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SUMMARY AND CONCLUSION

The present investigation entitled **"Harnessing the benefits of groundnut and toddy palm shell biocompost on selected crops"** was undertaken to study the effect of composted groundnut shell and toddy palm shell which are a natural fertilizer used as a growth promoter for vegetable crops and medicinal plants. Usage of organic fertilizers reduce the environmental hazards and ill effects of chemical fertilizers. The aim of sustainable agriculture is to develop farming system that are protective and profitable, conserve the natural organic waste base and enhance healthy environment. The recycling of groundnut shell and toddy palm shell would be a good organic fertilizer along with *Trichoderma asperelloides*, microbial consortium and *Eisenia fetida* to promote the crop productivity and ensure the hygienic disposal of organic wastes.

In the present study vegetative, yield parameters, biochemical characteristics and soil nutrient status as influenced by bio-composted groundnut shell and toddy palm shell along with microbial consortium and *Eisenia fetida* on 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). were analyzed. The conclusion drawn from all the four phases of the investigation are summarized in this chapter.

PHASE I

The total bacterial, fungal and actinomycetes population were increased in all the treatments compared with the control. The highest number of colonies was noted in C_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) on 60^{th} day of composting. During the thermophilic phase of composting the microbial count was increased. At the regular interval of 30 days (the cooling or maturation phase) microbial load was slightly decreased due to the lack of nutrients and environmental conditions.

The physical and chemical parameters such as pH, electrical conductivity (dS/m), organic carbon (%), C: N ratio, total nitrogen (%), total phosphorus (%), total potassium

(%), calcium (%), magnesium (%), lignin (%) and cellulose (%) were analyzed in six different compositions of composts and control (groundnut shell and toddy palm shell) to ensure the maturity of the compost. Among the six compost treatments, the C_6 (toddy palm shell composted by microbial consortium and *Eisenia fetida*) achieved maximum reduction of organic carbon, C:N ratio, lignin and cellulose and simultaneously increased the pH, EC, total nitrogen, total phosphorus, total potassium, calciumand magnesium followed by other treatments.

The maturity and quality of the compost ensured by the reduction of lignin, cellulose, organic carbon and carbon nitrogen ratio. A considerable reduction was observed in C_6 with the help of ligninolytic and cellulolytic enzymes produced by lignocellulolytic microorganisms present in the consortium of microorganisms which can be able to degrade the organic amendments and improved the plant nutrients.

The FT-IR spectra of groundnut shell and toddy palm shell compared with C_1, C_2, C_3, C_4, C_5 and C_6 composted samples. The spectral absorption showed the stretching and banding of vibrational bands of chemical groups observed in raw groundnut shell and toddy palm shell. The degradation of cellulose, hemicellulose and lignin was monitored by FTIR analysis due to the disappearance of the respective bands in C_3 (groundnut shell + microbial consortium + *Eisenia fetida*) and C_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) composted samples.

XRD results revealed that the degradation of lignocellulosic compounds in the bio-composted samples. In the present study, raw groundnut shell compared with C_3 (groundnut shell decompose with the help of microbial consortium and *Eisenia fetida*) and toddy palm shell compared with C_6 (toddy palm shell decompose with the help of microbial consortium and *Eisenia fetida*) respectively. A broad hump and sharp peak obtained in the raw materials which was disappeared in the processed composted samples (C_3 and C_6) indicates the degradation of cellulose and lignin. Scanning electron microscopic images of groundnut shell and toddy palm shell shows the presence of cellulose microfibers which completely disappeared in C_3 and C_6 composts due to the breakdown of cellulose and lignin compounds by lignocellulolytic enzymes produced by lignocellulolytic microorganisms present in the consortium of microorganisms.

PHASE II

The prepared composts (C_1, C_2, C_3, C_4, C_5 and C_6) were applied in the field as a treatment of T_1, T_2, T_3, T_4, T_5 and T_6 to evaluate the growth (on 25, 50 and 75 DAS) and yield (on 90 DAS) performance of bhendi, cluster bean, coriander and fenugreek. In the present study, significantly increased root length, shoot length, number of leaves and diameter of leaf were recorded in T_6 followed by T_3 compared to the C on 25, 50 and 75 DAS in bhendi. A remarkable increase in number of flowers was observed in T_6 followed by T_3, T_5, T_2, T_1, T_4 than C on 50 and 75 DAS respectively. Fresh weight and dry weight of bhendi was increased with the application of toddy palm shell decomposed by microbial consortium and *Eisenia fetida* (T_6) followed by T_3 (groundnut shell + microbial consortium + *Eisenia fetida*) than control on 25, 50 and 75 days after sowing.

The root length, shoot length, number of leaves and number of nodules were observed maximum in T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) followed by T_3 (groundnut shell + microbial consortium + *Eisenia fetida*) than control on 25, 50 and 75 DAS. On 75 DAS the decline of root nodules in cluster bean was noted in all the treatments than 25 and 50 DAS. However, maximum number of root nodules observed in T_6 followed by T_3, T_5, T_4, T_2, T_1 and C. The combined application of toddy palm shell bio-composted by using microbial consortium and earthworm (T_6) enhanced the number of flowers on 50 and 75 DAS followed by T_3, T_5 and C. Significantly increased fresh and dry weight of cluster bean was recorded in T_6 followed by T_3, T_5, T_2, T_4, T_2, T_1 compared with C on 25, 50 and 75 days after sowing.

The toddy palm shell decomposed with the help of microbial consortium and *Eisenia fetida* (T_6) enhanced the root length, shoot length, number of branches, fresh and dry weight of coriander followed by T_3 than C on 25, 50 and 75 DAS. Maximum number of umbels in coriander was influenced by T_6 followed by T_3, T_5 compared with other treatments on 50 and 75 days after sowing. Root length, shoot length, number of leaves and number of nodules were maximum in T_6 followed by T_3 compared to the control on 25, 50 and 75 DAS. On 50 and 75 DAS the number of flowers in fenugreek improved with the application of T_6 followed by T_3, T_5, T_2 than other treatments. The toddy palm shell decomposed by the joint action of microbial consortium and *Eisenia fetida* (T_6) achieved

maximum fresh weight and dry weight of fenugreek followed by T_3, T_5 when compared with other treatments on 25, 50 and 75 days after sowing.

In the present study, the number of fruits, length of fruit (cm), diameter of fruit (cm), number of seeds/fruit, yield/plot (kg), yield/ha (kg), fruit fresh weight (g) and fruit dry weight (g) of bhendi were maximum in T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) followed by T_3 (groundnut shell + microbial consortium + *Eisenia fetida*), T_5 (toddy palm shell + microbial consortium) than C (control) on 90 DAS. The application of toddy palm shell decomposed with the help of microbial consortium and *Eisenia fetida* (T_6) improves the number of pods, length of pod (cm), number of seeds/pod, yield/plant (g), yield/plot (kg), yield/ha (kg), pod fresh weight (g) and pod dry weight (g) of cluster bean followed by T_3 when compared to the other treatments and control on 90 days after sowing.

Significantly increased the number of seeds/plant, yield/plant (g), yield/plot (kg), yield/ha (kg), straw yield/ha (kg), seeds fresh weight (g) and seeds dry weight (g) of coriander were influenced by the application of toddy palm shell composed by using microbial consortium and earthworm (T_6) followed by T_3, T_5, T_4, T_2, T_1 and C on 90 DAS. On 90 DAS the 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) and seeds dry weight (g) of fenugreek were improved with the application of bio-composted toddy palm shell by using microbial consortium and *Eisenia fetida* (T_6) when compared with other treatments.

The vegetative and yield parameters of bhendi, cluster bean, coriander and fenugreek were improved by T_6 which may be due to the availability of nutrients supply from the organic compost. Organic manure incorporated into the soil enhanced the soil physical and chemical properties which enhanced the plant growth and development through boosting soil physico-chemical and biological properties. In the current study, the compost (C_6) the treatment - T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) achieved good quality and maturity of the compost thereby increasing the vegetative and yield characteristics of test crops.

PHASE III

On 25, 50 and 75 DAS the carbohydrate, protein, chlorophyll a, chlorophyll b and total chlorophyll content in leaves of bhendi, cluster bean, coriander and fenugreek were analyzed. The leghaemoglobin content in root nodules of cluster bean and fenugreek were evaluated on 25, 50 and 75 days after sowing. In the current study, maximum carbohydrate, protein, chlorophyll a, b and total chlorophyll content in the leaves of selected test crops and leghaemoglobin content in root nodules of cluster bean and fenugreek was influenced by T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) followed by T_3 as compared to the control.

The carbohydrate and protein content in fruits of bhendi, pods of cluster bean, seeds of fenugreek and coriander was enhanced with the application of toddy palm shell + microbial consortium + *Eisenia fetida* (T_6) followed by T_3 as compared to the C on 90 DAS. The increase in the biochemical content might be due to the application of organic manure which enhance the physiological and metabolic activities in the plant tissue.

The physical and chemical properties of experimental field soil was low when compared with pre and post-harvest soil. The value of soil pH, electrical conductivity (dS/m), available nitrogen (Kg/ha), available phosphorus (Kg/ha), available potassium (Kg/ha) were significantly increased by the addition of compost. In the present study, the co-inoculation of toddy palm shell decomposed with the help of microbial consortium and *Eisenia fetida* (T_6) improved the soil pH, EC, available nitrogen, available phosphorus and available potassium level.

After harvest stage of bhendi, cluster bean, coriander and fenugreek the post-harvest soil properties of pH, EC, available nitrogen, available phosphorus and available potassium content were improved by the application of T6 and minimum observed in C. However, a decline in electrical conductivity of bhendi was noted and maximum reduction obtained in T_6 followed by T_5, T_4, T_1, T_2, T_3 as compared to the C. The application of toddy palm shell composed by using microbial consortium and earthworm (T_6) significantly improved the soil physical and chemical properties of bhendi, cluster bean, coriander and fenugreek in post-harvest soil.

PHASE IV

Among the six treatments the T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) showed best result in vegetative, yield, biochemical and soil characteristics as compared with other treatments and control. In the current study, the treatment T_6 compared with market available product (coir pith) and effective microorganisms in field trial of same four test crops.

On 25, 50 and 75 DAS the root length and diameter of leaf shows maximum in T_1 (coir pith) and the shoot length, number of leaves, number of flowers, fresh and dry weight of bhendi was obtained maximum in T_3 (effective microorganisms) and minimum in C (control) respectively. The application of coir pith (T_1) enhanced the shoot length, number of leaves, number of flowers and the effective microorganisms improved the root length, number of nodules, fresh and dry weight of cluster bean followed by T_2, T_1 than C on 25, 50 and 75 days after sowing. The length of root and number of branches were influenced by the application of coir pith (T_1) and shoot length, number of umbels, fresh and dry weight of coriander increased by T_3 followed by T_2, T_1 as compared to the C on 25, 50 and 75 DAS. The application of effective microorganisms (T_3) improved the root length, number of flowers and coir pith (T_1) improved the shoot length, number of leaves, number of nodules, fresh and dry weight of fenugreek followed by T_2, T_3 than control on 25, 50 and 75 DAS.

Significantly increased number of fruits, yield/plant, yield/plot, yield/ha, fruit fresh weight and fruit dry weight were enhanced by the application of effective microorganisms (T_3) and length of fruit, diameter of fruit and number of seeds/fruit was influenced by coir pith (T_1) than control on 90 DAS in bhendi. Yield attributing characteristics (number of pods, length of pod, number of seeds/pod, pod fresh weight and pod dry weight) of cluster bean showed maximum in T_1 (coir pith) and yield/plant, yield/plot and yield/ha were obtained in effective microorganisms (T_3) followed by T_2 compared with C on 90 DAS. The influence of effective microorganisms (T_3) enhanced the number of seeds/plant, yield/plant, yield/plot, yield/ha, straw yield/ha, seeds fresh weight and seeds dry weight of coriander and number of pods, length of pod, number of seeds/pod, yield/plant, yield/plot, yield/ha, straw yield/ha, seeds fresh weight and seeds dry weight of fenugreek followed by T_2, T_1 than C on 90 DAS.

Carbohydrate content was significantly increased in T_1 (coir pith) followed by T_2 (toddy palm shell + microbial consortium + *Eisenia fetida*), T_3 (effective microorganisms) than C (control) on 25, 50 and 75 DAS in leaves of bhendi, cluster bean, coriander and fenugreek respectively. Protein content remarkably increased in leaves of bhendi, cluster bean and coriander in T_3 (effective microorganisms) and fenugreek was observed in T_1 than control on 25, 50 and 75 days after sowing. Chlorophyll a, chlorophyll b and total chlorophyll content in leaves of bhendi, coriander and fenugreek increased significantly with the application of effective microorganisms (T_3) and the cluster bean was influenced by coir pith (T_1) on 25, 50 and 75 DAS than other treatments. On 25, 50 and 75 DAS the leghaemoglobin content in root nodules of cluster bean, fenugreek and on 90 DAS the carbohydrate and protein content in fruits of bhendi, pods of cluster bean and seeds of coriander, fenugreek were enhanced by the application of coir pith (T_1) followed by T_2 (toddy palm shell + microbial consortium + *Eisenia fetida*), T_3 (effective microorganisms) as compared to the C (control) respectively.

Addition of compost (T_6), coir pith and sprinkling of effective microorganisms into the soil increased the value of pH, electrical conductivity, available nitrogen, available phosphorus and available potassium content than initial value of soil. The post-harvest soil of bhendi showed maximum pH and available nitrogen in T_3 and EC, available phosphorus and available potassium was found to be maximum in T_1 than C. The value of EC, available nitrogen, available phosphorus and available potassium in post harvest soil of cluster bean and fenugreek were improved by the addition of coir pith (T_1) and the pH value was enhanced by the application of effective microorganisms as compared to the control in both cluster bean and fenugreek plants. In coriander, maximum value of pH and electrical conductivity was observed in T_3 and the available N, P and K content were observed in T_1 followed by T_2 and minimum in C respectively.

CONCLUSION

The present research brightens the possibilities of using groundnut shell and toddy palm shell in enhancing the crop growth and productivity. The bio-composted groundnut shell and toddy palm shell produced by using *Trichoderma asperelloides*, microbial consortium and *Eisenia fetida* improved the quality of the compost thereby enhanced the

biometric, yield, biochemical and soil nutrient status of bhendi, cluster bean, coriander and fenugreek. The enhancement in growth and yield parameters of test crops may be due to the synergistic interaction of the constituents present in the bio-composted toddy palm shell by microbial consortium along with *Eisenia fetida*.

The present study not only can be viewed as an alternate solution for the disposal of groundnut shell and toddy palm shell waste but also minimizes the application of chemical fertilizers to crops and encourage organic farming. Good organic fertilizer obtains all necessary micro and macronutrients which is a key to enhance sustainability and productivity of crops. Well bio-composted organic matter applied under the right soil would not only improves moisture condition and the structure of the soil but also provide the crop necessary resistance against pest and disease. To conclude the integrated management of groundnut shell and toddy palm shell converted as an organic fertilizer in different combination improved the vegetative and yield parameters of the 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).

RECOMMENDATIONS FOR FUTURE STUDY

- The bio-compost prepared from groundnut shell and toddy palm shell can be utilized as growth promoter in gardening plants instead of using chemical fertilizer.
- Toddy palm shell fibers retain water holding capacity which can used as a substitute of coir pith in agriculture and horticulture plants.
- The compost generated can be tested as manure on different crop plants that need high nutrient supply within a shorter time period.
- The organic manure made from groundnut shell and toddy palm shell has physio-chemical parameters which can be used as nutrient enriched, pathogen free organic manure.
- It is an efficient and economical solution to the current issue of waste management and disposal in our country.