

INTRODUCTION

Agriculture is the science and art of rejuvenating the soil by cultivating crops and livestock. It consists of preparation of plant and animal products which provides most of the world's food and fabrics. Agriculture also defined as the science or practice of farming which include growing crop by cultivation or rearing of animal. People cannot survive without productive agriculture. From ancient time, man used various kinds of vegetable manures, dung, urine and decaying animal matter, chicken manure and green manure crops for enriching the soil. Organic agriculture is a holistic production management system in agriculture which enhances biodiversity, biological cycles and soil biological activity thus promotes the agro ecosystem.

Continuous use of organic manure will result in sustainable agriculture, safe food, good nutrition, animal welfare and sustainable ecosystems (Sivasankari, 2016). India holds the record for second-largest agricultural land in the world, with around 60% rural Indian households making their living from agriculture. Agriculture plays a vital role in India's economy with 54.6 % of the total workforce is engaged in agriculture and allied sector activities. India also produces about 600 million tonnes of crop residue each year, with the majority of being permitted to degrade naturally or burned on the spot as reported by the Intensive Agriculture survey (2022) of Indian Government. Agro-industrial wastes pose great economic and environmental hazard and their safe disposal is major distress to industries. Untreated organic wastes have high chemical and biological oxygen demand and uncontrolled disposal causes environmental pollution, landfills, eutropication, economic losses, health risks and climate change by producing green house gases (Musyoka, 2020).

Organic agriculture is a sustainable alternative to traditional agriculture using environmental friendly strategies in which application of organic fertilizers and pesticides from plant, animal waste and microbial consortia are used (Duran-Lara *et al.*, 2020). Increasing population causes serious challenges to Indian agriculture production of high yielding crops responsive to chemical fertilizers and cropping mechanism pose the

problem of weeds, insects and pests causing losses in output (Singh, 2021). However, organic farming has gained increasing prominence.

Organic farming is helpful for the production of safe food at low cost. There are different components in organic agriculture viz. green manures, biocomposting, vermicomposting, manure preparations with various wastes of agriculture and industries. Recycling of organic waste is an attractive method that is used as soil conditioner for waste management (Bhat *et al.*, 2017).

Organic waste management is regarded as a basic component in sustainable agriculture as it assists with maintaining the natural balance of nutrients in the soil. Organic cultivation is ecofriendly and maintains the harmony with nature. It encourages yield, grain quality and volatile organic compounds. Organic farming is indeed not restricted to practice of supplying organic manures, but also with the sole aim of strengthening crops (Hosamani *et al.*, 2023).

Vermicompost is an essential part of the broad system of waste management in organic farming because recycling of waste using eco-friendly agricultural techniques by introducing earthworm species. It alternates the usage of chemical fertilizers. Organic farming is a low-cost technology and it provides the soil with sufficient micro and macro nutrients required for the growth of the plants (Hand *et al.*, 1988; El Jawaher, 2020).

Agricultural wastes are residues generated from agricultural product processing units. The primary constituents of crop residue and agro-industrial wastes are cellulose, lignin and hemicellulose. However, their management poses a global challenge as much of it is currently disposed of through burning, leading to air pollution, as well as contributing to global warming (Koul *et al.*, 2022). This highlights the urgent need for sustainable solution to address the processing of these materials and mitigate their environmental impact. By using the knowledge of waste management we can convert wastes into beneficial materials (Obi *et al.*, 2016). Recycling of agrowastes helps in two ways, it helps in disposal mechanism and on other hand in resource management (Sakthi vigneswari and Vijayalakshmi, 2017).

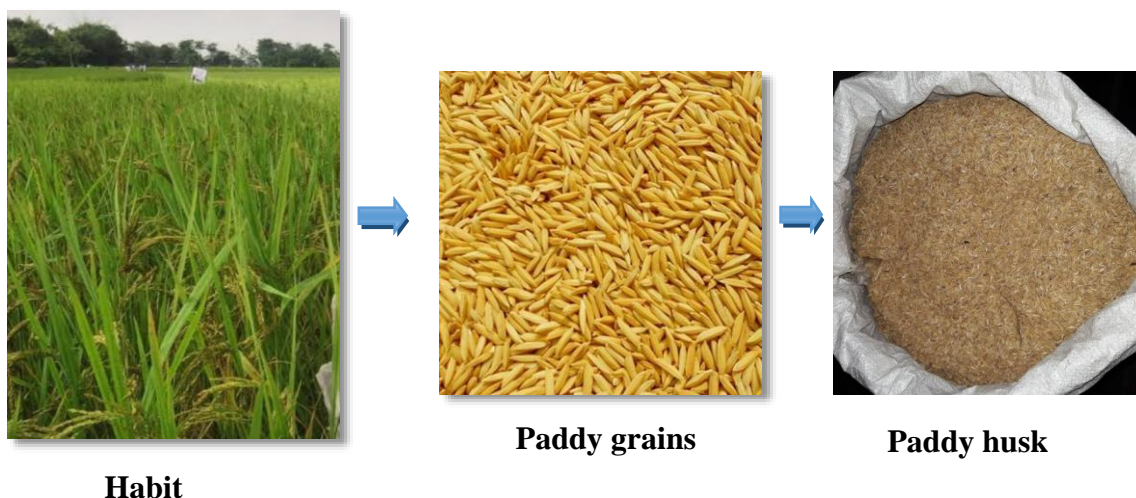
Paddy and coffee husk can be classified as agro-industrial wastes due to their origin from agricultural processes and their potential for industrial applications. These husks are

by-products of rice and coffee production respectively and are generated during the processing of these commodities. The Intensive Agriculture survey (2022) of Indian Government reported that paddy is the second most widely grown cereal crop. India has the largest paddy growing area (43.80 million hectares) in the world but contributes to less than a quarter of global production (177.65 million tonnes in 2019 with consumption of 106.5 million tonnes per year). Rice accounts for more than 40% of the food grain production of the country and has the highest export volume of rice worldwide at 15.5 million metric tonnes as of 2020-2021. Ministry of Agriculture and Farmers press release reported that total production of rice during 2022 - 23 is estimated at 1308.37 lakh tonnes. It is higher by 13.65 lakh tonnes as compared to previous year.

Paddy (*Oryza sativa* L.) is a member of poaceae. An annual crop grows upto 1.2 meters. Leaves are long, flattened. Inflorescence panicle with spikelets producing the fruit or grain. The harvested paddy is rice enclosed by the hull or husk. The paddy husk consists of silica and lignin which protects the seed during the growing season. Milling removes the hull and bran layers of the kernel, it is used as animal bedding material, fuel source in biomass power plants as pellets and raw material is used for paper and packaging products manufacturing.

Plate -1

Production of husk from paddy

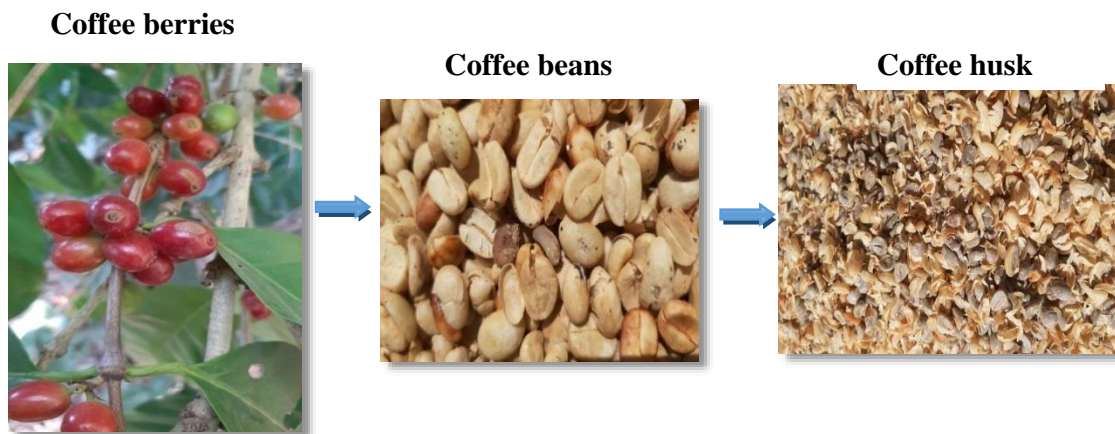


Paddy husk is the byproduct of the rice milling industries, therefore agroindustrial residue are abundantly available in various paddy producing countries. Approximately 140 million tonnes of paddy husk is produced worldwide annually. It is hard covering of rice grains and composed of cellulose, lignin and hemicelluloses due to this reason the paddy husk is either burnt or dumped as waste while some of the husk is converted to use for cattle feed (Plate - 1). When it is burnt, it causes environmental and health problems. Recycling of such waste can be beneficial to the environment and this agroindustrial waste can be used to produce useful agricultural soil input (Mohamed *et al.*, 2015; Britanica, 2023).

Coffee (*Coffea arabica* L.) is a member of rubiaceae. An evergreen shrub 5m tall and glabrous. It poses simple, alternate and opposite leaves. Star shaped white scented flowers are seen in clusters. Fruit a drupe possess shiny exocarp, fleshy mesocarp and tough endocarp. Dry seeds provide coffee beans (Prandi *et al.*, 2021).

Plate -2

Production of coffee husk from coffee plants



Coffee husk dumped as waste at coffee board (Araku Valley)



Coffee (*Coffea arabica* L.) is an important export product that has substantial foreign exchange for the producing countries. In India, coffee is cultivated mainly in southern states of Karnataka (72%), Kerala (20%) and Tamil Nadu (7%) (Velmourougane and Raphael, 2012). Ministry of Commerce and Industry press release reported that production of coffee during 2021-22 is 4.16 lakh tonnes. India was 5th largest exporter of coffee in the world with a share of about 6% of global coffee exports. One of the top commodities produced and commercialized worldwide is coffee. Processing of coffee generates significant amount of coffee pulp and cherry husk. Coffee husk is the dried out husk of the coffee cherry or coffee fruit and the process includes dehusking of the dried fruit by unraveling the dried husk from the coffee seed (Plate - 2). Husks and pulp are the major residues obtained during processing. They can be used as soil conditioner, feed stock for biofuel production and in cosmetic industry but their unsafe disposal causes a major environmental problem causing land pollution and water pollution.

India produces approximately 10 million tonnes of coffee husk annually. Large potential is noted by recycling of pulp and husk that can be composted and used as manure for several crops (Sekhar *et al.*, 2014; Oliveira and Franca, 2015). Resource recovered through composting is one of the best approaches for obtaining nutrient and organic-rich biowaste (Waqas *et al.*, 2018).

Agroindustrial wastes like paddy and coffee husks when burnt on the road sides or in the fields emit toxic smoke and disturb the environment which can be avoided and nutrients can be obtained through the biocomposting. Compost not only as primary source of nutrients but with diverse set of microbial consortia with high level of organic matter leads to significant benefits (Shilev *et al.*, 2007). As part of organic farming, agricultural wastes can be converted into biocomposts which will reduce the usage of chemical fertilizers. Hence it is an excellent option for reducing environmental threats.

Fertilizers, pesticides and fungicides are widely used in agriculture to improve crop yields. In the present scenario several countries are trying to reduce the use of agrochemicals. Vermicompost is an alternative method which allows composting with minimal space, vermicompost process is very easy method and its application in various scales made it an interesting topic in all over the world (Kumar *et al.*, 2018).

Compost consists of high microbial diversity. Compost bioremediation takes less time than land farming (Shilev *et al.*, 2007). Composting and vermicomposting are considered as promising methods for disposing of organic wastes. Vermicomposting helps in the management of food, agricultural and animal wastes into agricultural fertilizer which enhances the production of nontoxic and nutritional crops (El Jawaher, 2020). Vermicomposting is the technique of using earthworm species that convert organic waste into nutrient loaded compost. The earthworms' casting is nutritive organic manure rich in humus, NPK, micronutrients, beneficial microbes, antibiotics, enzymes and growth hormones (Kumar *et al.*, 2018).

Organic manure improves the soil structure, enhances soil fertility, increases soil microbial population and improves soil moisture holding capacity in the soil. Agriculturists have the additional responsibility of maintaining the soil health. Due to this reason there has been increasing demand of using beneficial micro organisms to improve plant health and productivity (El Jawaher, 2020).

The presence of lignocellulosic content in the waste materials may slow down the microbial degradation process. Paddy and coffee husk are rich in lignin and cellulose content and are usually dumped, when they are burned, it emits lot of smoke and pollutes the environment. All these undesirable process affects the soil and environment. Loss of nutrients could be avoided by recycling the agrowastes through composting and to make the process of degradation easier and viable.

The waste can be incubated with lignocellulytic microorganisms such as mushroom spawn (*Pleurotus eous* and *Pleurotus florida*) due to their exceptional ligninolytic properties. *Trichoderma asperelloides* mold has exceptional production of variety of enzymes in degrading the cellulose and lignin. Exotic earthworms *Eisenia fetida* are generally considered to be safe, efficient and they are found to degrade, provide nutrient rich vermicompost by facilitating the transfer of nutrients to plants (Gopal *et al.*, 2009; Velmourougane and Raphael, 2012).

The safe and advisable approach in today's world is the decomposition process with microorganisms though they are unnoticed in the compost pile but they are completely responsible for the organic material to break down because they are decomposers and use

enzymes to break down the organic matter. Legumes are important sources of nutrients and serve as rich dietary protein sources (Dent and Cocking, 2017). Leghaemoglobin is an oxygen carrier and has haemoprotein found in root nodules of leguminous plants. It is produced in response to nitrogen fixation in leguminous roots as part of the symbiotic interaction between plants and bacterium. Leghaemoglobin plays an important role by providing oxygen to the bacteria in the process of respiration and enzymatic activity (Singh and Vijayalakshmi, 2013).

In India, medicinal plants are readily available at low cost, but due to the over exploitation of local and traditional medicinal plants are becoming endangered. India also has the source of information and skill to increase its research and development of herbal medicines. The evidences show immense utility of medicinal plants in herbal medicine (Doshi *et al.*, 2014).

Increase of new diseases and unavailability of modern drugs has made everyone to search for other alternative medicines from the plant source and protect them. To cope up with this distressing situation recent developments in agriculture has given us the way of organically grown medicinal plant based drugs has come as great assistance to the pharmaceutical industries. Medicinal plants are considered to be gift of nature all around the world due to the availability of various antioxidant substances in them which will fight against the free radicals (Uthirapandi *et al.*, 2021).

Continuous use of chemical fertilizers can cause harmful effects to our human health as well as the quality of soil nutrition and its productivity. Many evidences of this chemical based fertilizer production and their uses show drastic changes in human health. Hence, keeping all this in account as well as for the benefit of protecting the environment, the present study deals with the promotion of biocompost on leguminous plants moth bean (*Vigna aconitifolia* (Jacq.) Marechal) Var. RMO - 40, black gram (*Vigna mungo* (L.) Hepper) Var. CO - 6 and medicinal plants fenugreek (*Trigonella foenum-graecum* L.) Var. Lam Selection -1 and kalmegh (*Andrographis paniculata* (Burm.f.) Nees) Var. CIM - Megha.

Moth bean (*Vigna aconitifolia* (Jacq.) Marechal) Var. RMO - 40 usually called as mat bean, moth bean, dew bean and Turkish gram in English. It belongs to the family fabaceae having prostrate, creeping habit (Plate - 3). The main stem is slender, erect grows

up to 40 cm height, with alternate, compound and trifoliate leaves. The inflorescence is axillary dense false raceme, papilionaceous and bisexual. Fruits are pods with rectangular to cylindrical seeds. It is one of the most drought resistant crops growing in semi - arid and dry areas of Gujarat, Karnataka, Rajasthan, Maharashtra and Haryana.

Plate - 3

HABIT

Moth bean (*Vigna aconitifolia* (Jacq.) Marechal) Var. RMO - 40



Moth bean is a multipurpose legume, outstanding in providing delicious hot season fodder, hay for livestock and seeds for human consumption. The seeds are rich in protein, vitamins, minerals, starch and amino acids. Moth beans used in strengthening of bones, boosting immunity, regulating the bowel movements, reducing stress and they are also called the power houses of vitamin B, used in protecting heart. Sprouted moth bean are rich in calcium, dietary fiber and play a prominent role in building stronger muscles (Saravanan and Ignacimuthu, 2015; Sipai *et al.*, 2018).

Black gram (*Vigna mungo* (L.) Hepper) (Plate - 4) is one of the most important pulse crops, grows throughout the country, resistant to adverse conditions of the climate and improves soil fertility by fixing atmospheric nitrogen. Black gram is commonly called as ‘urd’ or ‘urd bean’ and is native to central South Asia. It is a member of fabaceae. An erect annual plant growing to a height of 30 to 100 cm. It is an annual crop mainly grown South and South East Asian countries such as Afganistan, Bangladesh,

India, Pakistan, Nepal, Myanmar, Philipines, Sri Lanka and Thailand (Kaewwongwal *et al.*, 2015). Leaves are trifoliolate, inflorescence bears yellow small papilionaceous flowers.

Plate - 4

HABIT

Black gram (*Vigna mungo* (L.) Hepper) Var. CO – 6



Pods hairy with hooked beak and contains ellipsoid black seeds (Gomathinayagam *et al.*, 2021). India is the world largest producers and consumer of dal which can be eaten wholly or in split, boiled or roasted. It contains 24% of protein, 60% of carbohydrate and 1.3% of fat rich in essential nutrients, minerals, vitamins, dietary fiber and antioxidants. The seeds are being used as staple food South Asia (Shekhawat *et al.*, 2018).

Fenugreek (*Trigonella foenum-graecum* L.) (Plate - 5) is called as Greek hay in Latin and methi in Hindi. It is an annual plant belongs to the family fabaceae, cultivated worldwide as a semi arid crop for its leaves and seeds. The plant is erect, smooth, herbaceous grows up to 40 cm height, leaves are alternate, compound trifoliolate, flowers are papilionaceous born on leaf axils, fruits are sickle shaped thin and pointed pods. Seeds are oblong or square shaped brownish with very strong spicy odour and taste. Every part of the plant is being used as leafy vegetable, fodder and condiment.

Plate - 5

HABIT

Fenugreek (*Trigonella foenum-graecum* L.) Var. Lam Selection - 1

Leaves have large quality of protein as well as an essential source of diosgenin. Seeds are rich in proteins with tryptophan, lysine, carbohydrates, fixed oils (lipids), alkaloids, trigonelline, choline, gentianine, carpaine, free aminoacids, calcium, iron, vitamins B, A and C. The plant has been used for medicinal functions since earliest times and being used by pharmaceutical manufacturing industries.

Pharmaceutical properties of fenugreek accounts for its medicinal properties such as carminative, gastric stimulant, antidiabetic and galactogogue, hypocholesterolemic, antilipidemia, antioxidant, hepato protective, anti-inflammatory, antibacterial, antifungal, antiulcer, antilithigenic and anticarcinogenic due to these health benefits. Fenugreek is being treated as pharmaceutical, therapeutic and nutritional potential plant (Yadav and Baquer, 2014; Younis *et al.*, 2020; Gutema *et al.*, 2021 and Visuvanathan *et al.*, 2022).

Kalmegh (*Andrographis paniculata* (Burm.f.) Nees) (Plate - 6) also known as king of bitters or chiretta prioritized medicinal plant in India (Akbar, 2011). The whole herb is used as medicine with its properties (Sanjutha *et al.*, 2008). Kalmegh is an annual, herbaceous plant growing to a height of 30 - 110 cm. It belongs to the family Acanthaceae, native to India and Sri Lanka, widely cultivated in southern and

southeastern Asia, China, America, West India and Christmas Island. The stem is acute, quadrangular, fragile, dark green in colour leaves with simple, opposite, lanceolate and glabrous. Flowers are small in size born in spreading racemes. The fruit of the plant is capsule with many yellow brown small seeds.

Plate - 6

HABIT

Kalmegh (*Andrographis paniculata* (Burm.f.) Nees) Var. CIM - Megha



The plant also exhibits antimicrobial, antioxidant, anti-inflammatory, anti hyperglycemic and hypoglycemic activities with bioactive compounds, including terpenoids, flavonoids, alkaloids, phenols, glucosides and lactones, due to this, the plant got a broad spectrum of pharmacological applications and being used in commercial formulations. Mostly the aerial parts of the plant like leaves and stem are used as a traditional medicine because they contain larger quantities of major active metabolites (Dua *et al.*, 2004; Raina *et al.*, 2013).

Soil can be named as biological bliss with large number of organisms including macro to micro flora and fauna particularly the great biodiversity of microbes are present in soil. Soil is fertile for it is the provider of all nutrients and water to the plant. They retain nutrients by various mechanisms and are able to hold these in the form of ions. The greatest service they render to the ecosystem is by retaining water, recycle nutrients and wastes transforming them into biologically available forms. However,

recently due to increasing human population the soil experience a burden because of intensive use of various inorganic chemicals it has become a threat to the soil sustainability. Continuous use of these chemical fertilizers in larger quantity result in degradation of natural resources and the soil becomes unfit for the agriculture. Nitrogen supply and nitrogen management both are vital factors for crop production.

Indian agricultural scenario has become duller due to the depletion of nutrients, pollution, degradation of land and water resources. In this regard, use of organics biocompost and micronutrient fertilization increases the production of the crops as well as improves the soil nutrients which confirm the role of organic manure in crop production. The foundation for organic farming is to protect soil health hence organic farming is considered to be the holistic production system in Indian agriculture for it improves the ecosystem health and its biodiversity, biological cycles, soil health and microorganism's activity.

Organic farming is also called as natural farming helps in converting and improving the phytochemical content, antioxidant activity and antimicrobial activity of the plants. The study of antioxidant and antimicrobial activity of plants reveal its impact, efficiency of any medicine as well as the quality of food products deterioration, occurrence and propagation of degenerative diseases in the organisms (Needelman, 2013; Meena *et al.*, 2018; Elayaraja and Sathiyamurthi, 2020).

The present work reveals the importance of using paddy and coffee husk biocompost as an alternative source for chemical fertilization and it provides a sustainable production. Experimental work has been conducted to observe the effect of paddy and coffee husk biocompost and its efficiency on the vegetative, biochemical, yield, phytochemical analysis, antioxidant and antimicrobial activity of moth bean (*Vigna aconitifolia* (Jacq.) Marechal) Var. RMO-40, black gram (*Vigna mungo* (L.) Hepper) Var. CO - 6, fenugreek (*Trigonella foenum-graecum* L.) Var. Lam Selection - 1 and kalmegh (*Andrographis paniculata* (Burm.f.) Nees) Var. CIM - Megha. Based on the above reported information the present study is designed.

Objectives of the study

- Preparation of biocompost from paddy and coffee husk wastes.
- To determine the microbial dynamics and physico-chemical transformations during composting.
- To interpret the surface morphological characteristics of raw and biocompost using FESEM.
- To evaluate the functional group of the raw sample and compost by FT-IR spectroscopy.
- To evaluate the efficiency of biocompost on the growth and yield parameters of the selected plants.
- To study the biochemical parameters such as chlorophyll, protein, carbohydrates (leaves and seeds) and leghaemoglobin content in root nodules of selected plants.
- To analyze the antioxidant and antibacterial activity in the seed and leaf extracts of selected plants.
- To identify the phytochemicals present in the methanol extracts of leaves and seeds of the best treatment in medicinal plants.
- To assess the initial and post - harvest soil analysis.