and Satish (2016). During vermicomposting process the gut of earthworm secretes nitrogenous substances through excreta which may promote the pH level. Vermicomposted substrates encourages the maximum pH value was also supported by Gopal *et al.* (2017) in coconut leaves vermicompost, Haynes and Zhou (2016) in municipal green waste vermicompost and Karmegam *et al.* (2012) in sugarcane trash vermicompost.

Table - 1

Physico-Chemical Composition of Raw and Composted Groundnut Shell and Toddy Palm Shell

Parameters	GNS	TPS	C_1	C_2	C_3	C_4	C_5	C_6
pH	5.97	6.02	6.01	6.31	6.25	6.32	6.37	6.40
EC (dS/m)	1.37	2.54	1.39	1.47	1.43	2.58	2.55	2.59
Organic Carbon (%)	32.7	36.5	27.2	29.8	29.4	26.9	28.1	26.5
C:N ratio	38:1	40:1	29:1	25:1	21:1	28:1	22:1	19:1
Total Nitrogen (%)	0.86	0.91	0.91	1.17	1.38	0.96	1.27	1.39
Total Phosphorus (%)	1.82	2.32	1.98	2.24	2.49	2.37	2.45	2.51
Total potassium (%)	1.21	1.57	2.36	2.58	3.74	2.89	3.42	3.85
Calcium (%)	1.05	1.34	2.27	2.75	3.07	2.94	2.80	3.25
Magnesium (%)	0.98	1.24	2.18	2.74	2.94	2.60	2.57	2.99
Lignin (%)	28.5	37.4	9.54	9.12	7.30	8.72	7.67	6.69
Cellulose (%)	34.2	29.2	10.71	9.46	6.53	8.28	7.63	6.35

GNS – Groundnut shell, **TPS** – Toddy palm shell, C_1 – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida,* C_2 – Groundnut shell + microbial consortium, C_3 **-** Groundnut shell + microbial consortium + *Eisenia fetida,* C_4 – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida,* C_5 – Toddy palm shell + microbial consortium, C_6 **-** Toddy palm shell + microbial consortium + *Eisenia fetida.*

Increased pH value in the compost mainly due to the degradation of organic matter during the ammonification process which encourages the pH value by the production of ammonia during the thermophilic stage of composting. Simultaneously, the basic value of pH indicating the alkalinity of the compost creates more ammonium gas in the atmosphere improves the harmful pathogens in the environment (Mandal *et al.,* 2014). However, the pH range at near neutral suitable to promote the availability of macronutrients in the composts (Edwards and Bohlen, 1996). The increasing and decreasing of pH might be due to the mineralization of proteinaceous substances during the vermicomposting process was also reported by Arumugam *et al.* (2018). Likewise in the present study, pH value of composted groundnut shell and toddy palm shell are near neutral value which promotes the quality of the compost.

4.2.2 Electrical conductivity

The electrical conductivity (EC) reflects the concentrations of salt of organic substrates act as an indicator of safe and suitable compost for agricultural purposes. Increasing of EC value might be due to the breakdown of ammonium ions and phosphate in the organic materials. High electrical conductivity promotes the growth of plant was also reported by Sharma *et al.* (2023). The electrical conductivity of raw groundnut shell and toddy palm shell is 1.37 and 2.54 (dS/m) respectively. After the decomposition of both agricultural wastes the EC value was slightly increased ranged between 1.39 to 1.47 (dS/m) and 2.55 to 2.59 (dS/m) in groundnut shell and toddy palm shell are presented in Table 1.

During the composting process the mineralization of organic materials through earthworms improves the level of electrical conductivity. Similar results were observed by Ramnarain *et al*. (2019) who reported that the application of vermicomposted rice straw enhanced the value of electrical conductivity from 3.90 to 4.56 and Prakash and Hemalatha (2013) who observed an increase in EC from 1.20 to 1.42 dSm^{-1} over 60 days of degradation of pressmud subjected to vermicomposting using *Eisenia fetida.*

The earthworm’s excreta contain freely available minerals and ions by digestion process and also the earthworm secretes different kinds of soluble salts in the form of ammonium, potassium and phosphate through excreta, urine and mucoproteins (Khwairakpam and Bhargava, 2009). Composting through earthworms promotes the value of electrical conductivity. Likewise in the current study combined activity of consortium of microorganisms and earthworms accelerate the degradation process and resulted in a slight increase in EC value than raw materials. The EC value of $< 3\mu S^{-1}$ in organic fertilizer is suitable for the agricultural purposes. The compost with higher EC value prohibits the plant growth and may not be suitable for the breeding of earthworms was also reported by Fernandez-Gomez *et al.* (2010).

4.2.3 Organic carbon

A percentage of organic carbon present in groundnut shell and toddy palm shell is 32.7% and 36.5% respectively. After 90 days of complete vermicomposting process the considerable reduction of organic carbon was obtained in all the processed composts such as C_1 (27.2%), C_2 (29.8%), C_3 (29.4%), C_4 (26.9%), C_5 (28.1%) and C_6 (26.5%) as shown in Table 1.

Reduction of organic carbon in bio-composted groundnut shell and toddy palm shell might be due to the complete decomposition process by consortium of microorganisms and earthworms which led to the loss of carbon in the form of carbon dioxide from the substrates. During the composting process high emission of carbon dioxide, indicates a high rate of organic matter breakdown (Sharma *et al.*, 2023). Lignocellulolytic microbes (bacterial and fungal isolates) found in the consortium of microorganisms able to degrade more recalcitrant substances which considerably reduced the organic carbon level. Similar result was observed by Parveen and Padmaja (2010) who reported that the municipal solid waste water hyacinth degraded by using the fungal consortium decline the organic carbon ranged between 34.07% - 21.09% than uninoculated control 34.07% - 24.45% respectively.

In addition, the decomposition of organic materials through earthworm was partially degrade by microorganisms, mechanical effort, and enzyme activity from the gut of earthworm (Svensson and Fribergs (2007). Maximum reduction of organic carbon was appeared in earthworm treated compost than non-earthworm treated compost. Similar results were observed by Yuvaraj *et al.* (2019) who reported that the poultry litter decomposed with the help of cow dung and *Tectona grandis* leaf litter through vermicomposting using earthworm *Drawida sulcate* reduced the level of organic carbon. Considerable reduction of organic carbon obtained in vermicomposting of grass clippings and rice straw through *Eisenia fetida* was reported by Ramnarain *et al.* (2019).

4.2.4 C:N ratio

The raw groundnut shell and toddy palm shell has a higher amount of C:N ratio (38:1 and 40:1) which was considerably reduced after the bio-degradation of organic materials. Among the six treatments, a significant reduction of carbon nitrogen ratio was observed in C_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) of 19:1 followed by C_3 (21:1), C_5 (22:1), C_2 (25:1), C_4 (28:1) and C_1 (29:1) as given in the Table 1. Carbon nitrogen ratio is a good indicator for evaluating the quality and maturity of compost.

From the beginning of the experiment raw material have high amount of C:N ratio which was considerably reduced in final stage of composting (maturation or cooling phase). Less than 20% of carbon nitrogen ratio indicates the maturity and good quality of the compost (Khwairakpam and Bhargava, 2009). Thereby in this study, the maximum reduction of carbon nitrogen ratio was observed in C_6 and C_3 revealed a high rate of mineralization and decomposition of organic materials and loss of carbon as carbon dioxide. The addition of nitrogen by the joint action of microorganisms and earthworms through respiration and excretion. The microbial consortium incorporated treatment significantly reduced the carbon nitrogen ratio within a short period.

Similar finding was also reported by Arumugam *et al.* (2018) the maximum reduction of C:N ratio observed with the application of papercup waste vermicomposted by using bacterial consortium within 12 weeks. In addition, a decline of C:N ratio obtained in leaf litter (10:1) and sugarcane trash (12:1) compost by using microbial consortium on 90^{th} day during the composting process was also reported by Premalatha *et al.* (2017). The combined activity of microbial consortium and earthworm accelerate the degradation process thereby achieved nutrient rich and good quality of compost (Yuvaraj *et al.*, 2019). At the same time, maximum reduction of C:N ratio reflects the efficient activity of earthworms. The present study was positively correlated with the findings of Game *et al.* (2017); Chander *et al.* (2018); Omidi *et al.* (2017); Khomami *et al.* (2019); Mbarek *et al.* (2019) and Aslam *et al*. (2023).

4.2.5 Total Nitrogen

Nitrogen is a fundamental element required for successful plant growth. Total nitrogen in the raw groundnut shell and toddy palm shell was up to 0.86% and 0.91% as shown in table 1 respectively. After complete vermicomposting process the maximum amount of total nitrogen content was observed in C_6 (1.39%) and C_3 (1.38%). During the vermicomposting process increase in the amount of total nitrogen by conversion of ammonium nitrate into nitrate was observed by Suthar and Singh (2008). The combined application of groundnut shell and toddy palm shell biocomposted by using microbial consortium and *Eisenia fetida* promotes a higher level of total nitrogen than other composts C_1 (0.91%), C_2 (1.17%), C_4 (0.96%) and C_5 (1.27%) respectively.

The earthworm stimulates the metabolism process and secretes nitrogenous substance through excreta, urine and mucoproteins thus promotes the availability of macronutrients. The present finding coincides with the result of Gopal *et al.* (2017) who reported that the percentage of total nitrogen (1.85%) as influenced by the application of vermicomposted coconut leaves with *Eudrilus sp* and the influence of papercup waste vermicomposted by using bacterial consortium enhanced the level of nitrogen was reported by Arumugam *et al.* (2018).

The enhancement of total nitrogen in the vermicompost mainly was due to the activity of earthworms by excretory products, body fluid, mucus, enzymes and decayed tissues of dead worms. Normally, cow dung was incorporated into the vermicomposting unit to stimulate the process. Aslam *et al.* (2023) who found that vermicomposted cow dung enhanced the percentage of nitrogen (1.47%) than raw and composted wheat straw, rice straw and cow dung. Cow dung contains phosphorus (0.70%), nitrogen (1.61%), magnesium (0.91%), sodium (0.50%), potassium (0.53%) and calcium (2.71%) which quickness the decomposition. Similar results were reported by Omidi *et al.* (2017); Chander *et al.* (2018); Game *et al.* (2017) and Khomami *et al.* (2019).

4.2.6 Total Phosphorus

The initial total phosphorus content of raw groundnut shell and toddy palm shell was 1.82% and 2.32% which was gradually increased in all bio-composted samples such as C_1 (1.98%), C_2 (2.24%), C_3 (2.49%), C_4 (2.37%), C_5 (2.45) and C_6 (2.51%) was presented in Table 1.

Maximum phosphorus content was observed from toddy palm shell composted by using microbial consortium and *Eisenia fetida* which promotes mineralization and degradation of organic substrates. In addition, the gut of earthworm secretes phosphatases enzyme during the vermicomposting process which can convert insoluble phosphate into soluble phosphate with the help of phosphate solubilizing microorganisms thereby increasing the total phosphorus content (Padmavathiamma *et al.*, 2008). Further, the mineralization of phosphorus by microorganisms and enzyme could account for the increase in phosphorus during the composting process (Sharma *et al.,* 2023). Likewise, in the current study, the presence of phosphate solubilizing microorganisms in the consortium of microorganisms encourage the maximum level of total phosphorus in the end product.

The present result coincides with the result of Gopal *et al.* (2017) who reported that the influence of coconut leaves vermicompost by using *Eudrilus* sp. enhanced the maximum amount of total phosphorus (0.22%) on 105th day of composting compared with 15th (0.14%), 45th (0.16%) and 75th (0.21%) days. In addition, the amount of total phosphorus improved by the application of papercup waste vermicompost through bacterial consortium (Arumugam *et al.,* 2018).

4.2.7 Total potassium

A significantly increased total potassium content was obtained from C_6 (3.85%) followed by C_3 (3.74%), C_5 (3.42%), C_4 (2.89%), C_2 (2.58%) and C_1 (2.36%) is given in the Table 1. Before composting the raw groundnut shell and toddy palm shell has less amount of total potassium 1.21% and 1.57% than composted samples which was successfully increased after the composting process, inoculated with microorganisms and earthworms. More than two microorganisms (consortium of microorganisms) are used for composting stimulate the degradation process and enriched the essential nutrients. Similarly, the papercup waste biodegraded by using bacterial consortium achieved the maximum potassium content than vermicomposted papercup alone was reported by Arumugam *et al.* (2018).

During the vermicomposting process, acid producing microorganisms play a vital role in solubilization of insoluble potassium in the gut of earthworms. The joint action of consortium of microorganisms and earthworm enhanced the high mineralization rate due to the enzyme and microbial activities as a result enhanced the amount of total potassium content. This result agreed with the findings of Gopal *et al.* (2017) reported that maximum percentage of total potassium observed on 15th (0.99%) day of coconut leaves vermicompost than 45th (0.36%), 75th (0.18%) and 105th (0.17%) day and *Tectona grandis* leaf litter and cattle dung in the ratio of 1:10 improves the potassium level in the final compost was also reported by Sharma *et al.* (2023).

4.2.8 Calcium

Calcium is an important source for growth attributes of microbes in the composting site which increased the population of microbes and nutrition rich compost as fertilizer (Manohara *et al.*, 2017). The highest calcium content was noted in C_6 (3.25%) followed by C_3 (3.07%), C_4 (2.94%), C_5 (2.80%), C_2 (2.75%) and C_1 (2.27%) respectively. After the bio-degradation of groundnut shell and toddy palm shell which was progressively increased than raw materials like groundnut shell (1.05%) and toddy palm shell (1.34%) as shown in Table 1.

The increase in calcium content might be due to the mineralization of the organic matter by the microorganisms and cow dung. Cow dung enhanced the degradation process and promotes the level of calcium. A higher proportion of cow dung enhanced the quality of organic fertilizer thereby in the current study all the compost treatments have a substantial amount of cow dung. The chemical properties of cow dung (calcium 2.71%, potassium 0.53%, sodium 0.50%, nitrogen 1.61%, magnesium 0.91%, phosphorus 0.70%). Maximum level of calcium is found in the vermicomposted sample associated with the gut of earthworm which stimulate the metabolism of calcium ions. Similar results were agreed with the findings of Cabilovski *et al.* (2023) who observed that maximum calcium content was noticed in vermicompost (18.6 g kg^{-1}) respectively.

Mbarek *et al.* (2019) who observed that highest calcium content was noticed in date palm compost (38.000 mg/kg) followed by sheep manure (21.000 mg/kg) and maximum calcium content (46.543 mg kg^{-1}) was observed in aerobic composting of sorghum straw along with 0.5% urea and 4% rock phosphate was reported by Chander *et al.* (2018).

4.2.9 Magnesium

The process of vermicompost significantly enhanced the magnesium content in final product by the mineralization of organic matter. Magnesium is an important parameter for plant growth which is responsible for the production and transport of sugar for use by a plant in chloroplasts and also acts as a cofactor in photosynthesis (Ruan *et al.,* 2012). The magnesium content of non-composted substrates such as groundnut shell and toddy palm shell varied from 0.98% and 1.24% presented in the Table 1. The combined application of microbial consortium and earthworms significantly enhanced the percentage of magnesium content in composted samples. The maximum amount of magnesium recorded in C_6 (2.99%), C_3 (2.94%), C_2 (2.74%), C_4 (2.60%), C_5 (2.57%) and C_1 (2.18%) respectively.

Significantly increased magnesium content in C_6 and C_3 composts may be due to the mineralization of organic matter through consortium of microorganisms and earthworm. The microorganisms present in the compost play a vital role in transformation of plants metabolites into more available forms and the excreta of earthworm contain high amount of calcium and magnesium.

The present result coincides with the result of Chander *et al.* (2018) who obtained maximum magnesium content (5997 mg kg^{-1}) increased with the application of vermicomposted sorghum straw and a gradually increased total magnesium content from 0.36% to 0.72% in pressmud inoculated with the epigeic earthworm *Eisenia fedita* obtained on 60 days of decomposition was reported by Prakash and Hemalatha (2013). Similar results were also supported by Cabilovski *et al.* (2023) who observed significant increase in total magnesium content (6.50 g kg^{-1}) in vermicompost treatment.

4.2.10 Lignin

Lignin is a complex polymer composed of the most recalcitrant substance of plant biomass that binds tightly seal around the plant wall (Fang *et al.*, 2014). The percentage of lignin in raw groundnut shell and toddy palm shell are 28.5% and 37.4% respectively. The complete bio-degradation process a considerable reduction of lignin was observed ranged between 9.54% - 7.30% in groundnut shell and 8.72% - 6.69% in toddy palm shell as shown in Table 1.

A considerable reduction of lignin obtained from groundnut shell and toddy palm shell decomposed with the help of microbial consortium and earthworm. The presence of lignolytic fungi *Pleurotus florida* in the consortium of microorganisms enhanced the degradation by releasing lignolytic enzymes which completely degrade lignin to CO_2 and H_2O. In addition, during the biodegradation of organic materials the lignocellulolytic microorganisms are able to stimulate the composting process which release lignolysis byproducts and soluble substances thus promotes the activity of fungi and degradation rate.

Similar results was also supported by Wang *et al*. (2023) that inoculation of *Gloeophyllum trabeum* in swine manure and wheat straw reduced the period of compost and increased the rate of lignin, cellulose and hemicellulose degradation. Kumar and Ganesh (2012) who recorded reduction of lignin (6.24%) was noticed with the application of 1 kg of coir pith inoculated with 5% of cow dung, 5% panchagavya and 5 ml of *Phanerochaete chrysosporium*.

4.2.11 Cellulose

A higher level of cellulose content was observed from raw groundnut shell and toddy palm shell are 34.25% and 29.2% which was considerably reduced after the composting process. The maximum reduction was obtained in C_6 (6.35%) followed by C_3 (6.53%), C_5 (7.63%), C_4 (8.28%), C_2 (9.46%) and C_1 (10.71%) as shown in Table 1 respectively.

A drastic reduction of cellulose obtained in C_3 and C_6 composts might be due to the joined action of consortium of microorganisms and earthworms play an important role in degradation process. The presence of lignocellulolytic microbes (*Bacillus licheniformis*, *Pleurotus florida*, *Paecilomyces variotti* and *Streptomyces lavendulae*) in the consortium of microorganisms able to promotes the degradation process. Wang *et al.* (2023) reported that fungi and actinomycetes have good cellulose degradation ability. The result is also on par with Kumar and Ganesh (2012) who reported that the reduction of cellulose content (5.65%) in the treatment inoculated with coir pith (1kg) + cow dung (5%) + *Phanerochaete chrysosporium* (5 ml) + panchagavya (5%) which considerably reduced the amount of cellulose content after the composting as compared to the initial value (27.28%).

In addition, the influence fungal consortium includes lignocellulolytic microorganisms improves the rate of cellulose degradation in municipal solid waste and water hyacinth (20.56%) than control (31.55%) on 90 days. Further, the gut of earthworm produces cellulase, amylase and phosphatase enzymes which stimulates the decomposition faster.

4.3 Spectrochemical analysis

4.3.1 Fourier transform infrared spectroscopy

The FTIR spectra of raw groundnut shell, toddy palm shell and composted samples such as C_1, C_2, C_3, C_4, C_5 and C_6 are shown in Figure II. These spectra show the absorption bands associated to bending and stretching vibrations of distinguishing chemical groups of lignocellulosic compounds such as lignin, cellulose and hemicellulose.

The raw groundnut shell spectrum reveals a broad band at 3371 cm^{-1} region related to O-H and N-H stretching vibrational of the aliphatic primary amine in the cellulose molecules. The band at 2970 cm^{-1} corresponds to the C-H stretching vibration of alkane groups in aliphatic bands of lignin, cellulose and hemicellulose. The similar result was also reported by Sharma *et al.* (2023) in a mixture of cattle dung and leaf litter. A sharp peak at 2316 cm^{-1} corresponds to O=C=O stretching vibrations of carbon dioxide. The band around 1400 cm^{-1} corresponds to the O-H banding of cellulose respectively.

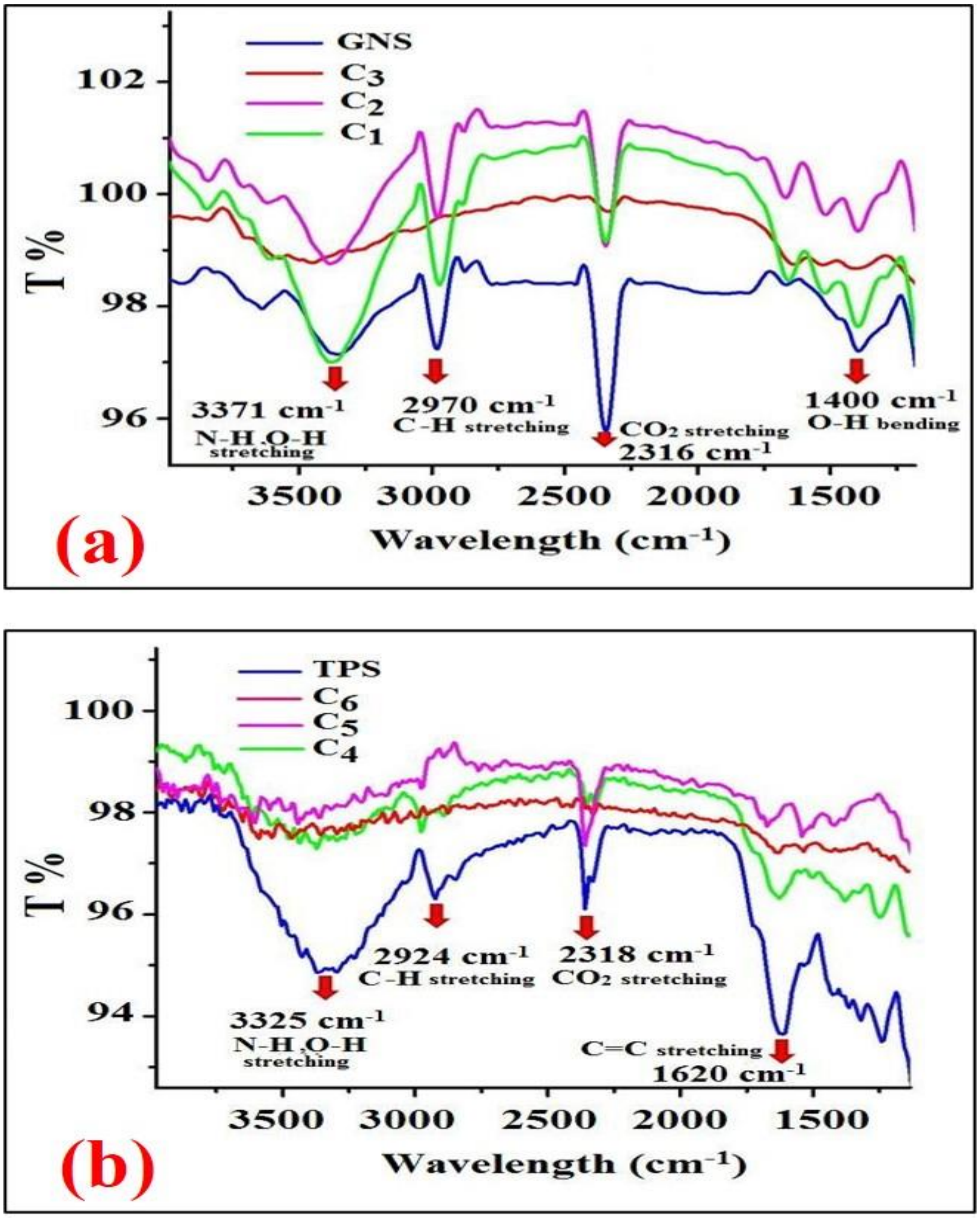
A prominent peak appeared at 3325 cm^{-1} regions related to N-H and O-H stretching of aliphatic amines. And next to the small bands appeared at 2924 cm^{-1} and 2318 cm^{-1} corresponds to the C-H and O=C=O stretching alkane and carbon dioxide of cellulose and hemicellulose. The absorption band strongly located at 1620 cm^{-1} which would corresponds to C=C stretching of α β - unsaturated ketone.

The degradation of cellulose, hemicellulose and lignin monitored by the disappearance of the respective bands. Figure II (a) showed a comparison of fourier transform infrared spectra of groundnut shell, C_1, C_2 and C_3 samples. The broad band at 3371 cm^{-1} and continuous to the small vibrational band at 2970 cm^{-1} indicating the degradation of cellulose, hemicellulose and lignin molecules. In addition, the disappearance of O–H bending vibrational band at 1400 cm^{-1} also ensure the degradation process. Among them, C_3 (Groundnut shell + microbial consortium + *Eisenia fetida*) got a considerable degradation in FTIR analysis than other samples. Similar result was also reported by Reddy *et al.* (2009) in untreated and alkali treated fine and coarse fiber of *Borassus*. During the chemical treatments maximum removal of lignin and hemicellulose absorbed around at 1450 cm^{-1} by microfibers extraction process was reported by Reddy *et al.* (2016).

Figure II (b) showed the comparison of toddy palm shell and their processed composts such as C_4, C_5 and C_6 respectively. A broad band at 3325 cm^{-1} and continuous to the small absorption bands located at 2924 cm^{-1} and 2318 cm^{-1} were completely disappeared in C_6. And the vibrational band at 1620 cm^{-1} was partially disappeared in all the composted samples. The study is par with the result of Usman *et al.* (2016) who observed disappearance of absorption peak at 1600 cm^{-1} corresponding to C-O stretching of lignin and cellulose. Similar result was also reported by Reddy *et al.* (2012) in untreated and alkali treated *Borassus* fine fibers.

Figure - II

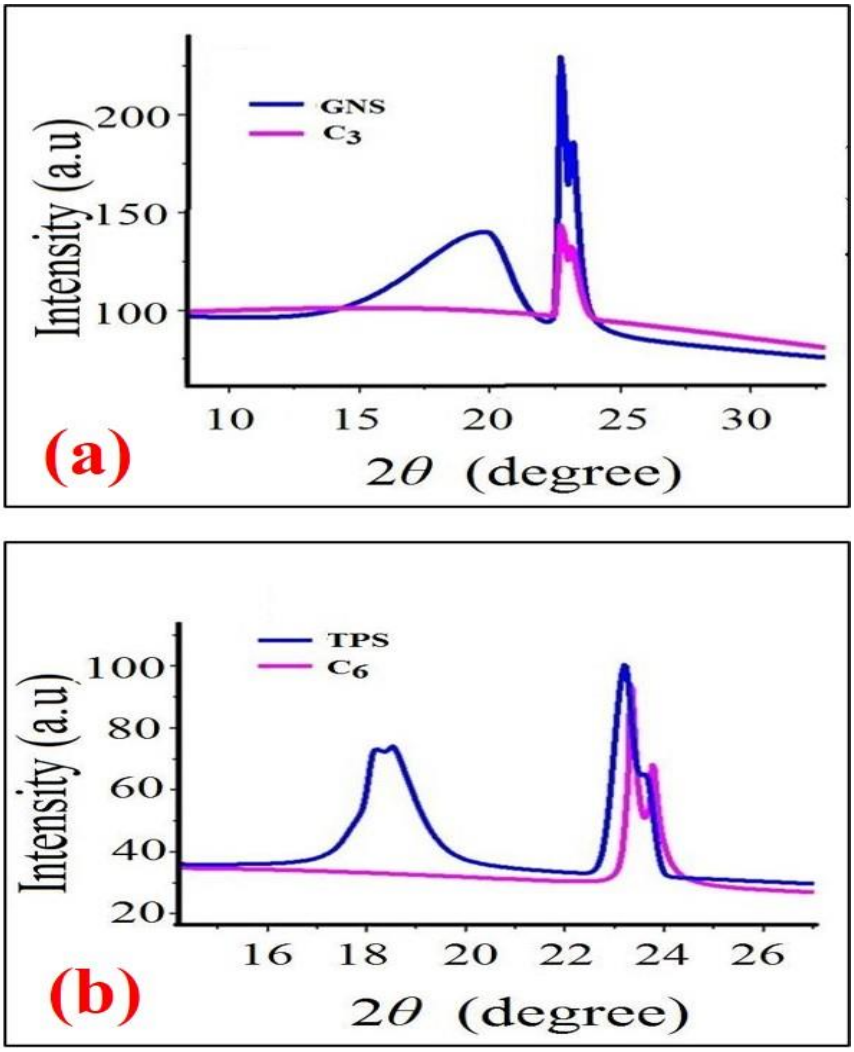
FT-IR Spectra of Raw and Composted Groundnut Shell and Toddy Palm Shell



GNS – Groundnut shell, **TPS** – Toddy palm shell, **C_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida,* **C_2** – Groundnut shell + microbial consortium, **C_3 -** Groundnut shell + microbial consortium + *Eisenia fetida,* **C_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida,* **C_5** – Toddy palm shell + microbial consortium, **C_6 -** Toddy palm shell + microbial consortium + *Eisenia fetida*

Figure – III

XRD Analysis of Raw Groundnut Shell, Toddy Palm Shell and Composted Samples



GNS – Groundnut shell, **TPS** – Toddy palm shell, **C_3** – Groundnut shell + microbial consortium + *Eisenia fetida*, **C_6** – Toddy palm shell + microbial consortium + *Eisenia fetida*.

A considerable degradation of cellulose, lignin and hemicellulose observed in microbial consortium and *Eisenia fetida* incorporated treatments like C_3 and C_6 which enriched the composting process and improves the quality of fertilizer. The present study coincides with the result of Arumugam *et al*. (2018) who observed a maximum degradation of carboxylic and aliphatic groups appeared in vermicomposting of paper cup waste using bacterial consortium than paper cup waste vermicompost.

The present study coincides with the result of Reddy *et al.* (2016) who observed that the considerable reduction of lignin, hemicellulose and cellulose disappeared in extracted cellulose microfibers than raw fiber of palmyra palm fruit fiber.

4.3.2 X-ray diffraction method

X-ray diffraction study is used to study the crystallographic structural information of cellulose present in the substrate (Cao and Tan, 2005). In the current study, XRD reveal substance crystal structure evolution during composting (Kong *et al.,* 2023). The continuation of FT-IR report, the degradation of C_3 and C_6 composts has been ensured by X-ray diffraction analysis.

Figure III (a) showed the comparison of groundnut shell (GNS) and C_3 – (Groundnut shell + microbial consortium + *Eisenia fetida*) respectively. A broad hump at 19^o and a strong peak at 22.5^o observed in groundnut shell was disappeared in the processed compost (C_3) indicating the degradation of cellulose. The reflection (22^o) had a higher intensity of crystalline material in cellulosic fine fibers of *Borassus*. Similar result was also supported by Ray *et al.*, 2001; Wang *et al.*, 2003; Mwaikambo and Ansell, 2002.

Figure III (b) showed the comparison of toddy palm shell (TPS) and (C_6) toddy palm shell biodegraded with the help of microbial consortium and *Eisenia fetida* respectively. The observed hump at 18.5^o and a sharp peak at 23^o for toddy palm shell were disappeared and slightly shifted in C_6 confirmed the degradation of lignin and cellulose.

Raw groundnut shell and toddy palm shell have considerable amount of lignin and cellulose content as previously mentioned in the Table 1. The disappearance of lignin, cellulose and hemicellulose were observed in C_3 and C_6 compost samples by XRD analysis. This is might be due to the attributes of consortium of microorganisms and earthworms. The presence of (*Bacillus licheniformis, Pleurotus florida, Paecilomyces variotti* and *Streptomyces lavendulae*) in the consortium of microorganisms ability to degrade lignin and cellulose by secreting lignocellulolytic enzymes which stimulate the degradation process faster.

The joint action of consortium of microorganisms and *Eisenia fetida* stimulate the degradation process and improves the fertilizer quality by lignocellulosic microorganisms. Similar result was also observed by Arumugam *et al*. (2018) who reported that the maximum reduction of cellulose obtained in vermicomposting of paper cup waste using bacterial consortium.

4.3.3 Scanning electron microscopy

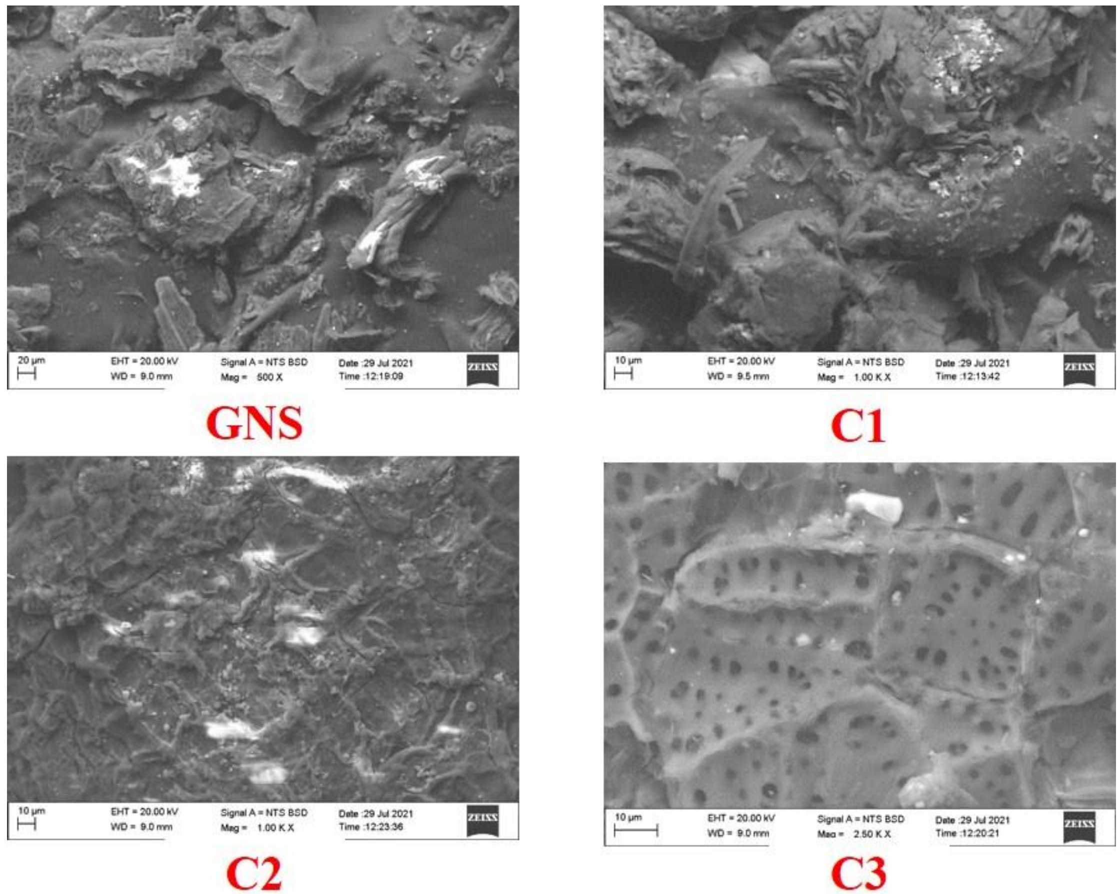
Scanning electron microscopy (SEM) provides high resolution image of the solid materials by focus an electron beam across the surface. The current study, provides the morphological structural changes of initial and final compost samples. SEM micrographs of final composts revealed the presence of many structural changes in the composted samples such C_1, C_2, C_3, C_4, C_5 and C_6. The maximum surface changes appeared in groundnut shell and toddy palm shell bio-composted by microbial consortium and *Eisenia fetida* which indicates the biodegradation and mineralization of organic materials by microorganisms and earthworms. The current study positively correlated with the result of Unuofin and Siswana (2019) who observed that vermicomposting of waste paper mixture decomposed by using cow dung and *Eisenia fetida* promotes the degradation rate within 6-8 weeks. Sharma *et al.* (2023) reported that increased number of surface changes indicated organic waste mineralization in the final vermicomposted samples.

The images of GNS (groundnut shell) and TPS (toddy palm shell) showed the presence of cellulose microfibers aggregated with the raw materials as shown in the Fig. IV and V respectively. After 90 days of composting process which was completely disappeared in C_3 and C_6 composts. This is mainly due to the breakdown of lignin and cellulose by lignocellulolytic microorganisms present in the consortium of microorganisms which are able to secrete lignocellulolytic enzymes like cellulase, xylanase, laccase, lignin peroxidase and manganese peroxidase (Dao *et al.*, 2021; Gonzalo *et al.*, 2016).

The maximum degradation of lignin and cellulose was clearly noted in groundnut shell and toddy palm shell degraded by using consortium of microorganisms and earthworms which accelerate the degradation process faster and improves the fertilizer quality with in small period. In addition, the presence of numerous hydrolytic bacteria in the gut of earthworm progressive the degradation rate. The present study coincides with the result of Arumugam *et al*. (2018) who reported that the maximum degradation of lignin and cellulose observed in paper cup waste vermicomposted by using bacterial consortium and *Eudrillus eugeinea* within 12 weeks. A similar result was obtained by Pampuro *et al.* (2016) who reported that the degradation of cellulose in municipal solid waste observed on 60 days of compost than 20 and 40 days respectively

Figure -IV

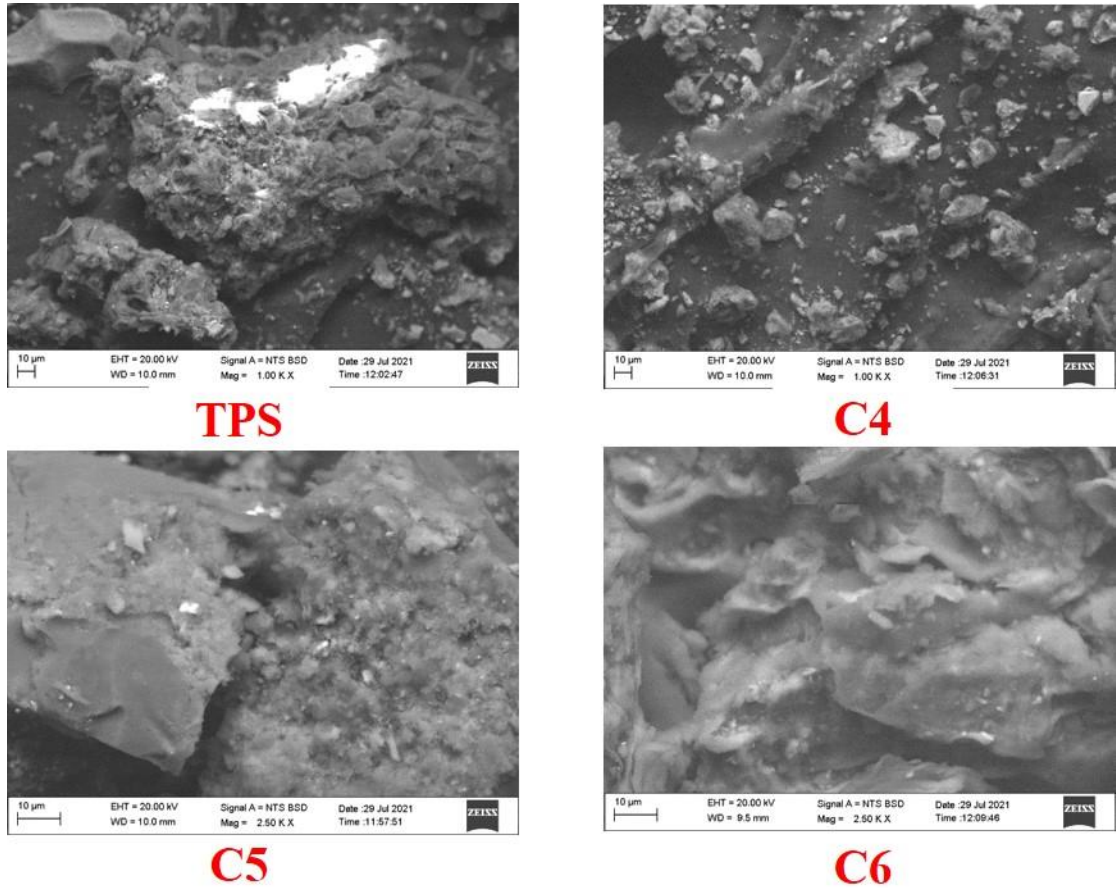
SEM Micrographs of Raw and Composted Groundnut Shell



GNS – Groundnut shell, **C_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida*, **C_2** – Groundnut shell + microbial consortium, **C_3 -** Groundnut shell + microbial consortium + *Eisenia fetida*.

Figure – V

SEM Micrographs of Raw and Composted Toddy Palm Shell



TPS – Toddy palm shell, **C_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida,* **C_5** – Toddy palm shell + microbial consortium, **C_6 -** Toddy palm shell + microbial consortium + *Eisenia fetida*

PHASE II

4.4 Field culture experiment

A field culture experiment was conducted with the influence of groundnut shell and toddy palm shell compost were recorded the biometric, yield, biochemical and soil nutrients status of Bhendi (*Abelmoschus esculentus* (L.) Moench Var. Co 4), Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1), Coriander (*Coriandrum sativum* L. Var. Co (CR) 4) and Fenugreek (*Trigonella foenum-graecum* L. Var. Co 2) at different stages of growth on 25, 50, 75 and 90 DAS (days after sowing) were statistically scrutinized.

4.4.1 Biometric characters

The effect of biocomposted groundnut shell and toddy palm shell on vegetative parameters of test crops such as bhendi, cluster bean, coriander and fenugreek were analyzed.

4.4.1.1 Root length

***Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)**

The maximum root length was observed in toddy palm shell composted with the help of microbial consortium and earthworm followed by groundnut shell composted by microbial consortium and earthworm compared to the control on 25 (19.7 cm, 18.3 cm and 8.5 cm), 50 (27.8 cm, 24.8 cm and 20.1 cm) and 75 (30.2 cm, 26.4 cm and 20.4 cm) days after sowing (Table 2, Plate 10).

***Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)**

The length of root was significantly increased with the application of toddy palm shell with microbial consortium and earthworm assistance followed by T_3 compared to the C on 25 DAS (12.4 cm, 12.1 cm and 3.9 cm), 50 DAS (18.3 cm, 16.9 cm and 12.2 cm) and 75 DAS (25.6 cm, 23.4 cm and 15.6 cm) as shown in Table 4, Plate 11.

***Coriandrum sativum* L. Var. Co (CR) 4 (Coriander)**

A gradual increase in root length of coriander was observed from 25 – 75 DAS in all the treatments as shown in Table 6, Plate 12. The T_6 (Toddy palm shell + microbial consortium + *Eisenia fetida*) achieved highest root length in all the three treatments examined on 25 DAS (9.2 cm), 50 DAS (13.9 cm) and 75 DAS (18.2 cm) and lowest root length in C (4.8 cm, 6.4 cm and 12.8 cm) when compared to the other treatments.

***Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)**

Among the treatments, increased root length was observed from toddy palm shell + microbial consortium + *Eisenia fetida* (10.9 cm, 12.9 cm and 23.9 cm) followed by T_3 (9.6 cm, 12.4 cm and 22.9 cm) compared with control (6.9 cm, 7.2 cm and 15.8 cm) on 25, 50 and 75 days after sowing (Table 8, Plate 13).

An equal amount of vermicompost and soil enhanced the length of root (8.4 cm) than farmyard manure (7.1 cm) and control (6.2 cm) in coriander seedlings was reported by Ravimycin (2016). Similar results was observed by Vaidyanathan and Vijayalakshmi (2017) who reported that the plants treated with vermicompost at 19 g per pot enhanced the maximum length of root (6.30 cm, 11.00 cm and 12.17 cm) on 30, 45 and 60 days in tomato than vermicompost treated at the level of 15 g, 17 g and 21 g per pot.

The present result coincides with the result of Sundari and Gandhi (2017) who observed that the length of root of bhendi (8.11 cm, 16.12 cm and 20.62 cm) enhanced with the application of 75% chemical fertilizer with *Pseudomonas fluorescens* and *Azospirillum brazilense* isolates under field culture on 30, 60 and 90 days. Omidi *et al.* (2017) reported that application of 75% peanut shell compost with 25% of the soil enhanced the length of root (13.52 cm) in violet plant (Viola sp.).

The present observation is in accordance with the findings of Premalatha *et al.* (2017) who observed an increase in length of root (15.7 cm) in black gram as influenced by 75% recommended dose of fertilizer +100% leaf litter compost. The influence of organic fertilizer enhanced the length of root (4.0 cm) in *Trigonella foenum-graceum* than control (2.3 cm) was reported by Balakrishnan and Arunprasath (2018).

Similar results were also reported by Saygi (2023) who observed that the application of municipal solid waste compost at 4 tons da^{-1} enhanced the length of root (18.88 pcs) in strawberry. The current finding is on par with that of Mohamed *et al.* (2023) who observed that the application of recommended dose of mineral nitrogen fertilizer and salicylic acid at 150 ppm improved plant height (63.8 cm) and (61.4 cm) of common bean during the season of 2020 and 2021.

The increase in root length may be due to the enhancement of nutrient availability and phytohormones in the compost promotes the growth of root. In additions, the plant growth promoting microorganisms such as *Bacillus licheniformis* and *Paecilomyces variotii* present in consortium of microorganism were able to produce auxin which would have enhanced the root growth and elongation of root cell.

4.4.1.2 Shoot length

***Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)**

The data presented in Table 2, Plate 10 shows that the gradual increase of shoot length recorded on 25, 50 and 75 DAS in bhendi. Among the treatments, the toddy palm shell composted by microbial consortium and earthworm significantly registered maximum length of shoot (16.1 cm, 37.6 cm and 63.3 cm) on 25, 50 and 75 DAS compared to control (10.3 cm, 23.1 cm and 35.7 cm) respectively.

***Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)**

The highest shoot length was observed from T_6 – Toddy palm shell + microbial consortium + *Eisenia fetida* (12.9 cm, 57.6 cm and 76.3 cm) followed by T_3 – Groundnut shell + microbial consortium + *Eisenia fetida* (9.9 cm, 38.4 cm and 71.2 cm) compared to the control (6.9 cm, 25.9 cm and 48.7 cm) on 25, 50 and 75 DAS respectively (Table 4, Plate 11).

***Coriandrum sativum* L. Var. Co (CR) 4 (Coriander)**

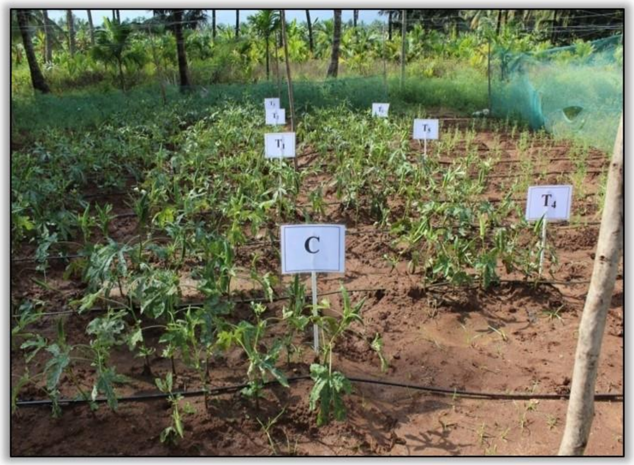
Maximum shoot length was obtained in T_6 (12.9 cm, 37.4 cm and 68.7 cm) followed by T_3 (12.3 cm, 36.2 cm and 63.5 cm), T_5 (12.1 cm, 35.4 cm and 58.7 cm), T_4 (11.5 cm, 31.6 cm and 57.8 cm), T_2 (11.3 cm, 30.9 cm and 55.4 cm), T_1 (10.4 cm, 24.6 cm and 54.8 cm) and C (8.7 cm, 20.4 and 51.1 cm) as shown in Table 6, Plate 12 respectively.

***Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)**

A significant increase in shoot length was noted on 25, 50 and 75 days after sowing in all the treatments as compared to the control as shown in Table 8, Plate 13. Among them, the highest shoot length was registered in T_6 (12.3 cm, 23.3 cm and 53.4 cm) and lowest in C (8.9 cm, 14.9 cm and 25.3 cm) on 25, 50 and 75 DAS respectively.

Plate - 10

Effect of composted groundnut shell and toddy palm shell on vegetative parameters of bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4) ON 25, 50 AND 75 DAS



Bhendi

DAS – Days after sowing; **C** – Control, $\mathbf{T_1}$ – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_2}$ – Groundnut shell + microbial consortium (5t ha^{-1}), $\mathbf{T_3}$ – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_4}$ – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_5}$ – Toddy palm shell + microbial consortium (5t ha^{-1}) and $\mathbf{T_6}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 2

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Bhendi

(*Abelmoschus esculentus* (L.) Moench. Var. Co.4)

Treatments	Root length (cm)			Shoot length (cm)			Number of leaves			Diameter of leaf (cm)		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	8.5	20.1	20.4	10.3	23.1	35.7	5.6	8.0	10.6	8.7	19.1	19.6
T_1	9.4	20.3	21.3	12.5	24.5	46.6	6.3	11.3	11.6	9.9	20.9	24.9
T_2	12.4	21.6	22.9	14.4	25.1	36.4	7.3	9.6	12.3	12.2	23.3	25.4
T_3	18.3	24.8	26.4	15.6	28.4	50.3	8.0	12.6	18.0	17.1	26.9	33.2
T_4	10.4	22.2	24.1	13.9	25.6	46.8	6.3	9.6	13.3	10.9	23.1	26.3
T_5	14.5	24.1	24.6	13.8	26.4	49.4	7.0	11.0	14.0	15.2	24.6	26.8
T_6	19.7	27.8	30.2	16.1	37.6	63.3	9.6	13.3	20.6	19.8	30.9	33.7
SEd	0.15635			0.16514			0.14708			0.18504		
Cd(p<0.05)	0.31560			0.33334			0.29689			0.37352		
Cd(p<0.01)	0.42186**			0.44559**			0.39686**			0.49929**		

** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 3

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4)

Treatments	Number of flowers		Fresh weight (g)			Dry weight (g)		
	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	2.3	1.6	3.02	25.81	67.82	0.42	3.75	10.34
T_1	3.0	2.3	3.94	28.17	74.51	0.48	4.24	12.77
T_2	3.6	2.6	5.23	31.01	87.20	0.82	4.91	14.97
T_3	5.3	3.6	6.02	36.81	106.48	1.40	5.62	19.01
T_4	2.6	2.0	4.72	32.78	98.57	0.64	5.18	13.18
T_5	4.0	3.3	5.91	34.27	97.81	1.09	5.24	15.32
T_6	5.6	4.0	6.87	37.54	112.72	1.46	5.78	22.78
SEd	0.17360		0.16903			0.17643		
Cd(p<0.05)	0.35561		0.34120			0.35613		
Cd(p<0.01)	0.47977**		0.45609**			0.47604**		

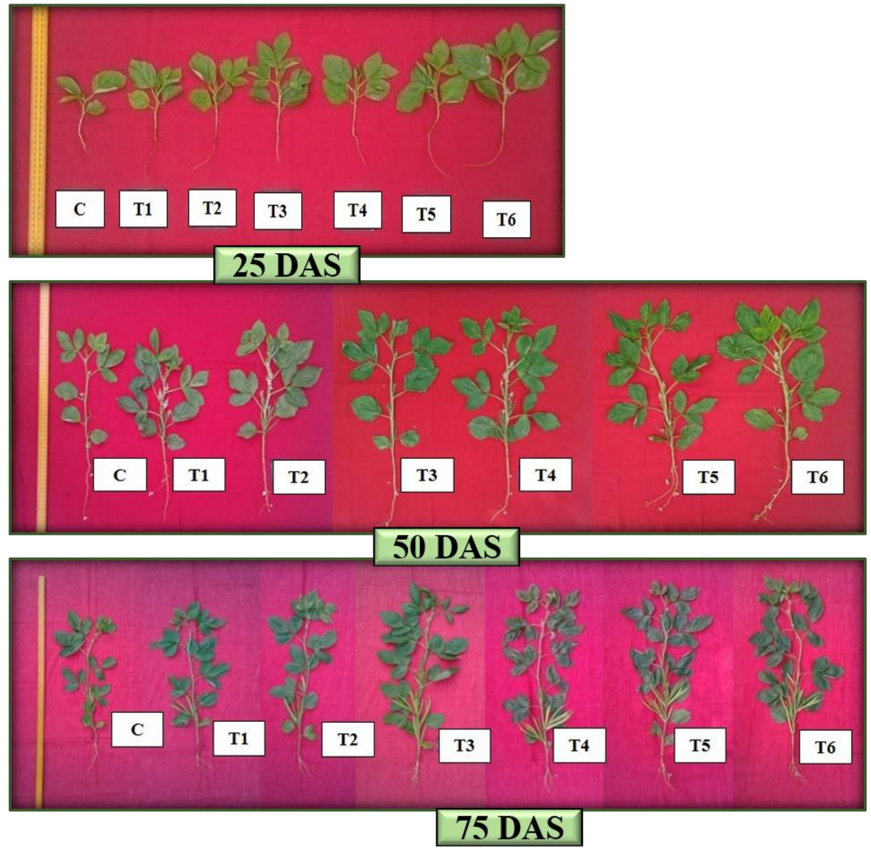
** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1})

Plate – 11

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Cluster Bean (*Cyamopsis tetragonoloba* (L.) Taub.) Var. MDU.1) on 25, 50 and 75 DAS

Cluster bean



DAS – Days after sowing; **C** – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 4

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Cluster Bean (*Cyamopsis tetragonoloba* (L.) Taub.) Var. MDU.1

Treatments	Root length (cm)			Shoot length (cm)			Number of leaves			Number of nodules		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	3.9	12.2	15.6	6.9	25.9	48.7	3.6	13.0	20.0	2.3	3.0	0.3
T_1	4.2	12.9	16.4	7.1	28.7	52.9	5.3	17.3	21.6	4.0	3.3	0.6
T_2	7.6	13.6	19.4	9.4	26.4	56.1	7.3	21.6	27.0	2.6	4.6	1.0
T_3	12.1	16.9	23.4	9.9	38.4	71.2	11.6	28.3	35.6	5.0	5.2	2.0
T_4	8.9	13.1	20.7	8.9	34.5	67.2	9.0	23.3	31.0	3.0	5.0	1.3
T_5	9.1	15.7	21.3	8.4	36.3	66.2	10.3	27.0	33.6	4.3	4.0	1.6
T_6	12.4	18.3	25.6	12.9	57.6	76.3	12.3	32.6	37.6	7.0	6.6	2.6
SEd	0.13586			0.17771			0.15283			0.13202		
Cd(p<0.05)	0.27424			0.35871			0.30849			0.26650		
Cd(p<0.01)	0.36658**			0.47950**			0.41236**			0.35623**		

** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 5

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Cluster Bean (*Cyamopsis tetragonoloba* (L.) Taub.) Var. MDU.1

Treatments	Number of flowers		Fresh weight (g)			Dry weight (g)		
	50 DAS	75DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	12.0	9.6	3.42	12.04	64.58	0.40	3.19	8.76
T_1	19.6	12.0	3.82	15.54	72.82	0.54	4.03	11.05
T_2	26.3	14.3	5.06	19.88	118.11	1.08	5.35	15.74
T_3	42.0	18.3	5.47	20.91	124.71	1.52	6.29	20.93
T_4	25.6	16.0	4.39	16.31	89.13	0.87	4.48	12.66
T_5	41.6	16.3	5.17	20.01	120.98	1.24	5.61	17.32
T_6	42.6	21.0	5.98	21.83	136.21	1.87	6.87	24.87
SEd	0.26552		0.18178			0.18443		
Cd(p<0.05)	0.54390		0.36694			0.37228		
Cd(p<0.01)	0.73380**		0.49049**			0.49763**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Plate – 12

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Coriander

(*Coriandrum sativum* (L.) Var. Co.4) on 25, 50 and 75 DAS

Coriander

DAS – Days after sowing; **C** – Control, $\mathbf{T_1}$ – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_2}$ – Groundnut shell + microbial consortium (5t ha^{-1}), $\mathbf{T_3}$ – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_4}$ – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_5}$ – Toddy palm shell + microbial consortium (5t ha^{-1}) and $\mathbf{T_6}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 6

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Coriander (*Coriandrum sativum* (L.) Var. Co.4)

Treatments	Root length (cm)			Shoot length (cm)			Number of branches		
	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	4.8	6.4	12.8	8.7	20.4	51.1	5.0	7.6	14.6
T_1	5.1	7.9	13.9	10.4	24.6	54.8	5.6	8.3	16.3
T_2	5.3	9.5	14.3	11.3	30.9	55.4	6.0	10.0	19.0
T_3	8.9	13.1	17.4	12.3	36.2	63.5	8.3	13.0	22.3
T_4	6.2	9.8	14.9	11.5	31.6	57.8	7.3	11.0	19.3
T_5	6.4	11.9	16.6	12.1	35.4	58.7	8.0	11.3	20.6
T_6	9.2	13.9	18.2	12.9	37.4	68.7	8.6	15.0	24.3
SEd	0.16746			0.15822			0.15474		
Cd(p<0.05)	0.33802			0.31938			0.31236		
Cd(p<0.01)	0.45184**			0.42692**			0.41754**		

** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 7

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Coriander

(*Coriandrum sativum* (L.) Var. Co.4)

Treatments	Number of umbels		Fresh weight (g)			Dry weight (g)		
	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	1.6	16.0	2.645	8.153	11.840	0.027	0.221	0.846
T_1	2.0	19.0	2.871	10.262	13.731	0.052	0.450	1.271
T_2	3.0	21.0	3.210	14.397	16.474	0.064	0.642	1.845
T_3	4.6	24.3	4.076	20.638	22.749	0.164	1.295	3.082
T_4	2.6	23.6	3.503	15.583	19.994	0.087	0.875	2.652
T_5	3.6	24.0	3.984	19.848	21.529	0.125	1.071	2.984
T_6	5.0	25.6	4.253	21.737	23.528	0.257	1.481	3.710
SEd	0.18350		0.17766			0.13721		
Cd(p<0.05)	0.37590		0.35863			0.27697		
Cd(p<0.01)	0.50714**		0.47938**			0.37023**		

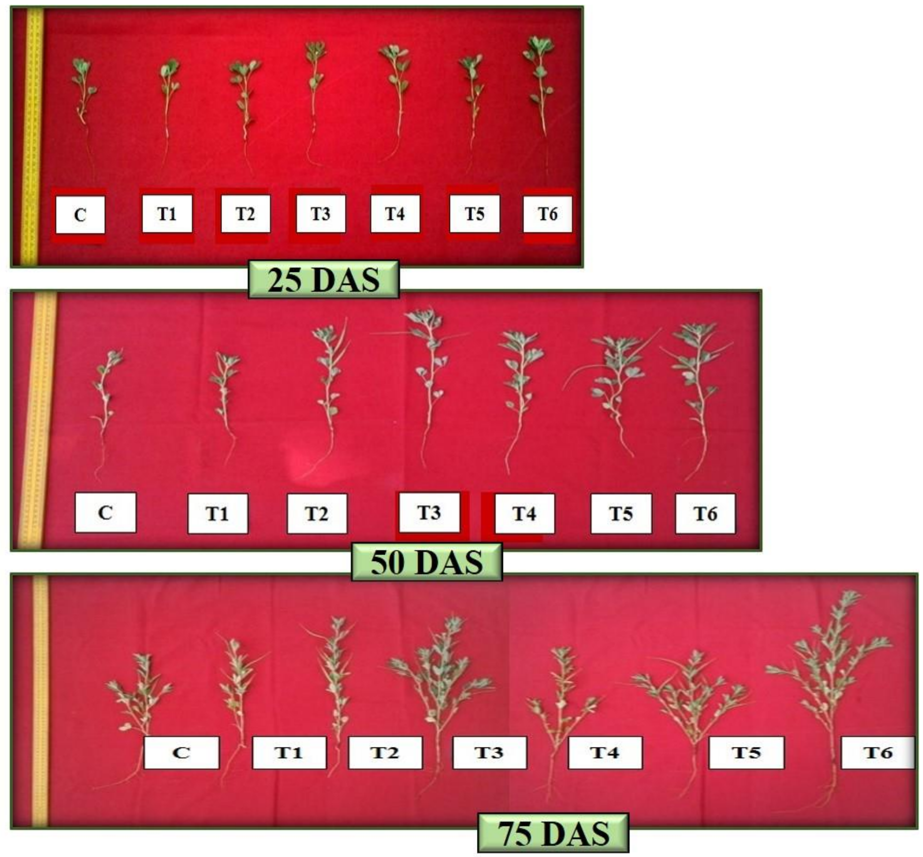
** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Plate – 13

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2) on 25, 50 and 75 DAS

Fenugreek



DAS – Days after sowing; **C** – Control, $\mathbf{T_1}$ – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_2}$ – Groundnut shell + microbial consortium (5t ha^{-1}), $\mathbf{T_3}$ – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_4}$ – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_5}$ – Toddy palm shell + microbial consortium (5t ha^{-1}) and $\mathbf{T_6}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 8

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Fenugreek

(*Trigonella foenum-graecum* L. Var. Co.2)

Treatments	Root length (cm)			Shoot length (cm)			Number of leaves			Number of nodules		
	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	6.9	7.2	15.8	8.9	14.9	25.3	16.3	22.0	86.3	4.3	9.6	0.3
T_1	7.3	7.9	18.1	9.8	16.6	29.3	18.6	24.6	144.6	5.6	12.6	0.6
T_2	8.3	11.4	20.7	9.2	19.6	29.1	21.0	26.3	180.6	5.0	13.0	2.6
T_3	9.6	12.4	22.9	11.3	20.6	36.8	24.3	43.6	254.0	7.3	14.6	3.6
T_4	7.6	11.0	20.4	10.4	19.9	31.6	18.3	35.3	240.6	6.0	11.3	1.3
T_5	8.9	10.4	21.3	10.9	20.3	35.9	22.0	36.3	222.3	6.6	14.0	2.0
T_6	10.9	12.9	23.9	12.3	23.3	53.4	28.3	46.3	278.0	8.0	15.3	4.0
SEd	0.21203			0.72142			0.16022			0.15765		
Cd(p<0.05)	0.42800			1.45624			0.32340			0.31822		
Cd(p<0.01)	0.57212**			1.94658**			0.43230**			0.42537**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 9

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Fenugreek

(*Trigonella foenum-graecum* L. Var. Co.2)

Treatments	Number of flowers		Fresh weight (g)			Dry weight (g)		
	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	3.6	2.3	2.84	6.71	9.48	0.028	0.291	0.722
T_1	4.6	3.0	2.98	9.52	10.22	0.084	0.435	1.435
T_2	6.0	4.0	3.07	10.92	12.11	0.079	0.722	0.913
T_3	7.0	5.3	3.27	12.02	17.29	0.108	1.090	3.034
T_4	5.3	2.6	2.92	8.25	11.54	0.101	0.567	1.758
T_5	6.3	4.6	3.18	11.34	16.05	0.106	0.889	2.847
T_6	7.6	5.6	3.65	12.48	18.38	0.140	1.424	3.920
SEd	0.15540		0.16903			0.14157		
Cd(p<0.05)	0.31833		0.34120			0.28576		
Cd(p<0.01)	0.42948		0.45609			0.38198		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

The combined application of 85% vermicompost and 15% NPK improved the height of the plant (101.2 cm and 102.3 cm) in okra cropping seasons of 2011 and 2012 was reported by Oroka and Oke (2016). The present finding is in conformity with Thilagar *et al.* (2016) who found a significant increase in height of plant as influenced by microbial consortium + 50% NPK (85.3 cm) on 70 days after transplanting and microbial consortium + 75% NPK (126.7 cm) on 140 days after transplanting. The current finding is on par with that of Ravimycin (2016) who observed that the application of vermicompost improves the shoot length (24.8 cm) of coriander (*Coriandrum sativum* L.) than farm yard manure (21.4 cm) and control (19.5 cm).

The inoculation of microbial consortium with humic acid enhanced the plant height (94cm) of blueberry seedlings was reported by Schoebitz *et al.* (2016). Similar observations were reported by Sundari and Gandhi (2017) who observed maximum improvement in shoot length (34.19 cm, 60.29 cm and 75.12 cm) with the application of 75% chemical fertilizers + *Pseudomonas fluorescens* + *Azospirillum brazilense* on 30, 60 and 90 days of bhendi growth under field culture. The present finding is in conformity with Premalatha *et al.* (2017) who found a significant increase in shoot length (27.7 cm) of black gram as influenced by the application of recommended dose of fertilizer (75%) + leaf litter compost (100%) than control (20.0 cm) respectively.

The present finding is in conformity with Shawky *et al.* (2023) who found significant increase in height of plant (42.3 cm) in fennel influenced by the combined application of 75% Nitrogen + *Spirulina platensis*. Abdou *et al.* (2023) who reported that the application of compost at 30 t/ha with 100% irrigation of water enhanced the plant height (60.19 cm) of black cumin. The improvement in shoot length might be due to the presence of plant growth promoting microorganisms such as *B. licheniformis* and *P. variotii* in consortium of microorganism ability to produce gibberellin which is responsible for elongation of shoot.

4.4.1.3 Number of leaves

***Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)**

On 25, 50 and 75 DAS the maximum number of leaves was observed from the toddy palm shell composed with the help of microbial consortium and *Eisenia fetida*

(9.6, 13.3 and 20.6) followed by T_3 (8.0, 12.6 and 18.0) and compared with control (5.6, 8.0 and 10.6) in bhendi as shown in Table 2.

Cyamopsis tetragonoloba **(L.) Taub Var. MDU 1 (Cluster bean)**

An appreciable increase in the number of leaves/plant was recorded in all the treatments (T_1 – T_6) on 25, 50 and 75 DAS as shown in Table 4. The maximum number of leaves was found in T_6 (12.3, 32.6 and 37.6), T_3 (11.6, 28.3 and 35.6), T_5 (10.3, 27.0 and 33.6), T_4 (9.0, 23.3 and 31.0), T_2 (7.3, 21.6 and 27.0), T_1 (5.3, 17.3 and 21.6) and C (3.6, 13.0 and 20.0) respectively.

Trigonella foenum-graecum **L. Var. Co 2 (Fenugreek)**

A significantly increased number of leaves per plant was observed in T_6 (28.3) followed by T_3 (24.3), T_5 (22.0), T_2 (21.0), T_1 (18.6), T_4 (18.3) and C (16.3) on 25 DAS (Table 8). After the regular interval of 25, 50 and 75 DAS the number of leaves drastically increased in all the treatments. The maximum number of leaves 46.3 and 278.0 registered in T_6 and 43.6 and 254.0 in T_3 compared with control (22.0 and 86.3) on 50 and 75 days after sowing.

Similar result was also observed by Oroka and Oke (2016) who reported that the application of 100% vermicompost enhanced the number of leaves (24.3) and (28.7) in okra of two cropping seasons (2012 and 2013). Among the seven treatments, the T_7 (75% chemical fertilizer + *Pseudomonas fluorescens* + *Azospirillum brazilense*) significantly improved the number of leaves per plant of bhendi on 30 (12.31), 60 (19.81) and 90 (34.09) days was reported by Sundari and Gandhi (2017).

The result is in agreement with the result of Vaidyanathan and Vijayalakshmi (2017) who reported increased number of leaves of 14.33, 26.33 and 28.67 when compared to control of 8.33, 19.67 and 22.33 on 30, 45 and 60 days in tomato plants with the application of vermicompost at 19 g per pot. A conspicuous increase in number of leaves per plant (89.73) was observed in T_8 (50 % N through poultry manure + recommended dose of nitrogen (50%) + Azotobacter + P and K in ridge gourd (*Luffa acutangular* L.) was reported by Rathod *et al.* (2018).

The present finding coincides with the result of Badiger *et al.* (2019) who reported that the application of recommended package of practices + rhizosphere consortia 1 + phyllosphere consortia enhanced the number of leaves plant^{-1} (37.33) of green gram at 60 DAS. The present finding is in conformity with Saygi (2023) who found a significant increase in number of leaves (26.88) in strawberry influenced by 4 tons/da of municipal solid waste compost and the application of 75% nitrogen with compost tea improved the number of leaves (70.7) of fennel was reported by Shawky *et al.* (2023).

The combined application of microbial consortium and vermicompost enhanced the number of leaves due to the activation of cell division and cell elongation in the axillary buds promotes increased number of leaves. The presence of *Paecilomyces variotii* in the consortium of microorganisms increased the availability of nutrient in soil thus resulted in improved vegetative growth and photosynthesis.

4.4.1.4 Number of branches

***Coriandrum sativum* L. Var. Co (CR) 4 (Coriander)**

The number of branches per plant in coriander was maximum in T_6 (8.6, 15.0 and 24.3), T_3 (8.3, 13.0 and 22.3), T_5 (8.0, 11.3 and 20.6), T_4 (7.3, 11.0 and 19.3), T_2 (6.0, 10.0 and 19.0), T_1 (5.6, 8.3 and 16.3) and C (5.0, 7.6 and 14.6) as shown in Table 6.

The present finding coincides with the result of Sundari and Gandhi (2017) who found a significant increase in the number of branches/plant (5.11) on 90 days was observed in T_7 (75% chemical fertilizer + *Pseudomonas fluorescens* + *Azospirillum brazilense*) than other treatments in bhendi. The combined application of 75% RDF + 12.5% FYM + 12.5% vermicompost ha^{-1} improves the maximum number of branches/plant (8.50) than control (6.60) in cucumber was reported by Singh *et al.* (2018).

The present finding is in conformity with Badiger *et al.* (2019) who reported that the application of recommended package of practices (POP) + rhizosphere consortia 1 (RC1) + phyllosphere consortia (PC) significantly enhanced number of branches (11.75 plant^{-1}) in green gram. A Similar result was obtained by Sharma *et al*. (2019b) who reported that the application of 75% RDF + presssmud + rhizobium enhanced the number of secondary branches plant^{-1} of 5.98 and 7.76 in *Cyamopsis tetragonoloba* on 60 DAS and at harvest.

The present finding is in conformity with Mohamed *et al.* (2023) who found a significant increase in number of branches (5.22) of common bean as influenced by 100% recommended dose of mineral nitrogen. The sufficient amount of macro nutrients (nitrogen, potassium and phosphorus) available in soil through organic composts stimulates the maximum number of branches.

4.4.1.5 Diameter of leaf

***Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)**

The maximum diameter of leaf of bhendi was observed in T_6 – toddy palm shell bio-composted by using microbial consortium and *Eisenia fetida* (19.8 cm, 30.9 cm and 33.7 cm) and minimum in control (8.7 cm, 19.1 cm and 19.6 cm) examined on 25, 50 and 75 DAS as shown in Table 2.

The present result is in accordance with Rather *et al.* (2018) who reported that the combined application of 60 kg N ha^{-1} + 30 kg K ha^{-1} + 45 kg P ha^{-1} + vermicompost (4t ha^{-1}) + biofertilizers @ 7.5 L ha^{-1} improves the maximum leaf area (260.42 cm^2) in lettuce. The combined application of indole butyric acid (IBA) and indole acetic acid (IAA) improves the leaf area of fenugreek was reported by Balakrishnan and Arunprasath (2018). The present finding is in conformity with Fazeel *et al.* (2019) who reported that the application of 25% urea + 75% jeewamirta significantly increased the leaf area (1177.85 cm^2) of *Abelmoschus esculentus* L.

The result is in agreement with Sharma *et al*. (2019b) who observed increase in leaf area index (0.79 and 4.75) on 30 and 60 DAS of cluster bean (*Cyamopsis tetragonoloba*) with the application of 75% recommended dose of fertilizer along with pressmud and rhizobium. Similar result was also reported by Bhunia *et al.* (2021) who observed that low dosage of bovine blood rumen digesta mixture enhanced the leaf surface area (48.6 cm^2) of bell pepper. Similar result was also observed by Singh *et al.* (2021) who reported that the area of leaf (28.42 cm^2) increased by the application of *Trichoderma viride* BHU-V2 VOCS treatment than control (22.52 cm^2).

The combined application of biogas digestate + biofertilizer enhanced the leaf area **(**2519.67 cm^2/plant) of feba bean was recently reported by Alhammad and Seleiman (2023) and the application of municipal solid waste compost at 4 tons da^{-1} enhanced the area of leaf (65.81 cm^2) of strawberry (Saygi, 2023). The activation of cell division and cell elongation promotes the maximum diameter of leaf by efficient supply of available plant nutrient in the soil. The combined application of consortium of microorganisms and *Eisenia fetida* promotes the nutrients availability through degradation and mineralization of organic materials.

4.4.1.6 Number of flowers

***Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)**

The maximum number of flowers per plant was observed on 50 DAS of bhendi plant growth which was reduced on 75 DAS. The highest number of flowers found in T_6 (5.6 and 4.0) followed by T_3 (5.3 and 3.6), T_5 (4.0 and 3.3), T_2 (3.6 and 2.6), T_1 (3.0 and 2.3), T_4 (2.6 and 2.0) and C (2.3 and 1.6) as shown in Table 3 respectively.

***Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)**

The application of groundnut shell and toddy palm shell bio-composted with microbial consortium and *Eisenia fetida* significantly enhanced the maximum number of flowers per plant of cluster bean on 50 and 75 DAS as given in Table 5. The highest count was observed from T_6 (42.6 and 21.0), T_3 (42.0 and 18.3), T_5 (41.6 and 16.3) than C (12.0 and 9.6) respectively.

***Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)**

The number of flowers per plant in fenugreek showed maximum increase in T_6 (7.6 and 5.6), T_3 (7.0 and 5.3) followed by T_5 (6.3 and 4.6), T_2 (6.0 and 4.0) than C (3.6 and 2.3) on 50 and 75 days after sowing (Table 9).

Maximum number of flowers/plant with the application of 150 ppm of gibberellic acids was reported by Maity *et al.* (2016). The present results correlated with the findings of Sundari and Gandhi (2017) who reported that the maximum number of flowers/plant in bhendi on 60 and 90 days (10.07 and 18.32) was obtained in the combined inoculation of *P. fluorescens* and *A. brazilense* with 75% chemical fertilizer.

The result was coincided with the findings Fazeel *et al.* (2019) who reported that jeewamirta (75%) and urea (25%) enhanced the number of flowers $plant^{-1}$ (2.75 and 3.87) at 4 and 5 weeks after planting in *Abelmoschus esculentus* L. Similar result was reported by Bhunia *et al.* (2021) who observed that enhanced number of flowers (8.6) in bell pepper obtained with the application of low dosage of bovine blood rumen digesta mixture.

The result is par with the result of Limbongan (2023) who reported that 400 g of chicken manure increased the number of flowers/plot (3.72) of *Cucumis sativus*. Increased in number of flowers/plant may be due to the application of bio-composted groundnut shell and toddy palm shell. The presence of *Bacillus licheniformis* in the consortium of microorganisms and its ability to produce gibberellins which is important for plant growth, production of bud and flowering may be the reason for the increase in flowers.

4.4.1.7 Number of umbels

Coriandrum sativum L. Var. Co (CR) 4 (Coriander)

The maximum number of umbels in coriander was observed from toddy palm shell composted with the help of microbial consortium and earthworm (5.0 and 25.6) compared with control (1.6 and 16.0) on 50 and 75 days after sowing is given in the Table 7.

Similar result was obtained by Darzi and Hadi (2012). They observed a significant increase in number of umbels per plant (15.1) with the application of 8 t ha^{-1} of vermicompost than control (11.1) in dill. The present finding is in conformity with Darzi *et al.* (2012) who reported that a significant increase in number of umbels per plant (33.2) with the application of 10 t ha^{-1} of vermicompost than control (19.2) in anise (*Pimpinella anisum* L.). The present finding is in conformity with Seghatoleslami (2013) who reported that the integrated application of 5 t ha^{-1} of manure with 25 kg ha^{-1} of nitrogen as urea enhanced the number of umbels per plant in cumin (5.97) in 2009-2010.

Similar result was obtained by Almasi (2020). He observed a significant increase in number of umbels per plant (9.88) in coriander with the application of 25 kg ha^{-1} of farmyard manure. The application of poultry manure at 2.5 t/ha^{-1} promotes the number of umbels per plant (17.30) over control (10.50) in carrot (*Daucus carota* L.). was reported by Dhaka *et al.* (2022). The combined application of 75% nitrogen + *Spirulina platensis* increased the number of umbel/plant of fennel in season 1 (106) and season 2 (79.0) was reported by Shawky *et al.* (2023) respectively.

Increased number of umbels per plant may be due to the supply of essential nutrients from groundnut shell and toddy palm shell vermicomposted samples with microbial consortium assistance. The microorganisms present in the consortium of microorganisms ability to produce auxin and gibberellin which stimulate the plant growth and early flowering.

4.4.1.8 Number of nodules

***Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)**

A significant increase in number of nodules per plant was found maximum in T_6 (7.0, 6.6 and 2.6), T_3 (5.0, 5.2 and 2.0) compared to the control treatment (2.3, 3.0 and 0.3) on 25, 50 and 75 DAS as shown in Table 4.

***Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)**

A substantial increase in number of nodules per plant in fenugreek was highest in T_6 – toddy palm shell + microbial consortium + *Eisenia fetida* (8.0, 15.3 and 4.0), T_3 – groundnut shell + microbial consortium + *Eisenia fetida* (7.3, 14.6 and 3.6) than C – control (4.3, 9.6 and 0.3) on 25, 50 and 75 DAS as shown in Table 8.

The co-inoculation of rhizobacterial isolates such as HCS43 + GSA110 increased the number of nodules per plant of cluster bean at 30 (42) and 60 (48) days of plant growth under chillum jar conditions was reported by Chaudhary and Sindhu (2016). The combination of 75% RDF and 100% leaf litter compost increased the maximum number of nodules per plant (12) in black gram was reported by Premalatha *et al.* (2017).

Similar result was observed by Anuradha *et al.* (2017) who revealed that the application of 100% recommended dose of fertilizer along with phosphate solubilizing bacteria and Zinc applied at 5t/ha improves the number of nodules of cluster bean on 20, 40, 60, 80 and 100 DAS. The present finding is in conformity with Badiger *et al.* (2019) who reported that the application of rhizosphere consortia 1 (RC1) + recommended package of practices (POP) + phyllosphere consortia (PC) enhanced the number of nodules (70.47) on 60 DAS in green gram (*Vigna radiata* L.). The present finding is in conformity with Sharma *et al*. (2019b) who found a significant increase in number of nodules of 41.01 on 45 days after sowing in cluster bean with the application of RDF (75%) + pressmud + rhizobium.

The combined application of soybean inoculated with olive pomace compost and *Bradyrhizobium diazoefficiens* enhanced maximum number of nodules (78) in soybean was reported by Tortosa *et al.* (2023). The combined application of composted groundnut shell and toddy palm shell may have improved the soil biological properties resulted in the enhancement of the root nodules.

4.4.1.9 Fresh weight of plants

Abelmoschus esculentus **(L.) Moench Var. Co 4 (Bhendi)**

A remarkable increase in the fresh weight of the plant was observed on 25, 50 and 75 DAS in all the treatments (C, T_1, T_2, T_3, T_4, T_5 and T_6) as shown in Table 3. The maximum fresh weight was registered in T_6 (Toddy palm shell + microbial consortium + *Eisenia fetida*) followed by T_3 compared to the C on 25 DAS (6.87 g, 6.02 g and 3.02 g) 50 DAS (37.54 g, 36.81 g and 25.81 g) and 75 DAS (112.72 g, 106.48 g and 67.82 g) respectively.

Cyamopsis tetragonoloba **(L.) Taub Var. MDU 1 (Cluster bean)**

Maximum fresh weight of cluster bean plant was found in T_6 (5.98 g, 21.83 g and 136.21 g), T_3 (5.47 g, 20.91 g and 124.71 g), T_2 (5.06 g, 19.88 g and 118.11 g) over the C (3.42 g, 12.04 g and 64.58 g) on 25, 50 and 75 DAS (Table 5).

Coriandrum sativum **L. Var. Co (CR) 4 (Coriander)**

Fresh weight of coriander showed a significant increase in toddy palm shell composted with the help of microbial consortium and *Eisenia fetida* (4.253 g, 21.737 g and 23.528 g) followed by groundnut shell composted with the help of microbial consortium and *Eisenia fetida* (4.076 g, 20.638 g and 22.749 g) as compared to the control (2.645 g, 8.153 g and 11.840 g) on 25, 50 and 75 DAS respectively (Table 7).

Trigonella foenum-graecum **L. Var. Co 2 (Fenugreek)**

The maximum fresh weight was found in T_6 (3.65 g, 12.48 g and 18.38 g), T_3 (3.27 g, 12.02 g and 17.29 g), T_5 (3.18 g, 11.34 g and 16.05 g), T_2 (3.07 g, 10.92 g and 12.11 g) compared to the C (2.84 g, 6.71 g and 9.48 g) on 25, 50 and 75 DAS in fenugreek (Table 9).

The present finding is in conformity with Oroka and Oke (2016) who reported that the influence of 100% vermicompost increased the fresh weight of okra in 2012 (861.6 g) and 2013 (962.1 g) than control (571.3 g and 562.5 g). A similar result was obtained by Ravimycin (2016). He reported that the application of vermicompost increased the fresh weight of coriander (16.7 g) than control (12.3 g).

Similar result was obtained by Alaghemand *et al.* (2017) who reported that the highest fresh weight of fenugreek plant increased with the application of vermiwash (57.12 g) than vermicompost (49.36 g), vermiwash + vermicompost (52.27 g) and control (43.86 g). The result is on par with the result of Omidi *et al.* (2017) reported that the fresh weight of canopy (28.22 g) in Viola sp. as influenced by 75:25 ratio of composted peanut shell and soil.

The present finding is in conformity with Vaidyanathan and Vijayalakshmi (2017) who found a significant increase in fresh weight of 1.80 g, 2.73g and 3.00 g over absolute control of 1.39 g, 1.20g and 2.08 g in tomato plants treated with vermicompost at 19g per pot. The result was coincided with the findings of Balakrishnan and Arunprasath (2018) who observed that the highest fresh weight (2.7 g) was observed from the application of organic fertilizer and lowest in control (2.4 g) in fenugreek.

The application of compost at 30 t/ha improves the fresh weight (60.58 g) of black cumin was reported by Abdou *et al.* (2023). The enhancement of fresh weight of plant may be due to the availability of composted groundnut shell and toddy palm shell in soil supplied essential nutrients in available forms. The absorption of water and potassium ions from the soil transported to all parts of the plant by xylem through root hairs may enhanced the plant growth and leaves. The size of the plant and fresh plant contains 70% water content which would be the reason for increase in the fresh weight.

4.4.1.10 Dry weight of plants

***Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)**

A significant increase in dry weight of bhendi was observed on 25, 50 and 75 DAS in all the treatments as shown in Table 3. Maximum dry weight was found in T_6 (1.46 g and 22.78 g), T_3 (1.40 g and 19.01 g), T_5 (1.09 g and 15.32 g), T_2 (0.82 g and 14.97 g),

T_4 (0.64 g and 13.18 g), T_1 (0.48 g and 12.77 g) and C (0.42 g and 10.34 g) on 25 and 75 DAS. The maximum dry weight of bhendi obtained in T_6 (5.78 g), T_3 (5.62 g), T_5 (5.24 g), T_4 (5.18 g), T_2 (4.91 g), T_1 (4.24 g) and C (3.75 g) on 50 days after sowing.

Cyamopsis tetragonoloba **(L.) Taub Var. MDU 1 (Cluster bean)**

The data presented in Table 5 shown that the highest dry weight was obtained in T_6 - toddy palm shell + microbial consortium + *Eisenia fetida* (1.87 g, 6.87 g and 24.87 g) followed by T_3 - groundnut shell + microbial consortium + *Eisenia fetida* (1.52 g, 6.29 g and 20.93 g), T_5 - toddy palm shell + microbial consortium (1.24 g, 5.61 g and 17.32 g), T_2 - groundnut shell + microbial consortium (1.08 g, 5.35 g and 15.74 g) on 25, 50 and 75 DAS when compared to the control (0.40 g, 3.19 g and 8.76 g) respectively.

Coriandrum sativum **L. Var. Co (CR) 4 (Coriander)**

The maximum dry weight was registered in T_6 (0.257 g, 1.481 g and 3.710 g), T_3 (0.164 g, 1.295 g and 3.082 g), T_5 (0.125 g, 1.071 g and 2.984 g), T_4 (0.087 g, 0.875 g and 2.652 g), T_2 (0.064 g, 0.642 g and 1.845 g), T_1 (0.052 g, 0.450 g and 1.271 g) and C (0.027 g, 0.221 g and 0.846 g) on 25, 50 and 75 days after sowing as shown in Table 7.

Trigonella foenum-graecum **L. Var. Co 2 (Fenugreek)**

The maximum dry weight was found in T_6 (0.140 g and 3.920 g) followed by T_3 (0.108 g and 3.034 g), T_5 (0.106 g and 2.847 g), T_4 (0.101 g and 1.758 g), T_1 (0.084 g and 1.435 g), T_2 (0.079 g and 0.913 g) and C (0.028 g and 0.722 g) on 25 and 75 DAS. On 50 DAS maximum dry weight of fenugreek plant was observed in T_6 (1.424 g), T_3 (1.090 g), T_5 (0.889 g), T_2 (0.722 g), T_4 (0.567 g), T_1 (0.435 g) and C (0.291 g) respectively (Table 9).

The current study was coincided with the results of Ravimycin (2016) who reported that dry weight of plant increased (7.8 g) as influenced by vermicompost in coriander (*Coriandrum sativum* L.). Similar result was also reported by Oroka and Oke (2016) who observed that dry weight of the plant as influenced by 100% vermicompost in 2011 (242.8 g), 2012 (258.5 g) and 2013 (317.5 g) than control (129.8 g, 136.0 g and 128.6 g) respectively. The result was positively correlated with the findings of Anuradha *et al.* (2017) who reported that the combined application of 100% RDF + PSB + Zinc (5t/ha) enhanced the maximum dry weight of cluster bean plant and the application of vermiwash enhanced the maximum plant dry weight (26.04 g) in fenugreek crop under green house was reported by Alaghemand *et al.* (2017).

The present study was in line with the work of Omidi *et al.* (2017) who recorded that the application of 25% soil with 75% composted peanut shell increased the dry weight of canopy (6.95 g) in Viola sp. The study was correlate with the finding of Vaidyanathan and Vijayalakshmi (2017) who reported that dry weight was maximum in tomato plants (1.00 g) as influenced by the application of vermicompost at 19g per pot. The present finding is in conformity with Balakrishnan and Arunprasath (2018) who observed that the maximum dry weight (0.21g) of *Trigonella foenum-graceum* influenced with the application of organic fertilizer. The study was coincided with the result of Abdou *et al.* (2023) who reported that the dry weight of cumin was influenced by the application of compost (30 t/ha). Plant fresh weight might be due to increase in level of water absorption and loss of water content promotes dry weight of the plant.

The maximum root length, shoot length, number of leaves, number of branches, diameter of leaf, number of flowers, number of umbels, number of nodules, number of fruits & pods, number of seeds, fresh weight and dry weight of plant were observed in T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*). The increased in vegetative parameters of bhendi, cluster bean, coriander and fenugreek may be due to the enhancement of nutrient availability and phytohormone in the compost which promotes the biometric characteristics of selected plants. The organic fertilizer incorporate into the soil can significantly improve the physicochemical properties, nutrient status and fertility of soil thereby promoting the growth of plant. Similar results was earlier reported by Papafilippaki *et al.* (2015).

Physico-chemical and biological conditions of soil may be promoting the better growth and development of the roots. Addition of vermicompost into the soil might have enhanced the soil micro flora and fauna resulted in improved enzymatic activity which helps in solubilization and mineralization of soil nutrients to more available form for plant uptake. The plant growth promoting microorganisms are capable of producing plant hormones such as auxin which stimulate the root growth and cell elongation.

The increased shoot length may be due to the combined application of microbial consortium and earthworms which have considerable amount of macro and micronutrients as well as growth regulators such as gibberellin and cytokinin. In the current study, gibberellin, auxin and cytokinin produced by plant growth promoting microorganisms (*Bacillus licheniformis* and *Paecilomyces variotti*) found in the consortium of microorganisms would have enhanced the length of root and shoot.

The combined application of microbial consortium and earthworms achieved the maximum number of leaves and number of branches per plant may be due to the availability of micro and macro nutrients from the soil through addition of organic fertilizer. The mixture of different sources of organic and inorganic fertilizer improves the maximum number of leaves and number of branches than single source was also reported earlier by Sharma *et al.* (2019b) in cluster bean, Badiger *et al.* (2019) in green gram, Sundari and Gandhi (2017) in bhendi and Singh *et al.* (2018) in cucumber.

The application of groundnut shell and toddy palm shell composts incorporated into the soil enhanced the diameter of leaf by inducing plant hormones which promotes the growth of beneficial microorganisms and leads to the activation of cell division and cell elongation may be the reason for maximum number of leaves and diameter of leaf. Similar result was also reported by Karthiya and Vijayalakshmi (2023); Sundari and Gandhi (2017); Oroka and Oke (2016).

Increased number of flowers and umbels might be due to better translocation of essential nutrients to the aerial parts of the plant and enhancement in reproductive phase. In addition, phosphorus plays an important role for reproductive organs and initiation of flowering. Similar results positively correlated with the finding of Anjanappa *et al*. (2012) and Singh *et al*. (2017).

The co-inoculation of microbial consortium and earthworm enhanced the maximum number of root nodules in leguminous plants such as cluster bean and fenugreek. These plants initiate the formation of root nodule when the soil contains low level of nitrogen. The roots of leguminous plants secrete flavonoids in the soil for attracting rhizobia towards the roots. The plants symbiotic relationship with a host bacterium results in root nodules. During later stages of plant growth, the reduction of root nodules may be due to fixation of nitrogen and utilization of it by the vegetative and reproductive organs.

The consortium of microorganisms incorporated treatment enhanced the maximum fresh and dry weight of plant which may be due to the presence of plant growth promoting microorganisms in the consortium of microorganisms promoting vigorous production of plant biomass. The result was correlated with the result of Sukeerthi *et al.* (2020) who reported that the plants treated with microbial consortium significantly increased the height of seedlings, diameter of stem, strength of plant, biovolume index, vigour index and dry weight of ornamental plants like zinna and balsam and the same results were observed by Desai *et al.* (2019) in tomato and capsicum.

Vermicompost applied treatment showed significant effect on fresh and dry weight of root and shoot. The present finding is in conformity with the results of Vaidyanathan and Vijayalakshmi (2017) in tomato, Ravimycin (2016) in coriander, Alaghemand *et al.* (2017) and Balakrishnan and Arunprasath (2018) in fenugreek. Simultaneously, the higher concentration of vermicompost about more than 40% could have negative impact on plant growth due to phytotoxicity (Tucker 2005).

Further, the joint action of microbial consortium and earthworm incorporated treatment got sufficient amount of essential nutrient like macro and micro nutrients present in the organic fertilizer are not only the main reason for increasing plant growth but also the most probable mechanisms for enhancing in plant growth are plant growth regulators and bio-stimulants such as humic acids, fulvic acids, hormones and chitin (Tang *et al.,* 2014; Edwards *et al.,* 2006).

The present research showed that the recycled organic amendment by composting and vermicomposting is a good alternative to reduce the consumption of fertilizers and the results indicated that the inoculation with microbial consortium helped to enhance the biometric, yield and biochemical parameters.

4.4.2 Yield characters

The effect of composted groundnut shell and toddy palm shell on yield parameters of bhendi, cluster bean, coriander and fenugreek.

4.4.2.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The data presented in Table 10 and Plate 14 revealed that the number of fruits, length of fruit, diameter of fruit, number of seeds/fruit, yield/plant, yield/plot, yield/hectare, fruit fresh weight and fruit dry weight were maximum in T_6 (Toddy palm shell + microbial consortium + *Eisenia fetida*) on 90 DAS respectively. Maximum number of fruits (9.0), length of fruit (18.9 cm), diameter of fruit (2.3 cm), number of seeds/fruit (79.9), yield/plant (241.02 g), yield/plot (4.338 kg), yield/hectare (1808 kg), fruit fresh weight (26.78 g) and fruit dry weight (2.024 g) was recorded in T_6 over the control (5.3, 14.3 cm, 1.3 cm, 48.8, 99.428g, 1.782 kg, 743 kg, 18.76 g and 1.007 g) respectively.

4.4.2.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

It can be inferred from the Table 11 and Plate 14 that the number of pods, length of pod, number of seeds/pod, yield/plant, yield/plot, yield/hectare, pod fresh weight and pod dry weight were maximum in toddy palm shell composted with the help of microbial consortium and earthworms on 90 DAS.

Maximum number of pods (68.3), length of pod (15.8 cm), number of seeds/pod (9.6), yield/plant (226.51 g), yield/plot (4.068 kg), yield/hectare (1696 kg), pod fresh weight (5.948 g) and pod dry weight (1.729 g) was recorded in T_6 followed by T_3 (60.6, 15.6 cm, 9.0, 204.37 g, 3.672 kg, 1531 kg, 5.721 g and 1.575 g) compared to the control (41.3, 12.8 cm, 5.6, 99.81 g, 1.782 kg, 743 kg, 4.029 g and 0.848 g) respectively.

4.4.2.3 *Coriandrum sativum* L. Var. Co (CR) 4 (Coriander)

The data presented in Table 12 and Plate 14 revealed that the substantial increase in number of seeds/plant (527.3), yield/plant (5.497 g), yield/plot (1.977 kg), yield/hectare (824.40 kg), straw yield/hectare (1625 kg), seeds fresh weight (3.291 g) and seeds dry weight (1.275 g) were examined in T_6 (Toddy palm shell + microbial consortium + *Eisenia fetida*) on 90 DAS as compared to the control (285.6, 2.873 g, 1.032 kg, 430.34 kg, 786.8 kg, 2.086 g and 0.741 g) respectively.

4.4.2.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The data presented in Table 13 and Plate 14 revealed that the maximum number of pods, length of pod, number of seeds/pod, yield/plant, yield/plot, yield/ha, straw yield/ha, seeds fresh weigh and seeds dry weight were obtained with the application of toddy palm shell bio-composted with microbial consortium and *Eisenia fetida* assistance.

A conspicuous increase in number of pods (24.3), length of pod (12.1 cm), number of seeds/pod (18.6), yield/plant (4.088 g), yield/plot (735 g), yield/ha (306.49), straw yield/ha (610.48 kg), seeds fresh weight (0.372 g) and seeds dry weight (0.129 g) were found in T_6 followed by T_3 (20.0, 11.3 cm, 16.6, 3.796 g, 681 g, 283.97 kg, 557.94 kg, 0.348 g and 0.105 g) compared with C (10.3, 7.1 cm, 7.3, 1.606 g, 288 g, 120.09 kg, 349.02 kg, 0.237 g and 0.018 g) on 90 DAS.

Similar result was obtained by Maity *et al.* (2016) who reported that gibberellic acid at 150 ppm enhanced the number of seeds/fruit, 1000 seed weight, yield/plant, length and girth of fruit of okra and Thilagar *et al.* (2016) reported that fruit yield of chilly as influenced by microbial consortia under microplot study.

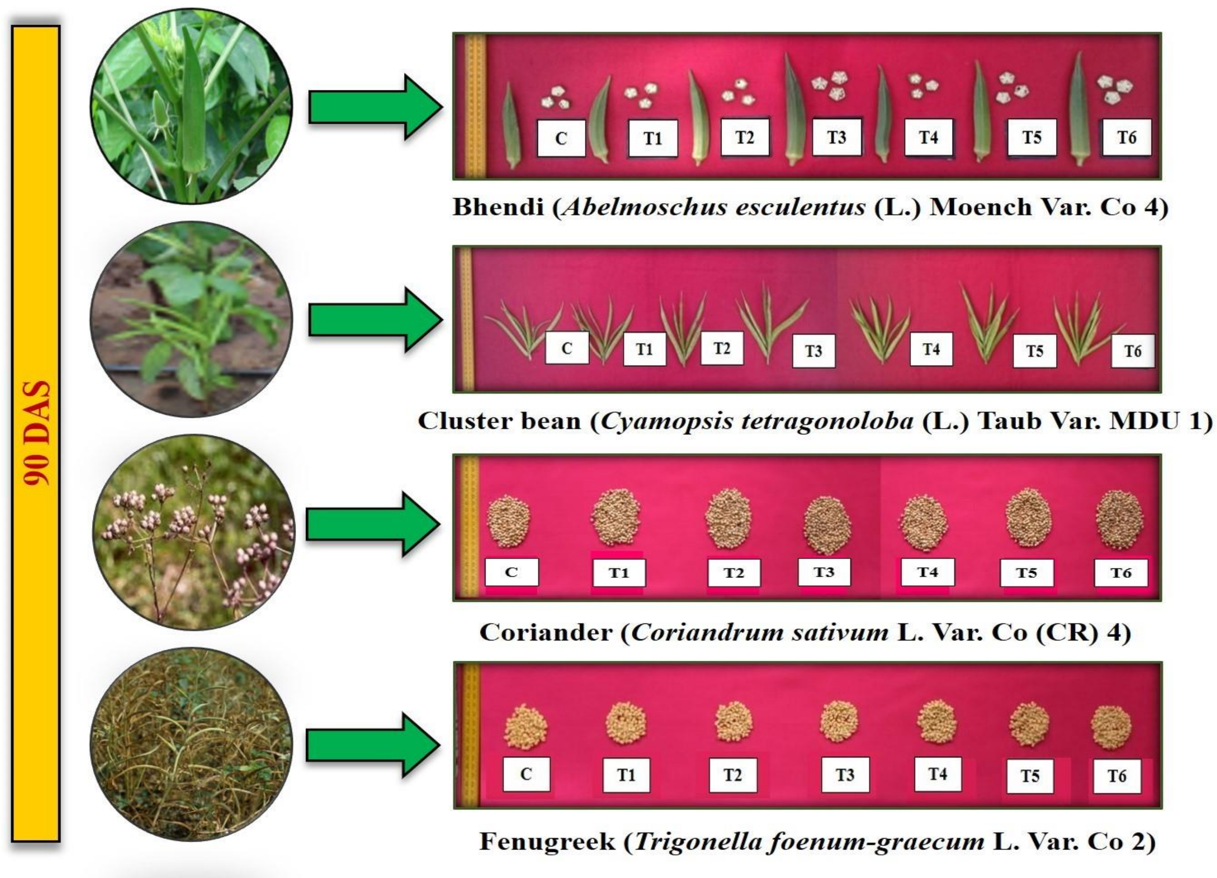
The present finding is in conformity with Mahmood *et al.* (2017) who reported that the co-inoculation of poultry manure at 7 t ha^{-1} with chemical fertilizers (nitrogen, phosphorus and potassium) at 150, 85 and 50 kg ha^{-1} improves the grain yield (8.43 t ha^{-1}), biological yield (14.60 t ha^{-1}) and 1000 grain weight (234.4 g) of maize. The consortium of microorganisms such as *P. fluorescens* and *A. brazilense* combined with 75% chemical fertilizer enhanced the maximum number of fruits/plant (17.24), length of fruit (9.62 cm), weight of fruit (2.88 gm), girth of fruit (7.36 cm), number of seeds/fruit (88.21) and average yield of fruit (8.27 kg/ha) was reported by Sundari and Gandhi (2017).

The combined application of 75% recommended dose of fertilizer with 6 t of vermicompost and bio-fertilizers enhanced the fruit yield of okra (37.65 q ha^{-1}) and bulb yield of onion (173.95 q ha^{-1}) was reported by Jat *et al.* (2017). The present finding is in conformity with Rather *et al.* (2018) who reported that the application of nitrogen, phosphorus and potassium in the ratio of 60:45:30 kg ha^{-1} along with 4 t ha^{-1} of vermicompost and 7.5 l ha^{-1} of biofertilizers recorded the highest value of leaf weight $plant^{-1}$ (518.25g), leaf yield $plot^{-1}$ (9.81 kg) and leaf yield ha^{-1} (23.83 t) in lettuce.

The present study positively correlated with the findings of Rathod *et al.* (2018) who observed maximum number of fruits (7.23), fruit length (39.27 cm), weight of fruit $plot^{-1}$ (19.96 kg), fruit yield ha^{-1} (16.64 t), dry matter yield of fruit ha^{-1}(14.89 q) and stover yield ha^{-1} (19.81 q) of ridge gourd influenced with the application of recommended dose of fertilizer (50%) + N through poultry manure (50%) + P and K + Azotobacter.

Plate -14

Effect of Composted Groundnut Shell and Toddy Palm Shell on Yield Parameters of Bhendi, Cluster Bean, Coriander and Fenugreek on 90 DAS



DAS – Days after sowing; **C** – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table -10

Effect of Composted Groundnut Shell and Toddy Palm Shell on Yield Parameters of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4) ON 90 DAS

Treatments	Number of fruits	Length of fruit (cm)	Diameter of fruit (cm)	Number of seeds / fruit	Yield / plant (g)	Yield / plot (kg)	Yield / ha (kg)	Fruit fresh weight (g)	Fruit dry weight (g)
C	5.3	14.3	1.3	48.8	99.428	1.782	743	18.76	1.007
T_1	5.6	14.7	1.6	54.7	124.09	2.232	930	22.16	1.574
T_2	7.0	16.4	1.9	60.5	155.49	2.790	1163	24.72	1.875
T_3	8.3	18.1	2.1	72.2	215.13	3.870	1613	25.92	2.006
T_4	6.6	15.9	1.8	57.3	173.04	3.114	1298	23.56	1.695
T_5	7.6	16.9	2.0	65.4	190.07	3.420	1426	25.01	1.981
T_6	9.0	18.9	2.3	79.9	241.02	4.338	1808	26.78	2.024
SEd	0.7533	0.4397	0.4546	0.4860	0.5084	0.4063	3.6904	0.4711	0.4690
Cd(p<0.05)	1.2762	0.9432	0.9751	1.0425	1.0905	0.8715	7.9160	1.0104	1.0061
Cd(p<0.01)	2.4285**	1.3090**	1.3534**	1.4468**	1.5134**	1.2096**	10.9865**	1.4024**	1.3964**

** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 11

Effect of Composted Groundnut Shell and Toddy Palm Shell on Yield Parameters of Cluster Bean (*Cyamopsis tetragonoloba* (L.) Taub.) Var. MDU.1) ON 90 DAS

Treatments	Number of pods	Length of pod (cm)	Number of seeds/pod	Yield / plant (g)	Yield / plot (kg)	Yield / ha (kg)	Pod fresh weight (g)	Pod dry weight (g)
C	41.3	12.8	5.6	99.81	1.782	743	4.029	0.848
T_1	46.6	13.6	6.3	127.32	2.286	953	4.291	0.971
T_2	51.0	14.9	7.3	142.01	2.556	1065	4.535	1.064
T_3	60.6	15.6	9.0	204.37	3.672	1531	5.721	1.575
T_4	48.0	13.9	7.0	174.08	3.132	1306	5.028	1.457
T_5	54.3	14.4	7.6	198.58	3.564	1486	4.784	1.249
T_6	68.3	15.8	9.6	226.51	4.068	1696	5.948	1.729
SEd	0.4483	0.4731	0.4231	3.0462	0.4309	3.8421	0.4475	0.5261
Cd(p<0.05)	0.9616	1.0148	0.9076	6.5341	0.9244	8.2414	0.9598	1.1285
Cd(p<0.01)	1.3345**	1.4084**	1.2597**	9.0686**	1.2829**	11.4382**	1.3321**	1.5662**

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 12

Effect of Composted Groundnut Shell and Toddy Palm Shell on Yield Parameters of Coriander (*Coriandrum sativum* (L.) Var. Co.4) on 90 DAS

Treatments	Number of seeds/plant	Yield /plant (g)	Yield / plot (kg)	Yield /ha (kg)	Straw yield / ha (kg)	Seeds fresh weight (g)	Seeds dry weight (g)
C	285.6	2.873	1.032	430.34	786.8	2.086	0.741
T_1	329.0	3.452	1.242	517.91	1085	2.381	0.822
T_2	371.3	3.984	1.434	597.97	1175	2.545	0.841
T_3	518.6	5.235	1.884	785.62	1568	3.141	1.098
T_4	486.3	4.741	1.704	710.56	1414	2.736	0.982
T_5	507.6	5.062	1.821	759.35	1537	2.948	1.081
T_6	527.3	5.497	1.977	824.40	1625	3.291	1.275
SEd	0.3638	0.4860	0.5118	0.4608	0.3904	0.4711	0.4860
Cd(p<0.05)	0.7804	1.0425	1.0977	0.9885	0.8373	1.0104	1.0425
Cd(p<0.01)	1.0832**	1.4468**	1.5236**	1.3720**	1.1621**	1.4024**	1.4468**

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 13

Effect of Composted Groundnut Shell and Toddy Palm Shell on Yield Parameters of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2) on 90 DAS

Treatments	Number of pods	Length of pod (cm)	Number of seeds / pod	Yield /plant (g)	Yield / plot (g)	Yield / ha (kg)	Straw yield / ha (kg)	Seeds fresh weight (g)	Seeds dry weight (g)
C	10.3	7.1	7.3	1.606	288	120.09	349.02	0.237	0.018
T_1	11.6	7.4	10.6	2.190	393	163.88	392.81	0.274	0.020
T_2	16.0	8.9	12.0	2.920	525	207.66	512.91	0.258	0.062
T_3	20.0	11.3	16.6	3.796	681	283.97	557.94	0.348	0.105
T_4	12.6	8.5	9.6	2.774	498	218.92	482.88	0.291	0.043
T_5	18.6	9.6	12.3	3.504	630	262.71	535.42	0.317	0.087
T_6	24.3	12.1	18.6	4.088	735	306.49	610.48	0.372	0.129
SEd	0.3968	0.4012	0.3192	0.5706	3.9521	0.5052	8.2421	0.1168	0.0440
Cd(p<0.05)	0.8512	0.8606	0.6847	1.2240	8.4773	1.0837	17.6794	0.2506	0.0943
Cd(p<0.01)	1.1813**	1.1944**	0.9503**	1.6988**	11.7656**	1.5040**	24.5370**	0.3478**	0.1309**

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

The result is on par with the result of Fazeel *et al.* (2019) who also reported increased fresh weight of pods (16.66 g), dry weight of pods (5.42 g) and total yield (0.87 t ha^{-1}) over the control in *Abelmoschus esculentus* L. with the application of jeewamirta (75%) and urea (25%) respectively.

The combined application of biogas digestate and biofertilizer enhanced the number of pods/plant, number of seeds/pod, 100 seeds weight, seed yield/plant, seed yield/ha and straw yield/ha of feba bean was reported by Alhammad and Seleiman (2023). The application of 400 g of chicken manure enhanced the number of fruits/plot (13.67) in *Cucumis sativus* was reported by Limbongan (2023). The present finding is in conformity with Mohamed *et al.* (2023) who found that the recommended dose of mineral nitrogen at 100% improved the yield attributing characters of common bean during the 2020 and 2021 seasons.

The combined application of groundnut shell and toddy palm shell decomposed with the help of microbial consortium and *Eisenia fetida* obtains considerable reduction of C: N ratio and greater level of N, P, and K which accelerates the synthesis of carbohydrate and better translocation in plant led to improvement in vegetative growth and yield attributing characters. Similar result was also reported by Salem and Awad (2005) in coriander and Godara *et al.* (2014) in fennel respectively.

Nitrogen play an important role in plant to ensure the availability of energy to optimize the yield of crop which is essential for the production of proteins, chlorophyll and nucleic acids. Phosphorus plays a vital role in plant growth and development which improves the growth of root, strengthens stalk and stem, formation of flowers and seed production by involving several key plant functions such as photosynthesis, energy transfer, transformation of starches and sugars and transfer of genetic characteristics from one generation to the next. Potassium play an important role in translocation of essential nutrients, water and other substances to stem and leaves by roots.

The application of groundnut shell and toddy palm shell decomposed along with *Bacillus licheniformis* promotes the growth of plant and soil health. Similar result was reported by Kumari *et al.* (2020) and Olanrewaju and Babalolo (2019) who found that the joint action of *Bacillus* sp. and *Pseudomonas* sp. improves the number of leaves, length of root, plant height and yield in maize.

In the current study, the presence of *Paecilomyces variotti, Bacillus licheniformis, Pleurotus florida* and *Streptomyces lavendulae* in the consortium of microorganisms improves the number of fruits, pods and seed yield in bhendi, cluster bean, coriander and fenugreek. This is might be due to increasing fertility of soil by improving nitrogen fixation and phosphate solubilization. Similar result was also reported by Pirlak and Kose (2009) in strawberry and Schoebitz *et al.* (2016) in blueberry.

The vermicomposting of groundnut shell and toddy palm shell obtained the maximum yield in selected test crops which contains high degree of humification than traditional composts (Jeyabal and Kuppuswamy, 2001). This is might be due to the supply of nutrients from vermicompost to plants gradually throughout the growth and development resulted higher biomass and plant yield. Similar finding was also reported by Lal and Singh (2016) in coriander.

In the present study a decrease in the carbon nitrogen ratio is mainly due to a rapid decomposition of organic amendments with the help of microbial consortium and earthworm. Senesi (1989) reported that C:N ratio of less than 20 revealed an advanced degree of maturity in the organic waste. A considerable reduction of C: N ratio (19:1) obtained in C_6 (Treatment 6) previously mentioned in the Table 1 indicates the maturity and good quality of organic fertilizer thereby increasing the yield of selected crops.

PHASE III

4.4.3 Biochemical characters

The effect of composted groundnut shell and toddy palm shell on carbohydrate, protein, chlorophyll content in leaves and leghaemoglobin content in root nodules of test crops.

4.4.3.1 Effect of composted groundnut shell and toddy palm shell on carbohydrate content in leaves of test crops on 25, 50 and 75 DAS

4.4.3.1.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The maximum carbohydrate content was observed in T_6 - toddy palm shell composted with the help of microbial consortium and *Eisenia fetida* (65.03, 106.42 and 93.61 mg g^{-1} tissue) followed by T_3 - groundnut shell biocomposted by microbial consortium and *Eisenia fetida* (57.70, 98.97 and 78.17 mg g^{-1} tissue) compared to the control (23.86, 57.62 and 45.62 mg g^{-1} tissue) on 25, 50 and 75 DAS as shown in Figure VI (a).

4.4.3.1.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The data presented in Fig. VI (b) shows that the maximum carbohydrate content in leaves of cluster bean was found to be higher in T_6 (70.18 and 76.75 mg/g tissue) followed by T_3 (68.86 and 75.21 mg/g tissue), T_5 (62.51 and 72.15 mg/g tissue) than control (43.35 and 55.07 mg/g tissue) on 25 and 75 DAS. On 50^{th} day the carbohydrate content was maximum in T_6 – toddy palm shell + microbial consortium + *Eisenia fetida* (100.83 mg/g tissue) followed by T_3 (98.97 mg/g tissue), T_4 (95.91 mg/g tissue), T_5 (91.09 mg/g tissue), T_2 (81.35 mg/g tissue), T_1 (78.61 mg/g tissue) and minimum in C – control (75.00 mg/g tissue) respectively.

4.4.3.1.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

Carbohydrate content in leaves of coriander showed a significant increase in T_6 - toddy palm shell composted with the help of microbial consortium and *Eisenia fetida* (47.34, 64.31 and 49.63 mg/g tissue) followed by T_3 (42.26, 61.28 and 45.15 mg/g tissue), T_5 (39.15, 54.41 and 42.30 mg/g tissue), T_4 (35.42, 53.05 and 40.17 mg/g tissue), T_2 (29.91, 49.20 and 37.54 mg/g tissue), T_1 (28.32, 47.03 and 34.20 mg/g tissue) than C (26.01, 42.91 and 31.95 mg/g tissue) on 25, 50 and 75 DAS (Fig. VI (c)).

4.4.3.1.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

An increase in carbohydrate content was noted in all the treatments. Among the treatments, maximum carbohydrate content was found in T_6 (67.61, 78.54 and 69.95 mg/g tissue) followed by T_3 (60.41, 76.49 and 68.51 mg/g tissue) than control (41.38, 60.87 and 45.87 mg/g tissue) on 25, 50 and 75 DAS as shown in Fig. VI (d).

This result is in accordance with a result of Kavitha *et al.* (2013) who reported that the combined application of chemical fertilizer + vermicompost + *Azospirillum* improved the total carbohydrate content (48.03 mg/g) in leaves of *Amaranthus tristis* on 40^{th} day of plant growth. Similar results were also reported by Bindhu *et al.* (2013) who reported that the influence of 3.5 kg red loamy soil with 3.5 kg of biodynamic compost increased the carbohydrate content (0.0467 mg/g) in leaves of soybean compared with control (0.0290 mg/g) on 75^{th} day. This result is in accordance with a result of Sarwar *et al.* (2018) who found that application of compost and NPK fertilizer in the ratio of 50:50 increased the carbohydrate content (494.94 mg g^{-1} dry weight) in leaves of *Moringa* than control (270.25 mg g^{-1} dry weight) respectively.

A similar result was obtained by Sarwar *et al.* (2020) who observed an increase in carbohydrate content (406.24 mg g^{-1} dry weight) in leaves of *Moringa oleifera* with the application of 50% NPK + 50% compost. The results coincided with the findings of Abdou *et al.* (2023) who confirmed that the inoculation of compost at 30 t ha^{-1} improves the carbohydrate content (2.8, 2.6 and 2.5%) at three irrigation levels (100, 175 and 150) in dried leaves of black cumin. On 25 to 50 DAS a significantly increased carbohydrate content was observed in toddy palm shell composted by microbial consortium and *Eisenia fetida* may be due to the better translocation of photosynthesis from leaves. The slight decline on 75 DAS might be due to the translocation of plant nutrients from leaves to fruits.

4.4.3.2 Effect of composted groundnut shell and toddy palm shell on protein content in leaves of test crops on 25, 50 and 75 DAS

4.4.3.2.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The protein content was found to be higher with the application of T_6 (35.81 mg/g tissue), T_3 (31.90 mg/g tissue), T_5 (29.45 mg/g tissue), T_2 (28.90 mg/g tissue), T_4 (25.00 mg/g tissue)

T_1 (22.63 mg/g tissue) and C (16.18 mg/g tissue) on 25 days after sowing respectively. On 50th and 75th day the maximum protein content was observed from T_6 (114.00 and 62.54 mg/g tissue) followed by T_3 (91.09 and 57.00 mg/g tissue), T_5 (80.36 and 48.63 mg/g tissue), T_4 (71.00 and 47.36 mg/g tissue), T_2 (54.00 and 41.27 mg/g tissue), T_1 (40.09 and 30.18 mg/g tissue) and C (34.00 and 26.72 mg/g tissue) as shown in Fig. VII (a).

4.4.3.2.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The Figure VII (b) revealed that the maximum protein content in leaves of cluster bean with the application of toddy palm shell bio-composted by microbial consortium and earthworm T_6 - (33.72, 58.54 and 51.81 mg/g tissue), T_3 (32.18, 56.36 and 48.90 mg/g tissue), T_5 (29.18, 53.90 and 42.81 mg/g tissue) than control (18.45, 37.81 and 31.09 mg/g tissue) on 25, 50 and 75 DAS.

4.4.3.2.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

The maximum protein content was found in T_6 (41.05, 57.46 and 45.62 mg/g tissue) followed by T_3 (38.51, 53.04 and 42.73 mg/g tissue), T_5 (36.94, 49.25 and 39.94 mg/g tissue), T_4 (34.56, 45.82 and 38.57 mg/g tissue), T_2 (31.02, 42.71 and 33.95 mg/g tissue), T_1 (29.41, 38.01 and 31.42 mg/g tissue) than C (24.16, 35.91 and 29.35 mg/g tissue) on 25, 50 and 75 DAS as shown in Fig. VII (c).

4.4.3.2.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

Among the treatments, T_6 – toddy palm shell + microbial consortium + *Eisenia fetida* registered maximum protein content of 47.36, 95.36 and 77.81 (mg/g tissue) followed by T_3 – groundnut shell + microbial consortium + *Eisenia fetida* (47.00, 93.18 and 74.27 mg/g tissue) than control (23.18, 62.27 and 45.63 mg/g tissue) on 25, 50 and 75 days after sowing (Fig. VII (d)).

The present study is on par with the result of Kavitha *et al.* (2013) who reported maximum increase of protein content (61.17 mg/g) in leaves of *Amaranthus tristis* enhanced with the application of chemical fertilizer + *Azospirillum* + vermicompost on 40th day of plant growth. This result is also in accordance with a result of Dwivedi *et al.* (2014) who reported a maximum increase in total protein content in leaves of soybean of 0.95, 0.91 and 0.97 mg ml^{-1} as influenced by *Eichhornia*, *Parthenium* and *Lantana* vermicompost than control (0.36 mg ml^{-1}) on 75 days. The present study are in accordance with the findings of Ravimycin (2016) who observed maximum protein content in leaves of coriander (23.32 mg of fresh weight) as influenced by the application of vermicompost than control (16.48 mg of fresh weight) on 90 DAS.

Similar result was also reported by Sarwar *et al.* (2018) who obtained that the application of 120 kg ha^{-1} of nitrogen, phosphorus and potassium enhanced total protein content (28.89 mg g^{-1} dry weight) in leaves of *Moringa oleifera* than control (19.77 mg g^{-1} dry weight). The maximum protein content (27.91 mg g^{-1}) in leaves of *Moringa oleifera* influenced by the application of 120 kg ha^{-1} of NPK was reported by Sarwar *et al.* (2020). The influence of green waste mixed with phosphate sludge + *Fusarium oxysporum* f. sp. *albedinis* improved the protein content in root and shoot of date palm seedling was reported by Anli *et al.* (2023) which also supports our findings.

The increase in the protein content up to 50 DAS may be due to the presence of microorganisms in the compost which stimulated the degradation process faster and resulted in availability of essential nutrients particularly, amino acids, nitrogen, vitamins and enzymes. They may be responsible for enhancing physiological and metabolic activities in plants consequentially, increasing nitrogen uptake from soil and assimilation for biosynthesis of protein. In addition, the decline of protein observed on 75 DAS might be attributed to utilization of nitrogen for formation of flowers and fruits.

4.4.3.3 Effect of composted groundnut shell and toddy palm shell on chlorophyll a, chlorophyll b and total chlorophyll content in leaves of test crops on 25, 50 and 75 DAS

4.4.3.3.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

Chlorophyll a, chlorophyll b and total chlorophyll content in leaves of bhendi significantly increased on 50 DAS and considerably reduced on 75 DAS in all the treatments as shown in Table 14. The maximum chlorophyll a, chlorophyll b and total chlorophyll content observed in T_6 (2.595, 3.962 and 2.325 mg/g tissue), (3.895, 3.528 and 2.621 mg/g tissue) and (3.586, 3.881 and 2.814 mg/g tissue) followed by T_3 (2.544, 3.504 and 2.246 mg/g tissue), (3.697, 3.237 and 2.244 mg/g tissue) and (3.323, 3.689 and 2.683 mg/g tissue) and compared to the control (1.413, 2.403 and 0.870 mg/g tissue), (2.643, 2.002 and 1.042 mg/g tissue) and (1.364, 2.246 and 1.494 mg/g tissue) on 25, 50 and 75 DAS.

4.4.3.3.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The maximum chlorophyll a, chlorophyll b and total chlorophyll content in leaves of cluster bean observed in T_6 - toddy palm shell composted with the help of microbial consortium and *Eisenia fetida* showed a remarkable increase in chlorophyll content (2.372, 3.683 and 2.588 mg/g tissue), (3.517, 2.772 and 3.566 mg/g tissue) and (2.673, 1.991 and 2.762 mg/g tissue) followed by T_3 (2.093, 3.442 and 2.474 mg/g tissue), (3.175, 2.598 and 3.200 mg/g tissue) and (2.368, 1.847 and 2.538 mg/g tissue) than control (1.067, 2.260 and 1.117 mg/g tissue), (1.843, 1.903 and 1.785 mg/g tissue) and (1.301, 1.295 and 1.477 mg/g tissue) on 25, 50 and 75 DAS as shown in Table 15 respectively.

4.4.3.3.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

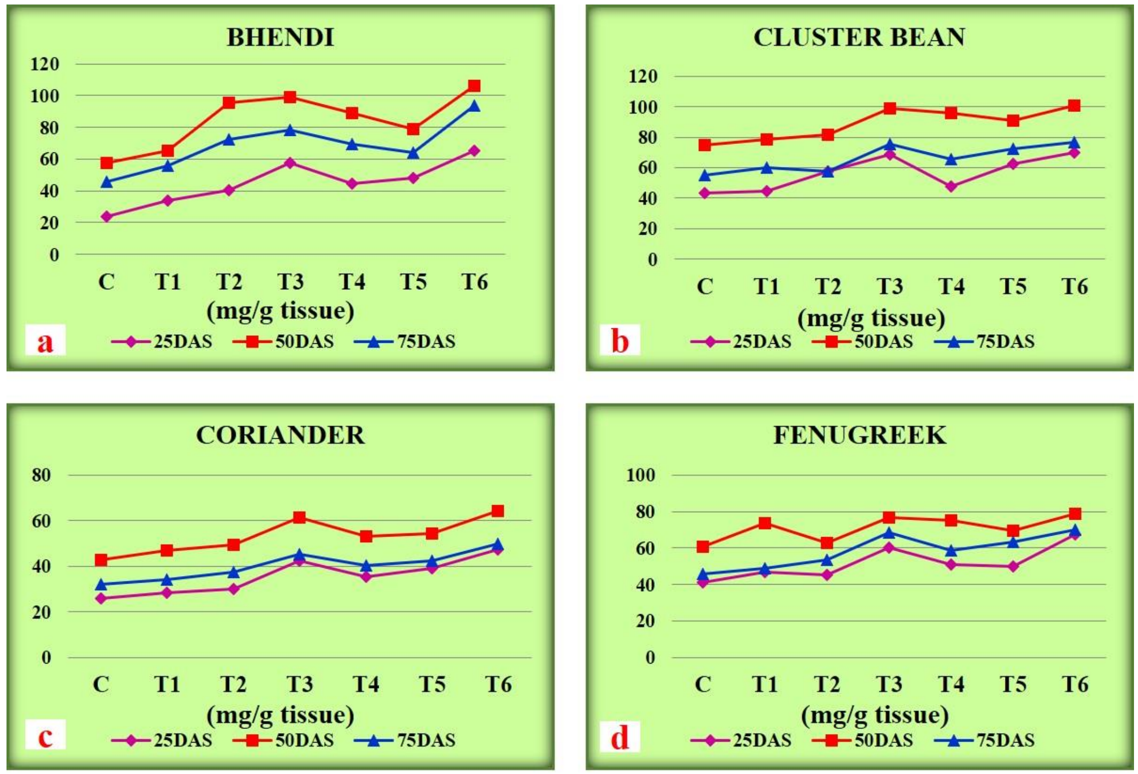
On 25, 50 and 75 DAS the highest chlorophyll a, chlorophyll b and total chlorophyll content was obtained in T_6 – toddy palm shell + microbial consortium + *Eisenia fetida* (2.945, 3.072 and 2.213 mg/g tissue), (3.737, 3.805 and 3.622 mg/g tissue) and (2.053, 2.998 and 3.679 mg/g tissue) and lowest in C (1.210, 1.743 and 0.145 mg/g tissue), (2.056, 2.724 and 2.057 mg/g tissue) and (0.489, 1.396 and 1.689 mg/g tissue) as given in the Table 16.

4.4.3.3.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

Significant increase in chlorophyll a and chlorophyll b content was obtained in T_6 – toddy palm shell + microbial consortium + *Eisenia fetida* ranged between (2.912 to 3.849 mg/g tissue), (1.827 to 2.539 mg/g tissue) and (2.205 to 3.811 mg/g tissue) followed by T_3 – groundnut shell + microbial consortium + *Eisenia fetida* (2.807 to 3.757 mg/g tissue), (1.592 to 2.059 mg/g tissue) and (2.111 to 3.585 mg/g tissue) than control (1.171 to 2.077 mg/g tissue), (0.384 to 1.230 mg/g tissue) and (1.437 to 2.579 mg/g tissue) on 25 to 50 DAS as shown in the Table 17. On 75 DAS chlorophyll a and total chlorophyll content was considerably reduced than 25 and 50 DAS registered in T_6 (2.630 and 3.751 mg/g tissue), T_3 (2.288 and 3.102 mg/g tissue), T_5 (1.693 and 2.866 mg/g tissue), T_4 (1.389 and 2.814 mg/g tissue) than C (0.883 and 2.344 mg/g tissue). The chlorophyll b was gradually increased in all the treatments T_6 (3.795 mg/g tissue), T_4 (3.087 mg/g tissue), T_3 (3.063 mg/g tissue), T_2 (2.773 mg/g tissue), T_5 (2.669 mg/g tissue), T_1 (2.582 mg/g tissue) and C (2.479 mg/g tissue) on 75 DAS as shown in Table 17.

Figure – VI (a to d)

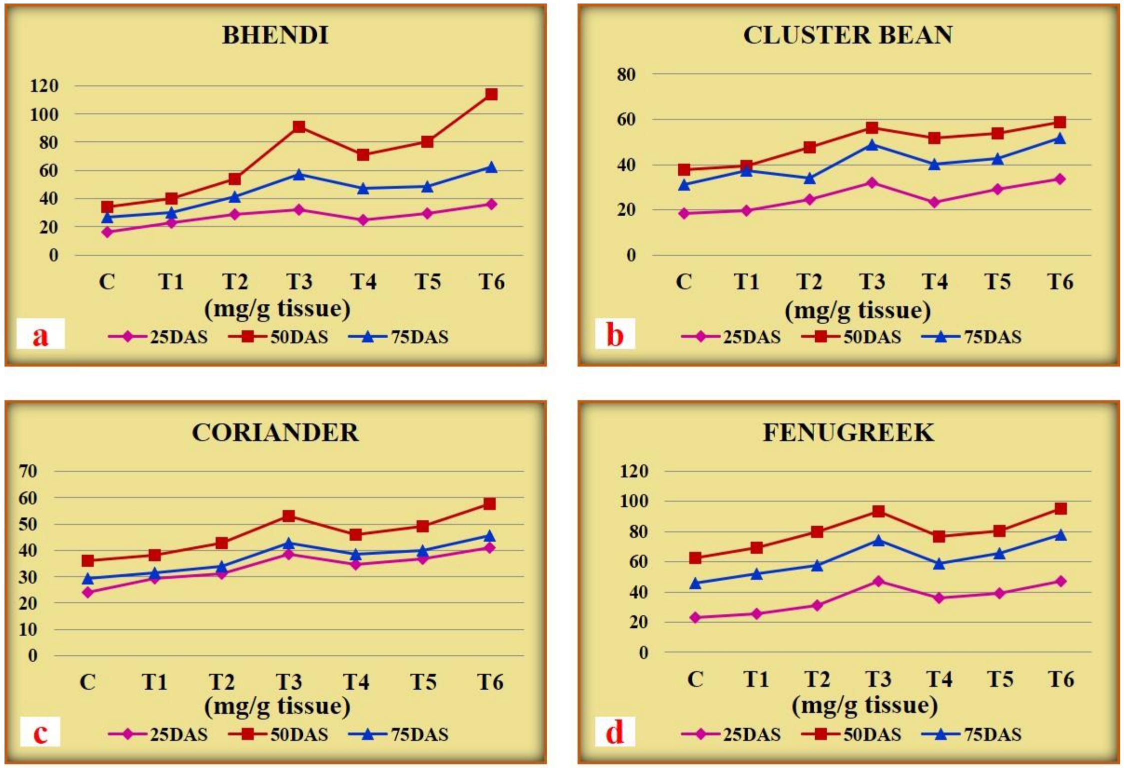
Effect of Composted Groundnut Shell and Toddy Palm Shell on Carbohydrate Content in Leaves of Bhendi, Cluster Bean, Coriander and Fenugreek



DAS – Days after sowing; **C** – Control, $\mathbf{T_1}$ – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_2}$ – Groundnut shell + microbial consortium (5t ha^{-1}), $\mathbf{T_3}$ – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_4}$ – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_5}$ – Toddy palm shell + microbial consortium (5t ha^{-1}) and $\mathbf{T_6}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Figure – VII (a to d)

Effect of Composted Groundnut Shell and Toddy Palm Shell on Protein Content in Leaves of Bhendi, Cluster Bean, Coriander and Fenugreek



DAS – Days after sowing; **C** – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

The present study was supported by Sundari and Gandhi (2017) who found that the maximum chlorophyll a (1.22, 1.31 and 2.02 mg/g of fresh weight), chlorophyll b (1.12, 1.89 and 2.38 mg/g of fresh weight) and total chlorophyll (2.30, 1.89 and 4.40 mg/g of fresh weight) content in leaves of bhendi influenced by 75% chemical fertilizer + *Azospirillum brazilense* + *Pseudomonas fluorescens* on 30, 60 and 90 days. Fazeel *et al.* (2019) who reported that 25% urea + 75% jeewamirta enhanced the maximum chlorophyll content (56.77%) in leaves of *Abelmoschus esculentus*. The present finding is in conformity with Sharma *et al*. (2019b) who reported that application of 75% RDF + pressmud + rhizobium significantly enhanced the chlorophyll content in leaves of cluster bean (41.01) on 45 DAS respectively.

Similar results was reported by Zhao *et al.* (2020) that different fractions of municipal solid waste compost enhanced the chlorophyll content in leaves of *Lolium perenne* L. They found maximum chlorophyll a (2.70 mg g^{-1}) in 0.8-1.6 mm compost and chlorophyll b (1.30 mg g^{-1}) and total chlorophyll (3.84 mg g^{-1}) in the whole compost of municipal solid waste than control (2.29, 1.05 and 3.34 mg g^{-1}). Similar result was reported by Bhunia *et al.* (2021) that low dose of bovine blood rumen digesta mixture enhanced chlorophyll a + b (2.3 mg g^{-1}) in leaves of bell pepper and bovine blood rumen digesta mixture improves maximum chlorophyll a + b (1.7 mg g^{-1}) in leaves of amaranth.

The present finding is in conformity with Aydi *et al.* (2023) who found a significant increase in chlorophyll content (3.09 mg g^{-1}) of greenhouse melon as influenced by the application of composted date palm trunk. Similar result was also reported by Abdou *et al.* (2023) who obtained that the application of compost at 30 t/ha increased chlorophyll a (1.36 mg/g) and chlorophyll b (0.68 mg/g) level in leaves of black cumin. Increase in chlorophyll content obtained from T_2 (toddy palm shell + microbial consortium + *Eisenia fetida*) might be due to the availability of phosphorus ions in the soil promotes photosynthetic reaction. A higher amount of chlorophyll content in the leaf tissues reflects nutrient availability in the plants and also plays a vital role in the photosynthesis. A availability of nitrogen in the compost helps to produce more chlorophyll content.

Table – 14

Effect of Composted Groundnut Shell and Toddy Palm Shell on Chlorophyll 'A', Chlorophyll 'B' and Total Chlorophyll Content in Leaves of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4)

Treatments	Chlorophyll 'a' (mg/g tissue)			Chlorophyll 'b' (mg/g tissue)			Total chlorophyll (mg/g tissue)		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	1.413	2.403	0.870	2.643	2.002	1.042	1.364	2.246	1.494
T_1	1.510	2.443	1.051	3.511	2.121	1.450	2.136	2.343	1.866
T_2	1.770	3.077	1.452	3.058	2.480	1.065	2.625	3.195	2.417
T_3	2.544	3.504	2.246	3.697	3.237	2.244	3.323	3.689	2.683
T_4	1.645	2.560	1.954	3.452	2.525	1.184	2.863	3.366	2.413
T_5	2.101	3.334	1.714	3.274	3.117	1.761	2.593	3.596	1.811
T_6	2.595	3.962	2.325	3.895	3.528	2.621	3.586	3.881	2.814
SEd	0.16012			0.16974			0.15606		
Cd(p<0.05)	0.32321			0.34264			0.31501		
Cd(p<0.01)	0.43204**			0.45801**			0.42108**		

** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 15

Effect of Composted Groundnut Shell and Toddy Palm Shell on Chlorophyll 'a', Chlorophyll 'b' and Total Chlorophyll Content in Leaves of Cluster Bean (*Cyamopsis tetragonoloba* (L.) Taub. Var. MDU.1)

Treatments	Chlorophyll 'a' (mg/g tissue)			Chlorophyll 'b' (mg/g tissue)			Total chlorophyll (mg/g tissue)		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	1.067	2.260	1.117	1.843	1.903	1.785	1.301	1.295	1.477
T_1	1.245	2.970	1.688	2.232	1.928	2.174	1.646	1.588	1.822
T_2	1.561	2.603	1.294	2.620	2.288	2.264	1.901	1.520	1.935
T_3	2.093	3.442	2.474	3.175	2.598	3.200	2.368	1.847	2.538
T_4	1.485	2.440	1.827	2.558	2.109	2.584	1.597	1.753	2.189
T_5	1.726	2.909	2.157	2.307	2.457	2.927	1.820	1.440	2.494
T_6	2.372	3.683	2.588	3.517	2.772	3.566	2.673	1.991	2.762
SEd	0.17652			0.15430			0.19557		
Cd(p<0.05)	0.35631			0.31147			0.39476		
Cd(p<0.01)	0.47628**			0.41635**			0.52769**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 16

Effect of Composted Groundnut Shell and Toddy Palm Shell on Chlorophyll 'A', Chlorophyll 'b' and Total Chlorophyll Content in Leaves of Coriander (*Coriandrum sativum* L. Var. Co.4)

Treatments	Chlorophyll 'a' (mg/g tissue)			Chlorophyll 'b' (mg/g tissue)			Total chlorophyll (mg/g tissue)		
	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	1.210	1.743	0.145	2.056	2.724	2.057	0.489	1.396	1.689
T_1	1.351	1.971	0.514	2.343	2.956	2.582	0.850	1.495	1.835
T_2	2.027	2.130	1.291	2.279	3.492	2.904	1.593	1.856	2.305
T_3	2.885	2.932	1.762	3.589	3.762	3.608	1.937	2.487	3.298
T_4	2.415	2.651	1.876	3.276	3.462	3.487	1.278	1.475	1.930
T_5	2.514	2.845	1.591	3.170	3.018	3.372	1.422	1.709	2.690
T_6	2.945	3.072	2.213	3.737	3.805	3.622	2.053	2.998	3.679
SEd	0.17077			0.17638			0.17906		
Cd(p<0.05)	0.34470			0.35604			0.36145		
Cd(p<0.01)	0.46077**			0.47593**			0.48315**		

** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 17

Effect of Composted Groundnut Shell and Toddy Palm Shell on Chlorophyll ‘a’, Chlorophyll ‘b’ and Total Chlorophyll Content in Leaves of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2)

Treatments	Chlorophyll ‘a’ (mg/g tissue)			Chlorophyll ‘b’ (mg/g tissue)			Total chlorophyll (mg/g tissue)		
	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	1.171	2.077	0.883	0.384	1.230	2.479	1.437	2.579	2.344
T_1	1.627	2.194	1.263	0.711	1.374	2.582	1.611	2.827	2.534
T_2	1.476	2.572	1.073	0.663	1.802	2.773	1.620	3.074	3.024
T_3	2.807	3.757	2.288	1.592	2.059	3.063	2.111	3.585	3.102
T_4	2.144	2.968	1.389	1.022	1.944	3.087	1.942	3.504	2.814
T_5	2.377	2.780	1.693	1.147	1.490	2.669	1.634	3.074	2.866
T_6	2.912	3.849	2.630	1.827	2.539	3.795	2.205	3.811	3.751
SEd	0.15936			0.16610			0.16372		
Cd($p<0.05$)	0.32168			0.33528			0.33047		
Cd($p<0.01$)	0.42999**			0.44817**			0.44174**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

4.4.3.4 Effect of composted groundnut shell and toddy palm shell on leghaemoglobin content in root nodules of test crops on 25, 50 and 75 DAS

4.4.3.4.1 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The leghaemoglobin content was found to be maximum in T_6 – toddy palm shell + microbial consortium + *Eisenia fetida* (0.281, 0.192 and 0.191 mg/g) followed by T_3 – groundnut shell + microbial consortium + *Eisenia fetida* (0.264, 0.185 and 0.182 mg/g) compared to the control (0.102, 0.116 and 0.092 mg/g) on 25, 50 and 75 DAS as shown in Fig. VIII (a) respectively.

4.4.3.4.2 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

Significantly increased leghaemoglobin content in root nodules of fenugreek was observed in all the treatments (T_1-T_6) up to 50 DAS and it was decreased on 75 days after sowing as shown in the Fig. VIII (b) respectively. The leghaemoglobin content was significantly increased in T_6 (0.188, 0.275 and 0.174 mg/g) followed by T_3 (0.174, 0.243 and 0.153 mg/g) compared to the control (0.062, 0.094 and 0.023 mg/g) on 25, 50 and 75 DAS.

Similar results was also reported by Figueiredo *et al.* (2008) that co-inoculation of *Rhizobium tropici* and *Paenibacillus polymyxa* enhanced leghaemoglobin content (27.98 mg/g) in root nodules of common bean (*Phaseolus vulgaris* L.). The present study coincided with the results of Edulamudi *et al.* (2023) who reported that the plants inoculated with the rhizobial strain HGR – 4 increased the leghaemoglobin content (580 µg/g) in root nodules of horse gram at 50 µg g^{-1} of concentration. The application of composted coir pith, farmyard manure and pressmud at 6.5 t ha^{-1} significantly increased the leghaemoglobin content (0.0470, 0.0560 and 0.0470 mg/g) in root nodules of *Vigna radiata* on 25, 45 and 55 DAS was reported by Singh and Vijayalakshmi (2013a).

Maximum leghaemoglobin content in root nodules of chickpea by the combined application of *Rhizobium* and phosphate solubilizing bacteria (2.3 mg/g) on 55 days after sowing was reported by Tagore *et al.* (2013). The present finding is in conformity with Sharma *et al.* (2019 b) who observed that the chickpea genotype variety IG-593 improves leghaemoglobin content (2.1, 2.6 and 2.5 mg/g of fresh nodule) on 35, 50 and 75 days after sowing respectively.

A application of olive pomace compost (84 t ha^{-1}) enhanced the leghaemoglobin content in soybean root nodules (7.32 mg $nodule^{-1}$) was reported by Tortosa *et al.* (2023) which supports our findings. Increasing trend of leghaemoglobin content in root nodules might be due to the activity of nitrogenous substances by bacterial respiration and decline of leghaemoglobin content in late stages may be due to less nitrogenous activity by microorganisms and the usage of fixed nitrogen to reproductive organs.

Carbohydrates are one of the major forms of energy obtained during photosynthesis by the utilization of light energy from sun. Plants convert light energy into chemical energy by building carbon dioxide into sugar molecules such as glucose. Carbohydrate is essential for growth and development of plants. In the current study, maximum amount of carbohydrates obtained in toddy palm shell decomposed with the help of microbial consortium and earthworm in all the four selected test crops.

Addition of compost enhanced the rate of photosynthesis and availability of carbon compounds to the plants was reported by Finlay and Soderstrom (1992). Similar results were positively correlated with the result of Kortei and Quansah (2016) in lettuce, Rady *et al.* (2016) in common bean and Sadak and Bakry (2020) in flax plant. In the present study, all the treatments were inoculated with substantial amount of compost. However, the combined application of microbial consortium and *Eisenia fetida* enhanced the carbohydrate content in leaves of bhendi, cluster bean, coriander and fenugreek. This may be due to the combination of consortium of microorganisms + *Eisenia fetida* and due to good degradation rate and maturity of composts. The vermicompost contains macro and micronutrients, plant growth regulators and humic acids (Krishnamoorthy and Vajrabhiah, 1986; Senesi *et al.,* 1992). Humic acids increased the plant growth by promoting plant growth hormones such as cytokinin, auxin and gibberellin which enhanced the concentration of chlorophyll in leaves. The result was coincided with the result of Atzmon and Staden (1994) and Ramya *et al.* (2010). The increased chlorophyll content improves the rate of photosynthesis and carbohydrates synthesis (Hend *et al.*, 2007) and the decline of carbohydrate content in leaves might be due to the conversion of plant nutrients from leaves to fruits.

The inoculation of organic fertilizers into the soil boosts the soil nitrogen, potassium, phosphorus, sulphur, magnesium and calcium. The plant absorb nitrogen from the soil in the form of nitrate and combines with carbohydrates like glucose and forms the amino acids. Amino acids are building blocks of protein. Maximum nitrogen content observed in toddy palm shell decomposed with the help of microbial consortium and *Eisenia fetida* enhanced the level of protein in leaves of bhendi, cluster bean, coriander and fenugreek.

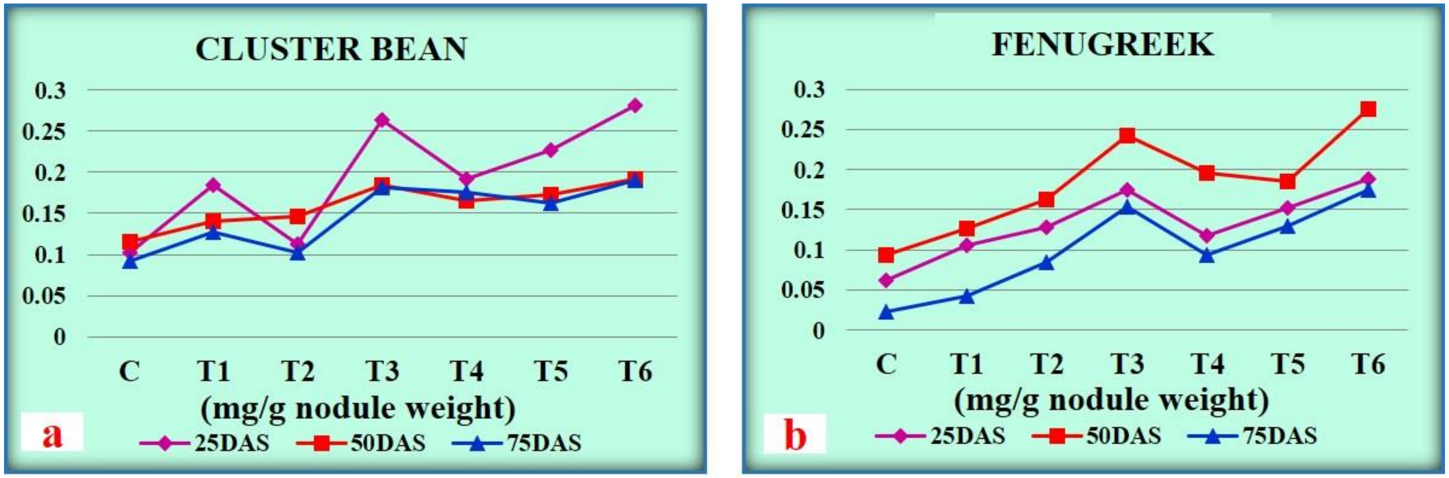
Similar result was positively correlated with the findings of Oyedeji *et al*. (2014) who reported that the availability of NPK significantly increased the protein content in leaves of *Amaranthus*. According to Abou El-Yazied *et al.* (2012) plant growth regulators and essential nutrients enhanced the amount of protein in leaves. Likewise, the consortium of microorganisms also produce plant growth hormones which might have improved the level of protein in leaves of selected test crops. The decline of protein content in leaves may be due to metabolisms changed more toward carbon-containing compounds such as cellulose, starch, terpenoids and phenolics when the availability of nitrogen is limited.

Chlorophyll is a green pigment in plant, algae and cyanobacteria which is essential for photosynthesis and metabolic activity. It absorbs sunlight and uses its energy to synthesis carbohydrates from carbon dioxide and water and also play an important role in ATP synthesis. The compost application significantly increased the chlorophyll content in various crops like common bean (Fernandez-Luqueno *et al.,* 2010), fenugreek (Suthar, 2010) and lettuce (Ali *et al.,* 2007). This is mainly due to the presence of microorganisms in the vermicompost that colonize in the rhizosphere and stimulate the biochemical contents and plant growth (Ravimycin, 2016).

Maximum amount of chlorophyll content observed in toddy palm shell biocompost by using microbial consortium and earthworms followed by the same combination with groundnut shell. In the current study, compost prepared by using consortium of microorganisms and *Eisenia fetida* were capable of producing plant growth regulators which enhanced the level of chlorophyll in leaves of bhendi, cluster bean, coriander and fenugreek. The result was in harmony with Atzmon and Staden (1994) and Ramya *et al.* (2010).

Figure – VIII (a to d)

Effect of Composted Groundnut Shell and Toddy Palm Shell on Leghaemoglobin Content in Root Nodules of Cluster Bean and Fenugreek



DAS – Days after sowing; **C** – Control, $\mathbf{T_1}$ – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_2}$ – Groundnut shell + microbial consortium (5t ha^{-1}), $\mathbf{T_3}$ – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_4}$ – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_5}$ – Toddy palm shell + microbial consortium (5t ha^{-1}) and $\mathbf{T_6}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

The composts contain higher amount of total nitrogen as previously mentioned in the Table 1 incorporated into the soil contain sufficient level of plant nutrients. The plant absorb nitrogen from the soil through root hairs. The availability of nitrogen increased the chlorophyll content and low availability decline the level of chlorophyll content.

Leghaemoglobin is an oxygen carrying phytoglobin found in the root nodules of leguminous plants. Inside the nodules of cluster bean and fenugreek symbiotic nitrogen fixation was carried out by the help of rhizobia produce nitrogenase enzyme that reduces the atmospheric nitrogen and convert into ammonia. This is utilized for the growth and development of plant (Poole *et al.,* 2018). In the current study, maximum leghaemoglobin content was observed in toddy palm shell + microbial consortium + *Eisenia fetida* which promotes symbiotic nitrogen fixation. The application of compost into the soil stimulates the maximum number of nodules was also reported by Ulzen *et al.* (2020); Cid *et al.* (2020); Tortosa *et al.* (2023) in soybean.

4.4.3.5 Effect of biocomposted groundnut shell and toddy palm shell on carbohydrate content in fruits, pods and seeds of test crops on 90 DAS

4.4.3.5.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

Maximum carbohydrate content in fruits of bhendi was obtained in T_6 the application of toddy palm shell composted by microbial consortium and *Eisenia fetida* (70.94 mg/g tissue) followed by T_3 (67.88 mg/g tissue), T_5 (57.91 mg/g tissue), T_2 (53.32 mg/g tissue), T_4 (51.45 mg/g tissue), T_1 (47.29 mg/g tissue) and C (38.75 mg/g tissue) on 90 DAS as shown in Fig. IX (a) respectively.

4.4.3.5.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

On 90th day the carbohydrate content in pods of cluster bean was found to be higher in T_6 - toddy palm shell + microbial consortium + *Eisenia fetida* (121.75 mg/g tissue) followed by T_3 - groundnut shell + microbial consortium + *Eisenia fetida* (110.47 mg/g tissue), T_4 - toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (104.23 mg/g tissue), T_5 - toddy palm shell + microbial consortium (102.04 mg/g tissue), T_2 - groundnut shell + microbial consortium (92.08 mg/g tissue), T_1 - groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (90.54 mg/g tissue) and C- control (74.89 mg/g tissue) as shown in Fig. IX (b).

4.4.3.5.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

The data presented in Fig. IX (c) shows that the carbohydrate content in seeds of coriander was found to be more in T_6 (86.36 mg/g tissue), T_3 (83.60 mg/g tissue), T_5 (79.87 mg/g tissue), T_4 (76.42 mg/g tissue), T_2 (72.54 mg/g tissue), T_1 (69.23 mg/g tissue) than control (64.07 mg/g tissue) (76.42 mg/g tissue), T_2 (72.54 mg/g tissue), T_1 (69.23 mg/g tissue) than control (64.07 mg/g tissue) on 90 DAS respectively.

4.4.3.5.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The carbohydrate content in seeds of fenugreek was found to be higher in T_6 with the application of toddy palm shell composted by microbial consortium and earthworms (106.42 mg/g tissue) followed by T_3 - groundnut shell bio-composted by microbial consortium and earthworms (100.07 mg/g tissue) compared with control (72.59 mg/g tissue) on 90 DAS as shown in Fig. IX (d) respectively.

The present finding is in conformity with Densilin *et al*. (2010) who reported that the combined application of vermicompost and inorganic fertilizer enhanced maximum carbohydrate content (3.68 %) in fruits of chilli compared with control (0.48%). The result coincided with the result of Sivakumar *et al.* (2012) who confirmed that the combined inoculation of bacterial fertilizers (*Rhizobium* + *Phophobacteria* + *Azospirillum*) increased the carbohydrate content of cowpea and green gram (15.74 and 15.57 mg/g tissue) respectively. The co-inoculation of biogas digestate and biofertilizer improves the carbohydrate content (59.68%) in seeds of feba bean was earlier reported by Alhammad and Seleiman (2023).

The fruits of bhendi, pods of cluster bean, seeds of coriander and fenugreek obtained maximum carbohydrate content was found in plants that received compost from T_6 treatment. It might be due to the availability of nutrients which increased the plant metabolism, leading to increase in the accumulation of carbohydrates in fruits and pods. The combined application of toddy palm shell + microbial consortium + *Eisenia fetida* leads to neutralizing carbon nitrogen ratio which resulted in suitable nutrient availability and enhanced plant metabolisms increasing the carbohydrate content.

4.4.3.6 Effect of biocomposted groundnut shell and toddy palm shell on protein content in fruits, pods and seeds of test crops

4.4.3.6.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The protein content in fruits of bhendi was found to be maximum in T_6 (58.90 mg/g tissue), T_3 (56.36 mg/g tissue), T_5 (48.09 mg/g tissue), T_4 (42.72 mg/g tissue), T_1 (39.45 mg/g tissue), T_2 (33.45 mg/g tissue) than C (25.81 mg/g tissue) on 90 DAS as shown in Fig. X (a) respectively.

4.4.3.6.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

Protein content in pods of cluster bean was found to be maximum in T_6 (88.90 mg/g tissue), T_3 (84.72 mg/g tissue), T_5 (79.81 mg/g tissue), T_2 (74.27 mg/g tissue), T_4 (68.36 mg/g tissue), T_1 (66.27 mg/g tissue) than C (59.36 mg/g tissue) on 90 days after sowing is given in Fig. X (b).

4.4.3.6.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

Maximum protein content in seeds of coriander was obtained in T_6 (81.44 mg/g tissue) followed by T_3 (74.94 mg/g tissue), T_5 (71.85 mg/g tissue), T_4 (67.84 mg/g tissue), T_2 (62.12 mg/g tissue), T_1 (59.41 mg/g tissue) and C (51.23 mg/g tissue) on 90 days after sowing as shown in Fig. X (c) respectively.

4.4.3.6.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The data presented in Fig. X (d) shows that the highest protein content in seeds of fenugreek was obtained in T_6 – toddy palm shell + microbial consortium + *Eisenia fetida* (88.36 mg/g tissue) and lowest in control (59.81 mg/g tissue) on 90 days after sowing.

Similar results was reported by Densilin *et al.* (2010) who observed that the total protein content (2.59%) in fruits of chilli enhanced with the application of vermicompost + triple – 17 complexes than control (0.85 %). The combined inoculation of bacterial fertilizers (*Rhizobium* +*Phophobacteria* + *Azospirillum*) increased the protein content of cowpea (1.44 mg/g tissue) and green gram (15.57 mg/g tissue) was reported by Sivakumar *et al.* (2012). Maximum protein content (1.89 mg/g of fresh weight) in fruit of bhendi as influenced by the co-inoculation of *Pseudomonas fluorescens* and *Azospirillum brazilense* with 75% chemical fertilizers compared with other treatments was reported by Sundari and Gandhi (2017).

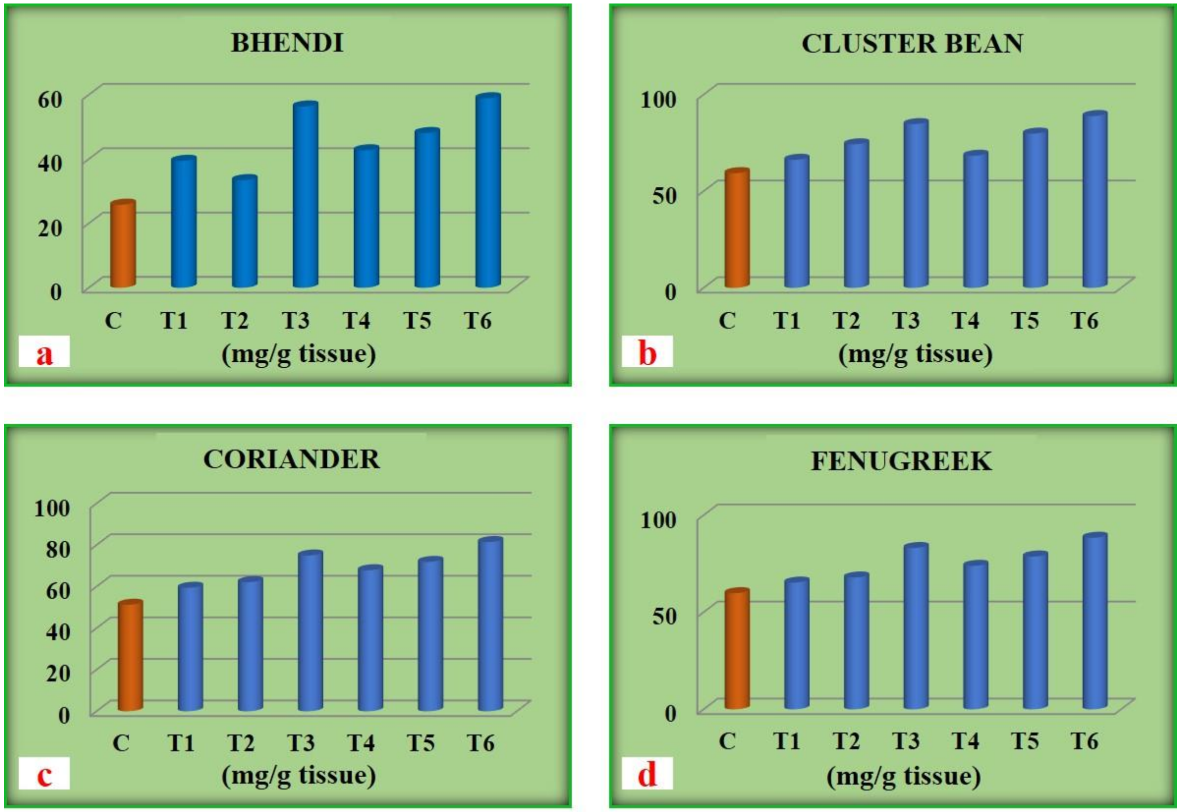
Figure – IX (a to d)

Effect of Composted Groundnut Shell and Toddy Palm Shell on Carbohydrate Content in Fruits, Pods and Seeds of Bhendi, Cluster Bean, Coriander and Fenugreek

DAS – Days after sowing; **C** – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Figure – X (a to d)

Effect of Composted Groundnut Shell and Toddy Palm Shell on Protein Content in Fruits, Pods and Seeds of Bhendi, Cluster Bean, Coriander and Fenugreek



DAS – Days after sowing; **C** – Control, $\mathbf{T_1}$ – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_2}$ – Groundnut shell + microbial consortium (5t ha^{-1}), $\mathbf{T_3}$ – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_4}$ – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_5}$ – Toddy palm shell + microbial consortium (5t ha^{-1}) and $\mathbf{T_6}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

The present finding was supported by Alaghemand *et al.* (2017) who reported that the combined application of vermiwash + vermicompost improves the protein content in seeds of fenugreek. The present finding is in conformity with Rathod *et al.* (2018) who reported that the application of 50% recommended dose of nitrogen + 50% nitrogen through poultry manure + phosphorus and potassium + *Azotobacter* significantly increased the protein content (1.32%) in fruits of ridge gourd (*Luffa acutangula* L.).

The present finding is in conformity with Alhammad and Seleiman (2023) who reported that the combined application of biogas digestate and biofertilizer enhanced protein content (27.67%) in seeds of feba bean. Higher amount of protein content present in T_6 may be due to the enhancement of the percentage of nitrogen and phosphorus content in the plant. The increased availability of nitrogen and phosphorus in plants would have increased the protein content.

The organic amendments decomposed by the influence of microbial consortium and earthworm enhanced the carbohydrate and protein content in fruits of bhendi, pods of cluster bean and seeds of coriander and fenugreek. The maximum carbohydrate and protein content were obtained in toddy palm shell + microbial consortium + *Eisenia fetida*. This may be due to degradation rate, availability of plant essential nutrients which accelerates the synthesis of amino acids and chlorophyll consequence translocation of photosynthetic products from leaves to fruits. Similar result was positively correlated with the findings of Eifediyi and Remison (2010); Moharana *et al.* (2017).

In addition, earthworms incorporated into the compost improves the growth and yield of different field crops, flowers, vegetables and fruits (Lekshmanaswamy, 2014). Similar results was earlier reported by Oroka and Oke (2016) in okra, Sivakumar and Karthikeyan (2016) in brinjal, Vaidyanathan and Vijayalakshmi (2017) in tomato and Alaghemand *et al.* (2017) in fenugreek. Furthermore, the consortium of microorganisms produces the plant growth hormone and this may be the reason for enhancement in carbohydrate and protein content in fruits, pods and seeds of selected test crops. The results was coincided with the result of Sundari and Gandhi (2017) in *Abelmoschus esculentus.*

4.4.4 Soil analysis

The data presented in the Table 18 shows the value of pH (5.3), EC (1.92 ds/m), available nitrogen (126 kg/ha), available phosphorus (10.8 kg/ha) and available potassium (129 kg/ha) in the soil of experimental field. The addition of composts into the soil gradually increased the pH value was observed from all the treatments ranged from T_1 (5.6), T_2 (5.8), T_5 (5.9), T_4 (6.0), T_3 (6.1) and T_6 (6.2). The value of EC observed maximum in T_6 (2.47 dS/m) followed by T_5 (2.44 dS/m), T_4 (2.35 dS/m), T_3 (2.29 dS/m), T_2 (2.23 dS/m), T_1 (2.19 dS/m) in pre harvest soil. The available nitrogen was maximum in T_6 – toddy palm shell composted by microbial consortium and earthworms (150 kg/ha) followed by T_5 (142 kg/ha), T_4 (138 kg/ha), T_3 (134 kg/ha), T_2 (133 kg/ha) and T_1 (130 kg/ha) respectively.

The pre harvest soil of the experimental field showed maximum available phosphorus in T_6 (14.1 kg/ha) followed by T_4 (13.3 kg/ha), T_5 (12.8 kg/ha), T_3 (12.1 kg/ha), T_2 (11.5 kg/ha) and T_1 (11.0 kg/ha) in the pre harvest soil as shown in the Table 19. The highest available potassium was noted in T_6 – toddy palm shell + microbial consortium + *Eisenia fetida* (154 kg/ha) followed by T_5 – toddy palm shell + microbial consortium (151 kg/ha), T_3 – groundnut shell + microbial consortium + *Eisenia fetida* (147 kg/ha), T_4 – toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (142 kg/ha), T_2 – groundnut shell + microbial consortium (135 kg/ha) and T_1 – groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (134 kg/ha) in the pre harvest soil (Table 19).

4.4.4.1 pH

4.4.4.1.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The pH gradually increased in all the treatments by the addition of compost. The pH value in post harvest soil ranged between 6.1 – 7.1 as shown in the Table 20 respectively. The maximum pH was found in T_6 (7.1) followed by T_3 (6.9), T_5 (6.7), T_2 (6.5), T_4 (6.2), T_1 (6.1) and C (5.9).

4.4.4.1.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The value of pH recorded in post-harvest soil of cluster bean showed maximum in T_6 (6.9), T_5 (6.7), T_3 (6.4), T_2 (6.3), T_4 (6.2), T_1 (6.0) than control (5.8) as presented in the Table 21 respectively.

4.4.4.1.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

The maximum pH value in post-harvest soil of coriander observed in T_6 - toddy palm shell + microbial consortium + *Eisenia fetida* (7.2), T_5 – toddy palm shell + microbial consortium (7.1), T_4 – toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (6.8), T_3 – groundnut shell + microbial consortium + *Eisenia fetida* (6.6), T_2 – groundnut shell + microbial consortium (6.5), T_1 – groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (6.2) and C (6.0) as presented in Table 22 respectively.

4.4.4.1.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The highest value of pH observed from T_6 (6.7), T_3 (6.5), T_4 (6.4), T_5 (6.3), T_2 (6.2), T_1 (5.8) compared with control (5.5) is given in the Table 23.

The value of pH recorded in the pre and post harvest soil ranged between 5.6 – 6.2 and 5.8 – 7.2 respectively. Near neutral values of pH encourages the accessibility of phosphorus, potassium and nitrogen in soil and soil had a pH value below 5.5 reflects the low availability of calcium, magnesium and phosphorus was reported by Edwards and Bohlen (1996). The present finding is in accordance with the result of Vimera *et al*. (2012) who recorded significantly increased value of pH (4.9) in the soil supplemented with 50% NPK + 50% FYM + biofertilizers as compared to the control (4.7) in post harvest soil of king chilli.

The application of farmyard manure (50 %), NPK fertilizer (50 %) and biofertilizer increased the pH value in post harvest soil of chilli was reported by Samsangheile and Kanaujia (2014). The current study is on par with the result of Avila-Juarez *et al*. (2015) who reported that maximum value of pH (6.85) found in post-harvest soil of tomato (*Solanum lycopersicum*) with the application of mushroom waste vermicompost leachates than pre harvest soil pH (6.66) respectively.

Similar results were also observed by Schoebitz *et al.* (2016) who observed that the maximum pH value (5.6) in post harvest soil of blueberry seedlings in response to the combination of microbial consortium and humid acid than microbial consortium alone (5.3). The pre-harvest soil pH (7.62) of strawberry was observed by Saygi (2023). The present finding is in conformity with Abdou *et al.* (2023) who reported that the application of compost at 15 t ha^{-1} increased the value of pH in post-harvest soil (7.65) of black cumin than initial soil (7.62) respectively.

4.4.4.2 Electrical conductivity

4.4.4.2.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

A considerably reduced EC value was observed in T_6 (1.95 dS/m) followed by T_5 (1.99 dS/m), T_4 (2.14 dS/m), T_1 (2.17 dS/m), T_2 (2.20 dS/m), T_3 (2.24 dS/m) than C (2.29 dS/m) as shown in the Table 20 respectively.

4.4.4.2.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The data presented in Table 21 shows that reduction in electrical conductivity was obtained in post harvest soil of cluster bean in all the treatments than pre harvest soil. The maximum EC value obtained in T_6 (1.97 dS/m), T_5 (1.94 dS/m), T_4 (1.92 dS/m), T_3 (1.89 dS/m), T_2 (1.84 dS/m), T_1 (1.80 dS/m) than control (1.74 dS/m) respectively.

4.4.4.2.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

Increased EC value was observed in T_6 (1.89 dS/m) followed by T_5 (1.85 dS/m), T_4 (1.80 dS/m), T_3 (1.72 dS/m), T_2 (1.70 dS/m), T_1 (1.63 dS/m) than control (1.58 dS/m) in post harvest soil of coriander as shown in the Table 22.

4.4.4.2.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

A slightly decreased electrical conductivity was found in post harvest soil of fenugreek than preharvest soil. Maximum EC value found in T_6 (2.31 dS/m) followed by T_5 (2.29 dS/m), T_4 (2.24 dS/m), T_3 (2.19 dS/m), T_2 (2.11 dS/m), T_1 (2.03 dS/m) than control (1.98 dS/m) is given in the Table 23 respectively.

The present finding is in accordance with the result of Kasthuri *et al*. (2011). They found maximum electrical conductivity (1.9 mS/cm) in pre harvest soil of green gram (*Vigna radiata*) and fenugreek (*Trigonella foenum-graecum*) with the application of 1000 g of municipal solid waste compost + 6 kg of soil under pot culture. The EC value of 0.25 (mS/cm) in post harvest soil was influenced by microbial consortium + 50% NPK was reported by Thilagar *et al.* (2016).

The present result coincides with the result of Srivastava *et al.* (2018) who reported that the electrical conductivity of soil enhanced by the different concentrations of municipal solid waste vermicompost at 20% (0.45 mS cm^{-1}), 40% (0.56 mS cm^{-1}), 60%

(0.87 mS cm^{-1}), 80% (1.09 mS cm^{-1}) and 100% (2.24 mS cm^{-1}) than unamended soil (0.26 mS cm^{-1}) respectively. Similar result was obtained by Bhardwaj *et al.* (2023) who reported that the municipal solid waste compost from Okhla (100%) inoculated into the soil increased the EC value (5.52 dS/m) in pre harvest soil of tomato, brinjal and okra and the influence of phosphate sludge compost enhanced the rate of electrical conductivity (0.93 mS/cm) in post harvest soil of date palm seedling than control (0.33 mS/cm) was reported by Anli *et al*. (2023).

Electrical conductivity indicates the salt concentration of soil dependent on liberally available minerals and ions from the microorganisms in the soil simultaneously, the excess amount of salt concentration in soil affects leaf damage and plant growth.

4.4.4.3 Available nitrogen

4.4.4.3.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The data presented in Table 20 revealed that the maximum available nitrogen was obtained in T_6 (178 kg/ha) followed by T_5 (172 kg/ha), T_4 (167 kg/ha), T_3 (162 kg/ha), T_2 (158 kg/ha), T_1 (154 kg/ha) than C (137 kg/ha) respectively.

4.4.4.3.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The post harvest soil of cluster bean showed maximum increased available nitrogen from T_6 (194 kg/ha) followed by T_5 (189 kg/ha), T_3 (183 kg/ha), T_4 (179 kg/ha), T_2 (175 kg/ha), T_1 (169 kg/ha) and C (154 kg/ha) as presented in Table 21.

4.4.4.3.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

Maximum available nitrogen was obtained in T_6 (157 kg/ha), T_5 (155 kg/ha), T_4 (151 kg/ha), T_3 (148 kg/ha), T_2 (144 kg/ha), T_1 (141 kg/ha) and C (132 kg/ha) in post harvest soil of coriander (Table 22).

4.4.4.3.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

Available nitrogen in post harvest soil of fenugreek showed maximum in T_6 (169 kg/ha) followed by T_5 (164 kg/ha), T_4 (159 kg/ha), T_3 (154 kg/ha), T_2 (151 kg/ha), T_1 (147 kg/ha) than C (139 kg/ha) is presented in Table 23 respectively.

The study was correlated with the finding of Karmegam and Daniel (2008) who obtained highest available nitrogen of 263.09 kg/ha in post-harvest soil of *Lablab purpureus* enhanced with the application of vermicomposted *Polyalthia longifolia* leaf litter with the help of *Perionyx ceylanensis* (5t ha^{-1}). Similar report was also observed by Kasthuri *et al*. (2011) who found that the maximum available nitrogen (0.10 %) in pre harvest soil analysis of green gram and fenugreek increased with the application of 1000 g of municipal solid waste compost with 6 kg of soil under pot culture. Similar results was also reported by Thilagar *et al*. (2016) who reported that the combined application of 75% nitrogen, phosphorus and potassium with microbial consortium improves the available nitrogen (335.9 Kg/ha) in post harvest soil of chilly under microplot study.

The available nitrogen level (124.85 kg/ha^{-1}) in post-harvest soil of okra and onion influenced by 6 t vermicompost with 75% recommended dose of fertilizer and bio-fertilizers was reported by Jat *et al.* (2017). Soil (75%) amended with municipal solid waste compost of Bawana (25%) decrease the value of available nitrogen (39 mg/kg) in pre harvest soil of *Solanum lycopersicum, Abelmoschus esculentus and Solanum melongena* than control (47 mg/kg) was reported by Bhardwaj *et al.* (2023). The percentage of nitrogen was 0.12% in pre-harvest soil of strawberry was reported by Saygi (2023).

Available nitrogen in soil significantly improved by addition of organic fertilizer which enhanced the plant nutrients and plant growth promoting microorganisms in the soil. The presence of microorganisms in the compost increased the nitrogen fixation and solubilization of phosphorus & potassium. The presence of *Bacillus licheniformis* and *Paecilomyces variotti* in the microbial consortium was able to fix nitrogen thereby improves the available nitrogen content in soil.

4.4.4.4 Available phosphorus

4.4.4.4.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The data presented in Table 20 showed maximum available phosphorus obtained in T_6 (14.3 kg/ha), T_4 (13.7 kg/ha), T_5 (13.2 kg/ha), T_3 (12.3 kg/ha), T_2 (11.8 kg/ha), T_1 (11.4 kg/ha) than control (11.2 kg/ha) in post harvest soil of bhendi than control (11.3 kg/ha) is given in the Table 21.

Table – 18

Nutritional Status of Experimental Soil

Parameters	Soil
pH	5.3
EC (dS/m)	1.92
Available N (Kg/ha)	126
Available P (Kg/ha)	10.8
Available K (Kg/ha)	129

Table – 19

Nutritional Status of Pre - Harvest Soil

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
T_1	5.6	2.19	130	11.0	134
T_2	5.8	2.23	133	11.5	135
T_3	6.1	2.29	134	12.1	147
T_4	6.0	2.35	138	13.3	142
T_5	5.9	2.44	142	12.8	151
T_6	6.2	2.47	150	14.1	154

T_1 – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 20

Effect of Composted Groundnut Shell and Toddy Palm Shell on Post Harvest Soil Nutrients Status of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4)

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Control	5.9	2.29	137	11.2	104
T_1	6.1	2.17	154	11.4	123
T_2	6.5	2.20	158	11.8	126
T_3	6.9	2.24	162	12.3	134
T_4	6.2	2.14	167	13.7	130
T_5	6.7	1.99	172	13.2	138
T_6	7.1	1.95	178	14.3	145

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 21

Effect of Composted Groundnut Shell and Toddy Palm Shell on Post Harvest Soil Nutrients Status of Cluster Bean (*Cyamopsis tetragonoloba* (L.) Taub. Var. MDU.1)

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Control	5.8	1.74	154	11.3	98
T_1	6.0	1.80	169	11.8	103
T_2	6.3	1.84	175	12.5	108
T_3	6.4	1.89	183	12.7	123
T_4	6.2	1.92	179	13.9	119
T_5	6.7	1.94	189	13.5	130
T_6	6.9	1.97	194	14.4	132

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 22

Effect of Composted Groundnut Shell and Toddy Palm Shell on Post Harvest Soil Nutrients Status of Coriander

(*Coriandrum sativum* L. Var. Co.4)

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Control	6.0	1.58	132	11.1	117
T_1	6.2	1.63	141	11.4	128
T_2	6.5	1.70	144	11.8	130
T_3	6.6	1.72	148	12.5	136
T_4	6.8	1.80	151	13.7	131
T_5	7.1	1.85	155	13.1	142
T_6	7.2	1.89	157	14.3	145

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

Table – 23

Effect of Composted Groundnut Shell and Toddy Palm Shell on Post Harvest Soil Nutrients Status of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2)

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Control	5.5	1.98	139	11.1	110
T_1	5.8	2.03	147	11.5	120
T_2	6.2	2.11	151	11.8	125
T_3	6.5	2.19	154	12.4	134
T_4	6.4	2.24	159	13.4	130
T_5	6.3	2.29	164	13.2	137
T_6	6.7	2.31	169	14.4	142

C – Control, **T_1** – Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_2** – Groundnut shell + microbial consortium (5t ha^{-1}), **T_3** – Groundnut shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_4** – Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5t ha^{-1}), **T_5** – Toddy palm shell + microbial consortium (5t ha^{-1}) and **T_6** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}).

4.4.4.4.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The available phosphorus in post harvest soil of cluster bean showed maximum in T_6 (14.4 kg/ha), T_4 (13.9 kg/ha), T_5 (13.5 kg/ha), T_3 (12.7 kg/ha), T_2 (12.5 kg/ha), T_1 (11.8 kg/ha) than control (11.3 kg/ha) is given in the Table 21.

4.4.4.4.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

A significantly increased available phosphorus in post harvest soil of coriander was observed in T_6 (14.3 kg/ha), followed by T_4 (13.7 kg/ha), T_5 (13.1 kg/ha), T_3 (12.5 kg/ha), T_2 (11.8 kg/ha), T_1 (11.4 kg/ha) than C (11.1 kg/ha) is presented in Table 22.

4.4.4.4.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

Toddy palm shell composted with the help of T_6 - microbial consortium and earthworm showed maximum increase of available phosphorus (14.4 kg/ha) followed by T_4 (13.4 kg/ha), T_5 (13.2 kg/ha), T_3 (12.4 kg/ha), T_2 (11.8 kg/ha), T_1 (11.5 kg/ha) compared with control (11.1 kg/ha) as showed in the Table 23 respectively.

The results coincide with the result of Karmegam and Daniel (2008) who observed higher phosphorus content (49.08 kg ha^{-1}) in post harvest soil of *Lablab purpureus* with the application of the soil amended with 2.5 t ha^{-1} vermicomposted *Polyalthia longifolia* leaf litter + *Pennisetum typhoides* + ½ dose of recommended NPK ha^{-1}. Similar results was also observed by Kasthuri *et al*. (2011) who reported maximum available phosphorus (0.022%) in pre harvest soil of green gram (*Vigna radiata*) and fenugreek (*Trigonella foenum-graecum*) with the application of 1000 g of municipal solid waste compost amended with 6 kg of garden soil.

The result is par with the result of Thilagar *et al*. (2016) who reported that the influence of 100% NPK improved the available phosphorus (44.3 Kg/ha) in post harvest soil of chilly under microplot study. The available phosphorus (15.85 kg/ha^{-1}) in post harvest soil of okra and onion influenced by the integrate incorporation of 75% RDF with 6t vermicompost and biofertilizers was reported by Jat *et al.* (2017). Similar results was obtained by Srivastava *et al.* (2018) who reported maximum total phosphorus of soil (15.81g kg^{-1}) influenced with the application of 100% municipal solid waste vermicompost than unamended soil (4.14 g kg^{-1}).

The study was correlated with the finding of Anli *et al.* (2023) who obtained a highest phosphorus of 52.09 mg/kg in post-harvest soil of date palm seedling enhanced with the combined application of green compost and phosphate sludge than control (15.22 mg/kg) respectively. Maximum amount of available phosphorus was obtained in T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) may be due to the attributes of microorganisms in the soil. The plant solubilizes soil phosphorus through the extraction of amino acids encouraging the growth and multiplication of soil microbes consequently leading to the mineralization of unavailable phosphorus to available phosphorus in the soil.

4.4.4.5 Available potassium

4.4.4.5.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

Maximum available potassium was observed in T_6 – toddy palm shell + microbial consortium + *Eisenia fetida* (145 kg/ha) followed by T_5 – toddy palm shell + microbial consortium (138 kg/ha), T_3 – groundnut shell + microbial consortium + *Eisenia fetida* (134 kg/ha), T_4 – toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (130 kg/ha), T_2 - groundnut shell + microbial consortium (126 kg/ha) T_1 - groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (123 kg/ha) than C (104 kg/ha) in post-harvest soil of bhendi (Table 20).

4.4.4.5.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The data presented in Table 21 shows that maximum available potassium in post harvest soil of cluster bean with the application of T_6 - toddy palm shell bio-composted by microbial consortium and earthworms (132 kg/ha) followed by T_5 (130 kg/ha), T_3 (123 kg/ha), T_4 (119 kg/ha), T_2 (108 kg/ha), T_1 (103 kg/ha) than control (98 kg/ha).

4.4.4.5.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

A slightly reduced available potassium was noted in post harvest soil than pre harvest soil of coriander as shown in the Table 22. The maximum available potassium was observed in T_6 (145 kg/ha), T_5 (142 kg/ha), T_3 (136 kg/ha), T_4 (131 kg/ha), T_2 (130 kg/ha), T_1 (128 kg/ha) than control (117 kg/ha) respectively.

4.4.4.5.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The highest available potassium content was observed from T_6 (142 kg/ha) followed by T_5 (137 kg/ha), T_3 (134 kg/ha), T_4 (130 kg/ha), T_2 (125 kg/ha), T_1 (120 kg/ha) than C (110 kg/ha) in post harvest soil of fenugreek represented in the Table 23.

The result coincides with the result of Karmegam and Daniel (2008) who observed higher potassium content in post harvest soil of *Lablab purpureus* (117.90 kg ha^{-1}) in the soil amended with 2.5 t ha^{-1} vermicomposted *Polyalthia longifolia* leaf litter + *Perionyx ceylanensis* + ½ dose of recommended NPK ha^{-1}. The present study correlates with the finding Thilagar *et al.* (2016) who stated that 100% NPK enhanced the available potassium content (338.1 kg ha^{-1}) in post harvest soil of chilly on 140 days after transplanting. The result coincides with the result of Jat *et al.* (2017) who observed higher available potassium (174.05 kg/ha^{-1}) in post harvest soil of okra and onion influenced by 75 % RDF + 6 t vermicompost + biofertilizers when compared to the control.

Similar results was also reported by Srivastava *et al.* (2018) who reported that the potassium level of soil increased by the addition of vermicompost. A gradual increase of total potassium content in pre harvest soil obtained with the application of 20% (6.54 g kg^{-1}), 40% (6.84 g kg^{-1}), 60% (7.99 g kg^{-1}), 80% (9.60 g kg^{-1}) and 100% (15.36 g kg^{-1}) municipal solid waste vermicompost than unamended soil (5.85 g kg^{-1}). Slightly decreased available potassium content was noted in soil amended with 100% municipal solid waste compost of Bawana (157 mg/kg) than control (175 mg/kg) was observed by Bhardwaj *et al.* (2023). A significantly increased available potassium was noted in pre harvest soil and it considerably decreased after harvest of test crops might be attributed to the plant's uptake of potassium ions from the soil. The increasing of potassium ions in post harvested soil reflects the presence of acid-producing microorganisms.

In the present study, addition of compost into the soil increased the value of pH, EC, available nitrogen, available phosphorus and available potassium. Application of organic amendments improves the soil quality (Dahama, 1997; Gwenzi *et al.*, 2016). The data presented in the Table 19 shows that slightly increased pH value was observed in pre-harvest soil of bhendi, cluster bean, coriander and fenugreek by the addition of organic fertilizer.

The concentration of salt in the soil was determined by the value of EC. The present study, compost incorporated into the soil increased the value of electrical conductivity by addition of cation and anions which will enhance the water-holding capacity of soil. Soil with very high electrical conductivity indicates the high concentration of sodium which is toxic to plants at the same time very lower EC also affect the growth and yield of plants.

The compost prepared by using microbial consortium and *Eisenia fetida* enhanced the maturity and quality of compost. This may be due to the presence of plant growth promoting microorganisms in the consortium increased the fixation of nitrogen, solubilization of phosphorus and potassium. Solubilization of soil phosphorus through extraction of amino acids encourages the multiplication and growth of soil microbes. Similar results was also reported by Singh *et al.* (2013) and Malik *et al.* (2013).

Compost prepared by using animal manure promotes the rate of degradation and essential plant nutrients. Likewise, in the current study all the treatments have substantial amount of cow dung which promotes the rate of degradation. The chemical properties of cow dung contain phosphorus (0.70%), magnesium (0.91%), nitrogen (1.61%), potassium (0.53%), sodium (0.50%) and calcium (2.71%) were reported by Asawalam and Onwudike (2011). Decline of available nitrogen, phosphorus and potassium may be due to the leaching of nutrients by excess supply of water or rain.

PHASE IV

4.5 Best Treatment

4.5.1 Effect of coir pith, effective microorganisms and bio-composted toddy palm shell on growth parameters of test crops

The effect of bio-composted toddy palm shell compared with coir pith and effective microorganisms on vegetative parameters of test crops (bhendi, cluster bean, coriander and fenugreek) respectively.

4.5.1.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

Maximum root length and diameter of leaf were observed with the application of T_1 - coir pith (10.4 cm, 24.8 cm and 41.6 cm) and (16.4 cm, 19.6 cm and 36.1 cm) followed by T_2 – toddy palm shell + microbial consortium + *Eisenia fetida* (9.6 cm, 23.4 cm and 38.9 cm) and (15.2 cm, 18.5 cm and 32.9 cm), T_3 - effective microorganisms (8.7 cm, 21.9 cm and 32.5 cm) and (14.9 cm, 17.1 cm and 27.9 cm) than control (5.4 cm, 20.5 cm and 25.1 cm) and (8.3 cm, 12.4 cm and 22.1 cm) on 25, 50 and 75 DAS respectively. Shoot length (19.6 cm, 27.2 cm and 64.3 cm), number of leaves (6.6, 12.3 and 16.0), fresh weight (6.96 g, 39.80 g and 126.83 g) and dry weight (1.52 g, 6.02 g and 25.8 g) of bhendi were increased with the application of T_3 – effective microorganisms compared with control (16.9 cm, 23.8 cm and 35.4 cm), (4.3, 7.6 and 8.0), (3.42 g, 26.81 g and 71.20 g) and (0.56 gm, 4.02 g and 10.2 g) on 25, 50 and 75 DAS. The highest number of flowers (5.6, 4.0) on 25 and 50 DAS obtained by the influence of effective microorganisms than control (2.6 and 2.0), (3.6) as shown in Table 24 & 25, Plate 15).

4.5.1.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

Significantly increased root length, number of nodules, fresh weight and dry weight of cluster bean were obtained from T_3 – effective microorganisms (12.1 cm, 16.3 cm and 23.4 cm), (5.0, 5.2 and 2.0), (5.47 g, 20.91 g and 124.71 g) and (1.52 g, 6.29 g and 20.93 g) followed by T_2 – toddy palm shell + microbial consortium + *Eisenia fetida* (7.6 cm, 13.1 cm and 19.4 cm), (3.0, 4.0 and 1.0), (4.39 g, 16.31 g and 89.13 g) and (0.87 g, 4.48 g and 12.66 g) than control (3.9 cm, 12.2 cm and 15.6 cm), (2.3, 3.0 and 0.3), (3.42 g, 12.04 g and 64.58 g) and (0.40 g, 3.19 g and 8.76 g) on 25, 50 and 75 DAS. Length of shoot and number of leaves of cluster bean were enhanced by T_1 – coir pith (9.9 cm, 57.6 cm and 71.2 cm) and (11.6, 28.3 and 35.6) followed by T_2 (8.4 cm, 28.7 cm and 56.1 cm) and (7.3, 21.6 and 27.0) on 25, 50 and 75 days after sowing. The number of flowers increased in T_1 (42.0 and 18.3) followed by T_2 (25.6 and 14.3), T_3 (19.6 and 12.0) than control (12.0 and 9.6) on (50 and 75 DAS) as shown in Table 26 & 27, Plate 16 respectively.

4.5.1.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

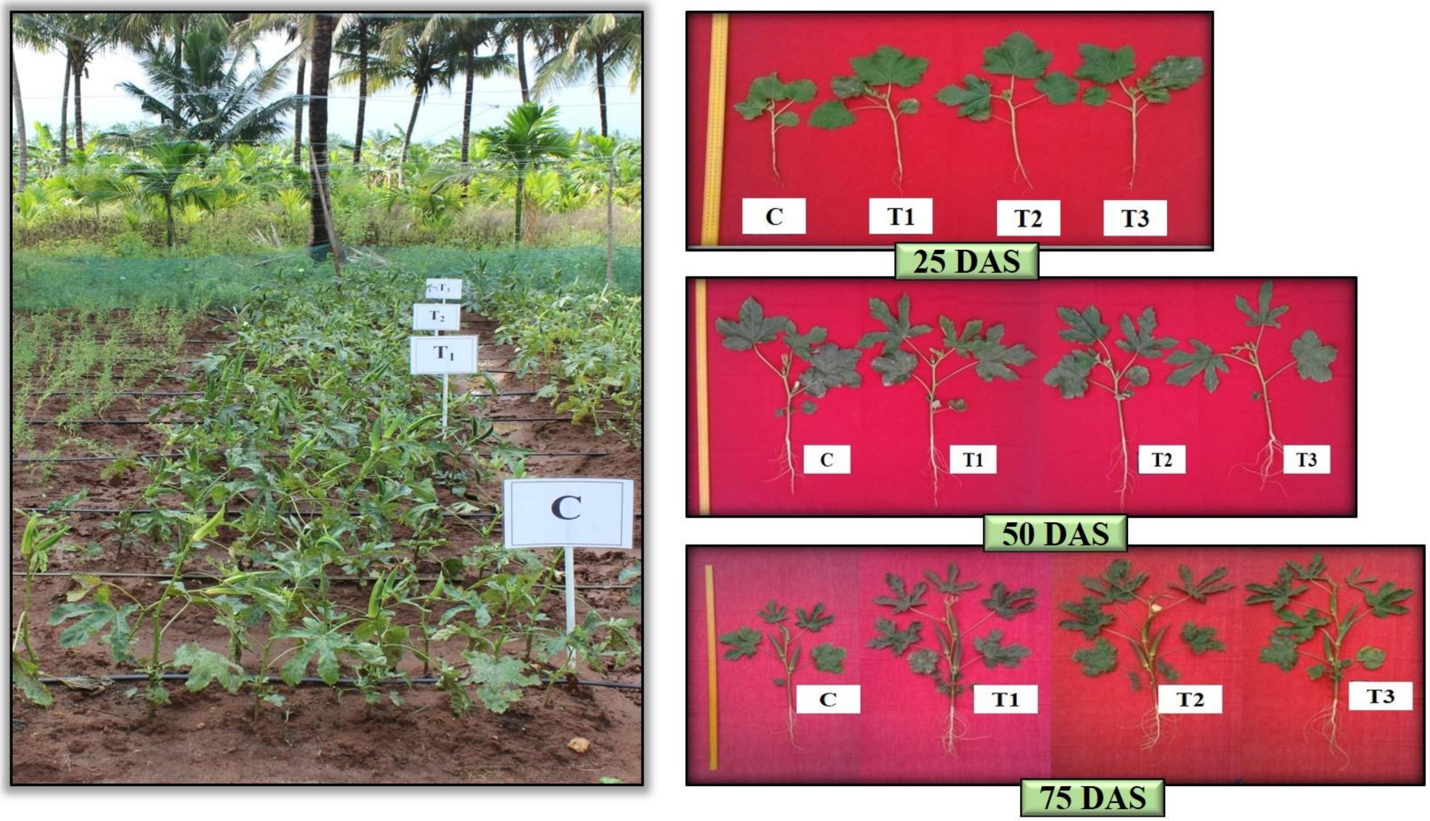
Length of root and number of branches were found to be higher with the application of effective microorganisms (9.7 cm, 14.6 cm and 19.9 cm) and (8.6, 16.0 and 26.0) followed by T_2 – toddy palm shell composted with the help of microbial consortium and earthworms (9.4 cm, 13.5 cm and 18.8 cm) and (8.0, 15.6 and 24.6) than control (4.6 cm, 9.2 cm and 12.9 cm) and (5.3, 8.0 and 17.0) on 25, 50 and 75 days after sowing as given in the Table 28 & 29 (Plate 13). The application of coir pith enhanced the length of shoot (14.4 cm, 40.2 cm and 72.9 cm), fresh weight (4.623 g, 23.495 g and 25.624 g) and dry weight (0.348 g, 1.739 g and 4.572 g) of coriander followed by T_2 - toddy palm shell composted by microbial consortium and earthworm (13.2 cm, 38.4 cm and 69.7 cm), (4.321 g, 21.634 g and 23.109 g) and (0.274 g, 1.484 g and 3.919 g) than control (7.3 cm, 28.1 cm and 55.7 cm), (2.845 g, 9.355 g and 12.497 g) and (0.048 g, 0.375 g and 0.936 g) on 25, 50 and 75 days after sowing as presented in the Table 28 & 29, Plate 17 respectively. Number of umbel (3.0 and 27.6) on 50 and 75 DAS was enhanced by the application of coir pith.

4.5.1.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

Length of root in fenugreek showed maximum in T_3 (10.4 cm, 13.9 cm and 23.9 cm), T_2 (8.9 cm, 12.8 cm and 22.7 cm), T_1 (8.6 cm, 11.2 cm, 21.8 cm) and minimum in C (6.4 cm, 10.4 cm and 20.5 cm) on 25, 50 and 75 DAS. Length of shoot, number of leaves, number of nodules, fresh weight and dry weight of fenugreek showed maximum in T_1 (13.1 cm, 23.9 cm and 48.3 cm), (32.3, 56.0 and 150.0), (8.3, 15.6 and 4.3), (4.02 g, 13.84 g and 18.90 g) and (0.230 g, 1.543 g and 4.294 g) followed by T_2 (11.1 cm, 22.8 cm and 48.1 cm), (28.3, 49.3 and 138.6), (7.6, 14.3 and 3.6), (3.95 g, 12.05 g and 17.65 g) and (0.189 g, 1.236 g and 4.007 g) than control (6.7 cm, 19.5 cm and 39.9 cm), (18.6, 36.6 and 112.3), (4.6, 10.3 and 2.6), (3.26 g, 7.39 g and 10.15 g) and (0.054 g, 0.329 g and 0.933 g) on 25, 50 and 75 DAS as shown in Table 30 & 31, Plate 18) respectively.

Plate - 15

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4)



DAS – Days after sowing, **C** – Control, $\mathbf{T_1}$ – Coir pith (5t ha^{-1}), $\mathbf{T_2}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_3}$ – Effective microorganisms ($1L/m^2$).

Table - 24

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4)

Treatments	Root length (cm)			Shoot length (cm)			Number of leaves			Diameter of leaf (cm)		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	5.4	20.5	25.1	16.9	23.8	35.4	4.3	7.6	8.0	8.3	12.4	22.1
T_1	10.4	24.8	41.6	18.3	24.7	51.9	5.3	9.3	12.6	16.4	19.6	36.1
T_2	9.6	23.4	38.9	18.9	25.9	57.1	5.6	11.0	13.3	15.2	18.5	32.9
T_3	8.7	21.9	32.5	19.6	27.2	64.3	6.6	12.3	16.0	14.9	17.1	27.9
SEd	0.24372			0.21180			0.18671			0.21093		
Cd(p<0.05)	0.50301			0.43714			0.38535			0.43534		
Cd(p<0.01)	0.68546**			0.59570**			0.52513**			0.59324**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 25

Effect of Composted Groundnut Shell and Toddy Palm Shell on Vegetative Parameters of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4)

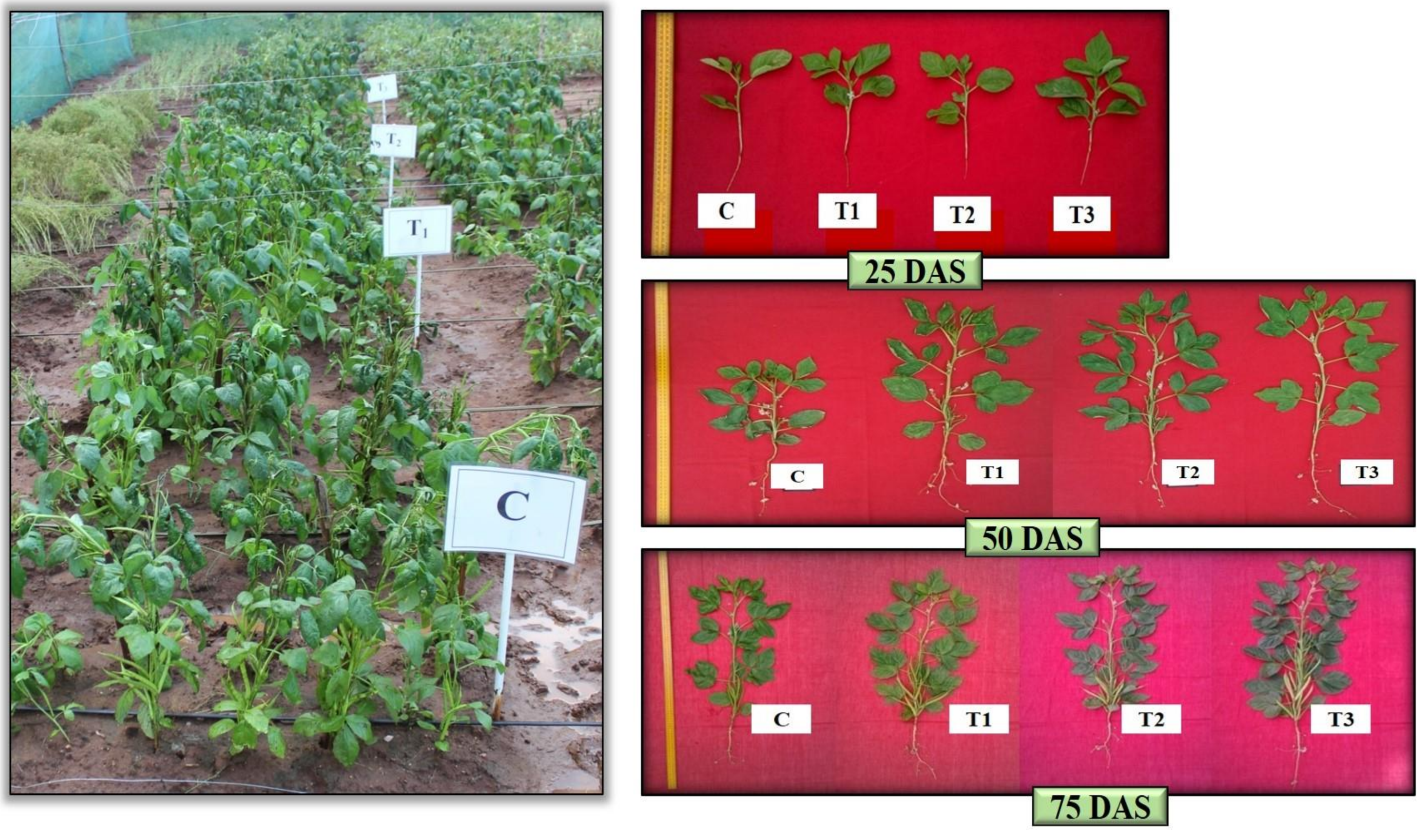
Treatments	Number of flowers		Fresh weight (g)			Dry weight (g)		
	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	2.6	2.0	3.42	26.81	71.20	0.56	4.02	10.2
T_1	3.6	2.6	5.75	32.39	94.68	0.98	5.35	19.4
T_2	5.0	3.3	6.28	35.37	105.64	1.34	5.78	21.7
T_3	5.6	4.0	6.96	39.80	126.83	1.52	6.02	25.8
SEd	0.30957		0.20683			0.21602		
Cd(p<0.05)	0.65627		0.42687			0.44585		
Cd(p<0.01)	0.90422**		0.58170**			0.60757**		

** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Plate – 16

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub. Var. MDU.1)



DAS – Days after sowing, **C** – Control, $\mathbf{T_1}$ – Coir pith (5t ha^{-1}), $\mathbf{T_2}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_3}$ – Effective microorganisms ($1L/m^2$).

Table - 26

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub. Var. MDU.1)

Treatments	Root length (cm)			Shoot length (cm)			Number of leaves			Number of nodules		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	3.9	12.2	15.6	6.9	25.9	48.7	3.6	13.0	20.0	2.3	3.0	0.3
T_1	4.2	12.9	16.4	9.9	57.6	71.2	11.6	28.3	35.6	2.6	3.3	0.6
T_2	7.6	13.1	19.4	8.4	28.7	56.1	7.3	21.6	27.0	3.0	4.0	1.0
T_3	12.1	16.3	23.4	7.1	26.4	52.9	5.3	17.3	21.6	5.0	5.2	2.0
SEd	0.18447			0.20616			0.14142			0.15957		
Cd(p<0.05)	0.38072			0.42548			0.29188			0.32934		
Cd(p<0.01)	0.51881**			0.57981**			0.39775**			0.44879**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 27

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub. Var. MDU.1

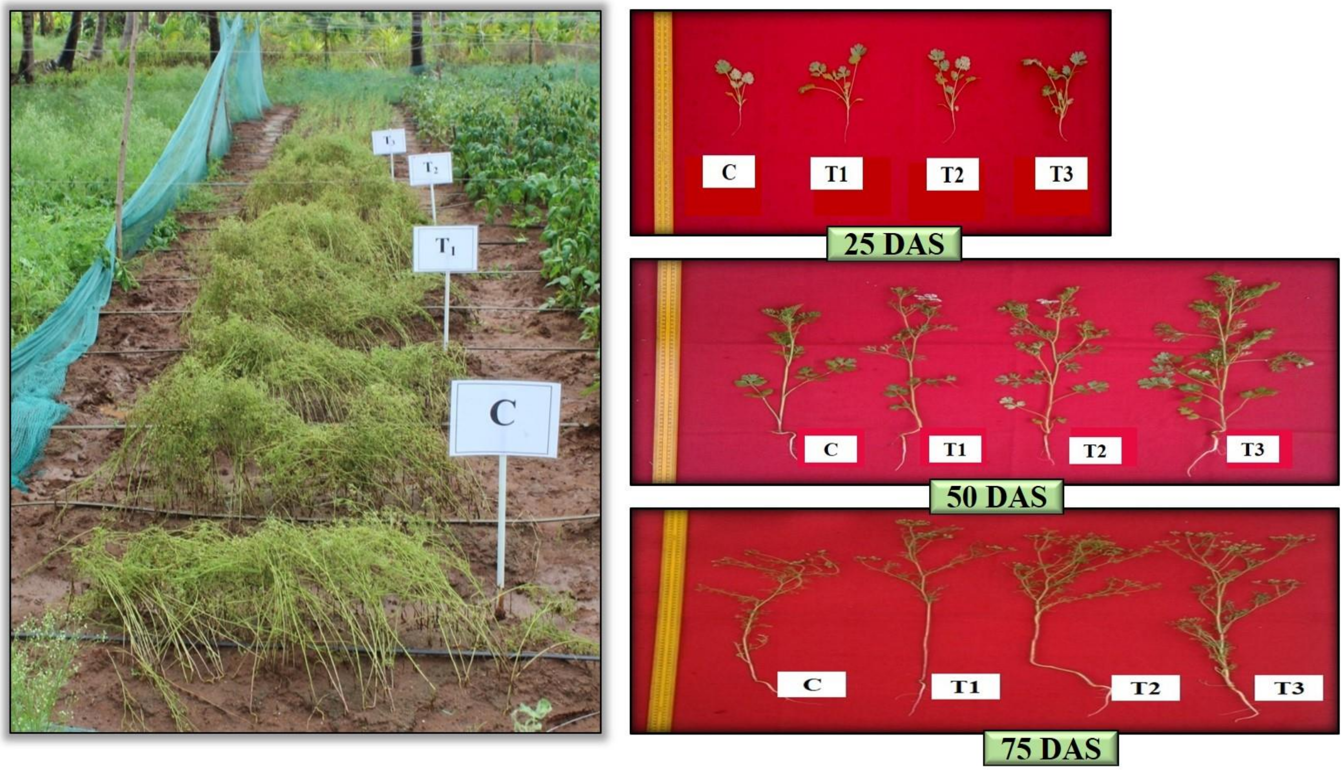
Treatments	Number of flowers		Fresh weight (g)			Dry weight (g)		
	50 DAS	75DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	12.0	9.6	3.42	12.04	64.58	0.40	3.19	8.76
T_1	42.0	18.3	3.82	15.54	72.82	0.54	4.03	11.05
T_2	25.6	14.3	4.39	16.31	89.13	0.87	4.48	12.66
T_3	19.6	12.0	5.47	20.91	124.71	1.52	6.29	20.93
SEd	0.18047		0.21180			0.22205		
Cd(p<0.05)	0.38258		0.43714			0.45829		
Cd(p<0.01)	0.52713**		0.59570**			0.62451**		

** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Plate – 17

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Coriander (*Coriandrum sativum* L. Var. Co.4)



DAS – Days after sowing, **C** – Control, $\mathbf{T_1}$ – Coir pith (5t ha^{-1}), $\mathbf{T_2}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_3}$ – Effective microorganisms (1L/m^2).

Table – 28

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Coriander (*Coriandrum sativum* L. Var. Co.4)

Treatments	Root length (cm)			Shoot length (cm)			Number of branches		
	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	4.6	9.2	12.9	7.3	28.1	55.7	5.3	8.0	17.0
T_1	7.8	11.5	15.6	14.4	40.2	72.9	7.6	14.6	22.0
T_2	9.4	13.5	18.8	13.2	38.4	69.7	8.0	15.6	24.6
T_3	9.7	14.6	19.9	12.5	33.5	63.3	8.6	16.0	26.0
SEd	0.24181			0.20000			0.20950		
Cd(p<0.05)	0.49907			0.41278			0.43238		
Cd(p<0.01)	0.68009**			0.56250**			0.58921**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 29

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Coriander (*Coriandrum sativum* L. Var. Co.4)

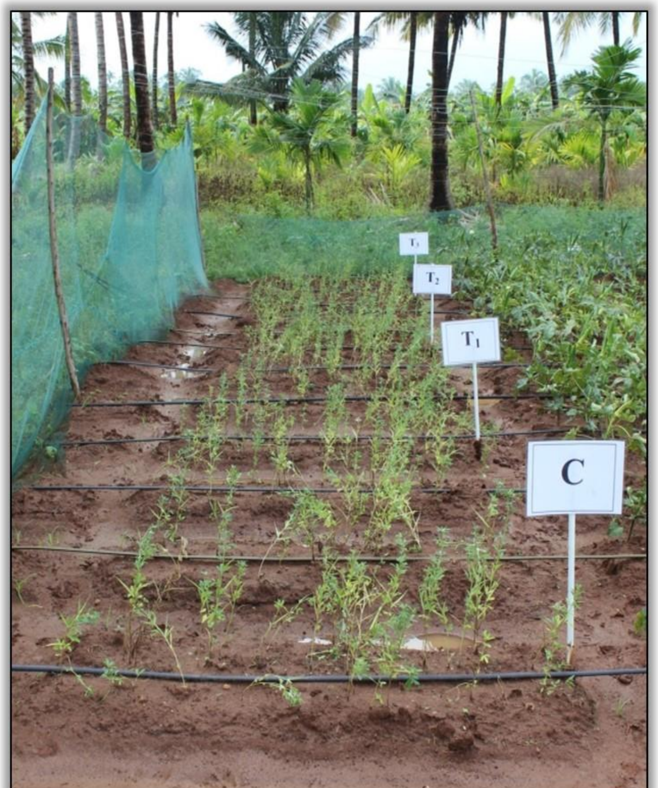
Treatments	Number of umbels		Fresh weight (g)			Dry weight (g)		
	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	0.6	18.0	2.845	9.355	12.497	0.048	0.375	0.936
T_1	3.0	27.6	4.623	23.495	25.624	0.348	1.739	4.572
T_2	2.6	25.3	4.321	21.634	23.109	0.274	1.484	3.919
T_3	2.0	21.6	4.027	19.954	20.486	0.112	1.228	3.625
SEd	0.24109		0.21506			0.18068		
Cd(p<0.05)	0.51110		0.44386			0.37290		
Cd(p<0.01)	0.70420**		0.60485**			0.50816**		

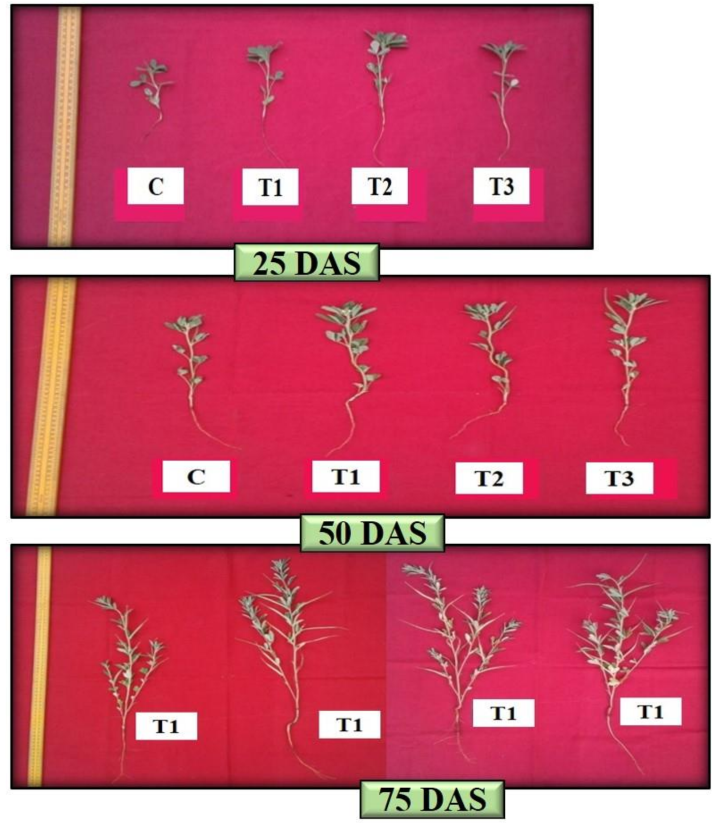
** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Plate – 18

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2)





DAS – Days after sowing, **C** – Control, $\mathbf{T_1}$ – Coir pith (5t ha^{-1}), $\mathbf{T_2}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_3}$ – Effective microorganisms (1L/m^2).

Table – 30

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2)

Treatments	Root length (cm)			Shoot length (cm)			Number of leaves			Number of nodules		
	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	6.4	10.4	20.5	6.7	19.5	39.9	18.6	36.6	112.3	4.6	10.3	2.6
T_1	8.6	11.2	21.8	13.1	23.9	48.3	32.3	56.0	150.0	8.3	15.6	4.3
T_2	8.9	12.8	22.7	11.1	22.8	48.1	28.3	49.3	138.6	7.6	14.3	3.6
T_3	10.4	13.9	23.9	9.1	22.6	45.8	22.0	41.6	126.3	7.0	13.0	3.0
SEd	0.25148			0.23805			1.84831			0.22700		
Cd(p<0.05)	0.51902			0.49131			3.81473			0.46850		
Cd(p<0.01)	0.70728**			0.66951**			5.19837**			0.63843**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 31

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Vegetative Parameters of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2)

Treatments	Number of flowers		Fresh weight (g)			Dry weight (g)		
	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	3.6	4.6	3.26	7.39	10.15	0.054	0.329	0.933
T_1	4.6	5.0	4.02	13.84	18.90	0.230	1.543	4.294
T_2	5.3	5.6	3.95	12.05	17.65	0.189	1.236	4.007
T_3	6.0	6.3	3.47	10.79	15.89	0.164	1.117	3.764
SEd	0.21409		0.25139			0.16828		
Cd(p<0.05)	0.45385		0.51883			0.34731		
Cd(p<0.01)	0.62533**		0.70702**			0.47329**		

** Significant at 1% (p<0.01); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms ($1L/m^2$).

The number of flowers on 25 and 50 DAS (6.0 and 6.3) were maximum in T_3 – effective microorganism than control (3.6 and 4.6) respectively. Similar results was also reported by Ravimycin (2016) who observed that the application of vermicompost enhanced the maximum length of root (8.4 cm), length of shoot (24.8 cm), fresh weight (16.7 g) and dry weight (7.8 g) of Coriander (*Coriandrum sativum* L.) than control (6.2 cm, 19.5 cm, 12.3 g and 4.22 g) respectively. The length of shoot was found to be higher (9.37 cm and 18.67 cm) on 30^{th} and 60^{th} day with pots treated with 19g of vermicompost in tomato was reported by Vaidyanathan and Vijayalakshmi (2017). The organic fertilizer improves the length of shoot (10.1 cm) in *Trigonella foenum-graceum* (Balakrishnan and Arunprasath, 2018).

The combined application of 60 kg nitrogen ha^{-1} + 30 kg potassium ha^{-1} + 45 kg phosphorus ha^{-1} + vermicompost (4t ha^{-1}) + biofertilizers @ 7.5 L ha^{-1} enhanced the maximum number of leaves per plant (36.58) in lettuce seedlings was reported by Rather *et al.* (2018). The study also coincided with the result of Sikder and Joardar (2019) who reported that plant height (29.82 cm), fresh weight (26.63 g) and dry weight (2.23 g) of the plant Gima kalmi (*Ipomoea aquatica*) was improved with the application of poultry litter compost. Similar results were also observed by Aydi *et al.* (2023) who reported that the compost of date palm trunk improves the shoot height (368.6 cm), stem diameter (15.06 cm) and leaf number (50.76/plant) of greenhouse melon (*Cucumis melo* L.).

4.5.2 Effect of coir pith, effective microorganisms and bio-composted toddy palm shell on yield characters of test crops

The effect of bio-composted toddy palm shell compared with coir pith and effective microorganisms on vegetative parameters of test crops.

4.5.2.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The data presented in Table 32 and Plate 19 revealed that number of fruits (9.6), yield/plant (226.26 g), yield/plot (4.071 kg), yield/ha (1697 kg), fruit fresh weight (25.14 g) and fruit dry weight (2.457 g) was maximum in T_3 followed by T_2 (9.3, 214.83 g, 3.864 kg, 1611 kg, 23.87 g and 2.083 g), T_1 (8.3, 173.20 g, 3.117 kg, 1299 kg, 21.65 g and 2.007 g) compared with control (5.6, 96.90 g, 1.743 kg, 726 kg, 19.38 g and 1.846 g) on 90 DAS.

The length of fruit, diameter of fruit, number of seeds/fruit were increased with the application of T_1 – coir pith (18.9 cm, 2.6 cm and 78.0) followed by T_2 – toddy palm shell + microbial consortium + *Eisenia fetida* (18.3 cm, 2.2 cm and 73.6), T_3 - effective microorganisms (17.2 cm, 1.9 cm and 61.8) on 90 days after sowing.

4.5.2.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

Number of pods (74.0), length of pod (15.6 cm), number of seeds/pod (9.0), pod fresh weight (5.721 g) and pod dry weight (1.575 g) were maximum in T_1 followed by T2 (72.6, 13.9 cm, 7.0, 4.535 g and 1.064 g), T_3 (65.0, 13.6 cm, 6.3, 4.291 g and 0.971 g) and compared to the control (42.6, 12.8 cm, 5.6, 4.029 g and 0.848 g) on 90 DAS. Simultaneously, the maximum yield/plant (204.37 g), yield/plot (3.672 kg) and yield /ha (1531 kg) were obtained in T_3 followed by T_2 (142.01 g, 2.556 kg, 1065 kg), T_1 (127.32 g, 2.286 kg and 953 kg) than C (99.81 g, 1.782 kg and 743 kg) on 90 days after sowing is presented in the Table 33, Plate 19 respectively.

4.5.2.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

Maximum number of seeds/plant (560.3), yield/plant (5.459 g), yield/plot (1.965 kg), yield/ha (819 kg), straw yield/ha (1630 kg), seeds fresh weight (3.523 g) and seeds dry weight (1.575 g) were influenced with the application of effective microorganisms followed by T_2 – toddy palm shell + microbial consortium + *Eisenia fetida* (548.0, 5.129 g, 1.845 kg, 769 kg, 1534 kg, 3.189 g and 1.429 g), T_1 – coir pith (512.3, 5.003 g, 1.800 kg, 750 kg, 1502 kg, 2.957 g and 1.258 g) than control (389.6, 3.854 g, 1.386 kg, 577 kg, 1144 kg, 2.689 g and 0.938 g) on 90 DAS as shown in the Table 34, Plate 19 respectively.

4.5.2.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The application of T_3 - effective microorganism significantly increased the maximum number of pods (22.0), length of pod (11.1 cm), number of seeds/pod (12.6), yield/plant (5.846 g), yield/plot (996 g), yield/ha (415.33 kg), straw yield/ha (723.07 kg), seeds fresh weight (13.468 g) and seeds dry weight (6.128 g) than control (15.6, 7.1 cm, 7.3, 2.432 g, 435 g, 181.39 kg, 436.59 kg, 9.308 g and 3.735 g on 90 days after sowing as given in the Table 35 and Plate 19 respectively.

Similar result was coincided with the result of Alaghemand *et al.* (2017) who observed that the fenugreek treated with vermicompost enhanced the length of pod (13.2 cm) and fresh weight of pod (8.41 g) than control (10.36 and 5.78 g). Maximum number of pod/plant (31) and 100 grain weight (4.4 g) of black gram as influenced by 75:100 ratio of recommended dose of fertilizer and leaf litter compost was reported by Premalatha *et al.* (2017).

The result is in agreement with the result of Singh *et al*. (2018) who found a substantial increase of number of fruits/plant, fruit width, fruit length, fruit weight, fruit yield per plant, fruit yield per plot and fruit yield per hectare of cucumber was noticed with the application of recommended dose of fertilizer (75%) + farmyard manure (12.5%) + vermicompost/ha (12.5%). The present observation was in accordance with the finding of Chaudhary *et al.* (2018) who reported that maximum yield/plot (0.861 kg) and yield/ha (119.59 q) of amaranth (*Amaranthus Spp*.) improved with the application of 6.25 t/ha of vermicompost. The results are in accordance with the result of Aydi *et al.* (2023) who found that the application of coconut fiber improves the yield (2.83 kg/plant) of *Cucumis melo* L.

4.5.3 Biochemical characters

The effect of bio-composted toddy palm shell compared with coir pith and effective microorganisms on biochemical characters of bhendi, cluster bean, coriander and fenugreek.

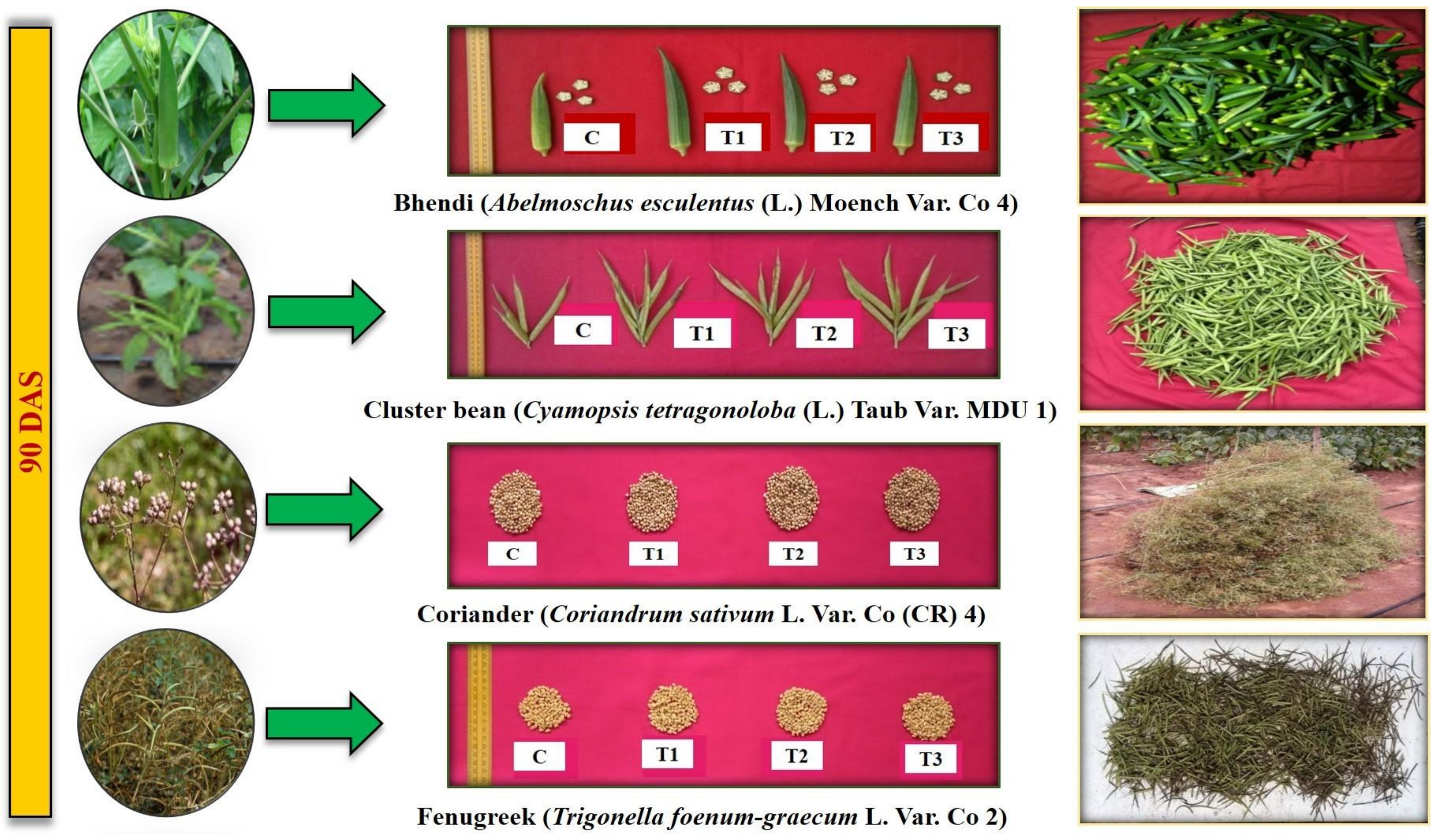
4.5.3.1 Effect of coir pith, effective microorganisms and bio-composted toddy palm shell on carbohydrate content in leaves of test crops

4.5.3.1.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

Gradual increase in carbohydrate content was observed in T_1 (66.04, 114.61 and 94.78 mg/g tissue), T_2 (62.70, 92.48 and 90.45 mg/g tissue), T_3 (58.28, 87.75 and 84.50 mg/g tissue) than control (24.65, 69.05 and 46.86 mg/g tissue) on 25, 50 and 75 DAS as shown in Figure XI (a) respectively.

Plate – 19

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Yield Parameters of Bhendi, Cluster Bean, Coriander and Fenugreek



DAS – Days after sowing, **C** – Control, $\mathbf{T_1}$ – Coir pith (5t ha^{-1}), $\mathbf{T_2}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_3}$ – Effective microorganisms (1L/m^2).

Table – 32

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Yield Parameters of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4)

Treatments	Number of fruits	Length of fruit (cm)	Diameter of fruit (cm)	Number of seeds / fruit	Yield / plant (g)	Yield / plot (kg)	Yield / ha (kg)	Fruit fresh weight (g)	Fruit dry weight (g)
C	5.6	15.1	1.5	52.4	96.90	1.743	726	19.38	1.846
T_1	8.3	18.9	2.6	78.0	173.20	3.117	1299	21.65	2.007
T_2	9.3	18.3	2.2	73.6	214.83	3.864	1611	23.87	2.083
T_3	9.6	17.2	1.9	61.8	226.26	4.071	1697	25.14	2.457
SEd	0.2887	0.3979	0.3512	0.4848	0.4123	0.3894	3.8730	0.4282	0.2769
Cd(p<0.05)	0.6657	0.9176	0.8099	1.1179	0.9508	0.8981	8.9312	0.9874	0.6385
Cd(p<0.01)	0.9686**	1.3352**	1.1784**	1.6266**	1.3835**	1.3068**	12.9957**	1.4367**	0.9291**

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 33

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Yield Parameters of Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub. Var. MDU.1)

Treatments	Number of pods	Length of pod (cm)	Number of seeds/pod	Yield / plant (g)	Yield / plot (kg)	Yield / ha (kg)	Pod fresh weight (g)	Pod dry weight (g)
C	42.6	12.8	5.6	99.81	1.782	743	4.029	0.848
T_1	74.0	15.6	9.0	127.32	2.286	953	5.721	1.575
T_2	72.6	13.9	7.0	142.01	2.556	1065	4.535	1.064
T_3	65.0	13.6	6.3	204.37	3.672	1531	4.291	0.971
SEd	0.3440	0.5627	0.3786	0.4123	0.4359	2.5495	0.4359	0.4637
Cd(p<0.05)	0.7933	1.2977	0.8730	0.9508	1.0052	5.8792	1.0052	1.0693
Cd(p<0.01)	1.1543**	1.8882**	1.2704**	1.3835**	1.4626**	8.5548**	1.4626**	1.5559**

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms ($1L/m^2$).

Table – 34

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Yield Parameters of Coriander (*Coriandrum sativum* L. Var. Co.4)

Treatments	Number of seeds/plant	Yield /plant (g)	Yield / plot (kg)	Yield /ha (kg)	Straw yield / ha (kg)	Seeds fresh weight (g)	Seeds dry weight (g)
C	389.6	3.854	1.386	577	1144	2.689	0.938
T_1	512.3	5.003	1.800	750	1502	2.957	1.258
T_2	548.0	5.129	1.845	769	1534	3.189	1.429
T_3	560.3	5.459	1.965	819	1630	3.523	1.575
SEd	0.3440	0.4203	0.8851	2.2361	2.2361	0.4882	0.4583
Cd(p<0.05)	0.7933	0.9693	2.0410	5.1564	5.1564	1.1258	1.0568
Cd(p<0.01)	1.1543**	1.4104**	2.9698**	7.5031**	7.5031**	1.6381**	1.5377**

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 35

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Yield Parameters of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2)

Treatments	Number of pods	Length of pod (cm)	Number of seeds / pod	Yield /plant (g)	Yield / plot (g)	Yield / ha (kg)	Straw yield / ha (kg)	Seeds fresh weight (g)	Seeds dry weight (g)
C	15.6	7.1	7.3	2.432	435	181.39	436.59	9.308	3.735
T_1	19.0	8.9	10.3	4.684	843	351.53	617.99	11.690	5.265
T_2	21.3	9.9	12.0	5.269	948	395.31	631.75	15.397	7.039
T_3	22.0	11.1	12.6	5.846	996	415.33	723.07	13.468	6.128
SEd	0.4726	0.4726	0.3440	0.4472	4.1231	0.2550	0.6042	0.3215	0.3873
Cd(p<0.05)	1.0898	1.0898	0.7933	1.0313	9.5080	0.5879	1.3932	0.7413	0.8931
Cd(p<0.01)	1.5857**	1.5857**	1.1543**	1.5006**	13.8350**	0.8555**	2.0272**	1.0786**	1.2996**

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

4.5.3.1.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

Among the treatments, a significant increase in carbohydrate content was observed in T_1 (45.23, 72.67 and 112.62 mg/g tissue), T_2 (39.56, 67.20 and 99.12 mg/g tissue), T_3 (36.59, 59.28 and 94.57 mg/g tissue) than C (30.98, 46.28 and 80.36) on 25, 50 and 75 DAS (Fig. XI (b)).

5.3.1.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

The data presented in Figure XI (c) shows increased carbohydrate content in T_1 (49.45, 65.82 52.43 mg/g tissue) followed by T_2 (42.19, 59.77 and 48.65 mg/g tissue), T_3 (35.00, 55.98 and 42.00 mg/g tissue) than C (28.02, 43.78 and 34.45 mg/g tissue) on 25, 50 and 75 DAS.

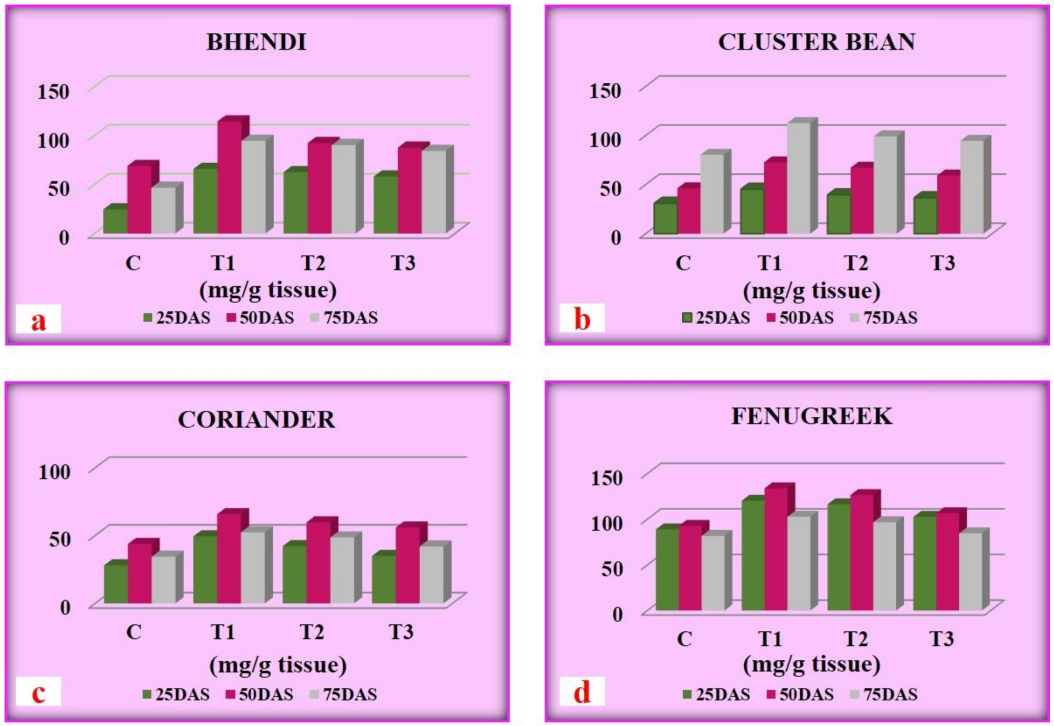
4.5.3.1.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

Carbohydrate content in leaves of fenugreek was higher with the application of coir pith – T_1 (120.23, 133.90 and 102.76 mg/g tissue), T_2 (116.38, 126.45 and 96.73 mg/g tissue), T_3 (102.58, 106.56 and 84.60 mg/g tissue) on 25, 50 and 75 DAS as shown in Fig. XI (d) respectively.

A similar result was obtained by Vijaya *et al.* (2008) who reported that application of compost with garden soil increased the carbohydrate content in leaves of *Andrographis paniculata* (0.94 mg/g) than control (0.68 mg/g). The influence of vermicomposted jackfruit peel with the help of *Pleurotus florida* and *Pleurotus eous* enhanced the carbohydrate content (72.82 and 87.97 mg/g tissue) in leaves of *Vigna unguiculata* (L.) on 25 and 35 DAS was reported by Silpa and Vijayalakshmi (2020). The combined application of recommended dose of mineral nitrogen (100%) with salicylic acid at 150 ppm enhanced the total carbohydrate content (20.5%) in leaves of common bean was reported by Mohamed *et al.* (2023).

Figure – XI (a to d)

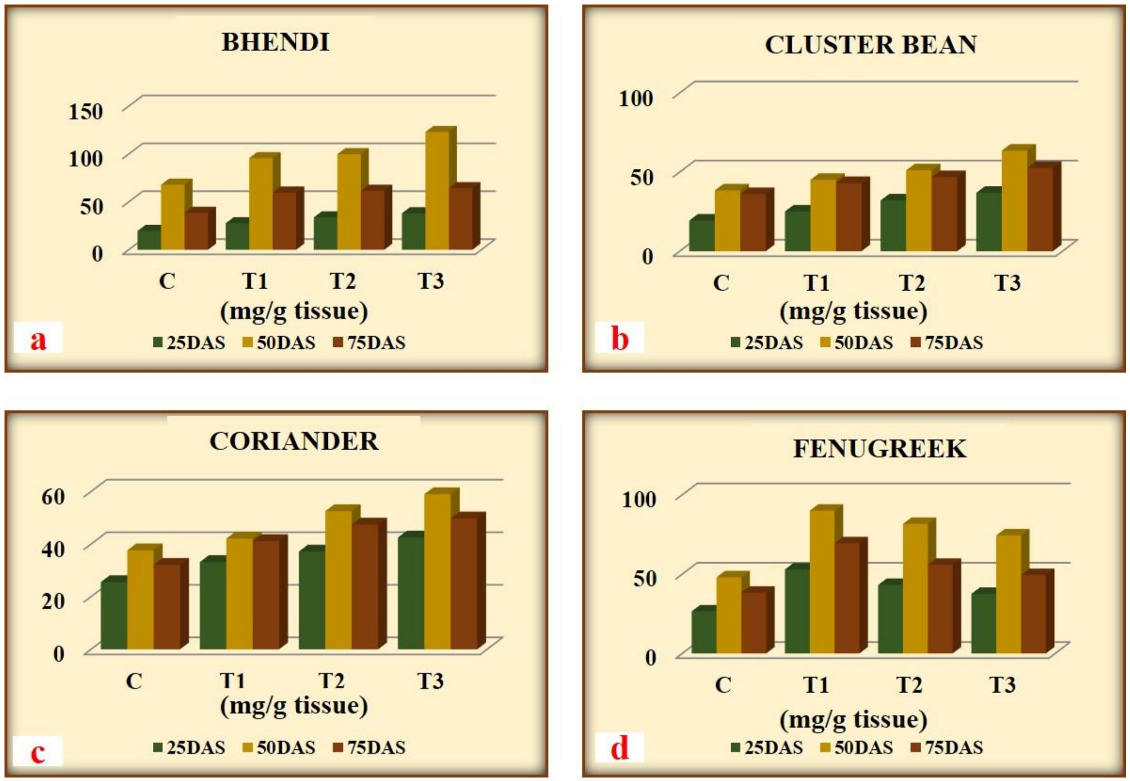
Effect of Composted Toddy Palm Shell Compared With Coirpith and Effective Microorganisms on Carbohydrate Content in Leaves of Bhendi, Cluster Bean, Coriander and Fenugreek



DAS – Days after sowing; **C** – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Figure – XII (a to d)

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Protein Content in Leaves of Bhendi, Cluster Bean, Coriander and Fenugreek



DAS – Days after sowing; **C** – Control, $\mathbf{T_1}$ – Coir pith (5t ha^{-1}), $\mathbf{T_2}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_3}$ – Effective microorganisms ($1L/m^2$).

4.5.3.2 Effect of coir pith, effective microorganisms and bio-composted toddy palm shell on protein content in leaves of test crops

4.5.3.2.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The data presented in Figure XII (a) shows that the maximum increased protein content was higher with the application of T_3 - effective microorganisms (38.08, 123.02 and 64.38 mg/g tissue), T_2 (33.78, 99.87 and 61.59 mg/g tissue), T_1 (27.65, 95.70 and 59.80 mg/g tissue) than C (19.64, 67.98 and 38.65 mg/g tissue) on 90 days after sowing.

4.5.3.2.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The protein content significantly increased in T_3 (36.91, 63.56 and 52.63 mg/g tissue) followed by T_2 (32.09, 51.12 and 46.81 mg/g tissue), T, (25.10, 45.09 and 43.09 mg/g tissue) than control (19.37, 38.39 and 36.10 mg/g tissue) on 25, 50 and 75 DAS as shown in Fig. XII (b).

4.5.3.2.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

Gradual increase in protein content was observed on 25 and 50 days which was slightly decreased on 75 days as shown in Fig. XII (c) respectively. The maximum protein content in leaves of coriander was found in T_3 (42.55, 59.02 and 49.80 mg/g tissue) followed by T_2 (37.22, 52.57 and 47.48 mg/g tissue), T_1 (33.21, 42.11 and 41.19 mg/g tissue) than C (25.57, 37.66 and 32.14 mg/g tissue) on 25, 50 and 75 DAS.

4.5.3.2.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

Among the treatments, maximum amount of protein content was observed in T_1 – coir pith (52.89, 89.94 and 69.40 mg/g tissue) followed by T_2 - toddy palm shell composted with the help of microbial consortium and *Eisenia fetida* (43.12, 81.62 and 55.82 mg/g tissue), T_3 - effective microorganisms (37.50, 74.38 and 49.40 mg/g tissue) than control (26.45, 47.98 and 38.29 mg/g tissue) on 25, 50 and 75 days after sowing as shown in Fig. XII (d) respectively.

The present study coincided with the results of Vijaya *et al.* (2008) who reported that the highest protein content (0.28 mg/g) in leaves of *Andrographis paniculata* improved by the joint action of garden soil + compost than garden soil alone (0.20 mg/g) and barren soil + compost (0.15 mg/g) respectively.

Table – 36

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Chlorophyll 'a', Chlorophyll 'b' and Total Chlorophyll Content in Leaves of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4)

Treatments	Chlorophyll 'a' (mg/g tissue)			Chlorophyll 'b' (mg/g tissue)			Total chlorophyll (mg/g tissue)		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	1.640	1.872	1.287	2.840	2.482	1.672	1.648	2.609	0.297
T_1	1.802	1.903	2.003	3.212	2.583	2.057	2.209	2.948	1.067
T_2	2.178	1.998	2.286	3.442	3.563	2.512	2.917	3.573	1.498
T_3	2.728	2.389	2.498	3.684	3.926	2.689	3.624	3.704	1.745
SEd	0.21409			0.22111			0.23551		
Cd(p<0.05)	0.44186			0.45635			0.48606		
Cd(p<0.01)	0.60212**			0.62187**			0.66236**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms ($1L/m^2$).

Table – 37

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Chlorophyll 'a', Chlorophyll 'b' AND Total Chlorophyll Content in Leaves of Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub. Var. MDU.1)

Treatments	Chlorophyll 'a' (mg/g tissue)			Chlorophyll 'b' (mg/g tissue)			Total chlorophyll (mg/g tissue)		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	1.899	2.172	1.678	1.900	1.462	1.953	1.520	0.830	1.630
T_1	2.829	3.002	2.674	3.812	2.024	2.812	2.930	1.820	2.831
T_2	2.562	2.896	2.278	3.004	1.903	2.334	2.712	1.609	2.309
T_3	2.120	2.371	2.117	2.823	1.783	2.121	2.234	1.245	2.201
SEd	0.18834			0.25386			1.1543		
Cd(p<0.05)	0.38872			0.52394			0.48199		
Cd(p<0.01)	0.52971**			0.71398**			0.65682**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 38

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Chlorophyll 'a', Chlorophyll 'b' and Total Chlorophyll Content in Leaves of Coriander (*Coriandrum sativum* L. Var. Co.4)

Treatments	Chlorophyll 'a' (mg/g tissue)			Chlorophyll 'b' (mg/g tissue)			Total chlorophyll (mg/g tissue)		
	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	1.298	1.634	0.882	2.329	3.028	1.904	0.690	1.388	1.486
T_1	1.650	1.894	1.228	2.981	3.308	2.230	1.209	1.489	1.590
T_2	2.003	2.292	1.575	3.125	3.473	2.902	1.647	2.284	1.893
T_3	2.342	2.449	1.901	3.392	3.902	3.183	1.834	2.529	2.299
SEd	0.22626			0.21279			0.19579		
Cd(p<0.05)	0.46698			0.43917			0.40409		
Cd(p<0.01)	0.63636**			0.59846**			0.55066**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 39

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Chlorophyll 'a', Chlorophyll 'b' and Total Chlorophyll Content in Leaves of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2)

Treatments	Chlorophyll 'a' (mg/g tissue)			Chlorophyll 'b' (mg/g tissue)			Total chlorophyll (mg/g tissue)		
	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS	25DAS	50DAS	75DAS
C	1.904	2.834	0.564	1.098	2.841	0.285	1.040	2.088	2.349
T_1	1.985	3.289	0.609	1.186	2.920	0.602	1.395	2.389	2.589
T_2	2.083	3.854	1.298	1.578	3.123	0.883	1.748	2.632	3.353
T_3	2.305	3.930	1.509	1.988	3.328	1.032	1.894	3.243	3.496
SEd	0.22515			0.25935			0.16976		
Cd(p<0.05)	0.46470			0.53528			0.35037		
Cd(p<0.01)	0.63325**			0.72943**			0.47745**		

** Significant at 1% ($p<0.01$); **DAS** – Days after sowing

C – Control, $\mathbf{T_1}$ – Coir pith (5t ha^{-1}), $\mathbf{T_2}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_3}$ – Effective microorganisms (1L/m^2).

The present finding is in conformity with Densilin *et al.* (2010) who reported that the influence of vermicompost + inorganic fertilizers improved the protein content (10.83 mg/g) in leaves of chilli than control (2.53 mg/g).

Similar observations were reported by Bharti and Kumar (2016) who observed maximum protein content in leaves of *Vigna mungo* (0.421 mg/g) enhanced by 15% of arbuscular mycorrhiza (*Glomus mossae*) than control treatment (0.210 mg/g). The present finding is in conformity with Joshi-Paneri *et al.* (2023) who found a significant increase in protein content (11.5 µg g^{-1}) in leaves of soybean was influenced by static magnetic field strengths of 200 mT respectively.

4.5.3.3 Effect of coir pith, effective microorganisms and bio-composted toddy palm shell on chlorophyll content in leaves of test crops

4.5.3.3.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

Maximum chlorophyll a, chlorophyll b and total chlorophyll content in leaves of bhendi influenced by T_3 treatment effective microorganisms (2.728, 2.389 and 2.498 mg/g tissue), (3.684, 3.926 and 2.689 mg/g tissue) and (3.624, 3.704 and 1.745 mg/g tissue) followed by T_2 – toddy palm shell + microbial consortium + *Eisenia fetida* (2.178, 1.998 and 2.286 mg/g tissue), (3.442, 3.563 and 2.512 mg/g tissue) and (2.917, 3.573 and 1.498 mg/g tissue) than control (1.640, 1.872 and 1.287 mg/g tissue), (2.840, 2.482 and 1.672 mg/g tissue) and (1.648, 2.609 and 0.297 mg/g tissue) on 25, 50 and 75 DAS as shown in the Table 36 respectively.

4.5.3.3.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The data presented in Table 37 shows that the maximum chlorophyll a, chlorophyll b and total chlorophyll content were observed with the application of coir pith (2.829, 3.002 and 2.674 mg/g tissue), (3.812, 2.024 and 2.812 mg/g tissue) and (2.930, 1.820 and 2.831 mg/g tissue) followed by T_2 (2.562, 2.896 and 2.278 mg/g tissue), (3.004, 1.903 and 2.334 mg/g tissue) and (2.712, 1.609 and 2.309 mg/g tissue) compared with control (1.899, 2.172 and 1.678 mg/g tissue), (1.900, 1.462 and 1.953 mg/g tissue) and (1.520, 0.830 and 1.630 mg/g tissue) on 25, 50 and 75 days after sowing.

4.5.3.3.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

Maximum chlorophyll content in leaves of coriander was observed on 50 DAS in all the treatments as shown in the Table 38 respectively. The application of effective microorganisms (T_3) achieved the highest chlorophyll a, chlorophyll b and total chlorophyll content (2.342, 2.449 and 1.901 mg/g tissue), (3.392, 3.902 and 3.183 mg/g tissue) and (1.834, 2.529 and 2.299 mg/g tissue) and lowest in control (1.298, 1.634 and 0.882 mg/g tissue), (2.329, 3.028 and 1.904 mg/g tissue) and (0.690, 1.388 and 1.486 mg/g tissue) on 25, 50 and 75 DAS.

4.5.3.3.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

Chlorophyll a, chlorophyll b and total chlorophyll content in leaves of fenugreek increased significantly up to 50 DAS which gradually declined after that in all the treatments from (T_1 to T_3) as presented in the Table 39. The effective microorganisms (T_3) showed highest chlorophyll content from 25 to 50 DAS which ranged from 2.305 to 3.930 mg/g tissue (chlorophyll a), 1.988 to 3.328 mg/g tissue (chlorophyll b) and 1.894 to 3.243 mg/g tissue (total chlorophyll) than control (1.904 to 2.834 mg/g tissue), (1.098 to 2.841 mg/g tissue) and (1.040 to 2.088 mg/g tissue). On 75 DAS slightly decreased chlorophyll a and b were noticed in all the treatments such as T_3 (1.509 and 1.032 mg/g tissue), T_2 (1.298 and 0.883 mg/g tissue), T_1 (0.609 and 0.602 mg/g tissue) than control (0.564 and 0.285 mg/g tissue) simultaneously, the total chlorophyll content was increased in T_3 (3.496 mg/g tissue), T_2 (3.353 mg/g tissue), T_1 (2.589 mg/g tissue) and C (2.349 mg/g tissue) on 75 DAS respectively.

The result was par with the result of Vijaya *et al.* (2008) who reported that the highest chlorophyll a and chlorophyll b improved by the dual action of garden soil + compost in leaves of *Andrographis paniculata* (1.34 and 0.14 mg/g) than other treatments. Similar result was obtained by Densilin *et al.* (2010). They reported that the application of inorganic fertilizer increased the chlorophyll content in leaves of chilli (3.23 mg/g) than control (1.92 mg/g).

The study coincided with the result of Neral *et al.* (2012) who reported that the co-inoculation of *Pseudomonas* and *Azotobacter* improves the total chlorophyll content in leaves of *Triticum aestivum*. Maximum total chlorophyll content (2.2 and 1.5 mg g^{-1}) in leaves of groundnut plant in field and pot culture as influenced by the combined application of *Pseudomonas fluorescens* and *Bacillus subtilis* was reported by Eswaran *et al.* (2023).

4.5.3.4 Effect of coir pith, effective microorganisms and bio-composted toddy palm shell on leghaemoglobin content in root nodules of test crops

4.5.3.4.1 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The application of coir pith (T_1) enhanced leghaemoglobin content (0.146, 0.363 and 0.243 mg/g tissue) in root nodules of cluster bean followed by toddy palm shell composted with the help of microbial consortium and *Eisenia fetida* – T_2 (0.125, 0.321 and 0.217 mg/g tissue) compared with control (0.098, 0.244 and 0.178 mg/g tissue) on 25, 50 and 75 DAS as shown in Figure XIII (a) respectively.

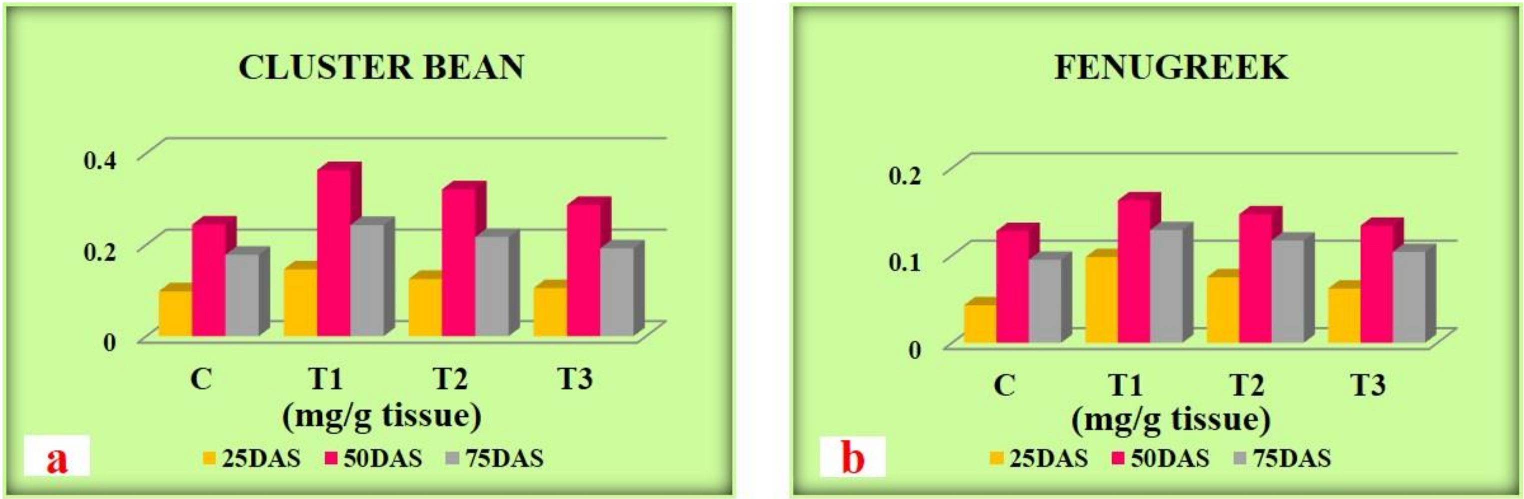
4.5.3.4.2 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The data presented in Figure XIII (b) shows increased leghaemoglobin content in T_1 (0.098, 0.163 and 0.129 mg/g tissue) followed by T_2 (0.075, 0.147 and 0.117 mg/g tissue), T_3 (0.062, 0.134 and 0.104 mg/g tissue) than control (0.043, 0.128 and 0.095 mg/g tissue) on 25, 50 and 75 DAS.

The results in on par with Abira (2006) who reported that fruit waste vermicomposted with *Pleurotus fluorescens* and *Phosphobacter* assistance increased the leghaemoglobin content (0.0098, 0.0256 and 0.0186 mg/g) in soybean on 30, 60 and 90 DAS. The present finding is in conformity with Tamilarasi (2006) who reported that maximum leghaemoglobin content of 1.48, 3.28 and 2.53 (mg/g) in *Vigna unguiculata* observed with the application of kitchen waste compost (8 t/ha) on 30, 60 and 90 DAS respectively. The present study is on par with the result of Araujo *et al.* (2007) who observed that the application of compost at 9.5t ha^{-1} significantly improved the leghaemoglobin content in root nodules of soybean and cowpea (91.6 and 45.5 mg/g) than control (63.4 and 37.5 g/g).

Figure – XIII (a to d)

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Leghaemoglobin Content in Root Nodules of Cluster Bean and Fenugreek



DAS – Days after sowing; **C** – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Similar results were obtained by Bharti and Kumar (2016) who reported that the mycorrhiza treated plants increased the leghaemoglobin content in root nodules of black gram (4.598 mM^{-1}) than control (1.717 mM^{-1}). The co-inoculation of *Pseudomonas fluorescens* and *Bacillus subtilis* improved the leghaemoglobin content (2.5 and 2.0 mg/g) in root nodules of *Arachis hypogaea* L. in field and pot trial was reported by Eswaran *et al.* (2023).

4.5.3.5 Effect of coir pith, effective microorganisms and bio-composted toddy palm shell on carbohydrate content in fruits, pods and seeds of test crops

4.5.3.5.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

Maximum carbohydrate content in fruits of bhendi was obtained in T_1 (84.67 mg/g tissue) followed by T_2 (82.10 mg/g tissue), T_3 (78.70 mg/g tissue) than C (48.64 mg/g tissue) on 90 DAS as shown in the Fig. XIV (a) respectively.

4.5.3.5.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The data presented in Fig. XIV (b) shows that the carbohydrate content in pods of cluster bean found to be maximum in T_1 (126.67 mg/g tissue) followed by T_2 (114.09 mg/g tissue), T_3 (95.63 mg/g tissue) than control (88.91 mg/g tissue) on 90 days after sowing.

4.5.3.5.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

The application of coir pith (T_1) enhanced the maximum carbohydrate content (88.39 mg/g tissue) followed by T_2 (84.13 mg/g tissue), T_3 (79.29 mg/g tissue) than control (67.98 mg/g tissue) in seeds of coriander showed in Fig. XIV (c) respectively.

4.5.3.5.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The data presented in Fig. XIV (d) showed that the carbohydrate content in seeds of fenugreek was found to be higher in T_1 (118.40 (mg/g tissue) followed by T_2 (103.58 mg/g tissue), T_3 (94.02 mg/g tissue) than control (87.30 mg/g tissue) on 90 DAS.

The results coincided with the result of Zodape *et al.* (2010) who reported that maximum amount of carbohydrate content (61.995 %) was obtained with the application of 10% extract of seaweed (*Kappaphycus alvarezii*) than control (58.950 %) in seeds of green gram. Similar result was also observed by Kumar and Ganesh (2013) who reported that the combined application of coir pith, poultry manure, *Pleurotus sajor-caju* and NPK fertilizer improved the carbohydrate content in seeds of *Arachis hypogea*.

4.5.3.6 Effect of coir pith, effective microorganisms and bio-composted toddy palm shell on protein content in fruits, pods and seeds of test crops

4.5.3.6.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The protein content in fruits of bhendi showed maximum in T_1 – coir pith (59.14 mg/g tissue) followed by T_2 – toddy palm shell + microbial consortium + *Eisenia fetida* (57.28 mg/g tissue), T_3 – effective microorganisms (49.05 mg/g tissue) than control (26.98 mg/g tissue) on 90 DAS (Fig. XV (a)).

4.5.3.6.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The data presented in Fig. XV (b) shows that maximum protein content in pods of cluster bean with the application of T_1 – coir pith (95.67 mg/g tissue) followed by T_2 – toddy palm shell + microbial consortium + *Eisenia fetida* (84.67 mg/g tissue), T_3 – effective microorganisms (79.03 mg/g tissue) than control (63.48 mg/g tissue) on 90 DAS respectively.

4.5.3.6.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

The highest protein content was observed in T_1 (82.43 mg/g tissue) followed by T_2 (78.40 mg/g tissue), T_3 (64.13 mg/g tissue) than control (52.79 mg/g tissue) in seeds of coriander on 90 days after sowing as given in the Fig. XV (c).

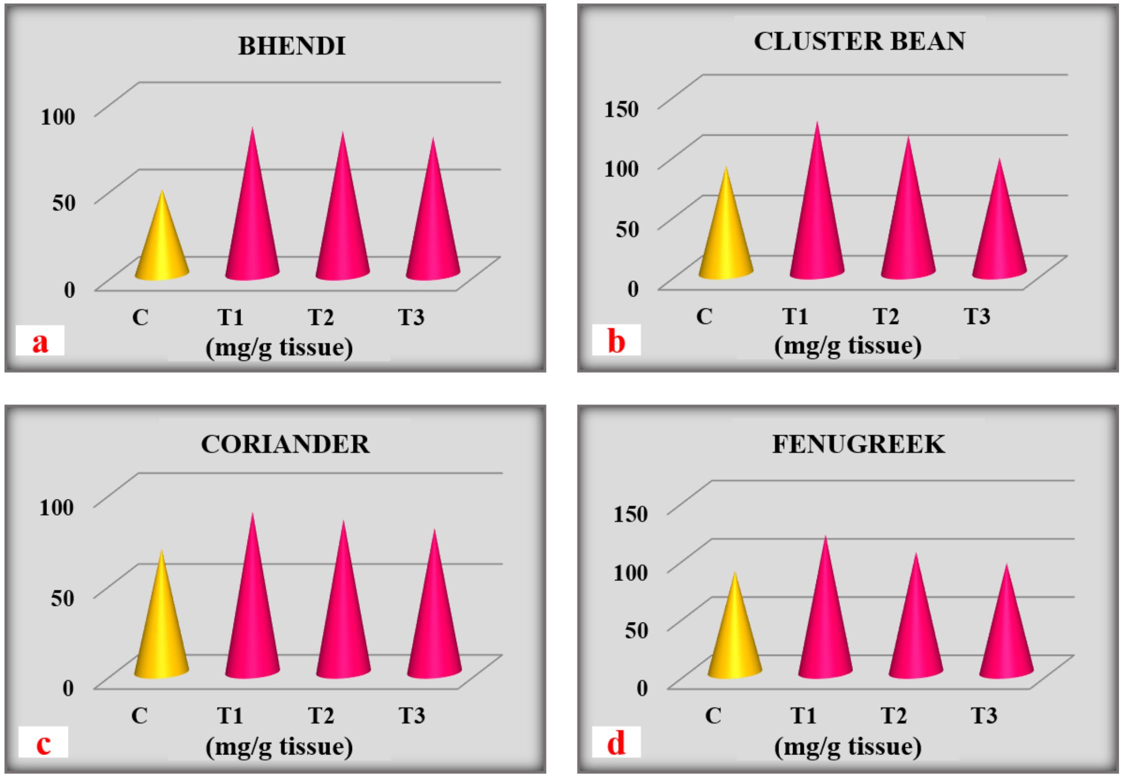
4.5.3.6.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The protein content in seeds of fenugreek shows increase in T_1 (95.62 mg/g tissue), T_2 (90.18 mg/g tissue), T_3 (78.40 mg/g tissue) compared with control (60.29 mg/g tissue) on 90 DAS as shown in Fig. XV (d) respectively.

A similar result was also reported by Zodape *et al.* (2010) who observed that the amount of carbohydrate content (19.430 %) in seeds of green gram obtained with the application of 10% foliar spray of seaweed (*Kappaphycus alvarezii*) extract than control (18.220 %) respectively.

Figure – XIV (a to d)

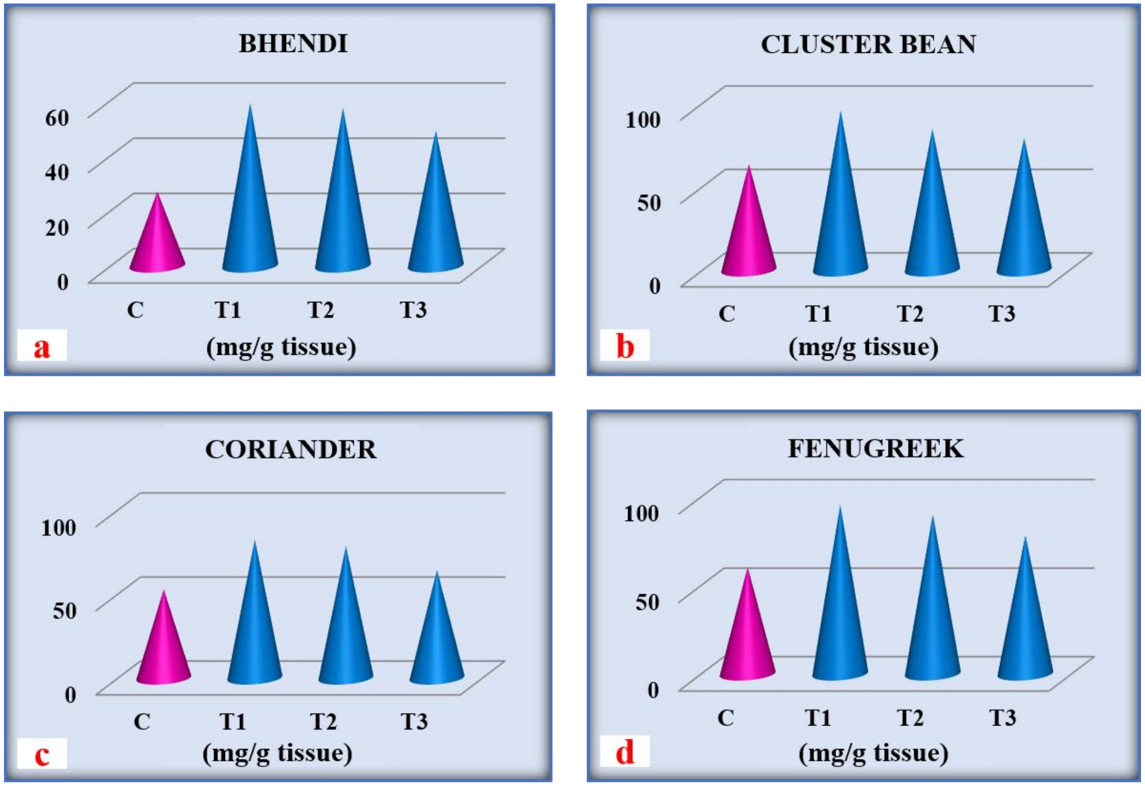
Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Carbohydrate Content in Fruits, Pods and Seeds of Bhendi, Cluster Bean, Coriander and Fenugreek on 90 DAS



DAS – Days after sowing; **C** – Control, $\mathbf{T_1}$ – Coir pith (5t ha^{-1}), $\mathbf{T_2}$ – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), $\mathbf{T_3}$ – Effective microorganisms (1L/m^2).

Figure – XV (a to d)

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Protein Content in Fruits, Pods and Seeds of Bhendi, Cluster Bean, Coriander and Fenugreek on 90 DAS



DAS – Days after sowing; **C** – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms ($1L/m^2$).

On 65th day the maximum protein content (67.80 mg/g tissue) in seeds of *Vigna unguiculata* improved with the application of jackfruit peel vermicomposted by using 10g of *Pleurotus florida*, 10 g of *Pleurotus eous* and *Eudrilus eugeniae* at 5t ha^{-1} was reported by Silpa and Vijayalakshmi (2020). The combined application of recommended dose of mineral nitrogen (100%) with salicylic acid at 150 ppm improves the total carbohydrate (58.4% and 57.4%) and total protein (22.56% and 21.75%) content in dried seeds of common bean during the seasons of 2020 and 2021 was reported by Mohamed *et al.* (2023).

4.5.4 Soil analysis

The data presented in Table 40 shows that the pH (5.7), EC (1.84 ds/m), available nitrogen (116 kg/ha), available phosphorus (10.6 kg/ha) and available potassium (118 kg/ha) content in soil of experimental site. Addition of organic amendments (coir pith, effective microorganisms and best treatment (Toddy palm shell + microbial consortium + *Eisenia fetida*)) into the soil significantly increased the value of pH, EC, available N, P and K content were noted in all the treatment as given in the Table 41 respectively. The maximum pH value was obtained in T_3 – effective microorganisms (6.4), T_1 – coir pith (6.3) and T_2 – toddy palm shell + microbial consortium + *Eisenia fetida* (6.1) and the value of electrical conductivity recorded in T_1 (2.50 ds/m) followed by T_2 (2.48 ds/m) and T_3 (2.47 ds/m). The available N, available P and available K were maximum in T_1 – coir pith (154 kg/ha, 14.9 kg/ha and 158 kg/ha) followed by T_3 (150 kg/ha, 14.4 kg/ha and 155 kg/ha) and T_2 (148 kg/ha, 14.3 kg/ha and 150 kg/ha) respectively.

4.5.4.1 *Abelmoschus esculentus* (L.) Moench Var. Co 4 (Bhendi)

The data presented in Table 42 shows that the value of pH and available nitrogen content were maximum in T_3 (7.2 and 184 kg/ha) respectively. The value of EC, available phosphorus and available potassium were found maximum in T_1 (1.95 ds/m, 15.2 kg/ha and 153 kg/ha) followed by T_3 (1.93 ds/m, 14.7 kg/ha and 150 kg/ha), T_2 (1.92 ds/m, 14.5 kg/ha and 147 kg/ha) than control (1.89 ds/m, 13.1 kg/ha and 136 kg/ha) in post harvest soil of bhendi.

4.5.4.2 *Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1 (Cluster bean)

The value of pH shows maximum in T_3 (6.9) followed by T_2 (6.8), T_1 (6.5) than C (6.0) is presented in the Table 43. The application of coir pith enhanced the maximum EC (1.98 ds/m), available N (204 kg/ha), available P (14.8 kg/ha) and available K (144 kg/ha) followed by T_3 (1.97 ds/m, 198 kg/ha, 14.2 kg/ha and 136 kg/ha), T_2 (1.93 ds/m, 192 kg/ha, 14.1 kg/ha and 130 kg/ha) than C (1.92 ds/m, 175 kg/ha, 12.9 kg/ha and 127 kg/ha) respectively.

4.5.4.3 *Coriandrum sativum* L. Var. Co 4 (Coriander)

The maximum pH value observed in T_3 (7.4) and maximum EC value observed in T_3 (1.99 ds/m) in post harvest soil of coriander as presented in the Table 44. The influence of coir pith (T_1) improves the maximum available nitrogen (159 kg/ha), available phosphorus (14.6 kg/ha) and available potassium 154 kg/ha) followed by T_3 (156 kg/ha, 14.1 kg/ha and 151 kg/ha), T_2 (152 kg/ha, 14.0 kg/ha and 148 kg/ha) than control (139 kg/ha, 13.5 kg/ha and 132 kg/ha).

4.5.4.4 *Trigonella foenum-graecum* L. Var. Co 2 (Fenugreek)

The value of pH obtained in post harvest soil of fenugreek showed maximum in T_3 (6.7), T_2 (6.5), T_1 (6.4) than C (6.2) is given in the Table 45. The highest EC, available N, P and K were found in T_1 (2.34 ds/m, 168 kg/ha, 14.6 kg/ha and 147 kg/ha) and lowest in control (2.19 ds/m, 148 kg/ha, 13.5 kg/ha and 125 kg/ha) respectively.

The soil amended with municipal solid waste compost gradually increased the value of pH (6.62, 6.90 and 6.95), EC (2.21, 2.22 and 2.22 dS m^{-1}) and total nitrogen (0.98, 1.05 and 1.12 g kg^{-1}) in 2, 4 and 7 kg compost than unamended soil (6.51, 2.15 dS m^{-1} and 0.95 g kg^{-1}) was reported by Civeira (2010). Similar result was also reported by Mahmoud and Ibrahim (2012) the influence of vermicompost at 10 g kg^{-1} enhanced the available phosphorus (52.72 mg kg^{-1}), available potassium (92.95 mg kg^{-1}) and available nitrogen (687 mg kg^{-1}) in post harvest soil of barley under pot culture.

Table – 40

Nutritional Status of Experimental Soil

Parameters	Soil
pH	5.7
EC (dS/m)	1.84
Available N (Kg/ha)	116
Available P (Kg/ha)	10.6
Available K (Kg/ha)	118

Table – 41

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Pre-Harvested Soil of Test Crops

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
T_1	6.3	2.50	154	14.9	158
T_2	6.1	2.48	148	14.3	150
T_3	6.4	2.47	150	14.4	155

T_1 – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms ($1L/m^2$).

Table – 42

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Post Harvested Soil Analysis of Bhendi (*Abelmoschus esculentus* (L.) Moench. Var. Co.4)

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Control	6.2	1.89	162	13.1	136
T_1	6.7	1.95	178	15.2	153
T_2	6.9	1.92	173	14.5	147
T_3	7.2	1.93	184	14.7	150

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 43

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Post Harvested Soil Analysis of Cluster Bean (*Cyamopsis tetragonoloba* (L.) Taub. Var. MDU.1)

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Control	6.0	1.92	175	12.9	127
T_1	6.5	1.98	204	14.8	144
T_2	6.8	1.93	192	14.1	130
T_3	6.9	1.97	198	14.2	136

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 44

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Post Harvested Soil Analysis of Coriander (*Coriandrum sativum* L. Var. Co.4)

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Control	6.8	1.77	139	13.5	132
T_1	7.0	1.94	159	14.6	154
T_2	7.3	1.85	152	14.0	148
T_3	7.4	1.99	156	14.1	151

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

Table – 45

Effect of Composted Toddy Palm Shell Compared with Coirpith and Effective Microorganisms on Post Harvested Soil Analysis of Fenugreek (*Trigonella foenum-graecum* L. Var. Co.2)

Treatments	pH	EC (dS/m)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Control	6.2	2.19	148	13.5	125
T_1	6.4	2.34	168	14.6	147
T_2	6.5	2.28	162	14.1	139
T_3	6.7	2.30	165	14.2	143

C – Control, **T_1** – Coir pith (5t ha^{-1}), **T_2** – Toddy palm shell + microbial consortium + *Eisenia fetida* (5t ha^{-1}), **T_3** – Effective microorganisms (1L/m^2).

The study coincided with the result of Dhanalakshmi *et al.* (2014) who reported that the addition of 500 g of vermicompost into 1 kg of soil enhanced the maximum nitrogen content (122 kg/ha) in pre harvest soil of okra, brinjal, tomato and chilli. The influence of vermicompost + triple 17 complex (inorganic fertilizer) increased the nitrogen (261.90 kg ha^{-1}) and potassium (494.28 kg ha^{-1}) content in post harvest soil of chilli was reported by Densilin and Srinivasan (2014).

Bhardwaj *et al.* (2023) reported that the municipal solid waste compost from Bawana (75%) amended with soil decrease the value of pH (7.00) in pre harvest soil of vegetable crops such as okra, brinjal and tomato than control (8.48) respectively. The soil inoculated with different combination of compost, phosphate sludge and *Fusarium oxysporum* f. sp. *albedinis* decrease the value of pH in post-harvest soil (8.20) of date palm seedling than control (9.06) was reported by Anli *et al.* (2023).

Abdou *et al.* (2023) confirmed that the inoculation of compost at 30 t ha-1 improves the value of EC (3.12 dS/m), available nitrogen (0.09%), available phosphorus (11.34 mg/kg) and available potassium (102.17 mg/kg) in post-harvest soil of black cumin (*Nigella sativa*). Bhardwaj *et al.* (2023) who reported that the municipal solid waste compost of Bawana (100%) amended with soil enhanced the value of available phosphorus (271 mg/kg) in pre-harvest soil of tomato, brinjal and okra than unamended compost (7.10 mg/kg) respectively.

In the current study, the application of coir pith, effective microorganisms and toddy palm shell + microbial consortium + *Eisenia fetida* gave positive results in vegetative, yield, biochemical parameters and soil nutrient status of bhendi, cluster bean, coriander and fenugreek. Coir pith is a spongy material, present in the fiber of coconut improves the water holding capacity, texture of soil hence used as soil-less medium for agri-horticultural purposes. Coir pith takes long period for decomposition due to higher amount of cellulose, lignin and hemicellulose. However, the composting of coir pith is rich in macro and micronutrients promotes the plant growth and development. Biodegradation of coir pith waste can be efficiently used as organic fertilizer for improving crop yield was also previously reported by Vijaya *et al.* (2008) in *Andrographis paniculata*, Reghuvaran and Ravindranath (2010) in medicinal plants, Singh and Vijayalakshmi (2013b) in green gram, Singh and Vijayalakshmi (2013c) in black gram and Sakthivigneswari and Vijayalakshmi (2016) in Solanum nigrum.

Effective Microorganisms (EM) are mixed cultures of beneficial naturally-occurring organisms inoculated into the soil increased the soil ecosystem and microbial diversity. Effective microorganisms improved the growth and yield of crop by enhancing photosynthesis activity, producing bioactive substances like enzymes & plant hormones (Yan and Xu, 2002) and (Javaid, 2011). They decompose organic material very fast and also control the soil borne diseases (Daly and Stewart, 1999).

The yield of bhendi, cluster bean, coriander and fenugreek were significantly increased by the influence of effective microorganisms. Similar results was obtained by Javaid and Mahmood (2010) in soybean, Javaid and Bajwa (2011) in mungbean, Hu and Qi (2013a) and Hu and Qi (2013b) in wheat. The use of organic effective microorganisms compost not only helps in the balancing of nutrients supply but also reduces the cost of cultivation and usage of chemical fertilizers.

In the current study, the biometric, yield, biochemical parameters and nutrients status of soil was observed maximum in either coir pith or effective microorganisms treatments. However, the application of bio-composted toddy palm shell showed near to maximum value. This may be due to the presence of consortium of microorganisms significantly increased the level of plant essential nutrients by producing plant growth regulators. Among the treatments, the combined application of toddy palm shell + microbial consortium + *Eisenia fetida* improves the growth, yield, biochemical characteristics and soil status of bhendi, cluster bean, coriander and fenugreek.