

INTRODUCTION

Agriculture play an important role in the world economy, particularly in India as many people are dependent on agriculture. Most farmers use chemical fertilizers for the cultivation of vegetables and seasonal crops. Chemical fertilizers are used to strengthen the fertility of the soil and increase crop yield. However, it had a negative impact on soil microorganisms, biochemical and geochemical cycles. The usage of toxic synthetic fertilizers plays a vital role in agro-ecosystem which causes various harmful effects like soil degradation, genetic diversity of crop loss, soil microorganisms reduction, groundwater resource contamination and atmospheric pollution (Erana *et al.*, 2019). The continuous routine usage of chemical fertilizers declines the yield of crops due to the soil acidification and loss of physico-chemical properties (Ghimire *et al.*, 2017). Hence, it is necessary to stop the conventional farming system and to practice agriculture through organic in order to reduce pollution and maintain healthy environment.

Organic agriculture is a holistic production management that promotes the biological cycle of soil and biodiversity (Vijayanand *et al.*, 2014) that uses fertilizers of organic origin such as compost manure, green manure, farmyard manure, biofertilizers and vermicompost which enrich the soil properties and promotes the crop growth and yield. Organic manures can serve as an alternative to mineral fertilizers for improving microbial biomass (Dhull *et al.*, 2004) and soil structure (Dauda *et al.*, 2008) which plays a direct role in plant growth as a source of all necessary micro and macro nutrients in available forms during mineralization (Chaterjee *et al.*, 2005). The use of organic fertilizer enhances soil physical, chemical and biological properties, and act as a good soil conservator by upholding its fertility, securing sustainable agricultural production and improving the quality of crop (Islami *et al.*, 2011; Adhami *et al.*, 2014). At the same time, agriculture faces another problem is the disposable of agricultural wastes.

The disposal of solid waste is a prominent environmental problem all over the world. The improper disposal of those wastes creates environmental pollution and vector-borne diseases spread by insects and rodents could result in health hazards to human

beings. The accumulation of waste generated from industries, municipal solid waste, domestic waste and agricultural wastes in the form of liquid, slurry and solid depends on the nature of the waste. India generates 500 million tons of agricultural waste per year. Agricultural wastes are crop residues, weeds, leaf litter, straw waste and forest wastes which are disposed of by dumping or burning in the open field creating environmental pollution. Dumped agricultural residues of groundnut shell and toddy palm shell are as shown in Plate 1a, b and c.

Plate - 1

Disposal of Agricultural Wastes



Groundnut (*Arachis hypogea* L.) is one of the most common commercial crops cultivated throughout the tropical and sub-tropical parts of the world. Annually, 45.6 million metric tons of groundnut are produced globally. Every kilogram of groundnut produces around 250-300 g of groundnut shell (Zhao *et al.*, 2012). Groundnut shell is a waste product obtained after the removal of groundnut seeds from its pod (Usman *et al.*, 2016). Every year the production of groundnut has increased simultaneously the waste materials also increased.

On the other hand, Toddy palm (*Borassus flabellifer* L.) is Tamil Nadu's state tree belonging to Arecaceae family. It is mainly grown for building materials, furniture, handicraft, medicinal, beverage and foods. The fruits are sedative, aphrodisiac, stomachic and laxative in nature. Almost all parts of the plant have economic value except their shells, about 70% of shells are considered waste. After separating the sweet jelly seed sockets, the fruit husk (shell) consists 40 - 50% of mesocarp and exocarp is thrown away or burnt in the open field creating environmental pollution (Rodiah *et al.*, 2019; Madhu *et al.*, 2016). To avoid this situation recycling is one of the best approaches for converting waste to wealth products.

Few reviewers reported on the application of recycled groundnut shell and toddy palm shell such as the production of hydrogen (Evans *et al.*, 2002), dye degradation (Zakariyya and Saifullahi, 2018), biodiesel (Udeh, 2018), paper production (Upendra *et al.*, 2018) from groundnut shell and toddy palm shell into activates carbon (Khaing *et al.*, 2020), cellulose microfibers (Reddy *et al.*, 2016), building materials (Osakwe *et al.*, 2015), biofuel (Madhu *et al.*, 2016) and biochar (Kongnine *et al.*, 2020).

However, the groundnut shell and toddy palm shell contain a higher amount of lignin and cellulose content which is the major weakness of their use on a large scale. Composting is a biological decomposition process that converts organic matter into a stabilized nutrient-rich products through microbial activities (Manohara *et al.*, 2017). It is cost-effective method suitable for all environmental conditions and acts as a good soil conditioner that contains major plant nutrients such as nitrogen, phosphorus and potassium (Ingelmo *et al.*, 2012). The composting along with cow dung accelerates the degradation process thereby enhancing the compost quality and eliminating harmful pathogens (Eg. *E. coli*) and ammonia gas which is a good source of organic fertilizer and contains plant essential nutrients.

Microorganisms play a vital role in the biodegradation of organic materials through breakdown of most recalcitrant substances such as lignin, cellulose and hemicellulose and the joint action of microbial consortium and earthworms biodegrade the organic waste at a faster rate (Lim *et al.*, 2016). Two or more microorganisms such as bacteria, fungi and actinobacteria symbiotically living in a group called as microbial consortium accelerate the

composting process, enhances plant growth, crop biomass and nutrients uptake (Akhtar and Siddiqui, 2008). Various studies have reported that more constant positive results were obtained by inoculating plants with microbial consortium than single source (Singh *et al.*, 2018). The present study bio-degradation on groundnut shell and toddy palm shell through microbial consortium such as Bacteria (*Bacillus licheniformis*), Cellulolytic fungi (*Paecilomyces variotti*), lignolytic fungi (*Pleurotus florida*) and Actinobacteria (*Streptomyces lavendulae*).

Bacillus licheniformis is a gram-positive, rod-shaped spore forming bacteria commonly found in the soil. *B. licheniformis* have a high level of cellulase activity which can degrade organic materials by secretion of hemicellulase and cellulase (Hong *et al.*, 2007). It has a high reproductive rate and do not produce any gas or foul odor in the atmosphere, hence suitable for a healthier environment. *Paecilomyces variotti* is a common saprophytic fungus that is widespread in decayed plant materials, soils and food products. The genus *Paecilomyces* contains several species and the most common are *P. variotti* and *P. lilacinus* growing rapidly and colonies are flat, funiculus and powdery to leathery. *Paecilomyces* plays a significant role as an endophyte in numerous plants and can be used indirectly or directly as a potential bio-stimulant and *P. variotti* are able to produce gibberellins and indole-acetic acid (Wang *et al.*, 2020; Khan *et al.*, 2012).

The lignolytic fungi *Pleurotus florida* is known as white rot fungi act as a primary decomposer on plant materials and woods which involves the degradation of lignin in their natural environmental conditions. The genus *Pleurotus* can degrade lignin through the production of ligninolytic enzymes like manganese peroxidase, lignin peroxidase and laccase (Ranjini and Padmavathi, 2012). There are several advantages of using white-rot fungi for the degradation of most recalcitrant substances such as lignin, cellulose and hemicellulose present in organic materials (Royer *et al.*, 1991; Glenn and Gold, 1993). In addition, the white rot fungi *Pleurotus* spp. used as a biocontrol agent (Rodriguez-Barrera *et al.*, 2021).

Streptomyces lavendulae (actinobacteria) are aerobic, gram-positive bacteria that resemble fungi in structure and have the potential to act against plant pathogens. The free-living actinobacteria (*streptomyces* spp) encourage the fertility of soil through a contribution of many components, enhancing the nutrients, solubilizing phosphate,

producing siderophores and different kinds of enzymes such as chitinase, lipase, amylase, cellulase, keratinase, invertase, pectinase, phytase, peroxidase, xylanase and protease which are able to degrade insoluble organic polymers such as cellulose and chitin breaking into simple mineral form (Jog *et al.*, 2016).

The filamentous fungi *Trichoderma asperelloides* are present in all types of soils belonging to the family Hypocreaceae. The genus *Trichoderma* is the ability to produce lytic enzymes such as chitinase, cellulase, β -1,3 glucanase, poly galacturonase and protease that can degrade cellulose, hemicelluloses and lignin in the plant materials and acts as a biocontrol agent against several phytopathogenic fungi (Pandya and Saraf, 2010).

Earthworms plays significant eco-functional role in the soil ecosystem by affecting the chemical, biological and physical properties of soil. Earthworms can convert large particles of organic waste into vermicasts thus significantly enhancing the amount of plant hormones, plant nutrients and microbial diversity. Composting of organic materials with the help of earthworms is called vermicomposting. Vermicomposting is being considered as a potential option for solid waste management that involves the stabilization of organic material by the joint action of earthworms and microorganisms (Wani and Rao, 2013) which is a rich source of micro and macronutrients improves chemical, physical, and biological properties of soil (Meena and Yadav, 2015). The beneficial microorganisms present in the earthworm gut produce gastrointestinal enzymes (protease, amylase, cellulases and lipases). The selection of earthworms is very important for composting which must be adapted to all environmental conditions and should have a high rate of digestion, consumption and assimilation. *Eisenia fetida* is a surface feeder more suitable for small scale farming which is adapted in decayed organic materials. The worm can consume food as 1/2 of its weight of body and called as tiger worm, red wiggler, red worm, panfish worm etc. Composting of waste materials with earthworm assistance is one of the good approach for recycling and improving production the production of crop (Garg *et al.*, 2006). Vermicompost plays an important role in improving the growth and yield of different field crops, flowers, fruits and vegetables (Lekshmanaswamy, 2014).

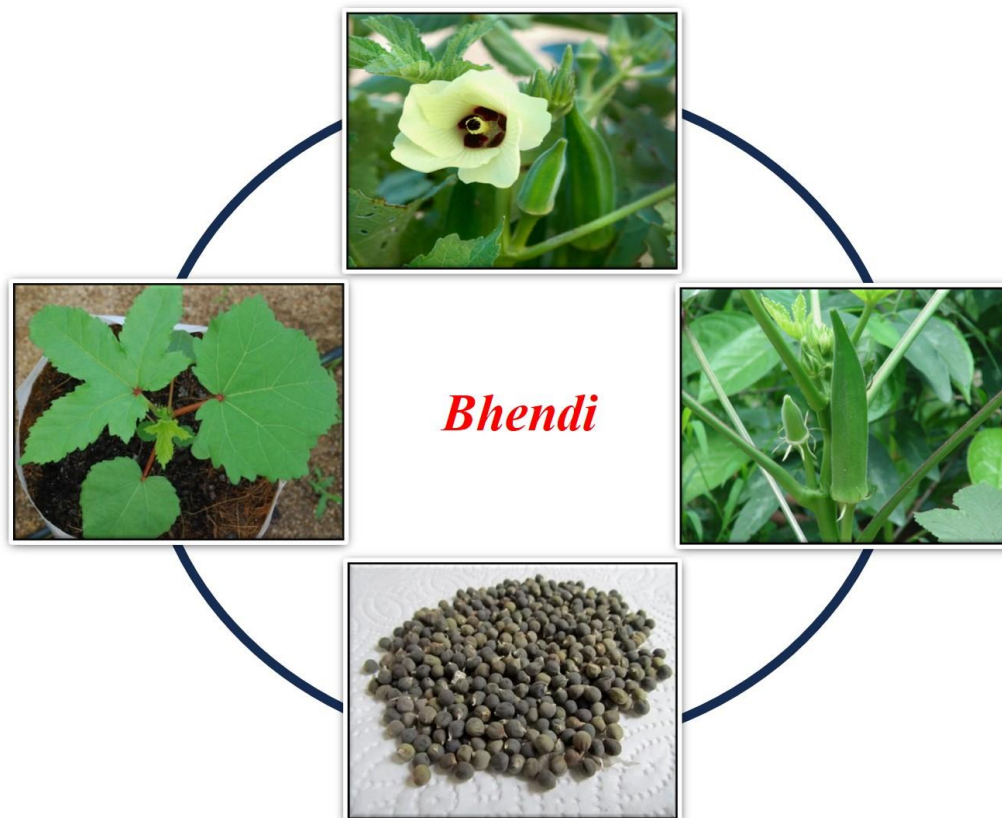
Keeping all this in mind the current study deals with the impact of bio-composting of agricultural residues groundnut shell and toddy palm shell on plant growth performance

of Bhendi (*Abelmoschus esculentus* (L.) Moench Var. Co 4), Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1), Coriander (*Coriandrum sativum* Var. Co (CR) 4) and Fenugreek (*Trigonella foenum-graecum* (L.) Var. Co 2).

Bhendi (*Abelmoschus esculentus* (L.) Moench) is one of the most important annual vegetable crop cultivated throughout the tropical and subtropical parts of the world (Emuh *et al.*, 2006). The plant is tall with upright heart shaped three to five lobed leaves (Plate 2). The flowers are yellow color with crimson centre like hibiscus flower and fruits are 10-20 cm long that contain numerous small oval seeds. The major bhendi producing states are Bihar, Andhra Pradesh, Uttar Pradesh, Orissa and Karnataka. Tender fruits are used as vegetables for culinary purposes and seeds contains good sources of proteins, vitamins, minerals, calories, oil and amino acids (Gemedé *et al.*, 2014; Brady and Weil, 1999). In addition, the seeds of bhendi contains galactomanan content which has several medicinal values and used for gum preparation. The mature fruit and stem containing crude fibre used in paper making industry.

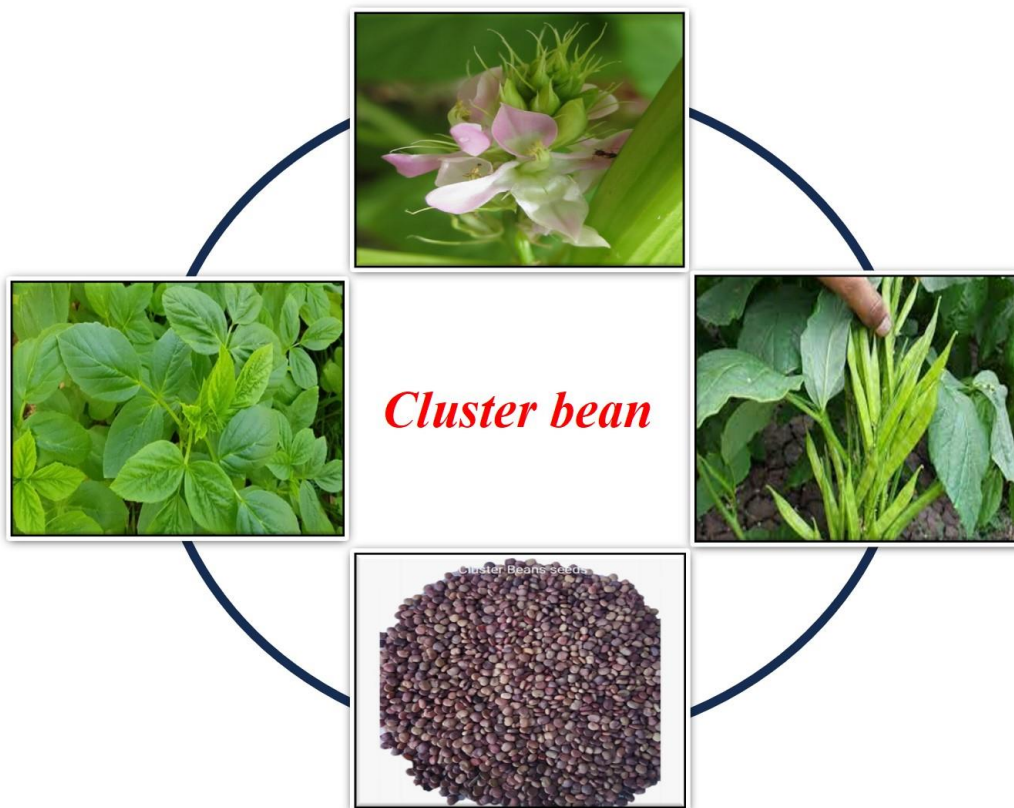
Cluster bean (*Cyamopsis tetragonoloba* L.) is an annual leguminous crop belonging to the family Fabaceae. Cluster bean is a rough, bushy, straight, drought resistant annual summer plant grown at two to four feet in height (Plate 3). The leaves are trifoliate, toothed, pointed and flowers are small purplish white borne along the axis of a spikelet, pods are arranged in cluster form at 3-4 inches long (Sharma *et al.*, 2011). In India, it is mainly grown in Haryana, Tamil Nadu, Maharashtra, Rajasthan, Punjab, Gujarat and Andhra Pradesh. The green tender pods are a rich sources of vitamin C & A and iron. The cluster bean plant has been much appreciated for its gum obtained from endosperm of seeds. Cluster bean mainly grown for food, animal feed and fodder to crop with various industrial uses such as paper, food, mining, textile, explosives, oil drilling and ore flotation etc. (Satyavathi and Vanaja, 2017).

Plate – 2

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

Coriander (*Coriandrum sativum* L.) is an annual herb belonging to the family Apiaceae. It is a soft plant growing 50 cm tall and leaves are arranged in variable shapes with a broad lobe present in the base of the plant (Plate 4). The flowers appear in small umbels with pale pink or white color and the fruit is globular in shape. Tamil Nadu, Madhya Pradesh, Rajasthan and Karnataka are major producers of coriander in India. Coriander seeds are rich in volatile oil used as a spice and folk medicine and seeds have laxative, diuretic, anti-diabetic, hypolipidemic, carminative, tonic and anti-cancer effects (Ghamarnia and Daichin, 2013). It is a medicinal and culinary plant cultivated for both seeds and tender leaves.

Plate – 3

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

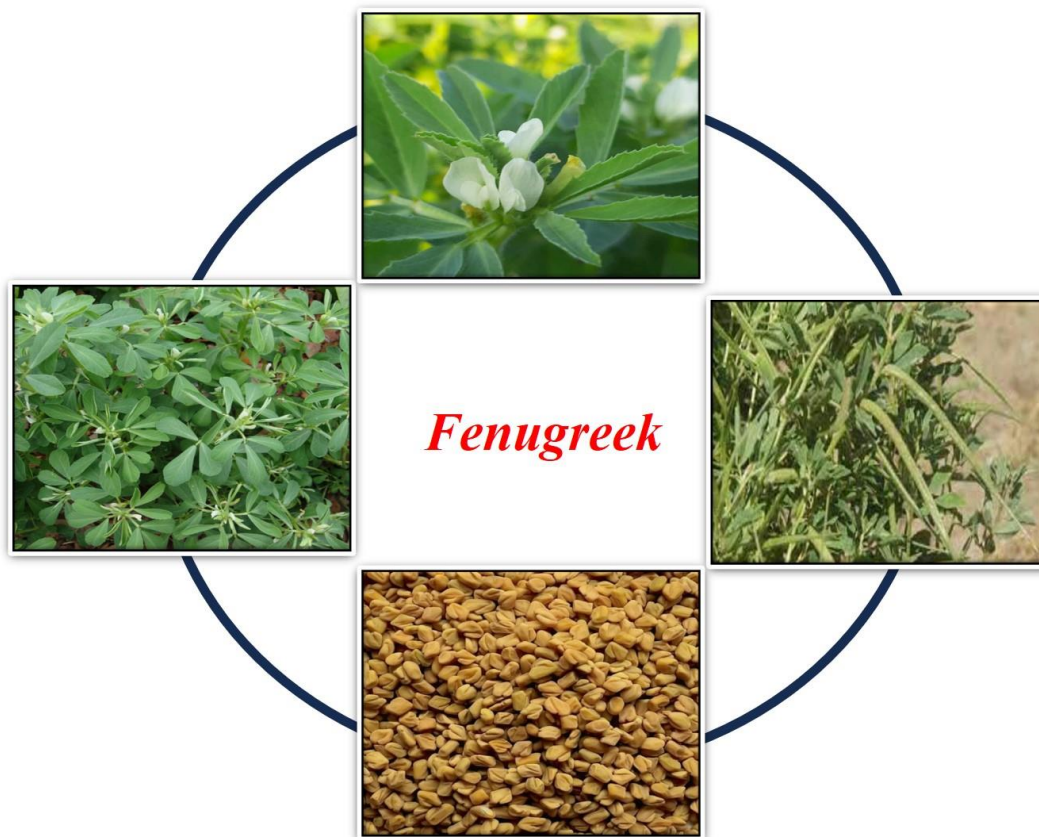
Fenugreek (*Trigonella foenum-graecum* L.) is an annual forage legume belonging to the family Fabaceae. Fenugreek leaves and seeds are used in many countries around the world for different purposes. The plants are erect, tall about 90 cm in height with trifoliate leaves. The flowers are small with white color and pods are long up to 15 cm, contains small brownish yellow color seeds (Plate 5). In India, the highest production was obtained from Rajasthan followed by Madhya Pradesh, Gujarat and Uttaranchal. Fenugreek seeds and leaves are the best medicine to treat hypercholesterolemia and diabetes in India and China (Basch *et al.*, 2003) and it is the best remedy for antiviral, antitumor, antimicrobial, antioxidant and antidepressant activities (Shetty, 1997). It is one of the major seed spices crop grown throughout the country and seeds of fenugreek contains L-tryptophan and lysine, mucilaginous fiber, proteins, coumarin, nicotinic acid, saponins, fenugreekine, phytic acid, trigonelline, saponins and scopoletin (Bukhari *et al.*, 2008).

Plate – 4

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

The fertility of soil is one of the most important characteristics of soil for crop growth. For optimum plant growth, it requires a soil that provides deep rooting, good aeration, good water retaining capacity and contains an adequate level of plant nutrients. Nitrogen, phosphorus and potassium are the three most important macronutrients required for crop production. Plants need 16 elements for successful plant growth, each one of which has one or more special functions in the growth and development of plants. Soil microorganisms play a vital role in soil fertility, organic matter decomposition, nutrient cycling and plant growth promotion which are able to transform biochemicals within plants. Practicing soil fertility management by enhancing fertility of soil through use of fertilizers, crop rotation, organic inputs and leguminous grain. The cultivation of legumes enhances the soil fertility through biological nitrogen fixation and helps to reduce the use of commercial nitrogen fertilizer.

Plate – 5

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

Organic farming helps to improve the quality of crops and reduce environmental pollution. Organic fertilizers increase the fertility of the soil, microbial activity and provide long term nutrients by gradual decomposition (Angin *et al.*, 2017) which reduces the use of chemical fertilizers and pesticides. The current study will provide not only an alternate solution for the dispose of groundnut shell and toddy palm shell but also reduce the application of chemical fertilizers for sustainable crop production through organic agriculture.

Keeping all this in mind, the study was conducted to investigate the efficacy of biocomposted groundnut shell and toddy palm shell on biometric, yield, biochemical and soil nutrients status 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).

Objectives of the Study

- To evaluate the efficacy of bio-composted groundnut shell and toddy palm shell by microbial consortium, *Trichoderma asperelloides* and *Eisenia fetida*.
- To count the microflora present in the bio-compost.
- To study the physico-chemical and spectrochemical analysis of raw and composted groundnut shell and toddy palm shell.
- To assess the effect of bio-compost on the growth and yield parameters of selected crops such as bhendi, cluster bean, coriander and fenugreek under field culture.
- To estimate the biochemical parameters of selected plants in different treatments of agricultural wastes.
- To analyze the pre and post harvested soil of selected plants.
- To evaluate the influence of effective microorganisms and coir pith under field culture.
- To study the growth, yield, biochemical attributes and soil nutrient status of bhendi, cluster bean, coriander and fenugreek under the best treatment.