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Preface

We would like to present, with great pleasure, the inaugural volume-6, Issue-4, April 2020, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development*, and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas

Environmental Research:

Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.

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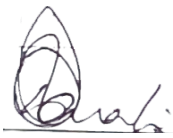

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Nematophagous Fungi: A Biological Agent for Regulation of Plant Parasitic Nematodes

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Abstract— *The occurrence of plant-parasitic nematodes amongst farmers around the globe is a major concern. Farmers also turn to organic pesticides as an additional method to combat pests and diseases. Nematicides are widely available and of significant toxicity in the natural environment, for example, Aldicarb (Temik). Meanwhile, one of the major components of Integrated Pest Management (IPM) is the biological control using other organisms. Many microorganisms predate nematodes, but only handfuls are used for commercial purposes. In addition, the success of a nematode check is strengthened by a combination of two or more biocontrol agents. Fungi can be an efficacious biocontrol agent in particular, and can be feasibly obtained on a large scale. This review would include an outline of the different biomonitoring processes of technological development, but more on the morphological and biochemical dimensions and interactions of nematophagous fungi must be made available. This analysis will contribute to more nematodes and fungal biodiversity resources*.

Keywords— Plant-parasitic nematodes, Biocontrol agent, Integrated pest management (IPM), Nematophagous fungi, Nematicides.

I. INTRODUCTION

The nematodes under the phylum Nematoda (Britannica) are often referred to as roundworms or eelworms. They are the most extensive taxon of the helminth group (Schouteden, De Waele, Panis & Vos, 2015) and all plant and animal groups including aquatic habitats are prone to nematodes (Blouin, Liu, and Berry, 1999). Furthermore, its high fertility rate and reduced lifespan characterize it and survive at varying ambient temperatures, e.g. daily average temperature between < 0 and > 25 ° C, on land and in water. (Moens & Vincx, 2000, p. 2).

Plant-parasitic nematodes are peculiar in terms of feeding behavior by using a stylet to penetrate the feeding host (Jones et al., 2013). The tube known as a stylet begins with the digestive tract. Collagen protein was the precursor to nematode elasticity (Bird and Bird, 1991). Typically, nematodes moult four times during their lifespan before entering an adult stage. In the case of root-knot and cyst nematodes, the most destructive is second-stage juveniles J2 (DACKMAN & JANsson 1991). Besides they are classified into two classes of destructive nematodes, ectoparasite, and endoparasite. Ectoparasitic nematodes feed on the outer layer and cause less damage, while endoparasitic nematodes penetrate the roots and remain destructive for a long time (Agrios, 1997). Other nematodes such as Dagger nematode (*Xiphinema* spp.,) Needle nematode (*Longidorus* spp.,) and stubby-root (*Trichodorus* spp.,) transmit the virus and main mode of ingestion by sucking root sap (Wyss, 1981).

Some plant-parasitic nematodes (PPN) had an impact and ongoing depletion of yield on important agricultural crops. In addition, sedentary endoparasites have a complex structure and are considered to be an important nematode group, e.g. root-node nematodes (*Meloidogyne* spp.) and cyst nematodes (*Globodera* and *heterodera* spp.) (Janson & Lopez-Llorca, 2004). Root-knot nematode (*Meloidogyne* spp) with a huge array of hosts for all communities and the capacity to disperse quickly being the most economically disastrous genera of the plant-parasitic nematode. They are sedentaries and plunge towards the roots for the so-called "root-knot" for nourishment (Elling, 2013). Some root-knot species are *Meloidogyne javanica*, *M.incognita* and *M.arenaria*. Nevertheless, the infestation is probably due to the formation of gall and depletion of water and food. That it would eventually cause the shootings to bolt, wilt, and chlorosis (Crow & Dunn, 2009).

It also poses a serious threat to horticulture crops such as vegetables and cereals and an estimated loss of yield of approximately 50-80 percent (Mukhtar & Kayani, 2019) of nematodes in particular. So far, about one hundred species of nematodes have been recorded. The amount of nematode losses is 20.6 percent in crops reported by Jain et al., 2007 (SHARMA & TRIVEDI).

Heterodera avenae, a cereal cyst nematode called CCN, causes about 15-20% of wheat and 20% of barley due to "Molya" disease (Nicol, Rivoal, Taylor and Zaharieva, 2003). Annual plant-parasitic nematode damages are projected to increase to about $100 billion (Degenkolb & Vilcinskas, 2016).

The most common way in the previous decade of the eradication of Plant-parasitic nematodes by using nematicides. They are inexpensive, and they effectively control nematodes. There are two groups of nematicides, for example, fumigants (1,3 dichloropropene (TeloneII)) and non-fumigants (granules and liquid), e.g. fenamiphos (Nemacur) and aldicarb (Temik). Fumigants became popular because they reduced nematode populations rapidly. (Whitehead, 1986) The predominant toxic compound found in nematicides is Methyl bromide, a multi- purpose fumigant recognized as an ozone-depleting substance (Jansson &Lopez-Llorca, 2004). In addition, nematodes developed resistance to nematicides (Resurgence) and were no longer destroyed by chemical substances (Yang, Tian, Liang, & Zhang 2007). Alternative nematode control measures are less prevalent, such as crop rotation or biological control, an important strategic approach to plant defense (Moosavi & Zare2012). Such problems may be overcome with the use of biological control solutions. This review article focuses on one of these approaches, the nematophagous fungi.

II. NEMATOPHAGOUS FUNGI

Nematodes were found to be a food source that could be parasitized by nematophagous fungi in the 1800s. They are found in fungal taxonomy including Ascomycetes, Basidiomycetes, Zygomycetes, Chytridiomycetes and Oomycetes (Moosavi & Zare, 2012). The majority of fungi live in soil, and their prevalence in organic soils is increased (Janss on & Lopez-Llorca, 2004). The fungi that prey on nematodes are mainly present in nitrogen-deficient soils, including the most available species called nematophagous fungi. Over 150 fungal parasites were taken from cysts and root-knot nematodes. This colonizes the females and attacks *Heterodera glycine* cysts by penetrating the cuticle. *Verticillium chlamydosporium* and *Dactylella oviparasitica* were identified as facultative parasites for attacking cyst and Root-knot nematode young females. *Nematophthora gynophyla* has been found in Northern Europe to be a beneficial Cereal cyst nematode destruction fungus (Kerry,1989).

Some relevant fungal genera include *Trichoderma harzianum*., *Pochonia* Spp., and *Paecilomyces* Spp., which are an excellent monitor of root-knot nematodes (Peiris, Li, Gray, & Xu, 2020). Sharon et al., (2009) have shown that the induction of systemic resistance to *Meloidogyne incognita* by *Trichoderma asperellum* and *Trichoderma harzianum* by virulent genes in tomato cultivars (Pocurull et al., 2020). The combined use of *Pochonia chlamydosporia* and soil residues subsequently decreases the population count of *Meloidogyne javanica* in greenhouse tomatoes (Dalla Pasqua, Dallemole-Giaretta, dos Santos, Reiner, & Lopes, 2020). Trichoderma decreases root-galls and the explanation behind the fact that highly-branched conidiophores and conidia invade various stages of nematodes. Fungi including *Purpureocillium lilacinum*, a filamentous fungi *and Glomus mosseae* have significant potential for handling *Meloidogyne incognita* in cassava and other vegetable cultivation (AKINLESI, 2014). *P. Chlamydosporia* (Horta, 2017) has also encountered potato cyst nematodes, such as *Globodera rostochinensis* and *Globodera pallid* (Nagachandrabose).

Nematodes will inevitably be parasitized, when fungal culture such as *Hirsutella rhossiliensis* and *Drechmeria coniospora* is introduced (Jaffee, Muldoon and Tedford, 1992). Linford (1937), for instance, has found that Meloidogyne in pineapple is suppressed with inoculation in soil by predecious fungal culture.

III. MODE OF ACTION

There are many processes in the tripartite association of nematodes, fungi and roots, including the production of sticky and toxic substances such as Appressoria to infect nematode eggs (Tunlid, Jansson, & Nordbring-Hertz, 1992). The host cells were modified by nematodes secretions and the interface between the plant host and nematodes pathogen was established. The following examples are the adhesive trapping mode in various dimensional networks in the *Arthrobotrys Oligospora* and knobs in *Monacrosporium haptotylum* and branching network in *M.gephyropagon* (Jansson & Lopez-Llorca, 2001). Moozavi & Zare, 2012 illustrated various modifications of fungal infection structures listed in the table below.

TABLE 1
TAXONOMY OF PARASITIC FUNGI AND THEIR INFECTING STRUCTURES

Fungi	Phyllum	Genera	Infecting structures
Nematophagous fungi	Zygomycota	Arthrobotrys	Adhesive hyphae
	Ascomycota	Dactylellina	Adhesive branches Knobs or constricting rings
	Basidiomycota	Nematoctonus	Adhesive knobs
Endoparasitic fungi	Oomycota Chytridiomycota Ascomycota Basidiomycota Blastocladiomycota	Myzoctiopsis Haptoglassa Hirsutella Nematoctonus Cateneria	Zoospores Injecting gun cells Adhesive conidia Spores Zoospores
Egg parasitic fungi	Ascomycota	Paecilomyces	Appressoria
Toxin producing	Basidiomycota	Pleurotus and Coprinus	Pleurotin and Dihydropleurotinic acid, Thorny structure in Coprinus

Source: 'Adapted from Moosavi & Zare, 2012'

Fungal biodiversity and predatory mechanisms rely mainly on environmental factors in soil conditions such as nutrition and temperature (Liu, Xiang, & Che, 2009). Traps are indeed an essential morphological phenomenon and are triggered by artificial means such as peptides, e.g., Phenylalanyl valine or by nematodes (Persmark & Nordbring-Hertz, 1997). The most common form of trapping fungi is sticky branches (e.g. *Arthrobotrys oligospora*, *A.superba*, *Dactylella pseudoclavata*). The tensile strength of the adhesive is a prominent trait of nematode-trapping fungi and increased adhesive secretion after initial contact seems to be necessary for host invasion as seems appropriate for many other host-parasite interactions. The host adhesive is mainly due to the lectin that traps nematode. The random fibrils of the *A.oligospora* are directed in one direction and are perpendicular to the surface of the nematode in their early phases of adhesion (DACKMAN & JANsson, 1991). But due to its nematotoxin, linoleic acid, *Arthrobotrys* Spp., proved damaging (Stadler, Anke & Sterner, 1993). In the genus community, for instance, *Nematoctonus leptosporus* and *N.angustatus* that vary greatly between the trapping Structures on conidia and hyphae illustrate in the following figure 1 and 2.

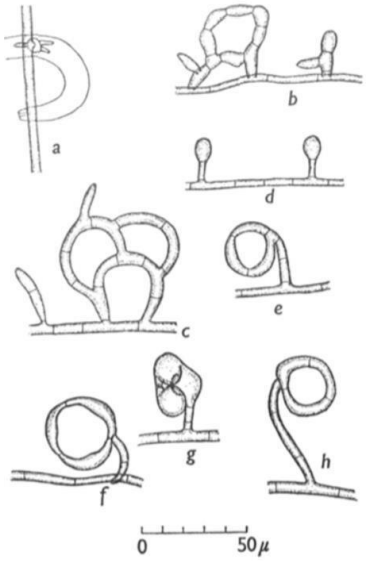

FIG.1.a) Unmodified hyphae with nematode; b) Together, two sticky branches formed a loop; c) adhesive complex or network; d) adhesive knobs or outgrowth; e, f, and g) constricting rings open and closed; h) non-constricting rings

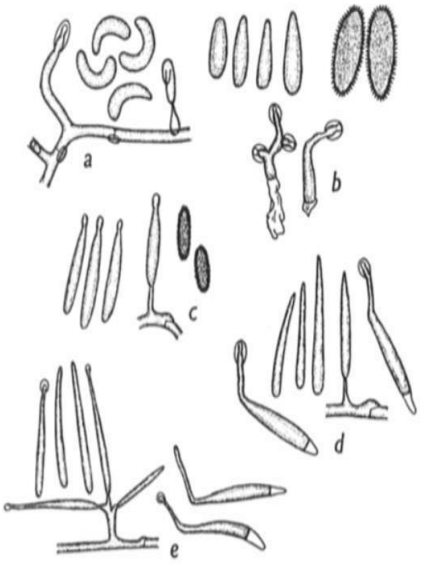

FIG.2. a) conidia and sticky cells of *Nematoctonus campylosporus*; b) chlamydospores, conidia and sticky cells of *N.pachysporus*; c) conidia and chlamydosporus of *N.tylosporus*; d) conidia and adhesive cells of *N.leiosporus*; e) conidia of *N.leptosporus*

Typically, trapping devices originate from mycelium and build on conidia. Unregulated protein (proteases) primarily plays a major role in forming structures such as knobs or constricting rings on hyphae (Andersson et al., 2013). Nematodes are attracted by compounds e.g. CO2 released from host roots (Green, 1971). At the same time, secondary metabolites such as pleurotin and dihydro-pleurotinic acid formed by *Nematoctonus*spp., (Anke, Stadler, Mayer & Sterner, 1995) have both nematicidal and antimicrobial properties. Food substances are competing and the infection structure can develop and make them parasitic and aggressive (Moosavi and Zare, 2011). Similarly, a certain antagonistic fungus develops spores that grow in the esophagus and digest the nematode (Mankau, 1981).

IV. DISCUSSION

Problems with the Use of Nematophagous Fungi

Besides some nematodes are digested by a fungal parasite, some nematodes can parasitize as well, for example, *Filenchusmisellus* (Du, Xu, Dong, Li, & Wang, 2020). A soil ecosystem cannot suit all parasitic fungi, leading to incomplete colonization and exploitation (Mankau, 1981). Some research shows clearly that fungal inoculum cultureis properly connected with crop planting so as to enhance root colonization, for example, Arbuscular Mycorrhizal Fungi. Biocontrol agents (BCAs) are overlooked due to the high- value markets in developing countries, but farmers are not aware of the use of BCA.

Nevertheless, the virulence and the potential of nematophagous fungi are unclear in many respects, when opposed to nematicides and Tolerant varieties. Therefore, two or more Biocontrol agents and nematophagous fungal strains (Abd-Elgawad, 2016) may be successful for control and combined with other pesticide management strategies, due to their less-skilled existence, which could resolve problems.

V. CONCLUSION

The Biological control of plant-parasitic nematodes is well defined, and we need to be much more informed of their physiological and molecular levels (Jansson & Lopez-Llorca, 2004). Molecular techniques have specifically been developed to examine the characteristics of the nematophagous fungi and their control capacity involving DNA sequences and analysis of markers. This results in a more comprehensive development. Developing commercial products for its effectiveness is therefore significant. Such products also reflect the technical improvements that nematology has made in the progress of biological control technology. Biocontrol products are not extensively used as nematicides, owing to the higher manufacturing costs and the need to establish better control of nematodes on crops. In addition, further research is required to perform field experiments such as seed testing with fungal inoculum and pellet processing of a biological agent, as well as a liquid formulation to check its effectiveness. Farmers gain knowledge of recent technology for better understanding by extension service.

VI. FUTURE PROSPECTS

In the previous study, the majority of nematophagous fungi focused upon the involvement of fungi and nematodes in controlled systems. Although the issue of how to use fungus in biological control has been the driving factor, it is the context. There are top priority questions pertaining to the function of nematodes and nematophagous fungi and signals involved in interactions. In order to understand the biological control capacity of these fungi, input from both field and laboratory investigations should be compiled and incorporated in the future. Biological control of nematodes is a simple and feasible task, but it was indeed an inadequate method for management. Combined prospective efforts will concentrate on current knowledge of fungi and in-depth studies of the following characteristics.

1. Development of detailed but simple methods.
2. Population dynamics studies of both nematodes and fungi.
3. Studies of soil fungi and its survival strategies.
4. Continued work on basic interaction mechanisms.

In some experiments, the nature and the actions of nematodes and nematophagous fungi are already clarified by attracting nematodes to various sources. More thorough studies are expected of the adhesive bind of predatory fungi and endoparasitic spores and the adhesive mechanism in soil. The ability to manipulate nematode attraction behaviors or fungal adhesion processes have provided more ways of designing experiments in a competitive environment to explain the factors influencing the fungi.

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Sorghum Yield Under the Canopies of Faidherbia Albida (Delile) A.Chev and *Cordia africana Lam Parkland* Trees in Fedis District, Eastern Ethiopia

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Abstract— *Among several agroforestry practices in the east Hararghe of Ethiopia, Parkland agroforestry practices are common. However, the effect of tree species on the grain yield and above ground biomass of Sorghum has not scientifically quantified in the study area. Therefore, the study was conducted to investigating the effect of parkland trees on the grain yield and above ground biomass of Sorghum at Fedis District, Oromia, Ethiopia. Six isolated and nearly similar F. albida and C. africana trees of each species growing on similar site conditions were selected and the canopy coverage of each tree was divided into four radial transects. Three plots from the tree trunk were established for assessing the sorghum yields and above ground biomass. Sorghum yield and biomass samples from three horizontal distances: 2.5m, 5.0m and 25m were collected for analysis of Sorghum yield and biomass .The result revealed that sorghum grain yield were significantly ($p<0.05$) higher under the tree canopies than open field that means its higher by 2089.51 and 1789.53 kg /ha under F. albida and C. africana respectively at the distance of 2.5m and these values decreased to 1459.40 and 1266.01 kg /ha under F. albida and C. africana respectively, at the distance of 25m. The mean biomass recorded at three different distances from the two tree trunks, were not differently significant statistically ($p >0.05$). The research finding showed that trees have positive relation with grain yield and above ground biomass of sorghum. Hence, the growing of Faidherbia albida and Cordia africana trees on small holder farms improve crop productivity for improvement of this Parkland agroforestry system.*

Keywords— Fedis District, Parkland Agroforestry, Canopy cover, sorghum yield, open field.

I. INTRODUCTION

Climate change, soil erosion, unsustainable farming practices, excessive tillage, overgrazing and deforestation including loss of biodiversity, have led to severe land degradation and desertification Leakey *et.* al. [8]. Poverty levels and population growth rates of Ethiopia (more than 3% per annum) are high, the later exceeding the annual food production growth rates which stand at 2% per annum. The majority of the population (85%) practice subsistence agriculture Hiernaux and Turner, [5] and the dominant land use system and the main provider of food, nutrition, income, and environmental services is the traditional parkland system (integrated crop-tree-livestock systems). Through either farmers managed natural regeneration of trees (FMNR) or active planting, a massive-scale adoption of trees on farmlands can play an important role to enhance tree diversity and cover- at landscape level. Then potentially contribute to enhancing food security of resource poor smallholders through the provision of ecosystem goods and service.

The definition of agroforestry used by ICRAF Leakey, [7] is: "a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits. In addition, parkland trees and shrubs provide firewood and construction materials, and a range of services such as shade for humans and animals, wind protection and aesthetic and spiritual value. Retaining of mature trees on the farmlands is a common practice in most African countries. Thirty-nine percent of African farmland is under 10% or greater tree cover, benefitting more than 100 million people Zomeret al., [15]. Increased tree diversity at landscape level potentially contributes to enhancing food security of resource-poor smallholders through the provision of ecosystem goods and service. Therefore, the study was initiated the to investigate the effects of *F.albida* and *C.africana* trees on the grain yield and above ground biomass of Sorghum under and outside of the canopy to evaluate the grain yield of sorghum and above ground biomass under the canopies of trees species and compared to open field in Fedis district.

II. MATERIAL AND METHODS

2.1 Description of the Study Areas

The study was conducted in Fedis district of East Hararghe Zone, Oromia National Regional State; Ethiopia. It is located in the eastern part of the country at 550 km from Addis Ababa the capital city of Ethiopia and 24 km from Harar town in the southern direction (Figure 1).The geographical location of the district is 8^0 22' 00" and 9^0 14' 00" N and 42^0 62' 00" and 42^0 19' 00" E. The altitude of the area ranges from 500-2100 meter above sea level (FWANRDO, 2017/18).

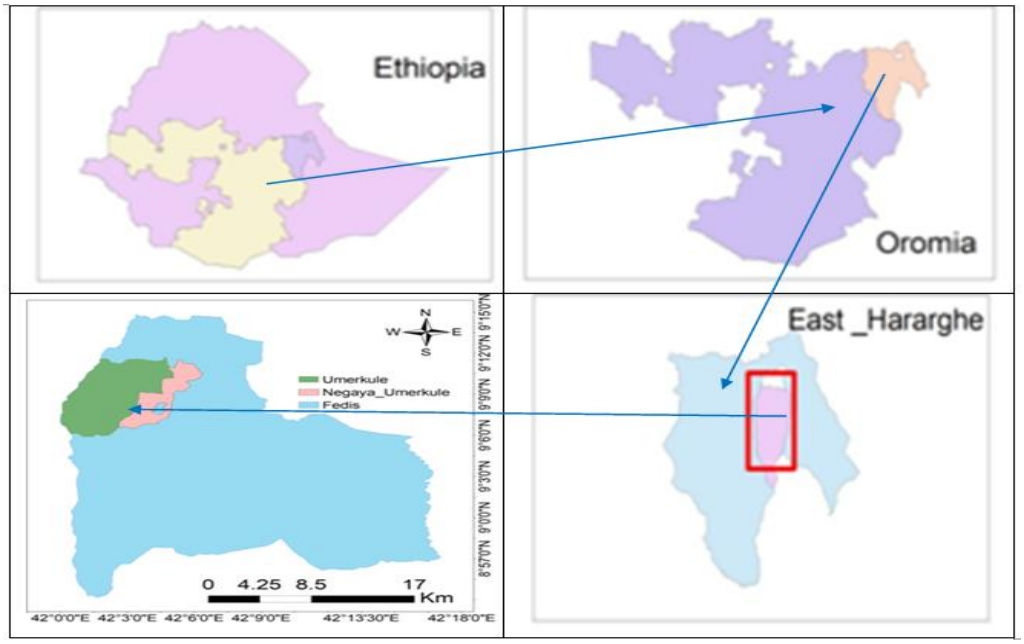

FIGURE 1: Location map of the study area

2.1.1 Climate and rain fall

According to FWANRDO (2017/18) report, the district has two basic agro-climatic conditions, namely Midland (39%), and lowland (61%). The district experience mean annual maximum and minimum rainfall, mean annual maximum and minimum temperature in the area were 850 to 650 mm, 30.4°C, and 10.0°C, respectively. Accordingly, the district has a bimodal rainfall distribution pattern with heavy rains from April to June and long and erratic rains from August to October.

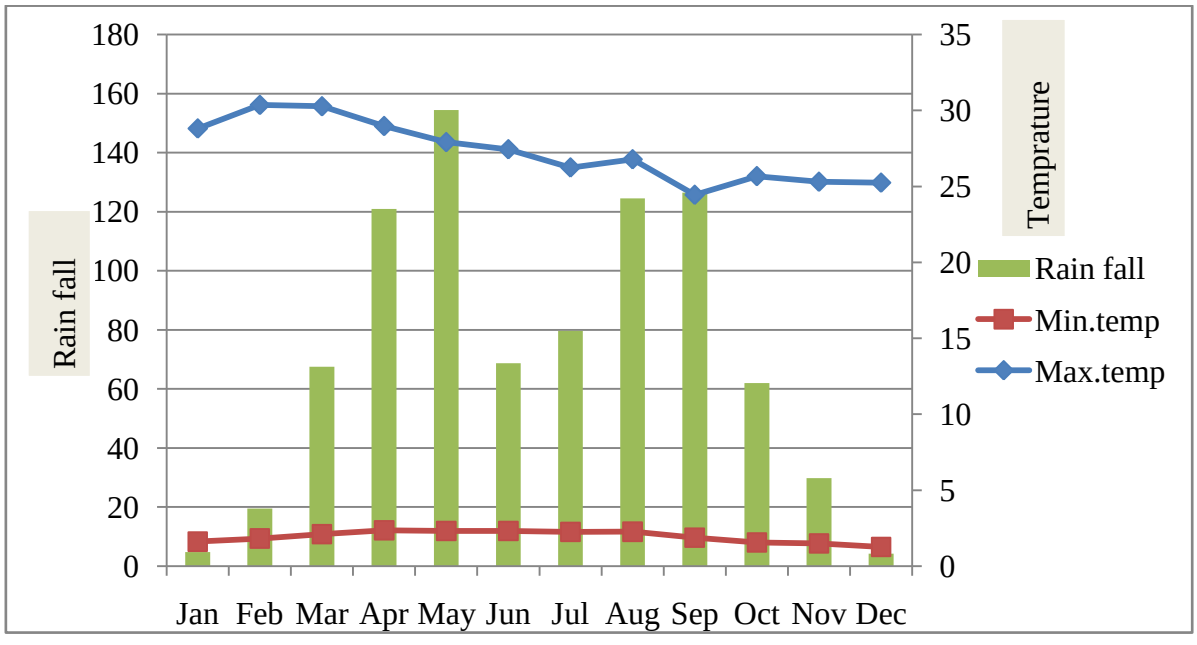

FIGURE 2: Rain fall and Temperature data of Fedis District, 2018 GC

2.1.2 Topography and land use

Topographic feature of the study area is 70% plain area, 28% plateau and 2% mountain or hill. Cultivable land/cropland (21.02%), pasture (2.80%), forest (11.2%) ,grass land (38.01%) ,communal land (10.5%) and remaining (14.04%) is considered as mountainous, valley and otherwise unusable (FWANRDO,2017/18).

2.1.3 Soil and vegetation

The soil of the study area was dominantly sand clay loam soils (moderately fine texture). The area of the district covered by forest, bushes and shrubs is 42,954 ha (FWANRDO, 2011). Fedis district has few patches of natural vegetation cover and some of the area is occupied by plantation forests and farmers incorporating trees on farmlands, boundary plantings, trees in croplands and woodlots agroforestry etc. The most dominant tree species found in the area include; acacia species, *Croton macrostachyus*, *Cordia africana*, *Fedhrbia albida*, *Eucalyptus camaldulences*, and many others (FWANRDO, 2011).

2.1.4 Agricultural activities

Agriculture in the district is characterized by small-scale subsistence mixed farming-system with livestock production as an integral part. The livelihood of the Fedis district is highly associated with agricultural activities for the fulfillment of household needs. Farmers are growing trees and /or shrubs in the agricultural landscape and also crop production is a leading economic activity of the area. Crop production is mainly rain-fed, practically all annual crops produced by this way for household consumption. Cereal crops including maize (Z*ea mays* L.), sorghum (S*orghum bicolor*), and haricot beans (*Phaseolus vulgaris*) are grown on the study area. Haricot bean (*Phaseolus vulgaris*) is growing as an intercrop with maize and sorghum crops in the study area. A cash crop such as *Chat* (*Catha edulis*) is also grown predominantly in the study area. In addition to these different fruits, vegetables, cereal crops, and tuber crops are the most common agricultural products of the study area (FWANRDO, 2017/18).

2.1.5 Tree management practices

There are certain management techniques which are applied to trees in park land agroforestry systems in the study area by some farmers. According to their respond there are two types of pruning i.e. Removal of branches from the lower part of the tree crown which is known as side pruning and pruning of a tree branches near the stem. Side pruning is specially used for young trees, in order to improve their growth. As they said, at least two or three layers of the green branches of young trees should remain uncut. For mature trees they cut the branches near the steam for the reduction of shade for crops near the tree. Sometimes Farmer of the study area uses pollarding for fodder that is out of the reach of livestock. There are also some farmers who remove trees from their farm land completely in order to insure suitable for machine harvesting technique. In general their objectives of pruning are to reduce shading effect of the tree and early harvest of branch for fencing or fuel wood. They also said good time for pruning is towards the start of rain season for fencing their farm land when the work will not interfere with growing crops and when the workload in other agriculture tasks is not so heavy.

2.2 Sampling Design and Methods of Data Collection

2.2.1 Tree sample selection

The study was carried out on farmers' field in Fedis District, East Hararghe Zone of Oromia Regional State to compare the sorghum yield performance under traditionally retained parkland *F. albida and C.africana* trees against the open field outside the canopy cover. *F. albida and C. africana trees being the most abundant scattered tree species on crop fields were selected for this study. The selected farm fields with this tree species are characterized by a gentle slope where sorghum and maize* are staple food crops of the area. Relatively homogenous site conditions in terms of aspect and topography and growth of the trees were also considered in the selection of the trees of each species. Farmers of the study area rarely apply inorganic fertilizers to their farmlands. *The farmers used manual land preparation methods like hand hoeing and oxen to cultivate the sampled farm fields. The sampled trees had also more or less similar management history.*On the selected field, individual trees of *F.albida and C. africana* having approximately similar height, diameter at breast height (DBH), crown diameter and from uniform site condition were marked to make other soil forming factors nearly constant. Of all the marked trees, six individuals of *F.albida and C. africana* trees were systematically selected for this study, their DBH, height and crown diameter was measured by using caliper, hypsometer and meter tape, respectively. Each tree species was replicated six times. The dimension of each replication was almost uniform with the average DBH, height, and crown radius of 27.5 cm, 10.67 m and 4.65 m for *F. albida*, respectively. Similarly, for *C. africana* the average DBH, height and crown radius were 31.83 cm, 12 m and5.49 m respectively.

2.2.2 Treatments and experimental design

There were two factors involved in this study: distance from the tree trunk and tree species were involved. The distance factor had three different treatment levels; at half of the canopy radius under the tree, canopy edge (radius of the canopy) and at three times canopy radius away from the trunk outside the canopy as control following the procedure by Jiregna *et al*., (2005). The tree species factors involved two tree species; *F.albida and C. africana* trees that are traditionally grown commonly on croplands were selected independently in the study area. The design employed had 3*2 factorial arrangements of treatments in randomized complete block design (RCBD) replicated six times, totaling 3*2*6 =36 *total* sample units or sample size for sorghum yield were used in this study.

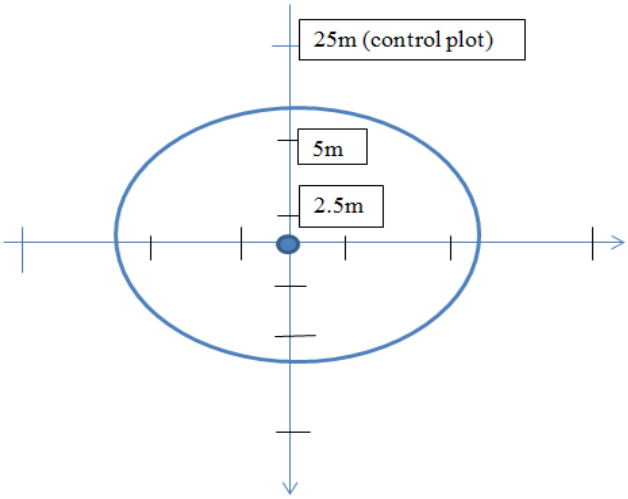

FIGURE 3: Experimental design of the sampling in the field work.

2.2.3 Grain yield data collection

Three plots of 1 m*****1 m was laid at mid canopy radius, at edge canopy radius and open field in four compass directions (North, South, East and West) under selected trees on the existing sorghum farm field for assessing the sorghum yield on the farmer managed farm field. Sorghum was harvested from each plot. The harvested sorghum from the same radial distance was composited for each replication. The grain yield of sorghum was harvested and weighed after drying. Grain yield of sorghum were measured in each plots. Threshing of sorghum were done manually, cleaned and weighed and the grain yield obtained was reported as kg /ha.

2.2.4 Statistical Analysis

Randomized complete block design (RCBD) with two ways (ANOVA) were carried out to statistically compare the difference among treatments using SAS computer soft ware SAS Institute (1996). Statistical differences were tested using the least significant difference (at 0.05%).

III. RESULTS AND DISCUSSION

3.1 Grain yield and biomass

The analysis of variance of the study showed that the grain yields of sorghum and biomass were significantly different ($P<0.05$) due to the effects of tree species and distance from the tree trunk. The grain yield of sorghum was decreased significantly and gradually as the distance from the trees trunk increased (table 1). The Highest values of sorghum grain yield were 2089.51 and 1789.53 kg ha^{-1} under *F.albida and C. africana* trees respectively at the distance of 2.50 m away from the tree trunks and these values decreased to 1459.40 and 1266.01 kg ha^{-1} under *F.albida and C. africana* respectively, at the distance of 25.0 m away from the tree trunks. The biomass also under both trees species were decreased as distance from the tree trunk increases (table 1). The increase in grain yield under the trees could be due to improvement of soil properties under the tree canopies than the open fields. Soils under tree canopies were better than the outside due to higher accumulation of soil organic matter, nutrient cycling and nitrogen fixation by tree species, especially *F.albida and C. africana*. Abebe [1] reported increased grain yield of sorghum and haricot bean under the canopy of *F.albida, C. africana* and C. macrostachyus trees as compared to the open cultivated land on Harergie high land.

TABLE 1

EFFECT OF TREE SPECIES AND DISTANCE FROM TREES ON GRAIN YIELD AND BIOMASS OF SORGHUM AT FEDIS DISTRICT

Distance (m)	*Faidherbia albida*		*Cordial aficana*	
	Grain yield kg/ha	Biomass kg/ha	Grain yield kg/ha	Biomass kg/ha
2.5	2089.51[a]	2860.00	1789.53[b]	2360.00 [a]
5.0	1805.02[b]	2831.50	1559.22[c]	2245 .30[a]
25	1459.40[c]	2808.61	1266.01[d]	1837.20[b]
CV	9.56	14.10	9.56	14.10
LSD (0.05)	109.31	NS	109.31	322.19

Means with the same letter are not significantly different at (P< 0.05)

The combined analysis of variance of the study showed that grain yield of sorghum were significantly different ($p < 0.05$) due to distance from the tree trunk and tree species. Similarly there were a significant difference of overall means between the two tree species ($p<0.05$). The Highest values of sorghum grain yield were 2022.17 kg/ha under *F. albida* and *C. africana* at distance of 2.50 m away from the tree trunks and these values decreased to 1354.40 kg/ha under *F. albida* and *C. africana* at the distance of 25.00 m away from the tree trunks. The finding indicated that, crop grown under the canopy of *F. albida* and *C. africana* obtained more advantage compared to the open field i.e. at distance 25.00 m from tree trunk. The mean variation at three distances might be come from modification of microclimate and soil physical and chemical properties by the trees species (Table 1).

Trees influence microclimate and soil property through organic matter accumulation and canopy produced shade which reduced evaporation from the soil surface and modifies air temperature extreme. Kho et al. [7] reported the same result and colleagues reported a 36% increase in dry matter production of pearl millet (Pennisetum glaucum) under tree canopies compared to open crop-only plots. This result suggested that the effect of *F. albida* on crop production is more pronounced in conditions of low soil fertility Sileshi [13] as nutrients are less limiting to crops at greater fertility levels. These yield increases under *F. albida* (often referred to as the 'albida effect') are attributed to the combined effects of improved soil fertility, soil water and microclimate. Trees can improve water holding capacity of soil, organic matter through addition of litter fall and root decay, reduce evaporation from the soil surface under the canopy, nutrient cycling and nitrogen fixation Buresh and Tian, [3]. These factors could boost grain yield and biomass production of sorghum under the canopy of the two species, since they advance contents of the indicated factors in the soil. Because of the fertility and moisture content under the canopies of both trees were better than that of out of canopy, the mean grain yield under the canopies were greater than the open cultivated land. Victor sh. [14] done research on yields of maize from plots under canopies of *F. albida* trees were significantly ($p < 0.05$) higher than those from plots outside the canopies.

TABLE 2

EFFECT OF *F.ALBIDA* AND *C. AFRICANA TREES* ON GRAIN YIELD AND BIOMASS OF SORGHUM

Effects		Grain yield and Biomass	
Distance (m)		Grain yield kg/ha	Biomass kg/ha
2.5		2022.17[a]	3818.21
5.0		1659.59[b]	3530.20
25		1354.40[c]	3281.03
CV		10.39	8.93
LSD (0.05)		103.9	NS
Tree species			
F.albida		1803.33[a]	3125.72[a]
C. africana		1555.14[b]	2679.19[b]
LSD (0.05)		8.48	6.70
Distance x Tree species			
2.5 m	*F.albida*	2055.02	3928.20
	C. africana	1889.12	3618.12
5.0 m	*F.albida*	1810.40	3408.02
	C. africana	1508.22	3418.33
25 m	*F.albida*	1443.14	3328.67
	C. africana	1266.23	3218.44
LSD (0.05)		NS	NS

**** Means with the same letter are not significantly different at (P< 0.05)***

The mean under the two species was significant from each other; the mean under *F.albida* was greater than that of grown under *C. africana*, which could be as result of phonological characteristics of the tree species. *F.albida* shades its leaves during crop growing season, which allows more lights for photosynthesis reaction. Therefore, crops grown under *F.albida* gets more advantages compared to those crops grown under *C. africana*. The mean biomass recorded at three different distances from the two tree trunk, was not differently significant statistically ($p > 0.05$) (table 2). In general, the result of analysis indicated that, decreasing pattern of mean biomass as distance from tree trunk increases, for both *F. albida* and *C. africana*. The mean values of biomass under canopy was 3818.21 kg/ha and decreased to 3281.03 kg/ha in open field. There were significant variation of biomass between tree species ($p<0.05$). The mean biomass obtained under *F. albida* was greater than that of mean biomass obtained under *C. africana* (3125.72 kg/ha and 2679.19 kg/ha respectively), which could be due to deference in the level of light incidence under the two trees and variation in soil fertility emanating from organic litter decomposition and subsequent nutrient release under the canopies of the species. The case of variation among distance from tree trunk was alike to that of the grain yield stated above i.e. fertility gradient cause for biomass difference was created by the role played by *F. albida* and *C. africana* on the soil under its canopy. Trees affect soil properties through several pathways Buresh and Tian [3]; Rhoades, [11]. Thus, higher biomass obtained under the canopy of *F. albida* and *C. africana* as compared to on field one.

IV. CONCLUSIONS AND RECOMMENDATIONS

The study has been done on the effect of *F. albida* and *C. africana* on yield and biomass of sorghum grown under canopies of both trees in Fedis District, East Hararghe, Oromia. As a result of significant difference in nutrient available between under canopy and open plot grain yield was greater under the canopy. According to combined analysis both trees showed significant effect on grain yield and biomass of sorghum grown under canopies compared to that grown out of canopies of both trees. The higher mean of grain yield and biomass were observed under canopies than that grown on open field, which could be as result of additional nutrients, through litter fall, root turnover and exudates, and n-fixation. Parkland agroforestry system is very important in soil fertility management especially for poor farmers in order to boost their productivity.

Retaining these tree species and in particularly *F. albida* on farms in the study area is of paramount importance for soil fertility enhancement so as to improve food security of small farming households. Based on the findings the following recommendations are forwarded. (1). Further research should be required on *F. albida* and *C. africana* trees on appropriate component management practices and the number of trees retaining per hectare associated crop productivity. (2) .In addition to their role in maintaining soil fertility, these two species provides various products and services to the farmers. Thus, the continued use of these species in the agricultural setting of Fedis district and other areas in the eastern Hararghe area to maintaining soil fertility and provide services to the farmers.(3) .The result of grain yield and biomass of sorghum reported in this study was from under farmer's management practice. So, further study is needed under controlled experiment in association with these trees.

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Growth Rate of Area, Production and Productivity of Sugarcane Crop in India

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Abstract— *Sugarcane is an important commercial crop of India. It plays a crucial role for overall socio-economic development of farming community. India ranks second in production of sugarcane after Brazil. In India about 4.73-million-hectare land is occupied by sugarcane crop. Based on the importance of sugarcane crop, present study was conducted to know growth rate of area, production and yield of sugarcane in India and performance of sugarcane crop in major sugarcane producing states of India. The study was based on secondary source of data. Simple statistical tools like compound annual growth rate, percentage methods were used in this study. The study reveals that compound annual growth rate in case of area, production and yield showing a positive sign. The area under sugarcane cultivation is reported an increase of 5.63 percent in a duration of thirty years between 1985 and 2015and the sugarcane production was increased by 7.40 percent in the same period. The area and production of crop is showing a fluctuating trend because there are many factors which is responsible sugarcane cultivation like monsoon conditions, government price polices etc.*

Keywords— Compound annual growth rate, Production, Sugarcane, Trends.

I. INTRODUCTION

Sugarcane is the main source of sweeteners globally and holds a prominent position as a cash crop. India occupies second position in Sugarcane cultivation after Brazil. Climatic condition of India is favorable for sugarcane cultivation therefore the production of Sugarcane spread across the country. There are two different agro-climatic regions of sugarcane cultivation in India namely tropical and sub-tropical. The tropical regions include the states of Maharashtra, Gujrat, Tamil Nadu, Andhra Pradesh and Karnataka, Madhya Pradesh, Goa, Kerala. Tropical region records the high sugar recovery due to the long sunshine hours, cool nights with clear sky and the latitudinal position of the area favorable for sugar accumulation. The sub tropical region includes the states namely Uttar Pradesh, Bihar and Haryana and Punjab. Climatic conditions are generally variable depending upon the season and sometimes within the seasons also. Sugarcane crop faces all the season in a year. Uttar Pradesh is having largest area under sugarcane crop. However, the highest sugar recovery can be obtained in the Maharashtra.

It is a major source of raw material not only sugar industry but other allied group of industries. Sugarcane and its by products provide employment opportunities to large number of people and responsible for socio-economic transformation of farming community. Sugar industry has been instrumental in resource mobilization, employment generation, income generation and creating social infrastructure in rural areas, in other words sugar industry has facilitated and accelerated pace of rural industrialization. Production of Sugarcane in India is not uniform, fluctuating trend of production has been found. This is due to the several problems faced by sugarcane industry, such as Low yield of Sugarcane, Prices fixed by government, delay in payments, unpredictable monsoon condition etc. (Gaikwad, C. 2017).Water scarcity is the major problem faced by sugarcane farmers in India, the major reason for low production and low productivity is the unpredictable monsoon condition. So, the present study will examine the growth of area, production and productivity of sugarcane crop in India and to analyze the performance of major sugarcane producing states in India.

II. MATERIALS AND METHOD

The Study is based on secondary source of data which is collected from various reports. The compound annual growth rate, percentage change or annual growth rate was calculated. Compound annual growth rates (CAGR) was worked out to study about the changes in area, production and yield of sugarcane over a period. The compound annual growth rate was calculated by fitting the following equation in the time series data area, production and yield.

$$Y_t=Y_0\,(1+r)^t \qquad (1)$$

Taking log on both side we will get

$$\mathrm{Ln}Y_t=\mathrm{Ln}Y_0+t\mathrm{Ln}\,(1+r)$$

$$LnY_t = a+bt \quad (2)$$

Where,

$a=LnY_0$

$b=Ln\ (1+r)$

Y_t= area/ production/ yield

Y_0= constant

t= time period in years and

b= regression coefficient

$$\%\ \text{compound growth rate} = (\text{Anti log } b-1) \times 100 \quad (3)$$

Percentage change in yield is given by:

$$\%\ \text{change in yield} = \frac{(\text{Current year yield} - \text{Previous year yield}) \times 100}{\text{Previous year yield}}$$

III. RESULT AND DISCUSSION

3.1 Area, Production and Yield of Sugarcane in India

As already discussed, India is the second largest producer of sugarcane in the world and it has enormous influence on economy of the country. So, it is important to study the area, production and yield of Sugarcane in the country. During, 1995-96 area under sugarcane crop was 4147 thousand hectares. The area increased to 4737 thousand hectares in 2017-18. As shown in the (table1) over the years area, production and yield has increased from 1995-96 to 2017-18. The area under sugarcane has sharply increased in 2006-07 i.e. 5151 thousand hectares. It is clear from the table that area, production and yield is fluctuating in the study period. Production of sugarcane in 2017-18 was increased as compare to 2006-07, but area in 2006-07 was more, this is due to the various incentives, high yielding verities etc. It is clear from the study that the trend of sugarcane cultivation in India is uneven.

TABLE 1
DESCRIPTIVE STATISTICS OF SUGARCANE CROP IN INDIA (1995-96 TO 2017-18)

Year	Area ('000 Hectare)	Production ('000 Tonne)	Yield (In Kgs./Hect.)
1995-96	4147	281100	67777
1996-97	4174	277560	66496
1997-98	3930	279540	71133
1998-99	4055	288720	71203
1999-00	4220	299320	70934
2000-01	4316	295960	68578
2001-02	4412	297208	67370
2002-03	4520	287383	63576
2003-04	3938	233862	59380
2004-05	3662	237088	64752
2005-06	4202	281172	66919
2006-07	5151	355520	69022
2007-08	5055	348188	68877
2008-09	4415	285029	64553
2009-10	4175	292302	70020
2010-11	4885	342382	70091
2011-12	5038	361037	71668
2012-13	4999	341200	68254
2013-14	4993	352142	70522
2014-15	5067	362333	71511
2015-16	4927	348448	70720
2016-17	4436	306069	69001
2017-18	4737	376905	79650

Source: Indian Sugar Mills Association. & Ministry of Agriculture & Farmers Welfare, Govt. of India

3.2 Annual growth rate of area, Production and Productivity of Sugarcane

TABLE 2
PERCENTAGE CHANGE IN AREA, PRODUCTION AND YIELD OF SUGARCANE IN INDIA (1995-96 TO 2017-18)

Year	% change in area ('000 hectare)	% change in production ('000 t)	% change in yield (Kgs/ hect.)
1995-96	0.65	-	-
1996-97	0.65	-1.26	-1.89
1997-98	-5.85	0.71	6.97
1998-99	3.18	3.28	0.10
1999-00	4.07	3.67	-0.38
2000-01	2.27	-1.12	-3.32
2001-02	2.22	0.42	-1.76
2002-03	2.24	-3.31	-5.63
2003-04	-12.8	-18.62	-6.60
2004-05	-7.01	1.38	9.05
2005-06	14.75	18.59	3.35
2006-07	22.58	26.44	3.14
2007-08	-1.86	-2.06	-0.21
2008-09	-12.6	-18.14	-6.28
2009-10	-5.44	2.55	8.47
2010-11	17.01	17.13	0.10
2011-12	3.13	5.45	2.25
2012-13	-0.77	-5.49	-4.76
2013-14	-0.12	3.21	3.32
2014-15	1.48	2.89	1.40
2015-16	-2.67	-3.83	-1.11
2016-17	-9.97	-12.16	-2.43
2017-18	6.79	24.12	16.23

Source: Calculated by authors, data obtained from Ministry of Agriculture & Farmers Welfare, Govt. of India

Compound annual growth rate was calculated on area, production and yield of sugarcane in India to know about the growth rate over a period of time. It is clear from the table that annual growth rate in area, production and yield is not even. The growth in terms of area has increased rapidly between 2005-06 and 2006-07. The highest annual growth in terms of area is found in 2006-07 i.e. 22.58 percent. The highest negative annual growth rate in area is found in 2003-04.The periods in which the area has increased; production has also increased in those periods. Compound annual growth for production is highest in 2006-07. Yield is showing better growth in 2017-18, which indicates that farmers can take up this crop in better way.

TABLE 3
COMPOUND ANNUAL GROWTH RATES OF AREA, PRODUCTION AND YIELD OF SUGARCANE (1985-2015)

Year	Area(in Percent)	Production (in Percent)	Yield (in Percent)
1985-1995	3.83	5.12	1.24
1995-2005	0.13	0.00	0.00
2005-2015	1.60	2.17	0.55
1985-2015	5.63	7.40	1.68

Source: Calculated by authors, data obtained from Ministry of Agriculture & Farmers Welfare, Govt. of India

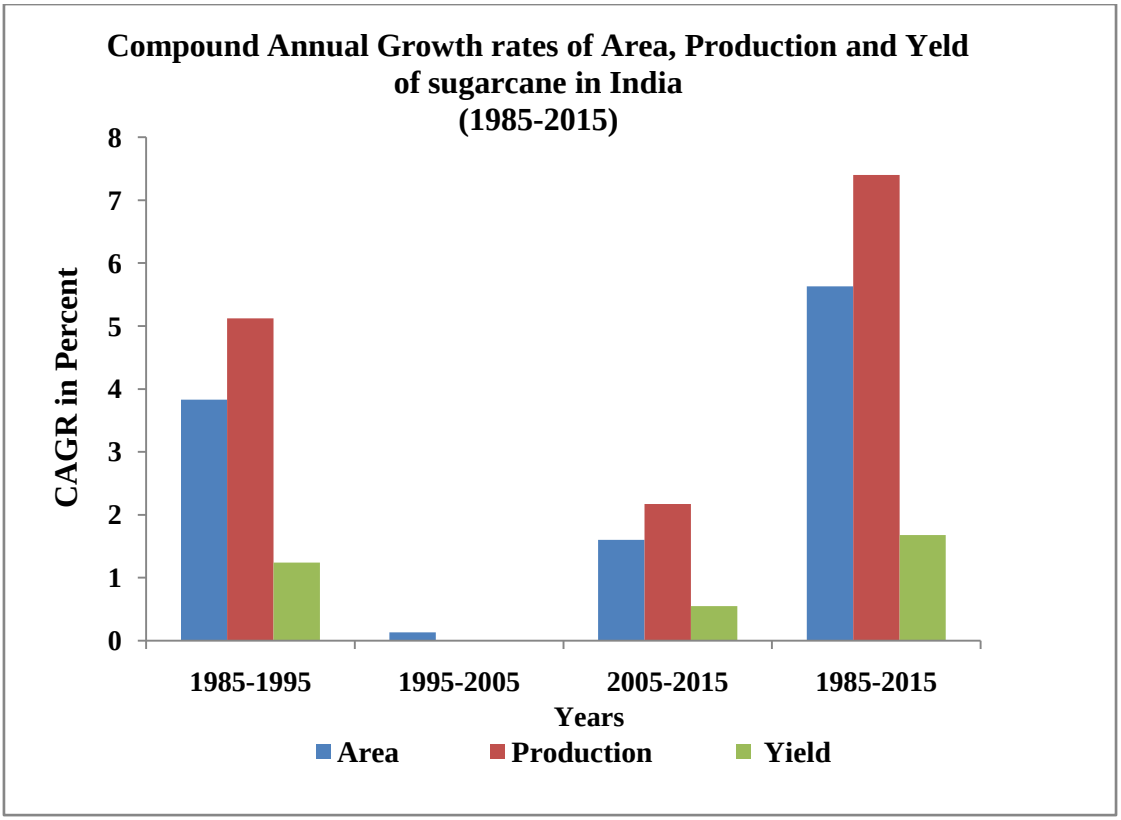

FIGURE 1: Growth rates of area, production and yield of sugarcane in India

It is clear from the table and figure that CAGR in area, production and yield is increasing between 1985-1995. But between 1995-2005 the production and yield are not increasing. After the 2005 the rate of area, production and yield started to increase but the rate of increment was very slow. The overall Compound annual growth rate of 30 years (1985-2015) for area under sugarcane crop in India is 5.63 percent. Compound Annual growth rate for production in 30 years is 7.40 percent, and for yield is only 1.68 percent.

3.3 State-wise Sugarcane cultivation in India

TABLE 4
AREA, PRODUCTION AND PRODUCTIVITY IN MAJOR SUGARCANE PRODUCING STATES, 2017-18

States	Area (Million hectare)	% to All India	Production (Million tonnes)	% to All India	Productivity (Kg. / hectare)
Uttar Pradesh	2.23	47.21	177.06	46.98	79255
Maharashtra	0.90	19.06	83.13	22.06	92166
Karnataka	0.35	7.40	28.26	7.50	80751
Tamil Nadu	0.18	3.80	16.54	4.39	92002
Bihar	0.24	4.99	13.98	3.71	59202
Gujrat	0.18	3.85	12.05	3.20	66220
Haryana	0.11	2.41	9.63	2.56	84500
Punjab	0.10	2.03	8.02	2.13	83583
Andhra Pradesh	0.10	2.09	7.95	2.11	80283
Uttarakhand	0.09	1.90	6.30	1.67	70044
Madhya Pradesh	0.10	2.07	5.43	1.44	55408
Telangana	0.04	0.74	2.56	0.68	73086
Others	0.12	2.45	5.98	1.59	-
All India	4.73	100.00	376.90	100.00	79650

Source: Ministry of Agriculture & Farmers Welfare, Govt. of India

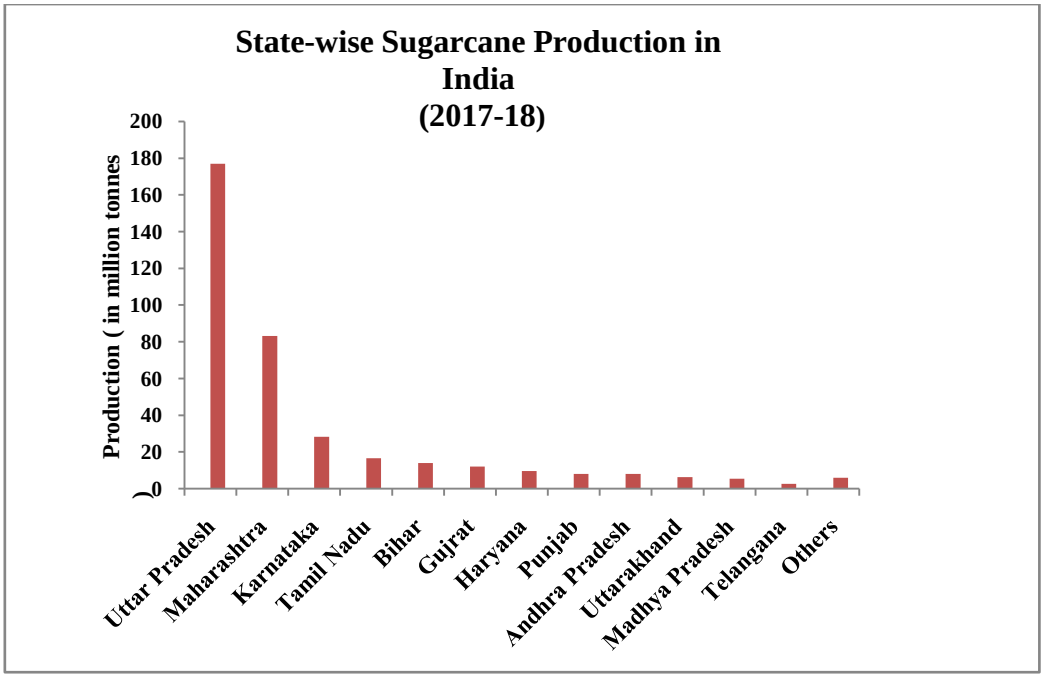

FIGURE 2: State-wise Production of Sugarcane in India

Table 4 depicts the state-wise area, production and productivity of Sugarcane in India. The data reveals that the Uttar Pradesh is the leading sugarcane producing state followed by Maharashtra and Karnataka. While analyzing the production of the states it is clear from the study that production is directly related to the area under sugarcane. The total production of the whole country was 376.90 million tonnes in 2017-18. As we have discussed that the highest area under sugarcane cultivation was contributed by the states of Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu. Thus, it is obvious that the production would be also higher in these states. Expectedly, the data shows, Uttar Pradesh is the largest producer of sugarcane in the country, this state alone produced 177 million tonnes, which is about 47 percent of the total production of the country. Maharashtra is the second leading producer of sugarcane in the country sharing about 22 percent of the total production of the country, which is about 83 million tonnes. As well as Karnataka is the third largest producer of sugarcane accounting about 8 percent production of the country, which is about 28 million tonnes. Similarly, Tamil Nadu produced 16.54 million tonnes of sugarcane and shares 4.39 percent production to the production of the whole country, this state ranks at fourth place in terms of production. In addition to this, Bihar Gujrat, Haryana, Punjab and Andhra Pradesh are the other significant producing states of India, the share of these states ranges between 1 and 4 percent to the total production of the country. Uttarakhand, Madhya Pradesh, Telangana and other many states had the minor production of sugarcane.

The productivity of any crop depends upon many factors, like physical conditions, technological advancement, market and payment with a good product value. The average productivity of India was 79650 KG/hectare in 2017-18. It has been found that the state of Maharashtra had the highest productivity i.e. 92166 KG/hectare in the same year. Haryana ranks second in terms of the sugarcane productivity; the productivity of sugarcane in Haryana was estimated 84500 KG/hectare. Punjab was scaled to the third position in terms of the productivity, i.e. 83583 KG/hectare. Uttar Pradesh, being the largest producer of sugarcane, has an average productivity which is quite similar to the average productivity of the country. The states of Bihar and Madhya Pradesh represented very low productivity because of low fertility in the soil and the lack of technological advancement.

IV. CONCLUSION

From the above discussion it was found that the area under sugarcane was found tobe increased by 5.63 percent over thirty years (1995 to 2015), whereas production and yield increased at 7.40 percent and 1.68percent. It is clear from the study that trend of sugarcane cultivation in India is fluctuating, no uniform pattern of growth has observed. This is due to many problems faced by sugarcane farmers includes the problem of scarcity of water, sugarcane pricing problems etc. Sugarcane crop requires regular supply of larger quantity of water for its growth. Availability of Sufficient water mainly depends on rainfall. Fluctuation in seasonal rainfall in India adversely affects the production of sugarcane. Sugarcane being a long duration crop which requires more irrigation. Poor water availability leads to drying of crop and yield loss. Other major reason of fluctuation in sugarcane crop is sugarcane pricing policies, major changes in agricultural product prices from year

to year affect product supply and producers' decisions about production. With the huge stakes involved in the cane crop and in the sweet commodity, government policies relating to the sector have always been arbitrary, with politicians formulating rules not on the basis of sound economic principles, but under the pressure of different interest and then resulted policies could provide benefit to different stakeholders. Despite of large area under sugarcane crop farmers are still using traditional methods and equipment in sugarcane cultivation. The lack of usage of mechanization in India is due to the small size of land holding, improper crop spacing, and lack of finance. Some machines are worthy, and these are not affordable to farmers but introduction of costly machines through custom hiring centers can help the farmers to get the benefits of machinery.

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Composting of floral waste by using indigenously isolated microbial consortium: An approach towards the Environment sustainability and waste management

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Abstract— *In India huge number of flowers are offered in temple creating a large amount of flower waste. The temple waste is released in the water bodies or dumped at the available places of land which creates severe environmental pollution and health hazards. Floral waste is biodegradable and contains elements required for growth of microorganisms. The present study focused on the use of Temple floral waste extract for preparation of microbial nutrient media in order to cultivate bacteria (pH7.4) and fungi (pH 5.4). Soil sample was used for screening of microorganisms capable of degrading the floral waste. Thus, in the present study instead of using conventional microbial media we have used the flower waste media to develop microbial consortium for degradation of floral waste. On the basis of capability to produce variety of hydrolytic enzymes two sets of consortia were developed and tested for development of compost as against the control without the microbial consortia. Physicochemical analysis of mature compost revealed that floral waste compost prepared by using the microbial consortium is enriched with the Nitrogen, Phosphorus, Potassium, Calcium and Magnesium. The mature compost developed using the microbial consortia has the potential to support the growth of tomato plants. This method is cost effective as well as pollution free. Thus, it can be promoted as potential mechanism to maintain the environmental sustainability at wider scales.*

Keywords— Compost, Floral waste agar media, Microbial consortia, Temple waste.

I. INTRODUCTION

Waste is defined as unwanted, unusable material and is regarded as a substance which is of no use. Waste disposal is the major concern of the society. If it is not disposed properly that leads to deterioration of environment. Industrial, commercial, agricultural and domestic are different sources of waste generation.

Floral waste is generated by various sources like Temple waste, marriage ceremony, hotels, various others cultural and religious ceremony. Every day the flowers offered in the temples or used in the various ceremony or functions left unused and later on it converted in to waste and it becomes the major constituents of municipal solid waste (Singh et al. 2013). Most of this waste is generally neglected and get added to water bodies which lead to water pollution.

By considering the characteristics of floral waste as it is rich in organic compound, macronutrients and micronutrients, composting is the best solution for proper disposal of floral waste. Composting is defined as the natural biological decomposition of organic matter under self heating, aerobic and moist conditions to produce a stable nutrient enriched product which is used as organic manure (Bustamante et al.2009). Thus floral waste can be converted in to agriculturally useful organic fertilizers which in turn have the potential to reduce the dependency on non-renewable chemical fertilizers and pesticides. Most of the time during the process of composting bulking agents like wood shaving, dry leaves, newspaper, wheat bran, Pumice are added to support the free passage of air during the composting. In this study we have added cow dung as a bulking agent (Sharma et al., 2017)

Degradation of floral waste is a very slow process as compared to kitchen waste degradation (Jadhav et al., 2013). By considering this we have made attempt to develop consortia having potential to degrade the floral waste. The exploitation of the metabolic versatility of microorganisms is advantageous in biological waste treatment this led to shortening of the time required for composting.

In this study, attempt was made to design the successful composting system by using the microbial consortium isolated by using the floral extract agar. Further the potential of floral waste compost to support the growth of plant was studied by pot assay.

II. MATERIALS AND METHODS

2.1 Sample collection (floral waste and soil sample)

Floral waste was collected from following selected temples from Baramati, Siddhivinayak temple at Sayali hills, Tuljabhavani temple, Siddheshwar temple, Ganapati temple at Kasaba and Kashiveshweshwar temple. The collected floral waste was brought to laboratory in polythene bags. The collected FW comprised of the flowers namely Marigold, Rose, Jasmine, and Lotus. In this study, only FW was used for composting without stems, roots and leaves. Soil samples were also collected from above mentioned different temple area for isolation of microorganisms capable of degrading the floral waste.

2.2 Extract from flower waste

After collection of floral waste from different temples, non-biodegradable part i.e plastic, paper, thread and other waste materials were removed by hand sorting and the biodegradable waste i.e garlands and flowers were segregated. The segregated floral waste was air dried by spreading over paper for 48 hours. The air-dried samples were then crushed using the using mixer grinder and made 300 ml paste of flower waste. Again, the homogenized mixture was prepared in mixture grinder. Then this mixture was allowed to stand without disturbance for 3 hour so that debris, if present get settle down. The clear supernatant was filtered through the muslin cloth. The filtrate obtained was referred as a floral extract.

2.3 Media preparation by using Floral waste

Original pH of the floral extract was 4.7, being too acidic, it was not suitable for cultivation of common bacteria and fungi, so pH was adjusted to 7.2 and 5.6 in order to support the growth of bacteria and fungi respectively. For solidification of media, 3.0 g/ 100 ml of agar powder was added in the floral extract, followed by media sterilization at 15psi 121 0C for 30 minutes.

2.4 Screening of floral waste degrading microorganisms

Soil samples were collected from above mentioned temple areas. 0.3 gm of each soil sample was inoculated in to 100 ml of floral waste media. These flasks were incubated at 28 ^{0}C at 125 rpm for 3 days. Flasks were allowed to stand undisturbed for 2 hour so that all the debris gets settled down. Serially diluted supernatant was spread on floral waste media. Plates were incubated at 28 ^{0}C till growth was observed in the form of colonies on agar plates (Jadhav et al., 2013).

2.5 Hydrolytic Enzyme Screening and Assay from isolates grown on floral waste agar

All the isolates were analyzed for their ability to produce different hydrolytic enzymes. All the isolates were grown on the respective substrate (1%, w/v, starch, cellulose, casein, colloidal chitin &pectin) containing agar plate for the determination of amylase, cellulase, protease, chitinase, pectinase activity. The plates were incubated for 5 days and detected enzyme activity. After addition of gram's iodine on starch agar development of halo zone around the colony indicate the amylase positive test. For detection of cellulase activity 0.1% Congo red was added followed by addition of 1M NaCl solution. Protease positive isolates shows development of halo around the colony. For detection of chitinase activity colloidal chitin agar was used Pectinase positive strains were detected by adding iodine solution on pectin plates (Naif et al; 2019).

For induction of above mentioned enzymes the selected isolates were inoculated in the minimal medium containing the following different substrate at 1 % (w/v) starch, cellulose, casein, colloidal chitin & pectin. Flasks were incubated for 5 days at 28^{0}C followed by centrifugation at 10,000 rpm at 4^{0}C for 10 minutes. The supernatant was used for enzymatic assay. Amylase and cellulase activity were determined by DNSA method. Protease activity of culture supernatant was assayed using casein (1%) as a substrate. The substrate was prepared in Tris buffer (pH8.0,50 mM). Then, 1.0 mL casein was mixed with 0.1mL culture supernatant and incubated for 30 min. Then, 10% (w/v) trichloro acetic acid (5 mL) was added and incubated for 30 min. It was centrifuged at 5000 rpm for 5 min and the supernatant was measured at 275 nm against reagent blank using a UV-visible spectrophotometer. L-tyrosine was used as the standard for the determination of protease activity. Pectinase activity of the sample was determined using pectin as a substrate. About 9.8 mL pectin (0.5%) was mixed with 0.2 mL culture supernatant. It was incubated for 10 min and 1 mL sodium carbonate (1 M), 5 mL iodine (0.1 N) were added and kept for 5 min. To this, 2 mL sulphuric acid (2 N) was added and kept in the dark for 15 min. The developed dark colour was further titrated against sodium thio sulphate (0.1 M) using soluble starch (1%) as an indicator. Chitinase activity of the culture supernatant was determined using colloidal chitin as a substrate. This substrate was prepared at the 1% level using 50

mM acetate buffer (pH 5.5). A 1.0 Ml substrate was mixed with a 0.1 mL sample and incubated for 30 min. After that, 1.0 mL DNS was added and further assay was continued following a similar procedure to the cellulase assay (Naif et al; 2019).

2.6 Development of consortia

Two different combinations of four bacterial isolates were prepared and used for composting of floral waste. A loopful growth from 24 hours old bacterial cultures of different organisms in selected combination were inoculated in broth prepared using flower waste. Broth was incubated at 28 ^{O}C for 48 hours. This mix culture was used as consortium and then 25% (v/w) of this consortium as inoculums was added to the flower waste (Pindi and Satyanarayana, 2012)

2.7 Floral waste composting

All organic waste materials were available in form of flowers were collected. As fleshy, pulpy waste material decompose very rapidly and it favors the compost formation, hence collected floral waste was crushed and converted in to small pieces which enhances rate of formation of compost. As moisture is necessary for the growth of microorganisms, soil was added to the floral waste which has capacity to absorb the moisture to support the growth of microorganisms. Then cowdung was added in 1:1 proportion. Four plastic chambers having holes at bottom and side walls for aerations and excess water removal were selected. To maintain the aerobic conditions at the bottom of the chamber layer of coconut coir 2cm height was prepared, it was covered with garden soil. On the top of soil, floral waste along with 25% consortium was added. Chamber filled up with alternative layer of soil and consortium inoculated floral waste were kept at moist and dark place for composting purpose.

Four different chambers were prepared having the following combinations

Chamber 1 Soil +Floral waste (Control1)

Chamber 2 Soil+ Floral waste + cow dung (Control 2)

Chamber 3 Soil+ Floral waste + cow dung + consortium 1 (Test 1)

Chamber 4 Soil+ Floral waste + cow dung + consortium 2 (Test 2)

2.8 Analysis of physicochemical properties of compost

Physical and chemical properties including temperature, pH, electrical conductivity (EC), total organic carbon, total organic matter, total nitrogen, total phosphorus, total potassium and C/N ratio were analyzed. For estimation of pH15g compost was mixed with 30ml of distilled water and kept on rotary shaker for 1 hour. Filtration was carried out and pH of filtrate was checked by using pH meter. Electrical conductivity of the filtrate was measured by using conductivity meter. For estimation of moisture, 5 gm of prepared compost was taken on a dry petri-dish and dried in an oven at 55^{0}C till constant weight was achieved then percentage moisture level was calculated. Compost was diluted in the ratio of 1:10 (w/v) and kept on rotary shaker at 150 rpm for 45 min. This sample was used for further analysis of compost. Nitrogen content was estimated by Kjeldahl method whereas organic carbon content was detected by the method of Walkley and Black (1934).Heating digester (Velp scientifica DK 20) was used for digesting the 0.2 g sample, 10 mL H2SO4 and HClO4 mixture (5:1) at 300°C ± 5°C for two hours. The digested samples were used for the determination of total phosphorous using stannous chloride methods (Adhikari et al., 2009). The concentrations of Na, K and Ca were determined by using flame photometer. The Ca and Mg contents of the samples will also be analyzed by using atomic absorption spectrophotometer. The C: N ratio will be calculated from the measured values of C and N (Maiti, 2003).

2.9 Analysis of plant growth promoting activity of compost

Twenty-five, Tomato plant seeds were sterilized and prepared as per the protocol given by Indananda et al. 2010. After germination of seeds, mature compost was added to the pots. Control set was prepared without addition of compost. After 35 days of treatment plants were analyzed with respect to root length, shoot length and weight of plant

III. RESULTS AND DISCUSSIONS

As shown in Fig1. Floral waste were collected and used for preparation of floral extract (Fig.2). Media was prepared by using floral waste extract; diluted soil sample was spread on floral waste agar media. After incubation of plates at 28^{0}C, plates were observed for the presence of colonies (Fig.3). Total 40 isolates were seen on floral waste agar plates. On the basis of their ability to produce different hydrolytic enzymes, from 40 different isolates, grown on floral waste agar plates, 8 were selected for the development of microbial consortia on the basis of their ability to produce different hydrolytic enzymes.

FIG 1: Floral waste collected from different temples of Baramati

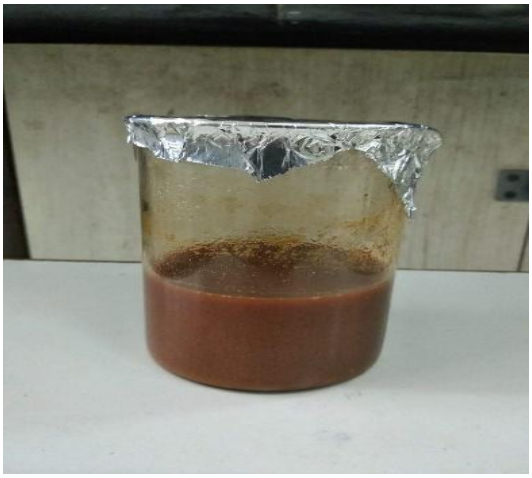

FIG 2: Floral extract prepared from floral waste.

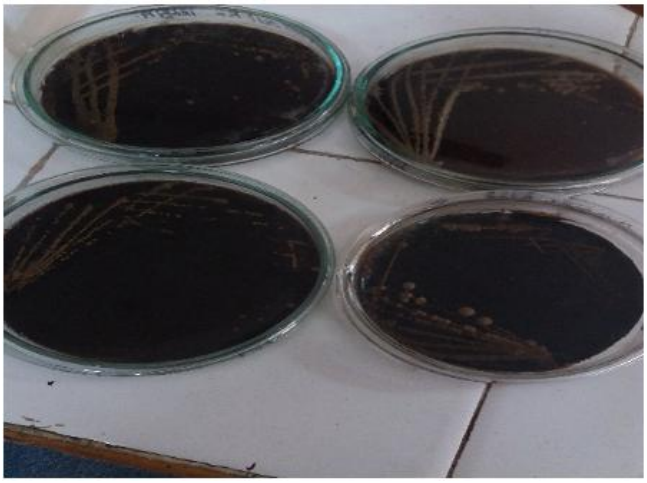

FIG 3: Growth of Microbial isolates on media prepared by using floral extract

TABLE 1

PRODUCTION OF EXTRACELLULAR ENZYMES BY THE VARIOUS STRAINS ISOLATED BY USING FLORAL WASTE AGAR

Name of isolates	Enzyme activity U/ml				
	Amylase	Cellulase	Protease	Chitinase	Pectinase
TW	0.9	34	12	25	1.6
DaA	4	27	39	20	1.3
DaD	12	56	46	34	0.94
KL	9	45	67	27	2.2
KM	12.4	23	98	34	1.9
KS	15	52	84	29	1.7
Min. S	11	48	57	37	1.1
Min. L	10	17	49	31	0.6

Table. 1 depicts the quantitative enzyme activity of selected isolates. All these isolates showed the amylase activity that ranged from 0.9 U/ml to 15U/ml. Cellulase production ranged between 17 U/ml to 56 U/ml. All the isolates were capable of producing protease enzyme. Maximum protease production 98U/ml was shown by KM isolate whereas lowest protease production 12 U/ml was shown by TW isolate. Lowest Chitinase production observed was 20 U/ml whereas highest Chitinase production was 37 U/ml. Pectinase ranged between 0.6 U/ml to 2.2 U/ ml. With this result we concluded that the selected isolates have the potential to degrade organic biomass present in the floral waste with the help of hydrolytic enzyme. This hydrolytic enzyme helps in the formation of compost as they convert complex organic matter in to simpler one. Similar

kind of study was carried out by Gopinath et al., (2014) in order to explore the potential of consortium for effect degradation of organic waste. The enzymes in the selected isolates are intended to start breaking down organic matter to speed decomposition. So that overall time required for compost formation get reduced.

TABLE 2
VARIATION IN THE TOTAL VOLUME CONTENT DURING COMPOSTING

Sr.No.	Days	Height of contain in chamber(in cm)			
		Sample 1	Sample 2	Sample 3	Sample 4
1	1	30	30	30	30
2	3	28	28	27	28
3	5	28	27	26	26
4	7	25	25	25	24
5	9	23	22	23	23
6	11	21	20	21	20
7	13	21	20	19	18
8	15	20	19	14	16

During the composting process overall decrease in the total volume was observed, this variation in the volume is summarized in the Table.2. For Test 1 and Test 2 decrease in volume was respectively 14 cm and 16 cm whereas for control1 and control 2 decrease in volume was 20 and 19 cm at the end of 15 days. This decrease in overall volume was observed because of biodegradation of organic compound. The rapid degradation was observed in Test 1, means consortia 1 is metabolically more active than consortia 2.

Characterizations of Compost obtained in four chambers were carried out and it is represented in Table 3. Physical characteristics of compost revealed that compost formed in Test 1 and Test 2 was of relatively uniform small particles and no big hard chunks were seen. Appearance was dark brown to black with no visible signs of original floral waste. Moisture content was 40%, 35%, 28%, 26 % in control 1, control 2 and Test 1 and Test 2 respectively. Ideally moisture content of compost should be in between 30 to 50%. If it is more than that then compost would be clumpier and if it is less than 30 t0 50% then it would be very dry and dusty.

pH of compost Test 1 and Test 2 ranged between 7.1 to 7.2, it was less than control1 and 2 (7.6 and 7.4) this may be because of the volatilization of ammonial nitrogen and hydrogen ions (H+) release through the nitrification activities of nitrifying bacteria, as well as the emission of large volumes of carbon dioxide (Huang et al. 2004). Similar results were reported for organic waste composting (Kalamdhad and Kazmi 2009). The final pH value between 6 and 8 shows the maturity of the compost (Varma and Kalamdhad 2014a).

TABLE 3
PHYSICAL AND CHEMICAL CHARACTERIZATION OF COMPOST

	Chamber 1	Chamber2	Chamber 3	Chamber 4
Parameter	**Control 1 Soil +FW**	**Control 2 Soil +FW+CD**	**Test 1 Soil+FW+CD+Consortia 1**	**Test 2 Soil+FW+CD+ Consortia2**
Colour	Black	Black	Brownish black	Brownish black
Moisture %	40	35	28	26
pH	7.6	7.4	7.2	7.1
Electrical conductivity mS/cm-1	4.9	4.5	3.4	3.3
Nitrogen (%)	1.67	1.7	1.9	1.85
Organic Carbon(%)	43	45	56.35	54.76
C:N ratio	25.74	26.47	29.65	29.6
P g/kg	3.3	3.9	5.56	5.1
K (g/kg)	16.7	18.7	22.6	20.3
Ca (g/kg)	3.9	4..6	6	5.2
Mg (g/kg)	0.35	0.43	0.54	0.51

Soluble salts in compost are typically measured on a scale of electrical conductivity associated with salt content. Electrical conductivity of Test 1, Test 2 and control 1, control 2 were 3.4, 3.3 and 4.9, 4.5 mS/cm-1 respectively. Electrical

conductivity value shown by the Test 1and Test 2 lie within the range recommended in the literature i.e between 2.0 and 3.5 mS/cm as optimal for using compost as fertilizer in agriculture (Fernández et al., 2007).Conductivity above 5 mS/cm in finished compost can damage roots, affect nutrient uptake, limit plant-available soil water, or cause seed germination to be inhibited (Lim et al., 2016). At low levels, these salts are potentially beneficial minerals that plants can use. It was observed that in combinations 1 and 2 the initial electrical conductivity was 5.44 and 4.87 mS/cm, respectively.

Total nitrogen content of compost formed in Test 1 and Test 2 were 1.9 and 1.85 % and in control 1 and control 2 were 1.67 and 1.7% respectively. Comparatively more nitrogen content was observed in Test 1 and Test 2 this may be because of mineralization of organic matter during the process of biodegradation. Thus the availability of nitrogen is increased which is good to support the growth of plants. These results are similar to those obtained by Benito et al. (2005) who found that the total nitrogen rate ranged from 0.99 to 2.01%.

Carbon to nitrogen ratio (C\N) means the ratio of carbon element in organic matter to the nitrogen element of organic matter. The finished compost of Test 1 and Test 2 revealed the C/N ratio around 29.6 whereas for control 1 and control 2 ratios were 25.74 and 26.47 respectively. According to Singh and Kalamdhad (2013), the best C\N ratio is 20-30 atoms of carbon for each atom of nitrogen (20-30 carbon atoms: 1 nitrogen atom). If the C:N ratio is too low (not enough carbon), the microbes don't have enough available energy to incorporate all the nitrogen into their cells. In that case, the microbes will "eat" all the carbon that's there, but the excess nitrogen will be eliminated as ammonia. If the C:N ratio is too high when land applied, micro-organisms compete with crop plants to consume the available soil nitrogen in order to degrade the carbon in the compost. The resulting nitrogen immobilization may affect the growth of plants.

In the present investigation, the compost showed the Phosphorus content as 5.56 and 5.1 g/kg for Test 1 and Test 2 respectively, whereas 3.3 and 3.9 g/kg respectively for control1 and control 2. Significantly more amount of phosphorus in test was seen as compared to the control this may be because of addition of consortia in test has contributed for rapid degradation of organic matter. The concentration of potassium content was high in case of all the four combinations. 22.6 and 20.3 g/kg respectively for Test 1 and Test 2 whereas 16.7 and 18.7 g/kg for control1 and control2. It shows the high inherent content in FW, suggesting that compost can be a good source of potassium fertilizer.

Calcium and Magnesium are secondary nutrients for the plants, they are required in very small concentration by the plants. Calsium content of compost were 6, 5.2 and 3.9 and 4.6 g/kg respectively in Test 1, Test 2 and control 1 , Control 2. Compost showed the concentration of Magnesium as 0.54, 0.51, 0.35, 0.43 g/kg respectively in Test 1, Test 2, Control1 and Control2.

TABLE 4

EFFECT OF FLORAL WASTE COMPOST ON GROWTH PROMOTING ACTIVITY IN TOMATO PLANT

Period of Treatment	Control/ Test	Root length (cm)	Shoot length(cm)	Total weight of plant in gm
15 days of treatment	Control (1)	1.7	6.2	1.65
	Test(1)	2.4	8.2	2.7
21 days of treatment	Control	2.2	6.9	2.3
	Test	3.1	10.5	4.2
28 days of treatments	Control	2.7	9.8	2.8
	Test	4.1	13.9	4.7
35 days of treatments	Control	3.4	12.3	3.7
	Test	4.7	17.5	5.9

In order to study the effect of floral waste compost on growth promoting activity in tomato plant we have used the compost prepared using consortia group 1 (Test 1). The addition of floral compost resulted in to increase in root length as well as shoot length of the plant as compared to result obtained in control set, result is represented in Table 4. Maximum root length and shoot was 4.7 cm and 17.5 cm respectively. This increased in the root and shoot length was observed from the 15 days of treatment and this trend continue till the 35 days of treatment. Same pattern was observed with respect to total weight of plant. Maximum weight obtained was 5.9 gm as compared to 3.7 gm in control. The observation of growth with respect to the root length, shoot length and weight of plant were in line with the results of Prabha et al., (2007), where scientist had tested the vermin compost on Hibiscus esculentus and Solanum melongena and medicinal plants (Adhatoda vasica and Solanum trilobatum).The overall result revealed the potential of floral waste compost to support the growth of the plant.

IV. CONCLUSION

We could design the successful composting system by using the microbial consortium isolated by using the floral extract agar. Further the potential of floral waste compost to support the growth of plant was studied by pot assay. Thus this process has not only contributed for waste management rather it has provided nutrient rich compost which can be used for variety of plantation. Floral waste compost prepared by using the microbial consortium is enriched with the Nitrogen, Phosphorus, Pottasium, Calcium and Mangnesium. This method is cost effective as well as pollution free. Thus it can be promoted as potential mechanism to maintain the environmental sustainability at wider scales.

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Trichoderma harzianum Enriched Vertical Column Enhances Black Pepper Growth

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Abstract— *The method of pepper cultivation with vertical columns is more efficient and effective because it can be planted with more pepper cuttings compared to the conventional method with only one plant per stake so that the productivity of the plant is higher. The application of Trichoderma harzianum in the vertical column can increase pepper growth. The results of this study indicate that there is an increase in plant height, number of leaves, number of nodes, and number of lateral fruiting branches by applying Trichoderma 1x10^9/ml in the vertical column. Statistically, the interaction of column media and the addition of Trichoderma shows a significant difference in plant height. Trichoderma can increase nutrient uptake and act as an antagonist for plant pathogens. This microbe is able to dissolve phosphates and certain types of soil minerals. Consequently, the strain effectively increases the growth of pepper. It is important to maintain the suitability of the Trichoderma environment around the pepper so that the microbes continue to survive and provide benefits for plant growth in the long term.*

Keywords— Organic material, Black pepper, Vertical column, Trichoderma harzianum.

I. INTRODUCTION

Black Pepper is a medicinal plant and spices with high value in foreign countries which plays an important role in the economy of Indonesia as it has been a leading export commodity in the plantation sector. Indonesia is also known as one of the largest pepper producers and exporters in the world and is incorporated in the International Pepper Community (IPC) along with other pepper exporting countries such as India, Malaysia, Brazil, Sri Lanka and Vietnam [1]. However, Indonesia's position as a pepper exporting country is currently weakening, occupying only the third position after it was recognized as the world's largest pepper exporter for a few decades. This is caused by a dramatic decrease in the productivity and quality of national pepper and in intensive pepper development from other IPC members [2]. Thus, improving cultivation technology to increase productivity seems to be the viable option to restore the glory of pepper in Indonesia. The most basic improvement in cultivation technology is the provision of quality seeds and adequate parent plantations.

The propagation technique of black pepper using the vertical column method is one of the alternative technologies because it is more efficient and faster [3]. This method is considered efficient and economical because it does not require large tracts of land and conventional stakes that are relatively expensive. Each column in the vertical column method can be used up to ten planting materials depending on the size of the column. Another advantage of using the vertical column method is the support stake which also serves as a medium for growing the vine pepper can be substituted with organic material so that the root can also help the absorption of nutrients from the degradation of the organic material.

This method does not require conventional stakes like those commonly used by pepper growers, but uses vertical columns made of 4 cm wire mesh covered with plastic and then formed cylindrical with a height of 2 m. The column section is then filled with organic material such as coconut coir, oil palm empty fruit bunches (OPEFB), coconut charcoal, or other types of organic material that has been sterilized beforehand. Moisture is maintained in the range of 75-80% at 25-28ºC. This method is very efficient because in one column, several plant cuttings can be planted.

The use of organic material on column provides enough pores for oxygen and biological agents to develop. Biological agents that can be applied to organic column media are *Trichoderma harzianum* because they can act as antagonists of plant diseases and also play a role in increasing growth through auxin production.

The waste of organic material in West Kalimantan is relatively abundant resulting from the processing of oil palm or deep coconut. Therefore, in this study the media from organic material was combined with *T. harzianum* in order to decompose properly. In addition, it is also important to further investigate the optimum dosage of this type of organic material if it is used as a medium in the vertical column method for breeding pepper plants. The application of the vertical column method will also increase the productivity of pepper plants and efficiency in land use.

II. MATERIALS AND METHODS

Pepper cultivation activities were carried out at the Experimental Field, while the analysis of parameters, fungi preparation, and observations were conducted in the Plantation Plant Science Laboratory of Agricultural Technology Department.

2.1 Equipment and Material

The equipment used in this study were shakers, petri dishes, test tubes, laminar airflow, autoclaves, incubators, stirring hot plates, spectrophotometers, analytical scale, pH meters, plant cutter, and wires. The materials used were black pepper cuttings, Podzolic soil, oil palm empty fruit bunches (OPEFB), coconut coir, coconut charcoal, manure, and sand. Materials used in laboratories such as PDA (Potato Dextrose Agar) media, ethanol, and chemicals for analysis

2.2 Methods

The stages in this research were the preparation of planting media, preparation of *Trichoderma harzianum* suspension, column preparation, planting, growth observation, analysis of soil chemical and biological properties. The details of the research stages are as follows:

2.2.1 Planting Media Preparation

Planting media preparation was carried out two weeks before planting. The soil used for the main roots was podzolic soil. Soil was mashed and sieved before it was used so that plant roots can develop properly. Media used in columns such as coconut coir, oil palm empty fruit bunches (OPEFB), coconut charcoal, and rocks / coral. All types of media were sterilized using autoclave.

2.2.2 Preparation of *Trichoderma harzianum* suspension

Trichoderma harzianum Isolate is a collection of Plantation Plant Laboratory, Pontianak State Polytechnic. Fungi were grown aseptically on Potato Dextrose Agar (PDA) media. *T. harzianum* isolates on PDA media aged 1 week after incubation were made a suspension with a concentration of 1x107/ml and $1x10^9$/ml. Referring to the research [4] conidia suspense used for Trichoderma liquid formulation was $1x10^3$-$1x10^9$ conidia/ml. Trichoderma culture that has been grown on PDA media aged 7 day is put into an erlenmeyer containing 50 ml of sterile distilled water. Subsequently, it was homogenized with a vortex mixer for several minutes. Then the conidia suspension was taken with a volumetric pipette and the number of conidia was calculated using a haemositometer so that the Trichoderma suspension density of 1 x 107 cell/ml was obtained. The *T. harzianum* inoculum was then propagated in the liquid media of Potato Dextrose Broth. The liquid suspension of *T. harzianum* was applied to the black pepper column media by being sprayed. The treatment dose given to the column was 500 ml.

2.2.3 Column Preparation

The column was made vertically as a climbed stake for black pepper with a height of 2 m. The column used a wire filled with several types of media enriched with *T. harzianum*. The pipe containing cement was placed in the middle of the column as a buffer so that the column stands upright and strong. Some media used to fill the column are coconut coir, oil palm empty fruit bunches and rock or coral. Black pepper column has a diameter of 30 cm and height of 2 m. In each column, 4 plants were planted around the column.

2.2.4 Planting

Black Peppers were planted in podzolic soil growing media. The pepper seedlings used was 8 months old and was obtained from seed breeding. Planting media used in the form of a mixture of sand, manure, and topsoil with a ratio of 1: 1: 2. Planting pepper seedlings of 4 plants in each column by surrounding the column. Plant maintenance included watering and controlling plant-disturbing organisms. Weed control was done manually.

2.2.5 Soil Analysis

Analysis on the column media was carried out at the beginning of planting and the end of observation. Soil chemistry observed consisted of total N, P_2O_5, and K. Soil samples were dried and sieved on a 2 mm sieve and continue to measure soil moisture and pH. Soil samples that pass a 0.5 mm sieve are used for analysis of water content, pH, total N, P, and K.

III. RESULTS AND DISCUSSION

3.1 Soil Analysis

Analysis of the planting and vertical column media to determine the nutrient content in each treatment.

TABLE 1
THE CONTENT OF NITROGEN, PHOSPHORUS, AND POTASSIUM ON BLACK PEPPER PLANTING MEDIA

Treatments	Total N (%)	P_2O_5 (ppm)	K (ppm)
M0	0.62	109.08	428.63
M1	0.31	97.08	559.37
M2	0.52	99.86	513.6
M3	1.35	100.76	509.01

M0: Planting Media with rocky vertical column, M1: Planting Media with coco charcoal vertical column, M2: Planting Media with coco coir vertical column, M3: Planting Media with OPEFB vertical column

Table 1. shows the results of the soil analysis in the planting media in each treatment. Soil test on the planting media aims to determine whether the column media affects the chemical composition of the planting media. From the results of the soil analysis, the NPK content in each treatment was relatively equal. This means that the column media does not have a large influence on the planting media and black pepper growth can be observed properly because it is mainly influenced by the vertical column media.

TABLE 2
THE CONTENT OF N, P, K ON BLACK PEPPER VERTICAL COLUMN MEDIA

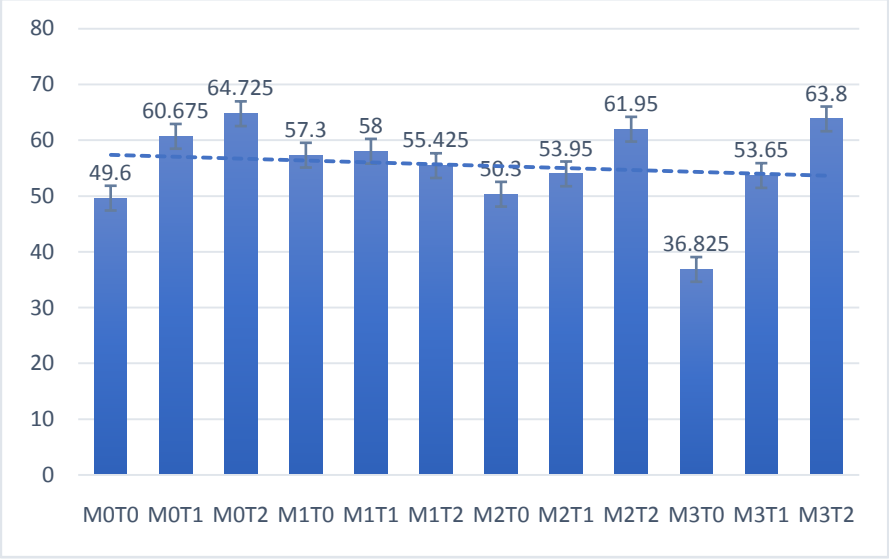
Treatments	Total N (%)	P_2O_5 (%)	K (%)
M1	0.61	0.08	0.4
M2	0.97	0.04	0.05
M3	0.97	0.05	0.03

M1: coco charcoal vertical column, M2: coco coir vertical column, M3: OPEFB vertical column

Media analysis on the column was carried out on the media of coconut charcoal, coconut coir, and oil palm empty fruit bunches (OPEFB). Coconut coir media (M2) and OPEFB (M3) had the same total N value and were higher than other media, while P_2O_5 (%) and K values were lower than coconut charcoal column media. Column media analysis was to determine the chemical characteristics of each treatment in each column.

3.2 Black pepper Growth

3.2.1 Plant Height



M0T0: rocky vertical column without *T. harzianum*, M0T1: rocky vertical column with *T. harzianum* 10^7/*ml*, M0T2: rocky vertical column with *T. harzianum* 10^9/*ml*, M1T0: coco charcoal vertical column *without T. harzianum*, M1T1: coco charcoal vertical column with *T. harzianum* 10^7/*ml*, M1T2: coco charcoal vertical column with *T. harzianum* 10^9/*ml*, *M2T0:* coco coir vertical column *without T. harzianum*, M2T1: coco coir vertical column with *T. harzianum* 10^7/*ml*, M2T2: coco coir vertical column with *T. harzianum* 10^9/*ml*, M3T0: OPEFB vertical column without *T. harzianum*, M3T1: OPEFB vertical column with *T. harzianum* 10^7/*ml*, M3T2: OPEFB vertical column with *T. harzianum* 10^9/*ml*.

FIGURE 1. The Effect of various Media and *T. Harzianum* in Vertical Column on Black Pepper Height

Trichoderma can promote growth of *P. nigrum* [5] and also it has the ability to colonize the roots and form a symbiotic relationship with the plant. Hence, they can be used as a biofertilizer [6]. Besides, Trichoderma can help plants survive in adverse environmental conditions by increasing root growth and promoting photosynthesis [7].

Application of *T. harzianum* on the column media can increase the height of the black pepper. Statistically, *Trichoderma* has a significant influence on the growth of pepper height. Fig. 1 shows the M0T2 treatment was the best high growth rate of 64.7 cm followed by the M3T2 treatment of 63.8 cm. The results of Tukey's HSD Test show that *T. harzianum* treatment concentration of $1x10^9$/ml (T2) was significantly different. Addition of *T. harzianum* on column media can increase height growth. It happens because *T. harzianum* can increase nutrient uptake which results in the addition of root length and stem length, as well as increasing plant chlorophyll.

Trichoderma spp. are major plant growth-promoting fungi that broadly exist in the natural environment and efficient in transformation of soil nutrients. These strains have the abilities to grow and do reproduction quickly. In addition, the plant rhizosphere soil environment can be modified by these microorganism [5].

3.2.2 The Number of Leaves

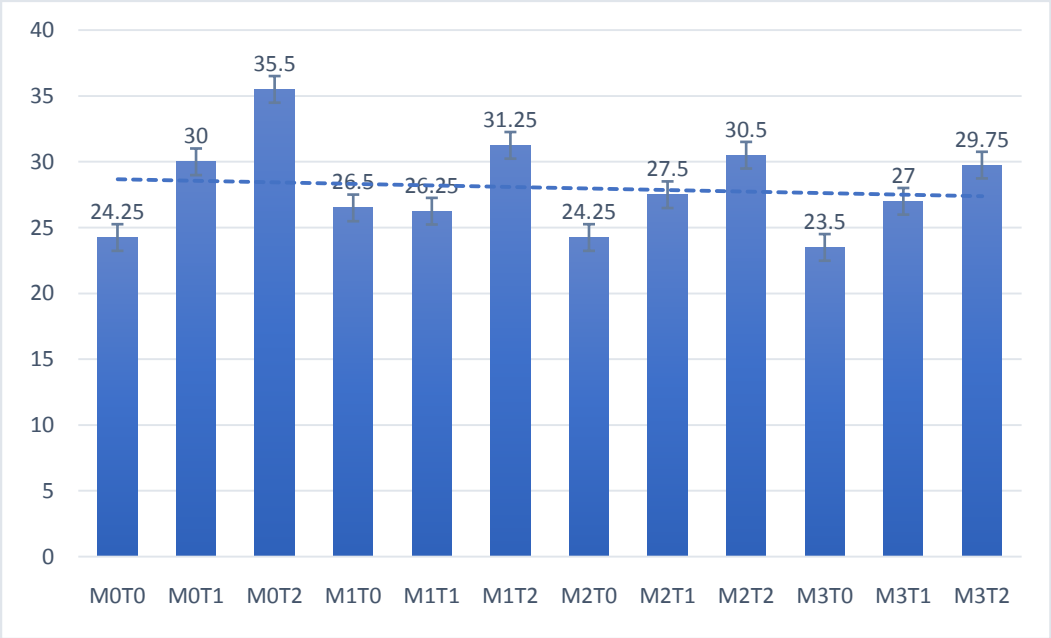


FIGURE 2. The Effect of various Media and *T. Harzianum* in Vertical Column on Leaves Number

T. harzianum essentially affects within the specific abundance of advantageous bacteria and fungi, and consequent growth of black pepper [8]. Trichoderma significantly influences the number of leaves of chili [9]. Based on Fig. 2, in the observation parameters of the number of leaves, M0T2 (rocky vertical column with T. harzianum 10^9/ml) and M1T2 (coco charcoal vertical column with T. harzianum 10^9/ml) treatments were the best with an average number of leaves of 35.5 and 31.25, respectively. Statistical analysis shows that the interaction between column media and *Trichoderma* concentration did not indicate significant effect on the number of leaves, but the concentration of *Trichoderma* significantly affected plant growth and number of leaves. A post hoc test was conducted to measure specific differences between pairs of means and it shows that T2 treatment had a significant difference (Table 3). *T. harzianum* has cellulase and xylanase enzymes so that this fungus acts as an organic material decomposer. Decomposed organic matter makes nutrients available to plants and is useful for supporting plant growth. The ability of *T. harzianum* to dissolve phosphate and certain minerals in the soil is an important key for plant growth. It is also able to excrete certain types of enzymes and can inhibit the pepper pathogens.

3.2.3 The Number of Nodes and Lateral fruiting branches

The use of coir pith compost (CPC) in potting medium under humid conditions can increase the growth of lateral rooting of pepper [10]. According to [11] application of compost lead to significant increase in soil organic matter content, and this will improve long term soil fertility. Fig. 3 shows the average number of nodes in the M0T2 and M2T2 treatments was 14.75, while the average number of fruiting branches was 6.5, in the M2T2 treatment.

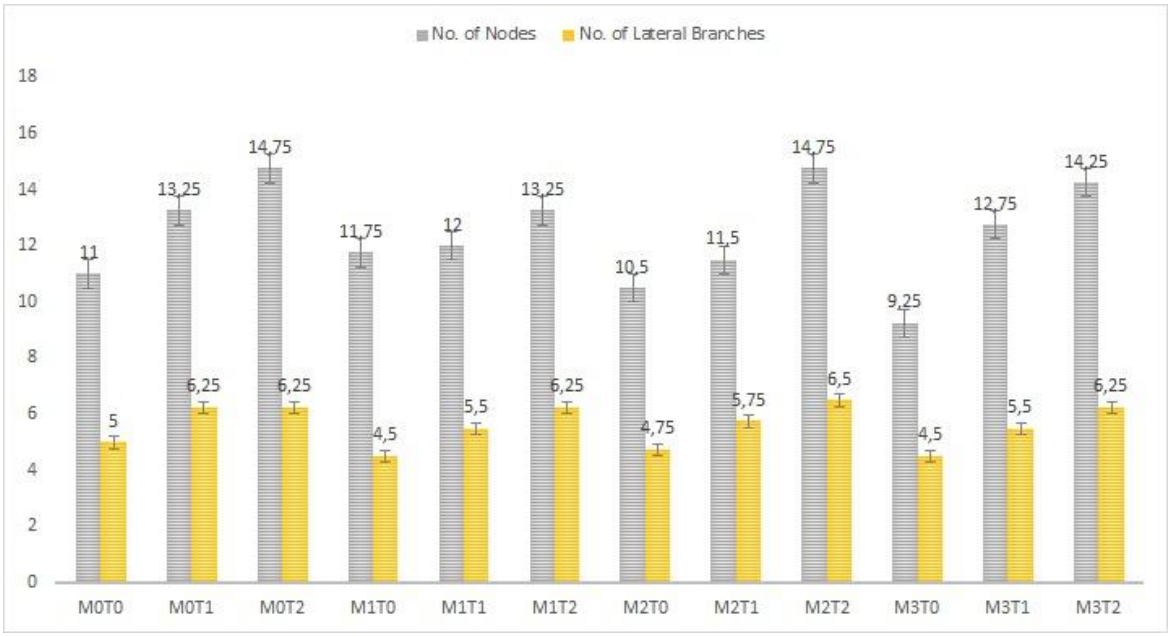


FIGURE 3. The Number of nodes and Lateral Fruiting Branches

In this study, *Based on Tukey's HSD* (*honestly significant difference*) *test* (Table 3), there were statistically significant differences in the parameters from T2 to T0 ($p<0.05$). The increase of the number of nodes and lateral branches is actually influenced by the concentration of *T. harzianum* compared to the type of column media. This shows the ability and contribution of *Trichoderma* in pepper growth. *T. harzianum* provide a significant influence on the number of nodes and lateral branches of pepper plants. The effectiveness of *Trichoderma* is related to various factors, both the abiotic environment such as nutrient concentration, pH, water content, temperature, soil treatment, and the use of fertilizers or pesticides as well as biotic factors such as microbial interactions, fungus species, host plants, and competition between fungi. On research by [12], the application of *Trichoderma* 100 grams/plant is able to influence the growth of pepper plants especially the length of the shoot, the number of shoots and the number of leave. These microorganisms can survive in the soil and the interaction will continue if the abundance of microbes compatible physiologically and inoculum density is quite high [13]. Application of Trichoderma promoted salicyclic acid formation in the root. Regular application of Trichoderma is important in maintaining the population steady, and reducing foot rot disease incidence in black pepper [14].

TABLE 3
TUKEY PAIRWISE COMPARISON

Treatments	**Tukey Pairwise**			
	Heights	Leaves	Nodes	Fruiting Branches
Control	a	a	a	a
T. harzianum 10^7/ml	b	a	b	b
T. harzianum 10^9/ml	b	b	c	b

IV. CONCLUSION

Some media such as oil palm empty fruit bunches (OPEFB), coconut coir, coconut charcoal, and rock can be used as a vertical column media for black pepper. The application of *T. harzianum* suspension has a significant influence on pepper growth. This microbe involves several mechanisms to influence plant growth. Its ability to survive in the soil under suitable environmental conditions and the availability of organic material makes this fungus effective as a biofertilizer especially black pepper. This study shows the positive influence of these microbes on plant height, number of leaves, lateral fruiting branches, and the number of nodes.

The suggestion from this research is to be more selective in choosing the type of column media that will be used by considering the cost and potential of carrying certain types of diseases. The column media must also be sterilized first in order to eliminate the pests and diseases.

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