
ORIGINAL ARTICLE

Evaluation of Biofortified Herbal Consortia-Coated Grow Coir Pots for Enhanced Plant Health and Sustainable Gardening

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ABSTRACT

The study investigated the efficacy of five herbal biocomposite formulations coated on coir pots in enhancing plant growth and controlling soil-borne diseases in *Vigna radiata* and *Zea mays*. All treatments exhibited 100% seed germination in *V. radiata*, with T1 showing the highest shoot (22.74 cm) and root length (13.57 cm). Total plant length reached 36.07 cm and biomass peaked at 1.230 g (fresh) and 0.427 g (dry) in T1. Lateral roots increased from 46 in control to 78 in T1. Chlorophyll content was highest in T1 (2.009 mg/g), indicating improved photosynthetic activity. In *Z. mays*, T1 and T4 significantly enhanced shoot/root length, biomass, and embryonic root number (up to 70 roots). Stomatal index also increased, reflecting enhanced physiological efficiency. Biochemical analysis revealed increased carbohydrate (0.036 g), protein (0.09 g), and amino acid (0.0054 g) content in T1-treated *V. radiata*. Phytochemical screening and GC-MS of T1 detected 47 compounds, with 12 linked to growth and antimicrobial action. T1, T3, and T4 exhibited strong antibacterial activity, inhibiting *Pseudomonas aeruginosa* and *Xanthomonas hortorum*. Overall, herbal biocomposites demonstrated dual benefits: promoting growth and suppressing soil pathogens, offering an eco-friendly alternative to chemical agents.

Keywords: Biofortified, Herbal, Coated coirpots, Sustainable Gardening.

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INTRODUCTION

In recent years, the quest for sustainable and effective solutions in horticulture has led to the development of innovative products that enhance plant health while addressing environmental concerns. One such advancement is the creation of antimicrobial herbal biofortified coir pots. These pots, made from coir a natural and renewable byproduct of coconut husk combine the inherent benefits of a biodegradable base material with the added advantages of antimicrobial and biofortifying properties. Gardeners who try to plant indoors or in the garden often fail at this because of improper plant selection or lack of experience in plant care. Gardening kits which include seedlings, pots, soil and gravel are an alternative solution for beginner gardeners. Gardening kits are in demand for extracurricular activities in childhood education, as well as in horticulture therapy. Public programs, and by a variety of individuals (6). Coir pots, made from the fibrous husk of coconuts, offer a promising solution. These eco-friendly pots not only support healthy plant growth but also contribute to reducing waste and environmental impact. Coir pots are biodegradable containers made from coir, a natural fiber extracted from the outer husk of coconuts. This material is rich in lignin and cellulose, making it a sturdy and resilient choice for growing plants. Unlike plastic pots, coir pots decompose naturally over time, integrating back into the soil and minimizing land-fill waste. In response to growing environmental and health concerns, there is increasing interest in developing sustainable horticulture solutions that promote plant health while minimizing ecological impact. One such innovation is the creation of antimicrobial herbal biofortified coir pots. Coir, a natural and renewable material derived from coconut husks, is prized for its biodegradability and superior water

retention properties. By integrating herbal extracts known for their antimicrobial properties such as neem oil, tea tree oil, and eucalyptus oil into the coir substrate, these pots offer dual benefits: they inhibit the growth of harmful microorganisms and provide essential nutrients to plants. This approach not only enhances the plant's growing environment by reducing the reliance on synthetic pesticides but also contributes to sustainable gardening practices by utilizing eco-friendly materials. In order to overcome the problem of pathogenic infestation through fungi, nematodes and bacteria the present work was planned innovatively to incorporate the herbal antimicrobial agents which biofortifies raw coir pots into a healthy and diseases free bio pots. Thus, antimicrobial herbal biofortified coir pots represent a significant advancement in combining traditional horticulture techniques with modern environmental and health consideration.

MATERIAL AND METHODS

Collection of Plant Materials:

The plant materials with the property of Antimicrobial and Biofortification nature which enhances the growth and development. The plant materials were collected from in and around Pollachi. The collected plant materials was shade dried separately and utilized for further studies.

S.NO	PLANT NAME	USED PART
01.	<i>Zingiber officinale</i> Roscoe	Rhizome
02.	<i>Moringa oleifera</i> Lam.	Seed
03.	<i>Cinnamomum verum</i> J. Presl	Bark
04.	<i>Syzygium aromaticum</i> (L.) Merr.& L.M.Perry	Seed
05.	<i>Coriandrum sativum</i> L.	Seed
06.	<i>Glycyrrhiza glabra</i> L.	Stem
07.	<i>Jasminum sambac</i> L.	Leaf
08.	<i>Carica papaya</i> L.	Leaf
09.	<i>Tagetes erecta</i> L.	Flower
10.	<i>Coleus amboinicus</i> Lour.	Stem and Leaf
11.	<i>Mentha spicata</i> L.	Stem and Leaf

Table:1 List of Plant materials and parts used

Preparation of plant powder:

The clean and healthy plants were collected, and shade dry method used to drying the collected plant materials. Then the dried plant materials were powdered using electrical blender, and the prepared plant powder was stored in glass container for further useage.

Preparation of Plant Extracts:

The powdered were used to take hot extract method by using soxhlet apparatus. (8). The powder was taken in the whatmann filter paper and packed. The solvent like ethanol were used to take extract. About 30gms of plant powder of different parts such as leaves, flower was taken separately and extracted. The extract will be converted to cured and used further. The cured of plant extract will be appropriately mixed using the solvent so as to prepare in different formulation and stored in sustainable container and environment.

Preparation of Bioconsortia formulation:

The herbal extract will be mixed in different ratio and to prepare the biofortified consortia. Which enhance the growth and development of selected studied crops. Such, as *Vigna radiata* and *Zea mays*. The prepared five different composite of biofortified consortia and named as, T₁, T₂, T₃, T₄ and T₅. The prepared bioconsortia formulation stored in suitable container and stored in appropriate condition.

Making of formulated Herbal Bioconsortia coated Coir Pots:

The prepared different composite of bioconsortia formulation were repeatedly coated for more than 10 times on the raw coir pots. The coated coir pots were used to evaluate for its support towards growth and development of the selected studied crops. These best performing biofortified herbal formulation coated coir pots were also tested for antimicrobial potential against pathogenic bacteria, fungi, nematodes for sustainable and healthier plant growth.

Physical parameters of studied crops: (15 and 22)

The physical parameters were evaluated in selected studied crops. Such as, *Vigna radiata* and *Zea mays*. To observe change in growth and morphological parameters caused due to bioconsortia coated coir pots grown crops were observed and tabulated. On following notable parameters Plant height, Number of leaves per plant, Shoot length, Root length and Number of Roots.

Biochemical and Proximate analysis:

(i). Estimation of Chlorophyll content: (4)

The contents of chlorophyll a, b and total chlorophyll were estimated on the bioconsortia coated and non-coated leaves and the contents were expressed as mg/g of fresh weight of each treatment.

(iii). Estimation of Protein: (11)

Soluble protein content of leaf was estimated by the Lowry method or Bradford method and expressed as mg /g of fresh weight. The bioconsortia treated leaves were taken for analysis.

Estimation is usually carried out with buffers used for the enzyme assay.

(iv). Estimation of total free amino acid: (12)

The total free amino acid content of the treated leaf was estimated and expressed as mg /g of fresh sample

Phytochemical analysis: (21)

The extract from was prepared from herbs using ethanol solvent. About 100mg was dissolved in 10 ml of its own mother solvents ethanol. The obtained extract was kept as stock were subjected to preliminary phytochemical screening

Test for tannin / polyphenol (19):

To the dil. extract, 3-4 drops of 10% FeCl₃ were added, blue color was seen for tannins and the presence of catechol tannin turned the solution green.

Test for reducing sugar (20):

To 0.5 mL of plant extract, 1mL of water, and 5-8 drops of Fehling's solution were added and heated. The presence of reducing sugar was indicated by the appearance of brick red precipitation.

Test for flavonoids (19) extract was taken with the addition of conc. H₂SO₄. The appearance of yellow-colored precipitation indicated flavonoids.

Test for terpenoids (2):

0.2 ml of extract was mixed with 2 mL chloroform, 3 mL conc. H₂SO₄. Reddish-brown coloration indicated the presence of terpenoids.

Test for alkaloids: Meyer's test ((19)):

To 2mL of extract, 1 mL of Meyer's reagent was added. The presence of pale yellow precipitate indicated the presence of alkaloids.

Test for saponins (2):

About 2 ml of extract was boiled in 20 mL of distilled water. 10 mL of filtrate, 5 mL of distilled water were quivered vigorously. The appearance of persistent frothing indicates the presence of saponins.

Test for volatile oils (19):

About 2 mL extract was shaken with 0.1 mL of NaOH and a small quantity of dilute HCl. White precipitate indicated the presence of volatile oil.

Test for cardiac glycosides (19):

About 5 ml of plant extract was treated with 2 mL of glacial acetic acid with one drop of FeCl₃ solution. A violet ring may appear or a greenish ring may form just which showed the presence of cardiac glycosides.

Test for steroids (19):

About 1 g of plant extract was dissolved in a few drops of acetic acid and a drop of conc. H₂SO₄ was added. The appearance of green color indicated the presence of steroids.

Antibacterial activity using standard agar well diffusion method (13)

The antibacterial activity of given samples (CC and ZC) was tested using standard agar well diffusion method. As an initial step, Sterile Mueller-Hinton Agar [MHA] (Composition g/L: Acid hydrolysate of Casein: 17.5g; Starch: 1.5g, Sodium chloride: 5.0g, Agar 17.0 g; Final pH (7.0 ± 0.2) media was prepared according to Microbiological standards. The media was poured on to sterile petri-plates and allowed to solidify. About 0.1% inoculum suspensions of the test organism (*Pseudomonas aeruginosa* and *Xanthomonas hortorum*) were swabbed uniformly over the agar surface separately. Under sterile conditions, 6mm wells were cut on the agar surface of each MHA plates. About 20µl of given samples from each concentration (10, 20 and 30µg/ml) were loaded into the well and the plates were incubated at 37°C for 24h. The antimicrobial activity was evaluated in terms of zone of inhibition around the wells in all the inoculated NA plates. The inhibition clear zones were measured and recorded in millimetre. In parallel, standard antibiotic (4µg/ml of streptomycin as positive control – PC and 10µl of DMSO as negative control) was also evaluated separately against the test organism to find the significant antimicrobial efficiency of given samples.

Gas chromatograph-mass spectrum (GC – MS) Analysis (17)

GC-MS analysis involved best performed treatment (T₁) was carried out on an Agilent 7890A system equipped with mass spectrophotometer detector and split less injection system. The GC was fitted with a

HP-5MS capillary column (30 m × 0.25mm; film thickness 0.25 µm). The temperature program was as follows: injector temperature 260 °C, initial oven temperature at 70 °C, then increased at 10 °C/min to 150 °C for 5 min, 12 °C/min to 200 °C for 15 min, and 12 °C/min to 220 °C for 15 min. Helium was used as the carrier gas at 17.69 psi pressure with flow 0.6 ml/min. Samples were dissolved in methanol, and 1 µl aliquot was injected automatically. MS was set in the scan mode. The mass range was set in the range of 50–550 m/z. MS spectra of separated components were identified.

RESULTS AND DISCUSSION

Herbs are considered to be promising antimicrobial agents to control many of the diseases. The plant diseases are considered to be biggest problem for growing many crops both in field and kitchen garden. The plant based herbal antimicrobial agents consider to be a promising solution for the controlling of many microbials borne diseases. Recently, the kitchen garden is getting familiar at every one's home many plants including medicinal, vegetables and fruits are grown in the home itself for leading a healthy life. But the soil borne diseases are considered to be causing a considerable loss of those crops. The making of herbal based composite is the only better solution to overcome and control the diseases that spread over the crop in kitchen garden. The chemical based antimicrobial products are presently occupying wide range of markets give to its fast and long-lasting effect over the diseased plants. But, the residual effects which enters the food chain and affect the ecological and ecotoxicology disturbance may cause many drastic changes in environment. This leads to various genetical and physiological complications in biodiversity. Some of the undesirable changes happened which are highly irreversible and unable to recover by the biological system. Hence, to overcome this problem an herbal based biocomposite made of plants rich in antimicrobial and plant growth enhancing property was prepared and treated with the coir pots for the betterment of growth and yield.

For the present study five different formulation used for treatment made of various plant extracts were prepared at the definite ratio at different concentration and coated on inner layers of the coir pots. The plants including *Zingiber officinale*, *Moringa oleifera*, *Syzygium aromaticum*, *Coriander sativum*, *Glycyrrhiza glabra*, *Jasminum sambac*, *Carica papaya*, *Tagetes erecta*, *Coleus amboinics*, *Mentha spicata*, *Cinnamum verum*. These five different formulations considered as five different treatment and coated separately in each coir pots with Three replicants for each treatment. The treatment was carried out on two plants such as, *Vigna radiata* and *Zea mays* separately. Clean healthy seeds were taken and preliminary germination studies were carried out to confirm the healthy seeds. Well germinated seeds with 100% germination were used for the present study.

The formulation (T₁) consists of *Zingiber officinale*, *Moringa oleifera*, *Syzygium aromaticum*, *Coriander sativum*, *Glycyrrhiza glabra*. Were to take 0.5 ml of extract was prepared and mixed with 9.5 ml of distilled water and coated on the studied coir pots. (Table: -1) The T₂ formulation including *Jasminum sambac*, *Carica papaya*, *Tagetes erecta*, *Coleus amboinics*, *Mentha spicata*. Were to take 0.5 ml of extract was prepared and mixed with 9.5 ml of distilled water and coated on the studied coir pots. (Table: -1) The T₃ formulation made out of the plant extracts of *Moringa oleifera*, *Syzygium aromaticum*, *Carica papaya*, *Coleus amboinics*, *Glycyrrhiza glabra*. Were to take 0.5 ml of extract was prepared and mixed with 9.5 ml of distilled water and coated on the studied coir pots. (Table: -1). The T₄ formulation was prepared use the plant extracts *Jasminum sambac*, *Moringa oleifera*, *Coriander sativum*, *Zingiber officinale*, *Mentha spicata*. Were to take 0.5 ml of extract was prepared and mixed with 9.5 ml of distilled water and coated on the studied coir pots. (Table:-1) The T₅ formulation was obtained from the plant extracts viz., *Coleus amboinics*, *Syzygium aromaticum*, *Cinnamum verum*, *Tagetes erecta*, *Zingiber officinale*. Were to take 0.5 ml of extract was prepared and mixed with 9.5 ml of distilled water and coated on the studied coir pots. (Table:-1). The prepared biocomposite was tested against on *V. radiata* of Fabaceae and *Zea mays* of Gramineae was taken. The germination ability was tested after growing the seeds in herbal coated coir pots were observed after 7day's and tabulated. (Table:-2) The plants *V.radiata* showed 100% germination in all the treated coir pots. This show that the extracts support the growth of studied plant *V.radiata* to considerable level.



Fig:1 The studied crop plants grown on coated coir pots *V.radiata* and *Z.mays*

The monocot plant *Zea mays* showed varied germination percentage. Most of the treated plant showed higher germination than the control. T₁ T₂ and T₄ supports the growth of *Zea mays* and show to 80% of germination rate of the seeds grow on herbal extract coated coir pots.(Table:-2). The majority of the treatment supports to growth and development of studied crops. The T₃ treatment showed above 60% of germination percentage after 7days. (Table:-2) The growth parameters are considered to be first and for most observation for understanding the effect of herbal composite treated. The shoot length of the treated dicot plant *V.radiata* was increased when compare with control. About 20.73cm shoot length was increased to 22.74, 21.68 and 23.0 in T₁, T₂ and T₃. Comparing the root length was also increased to 13.57cm in T₁, 10.03cm in T₂, 11.31cm in T₃ and 11.41cm in T₅ except to T₄ all the treatment supports to growth of roots. When control records only 9.68cm root. (Table: -2) Similarly results were obtained in priming tomato seeds with *Vinca*, *Chlorophytum* and *Azadirachta indica* has been shown to reduce mortality and increase seedling vigour (14). Herbal plants contain bioactive compounds, such as phytohormones, growth regulators, phenolic acid reported that the changes are happened might have played a significant role in regulating the metabolism associated with seed germination and seedling establishment. The entire plant length was also higher and reaches about 36.07cm in T₁ treatment followed by 34.36cm in T₅ treatment and 31.32cm in T₃ treatment.

Table:2The Physical Parameters of the crops grown on Bioconsortia coated coir pots of *V. radiata*

S.No	Treatment	Shoot Length (cm)	Root length (cm)	Plant entire Length (cm)	Fresh Seedling Weight (gm)	Dry Seedling Weight (gm)
01.	Control	20.73±0.85	9.68±1.68	30.54±2.6	1.006±0.3	0.234±0.2
02.	T ₁	22.74±1.14	13.57±3.17	36.07±3.88	1.230±1.2	0.427±0.5
03.	T ₂	21.68±1.63	10.03±1.50	31.33±2.16	1.184±0.8	0.296±0.4
04.	T ₃	18.51±1.86	11.31±2.87	29.81±4.25	1.194±0.9	0.352±0.6
05.	T ₄	17.55±1.12	9.73±0.80	30.01±1.71	1.036±0.8	0.215±0.2
06.	T ₅	23.01±1.35	11.41±1.75	34.36±2.72	1.144±0.5	0.326±0.5

n=7

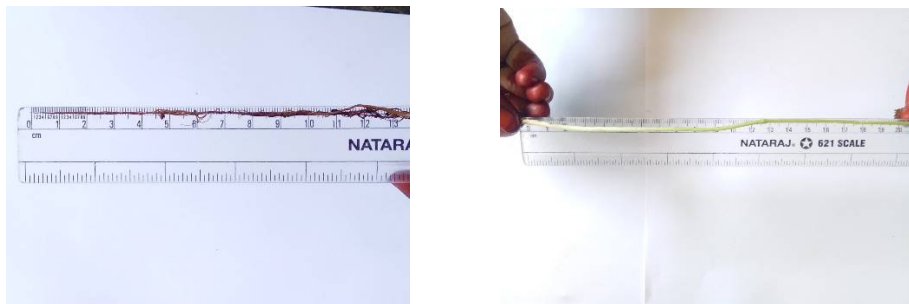


Fig: 3. Measuring root and Plant entire length of treated crop plants

The biomass of the plant was a physiological characters 1.230gm of seedling weight was found to be recorded in *V.radiata* (T₁) and 1.194gm in T₃ and 1.184gm in T₂ and 1.144gms in T₅ respectively when compared with control. The dry biomass of *V.radiata* recorded the highest value of 0.427gm followed by 0.352gm when compared with control with 0.234gm. The morphological parameters including Roots, No. of leaves and No. of stomata of various time intervals was calculated the Table:-3. The crop *V.radiata* showed that there is considerable change and variation according to concentration as per the previous

data. The present data also confirms the No. of lateral roots was considerably increased from 46 in control to maximum of 78 roots in T₁ and T₃ showed 56 lateral roots.



Fig.2 The images of well grown root system after treatment

The presence of no. of leaves are one of the important photosynthetic attributes was calculated and tabulated after 5,10,15 days accordingly. There is no much change was recorded. The herbal formulation supports the Growth and development of No. of leaves and there is no reduction in number. The stomatal number in the form of stomatal index was tabulated. The increase in number of stomata clearly depicts that increases in number when the treatment is varied. The control recorded on 45% whereas all other treatments showed that increase in stomatal index Table:3.

Table 3: The Rooting behavior and Stomatal index of plant species *V. radiata* grown in Bioconsortia coated coir pots.

S.No	Treatment	Roots		No of Leaves			No of Stomatal Index (%)
		No of Main roots	No of Lateral roots	After 5 days	After 10 days	After 15 days	
01.	Control	1	46	2	5	8	45
02.	T ₁	1	78	2	5	8	67
03.	T ₂	1	47	2	5	8	53
04.	T ₃	1	56	2	5	8	58
05.	T ₄	1	51	2	5	8	55
06.	T ₅	1	53	2	5	8	49

The treatment over the monocot crop *Zea mays* was carried out to assess the growth and development of plant. The herbal biocomposite coated coir pots enhance the Root length, Shoot length, Entire plant length, Fresh seedling weight and Dry seedling weight considerably. The entire length and fresh seedling weight of with 2.624gm and dry seedling weight of about 0.610gm all the parameters was comparatively and considerably graded when compared with control condition followed by T₄ treatment also has considerable increase in the morphological parameters. The embryonic roots were considerably increased in number about 7 roots has been recorded in T₁ and T₄ also exhibited the high number of roots in 70 roots has been recorded in T₁ formulation and T₂ has been recorded with 52 lateral roots. There is no considerable change has been recorded even the 5,10,15 days of interval Table:5



Fig.4 The images of Rooting ability and Shoot length of the treated crop plants.

Table:-4 The Physical Parameters of the crops grown on Bioconsortia coated coir pots of *Zea mays*.

S.No	Treatment	Shoot Length (cm)	Root length (cm)	Plant entire Length (cm)	Fresh Seedling Weight (gm)	Dry Seedling Weight (gm)
01.	Control	28.30±5.09	11.55±2.33	39.5±7.63	2.511±1.3	0.536±0.7
02.	T ₁	34.15±3.09	19.28±2.20	50.85±9.01	2.624±1.6	0.610±0.9
03.	T ₂	30.62±5.34	18.65±6.55	49.27±11.75	1.669±0.9	0.319±0.4
04.	T ₃	24.74±8.67	17.30±7.54	41.90±15.37	1.296±0.4	0.416±0.3
05.	T ₄	31.55±1.72	13.60±2.55	45.17±3.86	1.571±0.6	0.396±0.1
06.	T ₅	12.20±4.24	6.85±3.60	19.0±7.91	0.890±0.01	0.193±0.005

The No. of stomatal index in the monocot plant was recorded as stomatal index. About 34% of the remarkable increase in physiological efficiency of the studied plant crop. (Table:-5). The above changes are due to the presence of biostimulants have the potential to enhance a plant's physiological processes, thereby improving nutrient uptake and optimizing nutrient use (9). Among recent strategies aimed at promoting sustainable crop production, plant extracts have gained attention for their effectiveness in biostimulant development. For instance, aloe leaf extract has been shown to significantly boost plant height, leaf and branch number, yield, essential oil content, and improve leaf anatomical structure (1).

Table:-5 The Rooting behavior and Stomatal index of plant species *Zea mays* grown in Bioconsortia coated coir pots.

S.No	Treatment	Roots		No of Leaves			No of Stomatal Index (%)
		No of Lateral roots	No of Sub Lateral roots	After 5 days	After 10 days	After 15 days	
01.	Control	6	38	1	3	5	34
02.	T ₁	7	70	1	3	5	55
03.	T ₂	6	52	1	3	5	42
04.	T ₃	6	44	1	3	5	49
05.	T ₄	7	41	1	3	5	51
06.	T ₅	4	15	1	3	5	39

Similarly, the cucumber plants, foliar application of garlic extracts notably increased plant height, leaf number, foliar area, total chlorophyll content, node proportion, and total soluble solids (7). The present study results reports that, guava leaf and neem seed waste compost positively influenced the vegetative growth of plant enhancing traits such as plant height, stem diameter, and leaf dimensions (3). Additionally, aqueous extracts of alfalfa have been found to significantly improve root length and yield in beetroot (18). All these physiological changes are due to presence important biostimulants found in the plant extract.

The chlorophyll content of the plant was another important factor which determine the photo synthetic efficiency of the studied plant crop. The total chlorophyll content was increased to 2.009 mg/g . when compared with control has recorded only 1.269mg/g followed by the T₃ treatment increased the chlorophyll contents to 1.686mg/g in *V.radiata* (Table:-8). On the other hand the total chlorophyll content was increased the 1.269mg/g and 0.993mg/g in T₁ and T₂ treatment respectively, except T₅ treatment all others are showed higher the presence of chlorophyll content in monocot plant *Zea mays*.(Table:-6)

Table:-6. Estimation of chlorophyll content grown under different Bioconsortia treatment of *Vigna radiata*

S.No	Treatment	Chlorophyll a (mg /g)	Chlorophyll b (mg /g)	Total Chlorophyll (mg /g)
01.	Control	0.845	0.424	1.269
02.	T ₁	1.091	0.918	2.009
03.	T ₂	1.014	0.601	1.615
04.	T ₃	1.092	0.596	1.686
05.	T ₄	1.028	0.510	1.587
06.	T ₅	1.002	0.471	1.474

Table:-7 Estimation of chlorophyll content grown under different Bioconsortia treatment of *Zea mays*.

S.No	Treatment	Chlorophyll a (mg /g)	Chlorophyll b (mg /g)	Total Chlorophyll (mg /g)
01.	Control	0.524	0.214	0.738
02.	T ₁	0.904	0.365	1.269
03.	T ₂	0.724	0.269	0.993
04.	T ₃	0.646	0.217	0.863
05.	T ₄	0.555	0.196	0.751
06.	T ₅	0.289	0.118	0.407

The biochemical parameters of *V.radiata* grown under treatment of herbal composite coated coir pots were analysed and recorded. The carbohydrate content was 0.036gm was recorded on T₁ treatment and 0.09gm of protein in T₁ respectively. The total free amino acid was recorded as 0.0054gm in T₁ and T₃ treatment was recorded with 0.0038gm of total free amino acids. (Table:-7) The *Zea mays* crop showed carbohydrate content was about 0.044gm and 0.098gm of protein and 0.012gm of total free amino acids was recorded. Similarly, T₄ treatment recorded with 0.040gm of carbohydrate, 0.092gm of protein and 0.0011gm of total free amino acids. (Table:-8 & 9)

Table:-8 Biochemical parameters of study plant species *Vigna radiata* grown under bioconsortia coated coir pots.

S.No	Treatment	Carbohydrate (gm)	Protein (gm)	Total free Amino acids (gm)
01.	Control	0.032	0.064	0.0008
02.	T ₁	0.036	0.092	0.0054
03.	T ₂	0.030	0.075	0.0020
04.	T ₃	0.022	0.067	0.0038
05.	T ₄	0.023	0.088	0.0016
06.	T ₅	0.025	0.086	0.0028

Table:-9 Biochemical parameters of study plant species *Zea mays* grown under bioconsortia coated coir pots.

S.No	Treatment	Carbohydrate (gm)	Protein (gm)	Total free Amino acids (gm)
01.	Control	0.010	0.061	0.0038
02.	T ₁	0.044	0.098	0.0126
03.	T ₂	0.030	0.085	0.0111
04.	T ₃	0.023	0.087	0.0122
05.	T ₄	0.040	0.092	0.0114
06.	T ₅	0.001	0.070	0.0044

The results are justified Plant extract treatments have been widely recognized for their ability to enhance key biochemical constituents in plants, such as chlorophyll content, total carbohydrates, protein levels, and total free amino acids. The bioactive compounds found in these natural extracts, including phytohormones, antioxidants, vitamins, and enzymes, play a critical role in promoting plant metabolic activity and stress resilience. The yeast fungal extract on the plant *Pentas lanceolata* significantly increased chlorophyll a and b content, due to the presence of cytokinins that delay leaf senescence and stimulate chlorophyll biosynthesis (11). Enhanced chlorophyll levels directly contribute to improved photosynthetic efficiency, which in turn leads to a greater accumulation of carbohydrates. (11).

In addition to photosynthates, plant extracts are known to enhance nitrogen metabolism, reflected by increased protein and free amino acid contents. A study by (22) demonstrated that protein hydrolysates derived from *Cicer arietinum* and *Spirulina platensis* significantly elevated soluble protein concentrations in maize leaves and roots, suggesting that these natural compounds can effectively function as biostimulants by serving as accessible nitrogen sources. The aqueous extracts of herbal plants like bitter melon, brinjal, and Indian spinach have shown high levels of free amino acids, which are essential for cellular function and stress response mechanisms in plants (5). These results collectively indicate that the use of plant extracts not only boosts structural growth but also enhances physiological and metabolic health, supporting their application in sustainable agriculture.

The next important parameter is qualitative preliminary phytochemical analysis including Tannin, flavonoid, terpenoids, alkaloids, saponins, volatile oils and cardiac glycosides was recorded in the

prepared herbal bioconsortia. Next to T₁ formulation T₃ and T₄ formulation showed the major phytochemicals which is responsible for the antibacterial activity on the coir pots. (Table:-10)

Table:-10 The Qualitative phytochemical analysis for the prepared herbal Bioconsortia.

S.No	Phytochemicals	T ₁	T ₂	T ₃	T ₄	T ₅
01.	Tannin	+	+	+	+	+
02.	Flavonoids	+	-	+	-	+
03.	Terpenoids	+	+	+	+	+
04.	Alkaloids	+	-	+	-	-
05.	Saponins	+	-	+	+	-
06.	Steroids	-	+	-	+	-
07.	Volatile oils	+	-	+	-	+
08.	Cardiac glycoside	+	-	+	-	-

“+” – Present

“-” – Absent



Fig : 5 The antibacterial assay using agar well diffusing method for selected herbal bio consortia T₁ against *Pseudomonas aeruginosa* and *Xanthomonas hortorum*



Fig :6 The antibacterial assay using agar well diffusing method for selected herbal bio consortia T₃ against *Pseudomonas aeruginosa* and *Xanthomonas hortorum*

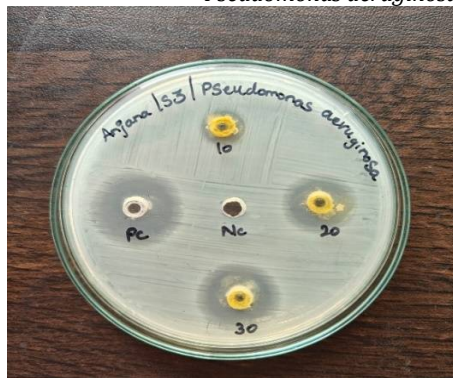


Fig: 7The antibacterial assay using agar well diffusing method for selected herbal bio consortia T₄ against *Pseudomonas aeruginosa* and *Xanthomonas hortorum*

The above phytochemical compound was confirmed using the GC MS analysis. The best performing formulation T1 herbal biocomposite was selected and analyzed for the presence of the compounds. About 47 compounds were detected from the prepared plant composite. In particular 12 compounds are directly involved in the antimicrobial and growth enhancing properties. The chemical compounds directly or indirectly involved in the growth development and controls the pathogenic microbial population in soil and growth media which enhances the growth of the plant both physically and physiologically. The healthy which gives good productivity and improves the health of the plants too. Hence the coated herbal biocomposite clearly indicates that it contains both growth enhancing property and disease controlling property (Table 11 & 12).

Table :- 11 Antibacterial efficacy for best performed Bioconsortia formulation.

S.No	Treatment	<i>Pseudomonas aeruginosa</i>					<i>Xanthomonas hortorum</i>				
		PC*	10 µg	20 µg	30 µg	DMSO#	PC*	10 µg	20 µg	30 µg	DMSO#
		Zone of Inhibition (mm)					Zone of Inhibition (mm)				
01.	T ₁	20	10	15	17	0	20	09	14	16	0
02.	T ₃	18	07	12	14	0	20	10	16	18	0
03.	T ₄	17	07	12	14	0	19	10	13	14	0

PC*- Positive Control: Streptomycin DMSO# - Negative Control

Table:-12 GC-MS Analysis for selected herbal bioconsortia formulation of T₁.

S.No	RT	Compound Name	CAS#	Formula	Area	Match Score	Area %- T	Area %- M	Molecular Weight
01.	4.1758	1,2Cyclopentanedione	3008-40-0	C5H6O2	22871	66.7	0.09	0.17	98.0999
02.	4.5647	Glycerin	56-81-5	C3H8O3	212875	75.1	0.85	1.63	92.0938
03.	4.8091	Oxirane, [[2-propenyloxy)methyl]-	106-92-3	C6H10O2	28021	66.7	0.11	0.21	92.0938
04.	4.8869	Octanal	124-13-0	C8H16O	22493	56.4	0.09	0.17	128.2120
05.	5.3646	Benzeneacetaldehyde	122-78-1	C8H8O	39794	77.5	0.16	0.30	120.1485
06.	120.1485	2,5-Dimethyl-4-hydroxy-3(2H)-furanone	3658-77-3	C6H8O3	12925	56.8	0.05	0.10	128.1259
07.	5.6312	2-Hexenal, 2-ethyl-	645-62-5	C8H14O	19904	60.8	0.08	0.15	126.1962
08.	5.8201	DL-Norleucine	616-06-8	C6H13NO2	15763	55.8	0.06	0.12	131.1729
09.	5.8978	1,6-Octadien-3-ol, 3,7-dimethyl-	78-70-6	C10H18O	911350	98.6	3.62	6.96	154.2493
10.	6.2645	Ethanamine, N-ethyl-N-nitroso-	55-18-5	C4H10N2O	6237	57.9	0.02	0.05	102.1350
11.	6.4089	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	28564-83-2	C6H8O4	94331	88.4	0.37	0.72	144.1253
12.	6.5089	(+)-2-Bornanone	464-49-3	C10H16O	44475	89.0	0.18	0.34	152.2334
13.	6.6533	Pipradrol	467-60-7	C18H21NO	13484	54.3	0.05	0.10	267.3654
14.	6.7422	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, (1S-endo)-	464-45-9	C10H18O	3845	60.0	0.02	0.03	154.2493
15.	6.8199	3,7-Octadiene-2,6-diol, 2,6-dimethyl-	13741-21-4	C10H18O2	141328	82.4	0.56	1.08	170.2487
16.	6.9422	L-.alpha.-Terpineol	10482-56-1	C10H18O	58985	81.1	0.23	0.45	154.2493
17.	6.9866	2-Decen-1-ol, (E)-	18409-18-2	C10H20O	22305	72.4	0.09	0.17	156.2652
18.	7.0755	Benzofuran, 2,3-dihydro-	496-16-2	C8H8O	26587	64.4	0.11	0.20	120.1485
19.	7.1532	5-Hydroxymethylfurfural	67-47-0	C6H6O3	45883	76.2	0.18	0.35	126.1100
20.	7.2088	7-Octene-2,6-diol, 2,6-dimethyl-	29210-77-3	C10H20O2	29665	79.8	0.12	0.23	172.2646
21.	7.3643	cis-3-Hexenyl iso-	41519-	C10H18O2	3801	52.4	0.02	0.03	170.2487

		butyrate	23-7						
22.	7.4199	Phenol, 4-(2-propenyl)-	501-92-8	C9H10O	114353	90.5	0.45	0.87	134.1751
23.	7.6310	2,7-Octadiene-1,6-diol, 2,6-dimethyl	64142-78-5	C10H18O2	68076	86.1	0.27	0.52	170.2487
24.	8.0420	2-Methoxy-4-vinylphenol	7786-61-0	C9H10O2	38012	78.0	0.15	0.29	150.1745
25.	8.4309	Eugenol	97-53-0	C10H12O2	13096262	97.9	52.05	100.00	164.2011
26.	9.1197	Caryophyllene	87-44-5	C15H24	315853	93.2	1.26	2.41	204.3511
27.	8.5753	1,6-Octadien-3-ol, 3,7-dimethyl-, formate	115-99-1	C11H18O2	47704	79.7	0.19	0.36	182.2594
28.	9.2752	1(2H)-Naphthalenone, 3,4-dihydro-	529-34-0	C10H10O	54117	61.0	0.22	0.41	146.1858
29.	9.4307	Humulene	6753-98-6	C15H24	35603	70.8	0.14	0.27	204.3511
30.	9.5529	Benzene, 1-(1,5-dimethyl-4-hexenyl)-4-methyl-	644-30-4	C15H22	20847	67.3	0.08	0.16	202.3352
31.	9.7973	Phenol, 2-methoxy-4-(2-propenyl)-, acetate	93-28-7	C12H14O3	2348000	96.5	9.33	17.93	206.2378
32.	10.2973	Phenol, 4-(3-hydroxy-1-propenyl)-2-methoxy-	458-35-5	C10H12O3	44017	72.7	0.17	0.34	180.2005
33.	10.4084	Diethyl Phthalate	84-66-2	C12H14O4	165112	94.5	0.66	1.26	222.2372
34.	10.5084	Caryophyllene oxide	1139-30-6	C15H24O	114575	86.2	0.46	0.87	220.3505
35.	10.8083	.beta.-Guaiene	88-84-6	C15H24	79436	79.7	0.32	0.61	204.3511
36.	11.2194	2',3',4'-Trimethoxyacetophenone	13909-73-4	C11H14O4	133870	90.4	0.53	1.02	210.2265
37.	11.8638	Benzyl Benzoate	120-51-4	C14H12O2	688867	96.7	2.74	5.26	212.2439
38.	12.9303	Pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro-3-(2methylpropyl	5654-86-4	C11H18N2O	236228	73.1	0.14	0.28	210.2728
39.	12.9747	Diphenyl sulfone	127-63-9	C12H10O2S	29436	55.7	0.12	0.22	218.272
40.	14.3634	Ethyl Oleate	111-62-6	C20H38O2	37174	80.7	0.15	0.28	310.5145
41.	15.1744	Gingerol	23513-14-6	C17H26O4	947967	69.3	3.77	7.24	294.3859
42.	15.3522	.alpha.-Amyrin	638-95-9	C30H50O	697882	91.2	2.77	5.33	426.7174
43.	16.4298	Di-n-octyl phthalate	117-84-0	C24H38O4	30700	55.5	0.12	0.23	390.5561
44.	17.2631	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	111-03-5	C21H40O4	97363	73.7	0.39	0.74	356.5399
45.	20.1294	Phenol, 2,6-bis(1,1-dimethylethyl)-4-(1-methyl-1phenylethyl)-	34624-81-2	C23H32O	41029	54.7	0.16	0.31	324.4996
46.	20.3071	1-Monolinoleoylglycerol trimethylsilyl ether	54284-45-6	C27H54O4Si	57830	55.4	0.23	0.44	498.8863
47.	22.5180	.beta.-Sitosterol	83-46-5	C29H50O	38865	59.0	0.15	0.30	414.7067

The above results clearly shows that plant extract treatments not only enhance plant growth and physiology but also play a crucial role in protecting soil and plant health due to their inherent antimicrobial properties. Many medicinal and aromatic plants contain potent phytochemicals such as alkaloids, flavonoids, saponins, tannins, and glycosides that exhibit broad-spectrum antimicrobial activity. These bioactive compounds can suppress or inhibit the growth of harmful soil-borne pathogens, including fungi, bacteria, and nematodes, thereby contributing to a healthier rhizosphere environment. For instance, aqueous and methanolic extracts of neem (*Azadirachta indica*), garlic (*Allium sativum*), and tulsi (*Ocimum sanctum*) have shown strong inhibitory effects against soil pathogens like *Fusarium spp.* and *Rhizoctonia solani*, due to the presence of high levels of flavonoids and alkaloids (Jeeva *et al.*, 2017).

The phytochemical screening through GC-MS analysis has further confirmed the presence of various secondary metabolites with known antimicrobial and antifungal potential. Compounds such as eugenol, gingerol, thymol, phytol, and squalene, commonly found in plant extracts like clove, tulsi, and moringa, have been identified in GC-MS studies as key constituents contributing to the antimicrobial effects (16). These compounds work by disrupting microbial cell membranes, inhibiting enzyme function, or interfering with microbial reproduction. In this way, plant extracts act as eco-friendly alternatives to chemical pesticides, enhancing soil microbial balance while reducing the incidence of plant diseases. The dual role of plant extracts improving plant growth and providing protection from soil-borne pathogens makes them valuable tools in sustainable and organic agricultural systems. Finally, the antibacterial assay was performed to determine the antibacterial potential of prepared bioconsortia. Three out of 5 formulations was taken the best performing bioconsortia T₁, T₃ and T₄ from various previous studies. The maximum zone of inhibition was observed 30µg/ml of herbal composite was 17mm against *Pseudomonas aeruginosa* followed T₃ and T₄ treatment with 14mm was reported in 30µg/ml concentration of bioconsortia respectively. When compared with positive control *Streptomycin*. The bacteria *Xanthomonas hortorum* was recorded 18mm of zone of inhibition while 30µg/ml T₃ composition followed by 16mm zone of inhibition was observed 30µg/ml of T₁ composition of herbal biocomposite. These compounds work by disrupting microbial cell membranes, inhibiting enzyme function, or interfering with microbial reproduction. In this way, plant extracts act as eco-friendly alternatives to chemical pesticides, enhancing soil microbial balance while reducing the incidence of plant diseases. The dual role of plant extracts improving plant growth and providing protection from soil-borne pathogens makes them valuable tools in sustainable and organic agricultural systems. As conclusion the above interpreted results and discussion proves that the prepared herbal extract biocomposite has rich antimicrobial properties with growth enhancing factor which intervenes the biological system of the plant coated on the coir pots. This leads to improve the productivity of plant in healthy way without using any toxic effects to environment and humans.

CONCLUSION

The present study demonstrated the potential of herbal extract-based biocomposites in enhancing plant growth and providing antimicrobial protection in sustainable agricultural practices, particularly in kitchen gardening. Five distinct formulations composed of various medicinal plant extracts were developed and coated onto coir pots. These formulations were tested on *Vigna radiata* (a dicot) and *Zea mays* (a monocot), where they showed improved germination rates, shoot and root length, biomass accumulation, and enhanced physiological and biochemical parameters compared to the control. Notably, T₁, T₃, and T₄ treatments consistently exhibited superior performance across multiple metrics such as chlorophyll content, protein and carbohydrate levels, and total free amino acids. *V. radiata* in T₁ recorded a shoot length of 22.74 cm, root length of 13.57 cm, and total biomass of 1.230 gm, while *Zea mays* in the same treatment exhibited notable increases in root development and physiological efficiency. The increased stomatal index and enhanced biochemical profiles reflect the bioactivity of phytochemicals such as phytohormones and antioxidants present in the extracts, which promote metabolic activity and stress resilience. Additionally, the herbal formulations showed strong antimicrobial properties, confirmed through GC-MS analysis and antibacterial assays. T₁, T₃, and T₄ formulations were rich in bioactive compounds such as eugenol, gingerol, thymol, and phytol, known for their antimicrobial efficacy. These compounds disrupted pathogenic bacteria like *Pseudomonas aeruginosa* and *Xanthomonas hortorum*, with inhibition zones reaching up to 18 mm. Phytochemical screening confirmed the presence of secondary metabolites including alkaloids, flavonoids, tannins, and glycosides—further reinforcing the antimicrobial and plant growth-promoting nature of the biocomposites. These results affirm that herbal extract-coated coir pots not only enhance plant development but also provide a natural, eco-friendly alternative to synthetic chemicals in managing soil-borne diseases. Thus, integrating plant-based biostimulants into home and organic gardening systems presents a sustainable approach to improving plant productivity and soil health without adverse environmental effects.

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