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A STUDY ON BIODEGRADATION OF COIR PITH BY SOIL FUNGI AND ITS UTILIZATION IN PLANT GROWTH

A. Kanagarathinam* & Dr. K. Shanthi**
* Research and Development Centre, Bharathiyar University. Coimbatore, Tamilnadu
** Research Supervisor, Department of Environmental Sciences, PSG College of Arts & Science, Coimbatore, Tamilnadu

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Abstract:

Coconut (cocus nucifera) plays a significant role in the agrarian economy of India. The husk of the coconut is a source of fibre, which supports a sizable coir industry. Coir pith is a lignocellulosic waste material obtained from coir processing factories which causes major disposal problem and thereby causes environmental hazard. Recent studies, prove coir pith waste as a source of agricultural manure. But, when coir pith is treated biologically using micro-organisms, studies reveal its significance as organic manure and shows good results in plant growth.In the present study, an attempt was made to biodegrade coir pith using suitable microbes, fungi, isolated from the municipal sewage .The isolated fungi, Aspergillus flavus and Aspergillus tubingensis, were identified and using coir pith,compost were prepared from both the fungi, Aspergillus flavus and Aspergillus tubingensis .The composts prepared was used for plant growth (Fenugreek- Trigonella Foenum Graecum). Compost of various mixtures and various compositions were used as growing media and the efficiency of compost was judged.The efficiency of both the compost individually and in combination were identified at various intervals of plant growth and at various ratios of culture. Aspergillus tubingensis was identified to be more efficient in all growth media and in all the study .Analysis of the plant and various growth media were analyzed for proving the efficiency of plant growth.Compost with Aspergillus tubingensis shows better results than compost with Aspergillus flavus .Both the compost in combination also proved good result in plant growth.

Key Words: Coir Pith, Compost, Aspergillus Flavus ,Aspergillus Tubingensis & Fenugreek

Introduction:

India is a developing country and plenty of organics are present in india. Most of the waste are not properly used .There is a possibility of using all these wastes for the production of organic waste which is not properly processed and recycled in india. This study is aimed at developing a technology for rapid degradation of coir pith and enrichment using microbes. (Leishipem et.al,2013). Coconut is one of the most useful and extensively, cultivated palm in tropical countries. Coir pith is a byproduct of coconut industry. The dust left behind after extracting long fibres from the husk of a coconut is known as coco peat or coirdust. It is a fluffy and spongy material with significant water holding capacity (Meerow.A.1995). Coir pith will not degrade by itself and will remain over the soil years together, whenever it is burnt, it is not destroyed completely.It emits smoke continuously for a longtime thereby pollute the environment and causes disposal problem. However at present the coir pith has now become a moneyspinner. Coir pith is used as a moisture conserving agent in rain fed agriculture (Leishipem ningshen, 2013). Coir pith, a waste material from coir industries causes major environmental problem. Coir pith has high lignin and C: N ratio, also rich in potash but low in nitrogen and phosphorus. Compost prepared from coir pith which is treated biologically with soil fungi acts as organic manure shows good result in plant growth. Previous studies prove that composts have potential to improve plant growth when added to soil or growth media. Coir pith waste require large quantities of land for disposal ,release odor and ammonia into the air, could contaminate groundwater with pollutants and might damage soil fertility severely and result in structural incompatibility, nitrogen immobilization and phyotoxicity. Some form of treatment of these wastes can make them suitable for land application and for safe disposal into the environment (R.M Atiyeh et.al, 2000).

This problematic waste is a valuable biomass and it can be converted into manure through biological source with a way to finding solution for the problematic waste material. Central coir research institute (CCRI) has developed a technology to convert the coir pith into an organic manure within 30 days ,by applying a fungus known as 'pith-plus'(Unnithan, 2001). Unlike Sphagnum peat, coir pith is a renewable resource, as it can be sustainably produced from coconut husk regularly available from well managed coconut gardens (Richard, 2006). At present, coir pith is being utilized for many commercial application, however the disposal of coir pith is a major problem for the industries. It has a high water holding capacity of 5-6 times its weight coir pith takes decades to decompose. (Abhijith and prashant, 2003). Generally coir pith is dumped around the coir industries, on the road sides and in no man's land and allowed to degrade ever several years. It takes decades for decomposition because of its pentoson lignin ratio less than 0.5 (Ramalingam.et.al, 2005).Coir pith can retain 5-6 times of water. It is a good mulching agent. Observation shows that the microbes carry necessary enzymes for the biodegradation of coir pith (Leishipem et al,2013).The shifting of PH to lower levels could be alternated to mineralization of nitrogen and orthophosphates and bioconversion of organic materials into intermediate species of organic acids(Nedegwa et al,2000).Strong and nearly impervious to the weather, coir wine is the material hops, growers in the United States prefer for tying vines to supports (Mahmoud and Ibrahim,2012)

Materials:

In the present study, coir pith samples were collected from Pollachi (Coconut city), Coimbatore district, Tamilnadu, India and subjected to biodegradation using soil fungi, , Aspergillus flavus and Aspergillus tubingensis collected from sewage treatment plant of PSG College of Arts and Science, Coimbatore. Cultures were collected, identified and isolated from sewage plant. Fenugreek seeds were obtained from Tamilnadu Agricultural University, Coimbatore and grow bags were used for plant growth.

Methodology:

Aspergillus flavus & Aspergillus tubingensis are collected, identified and isolated from sewage. Compost was prepared using the cultures, in coir pith. The compost prepared was used for plant growth. Biodegradation is increasingly being considered as less expensive alternative to physical and chemical means of decomposing organic pollutants. Composting of coir pith results in increased content of N, P, K and micronutrients and reduction in lignin and C:N ratio (Ladwani Kiran et al., 2012). Because of high fertilizer prices and environmental concerns associated with its use and with the enhanced emphasis on commercial horticulture and organic farming, recent years have witnessed growing interest in utilizing coir pith in a more productive way in agri-horticulture (Prabhu and Thomas, 2001). It has been hypothesized that through an evolutionary selection process, some species of plants developed characteristics that enhance the fitness of their environment for themselves at the expense of their plant species (Thampan, 2000).The biofertilizers are found positive contribution to soil fertility, resulting in an increase in crop yield without causing any environmental, water or soil pollution hazards (S.Umesha et., al). Fenugreek seeds were grown in growbags, according to the experiments. Plants were grown in soil individually, Coir pith individually, and coir pith & Soil in combination were considered to be controls.Compost-1(Aspergillus flavus) mixed with coir pith & soil individually and in combination, compost-2 (Aspergillus tubingensis)mixed with coir pith & soil individually and in combination and both the compost mixed with coir pith & soil individually and in combination. First experiments were conducted to find the number of days needed for the plant with maximum efficiency. Gradually compost mixed to soil, coir pith individually and in combination .After fixing the duration optimum amount of culture needed was estimated. After the plant growth for each experiment, the plants and growing media were analysed. From the results, the culture (Compost) efficiency in plant growth is found out.

Experimental Design:

Description of the Growing Media:

Compost 1- Aspergillus flavus, Compost 2 - Aspergillus tubingensis
S - soil alone (3kg)
S1 - soil (3kg) + compost1 (100gm/kg)
S2 - soil (3kg) + compost 2(100gm/kg)
S1+2 - soil (3kg) + compost 1+compost 2(100gm/kg of each compost)
CP - Coirpith alone(3kg)
CP1 - coirpith (3kg) + compost 1(100gm/kg)
CP2 - coirpith (3kg) + compost2(100gm/kg)
CP1+2 - coirpith (3kg) + compost 1+compost 2(100gm/kg of each compost)
SCP – soil with coir pith (3+3 kg)
SCP1 – soil & coirpith (3+ 3kg) + compost 1(100gm/kg)
SCP2 - soil & coirpith (3+ 3kg) + compost 2(100gm/kg)
SCP1+2 - soil & coirpith (3+ 3kg) + compost 1+compost 2(100gm/kg of each compost)

Statistical Analysis:

All the results were statistically analysed after the data collection. Datas were evaluated by statistical analysis method –Anova, mean,median, standard deviation were used for comparison of means and statistical significance of hypothesis was assessed at $\alpha<0.05$. All statistical analysis were performed using statgraphics programme version 5.1. The results were expressed as means $\pm$ standard error and the data was analysed using Turkey new multiple orange Test for significant differences with SPSS package. A level of $P<0.05$ was accepted as statistically significant.

Result & Discussion:

Preliminary experiments: The plants were grown in various ratios of culture such as 10gm,25,50,75,100,150,&200gm per kg of sample(growing media).In higher concentrations of composts the shoot length was gradually reduced in all the treatments. This may be due to the availability of the bioactive substance is high in lower concentration of composts but in higher concentration of composts it was gradually reduced (Zakaria Sharifian et al., 2014). Experiment was done to find out the optimal weight of compost needed as growing media for plant growth. The plant were grown for 10,20,30& 60 days and plants were analysed for number of seeds, root length, shoot length, biomass, chlorophyll, protein and carbohydrate. From the results, 100gms of compost and 20 days of duration for plant growth were decided as optimum and it was found that compost 2 and compost1&2 in combination of coir pith & soil showed good results. The amount of carbohydrate content was high in lowest concentration and it was decreased in the highest concentration of composts in all the treatments (Abraham Christopher et al., 2007) (Shozeb Jeved and Aruna Panwar., 2013).Generally lower pH has been preferred in soilless medium since most of the macro and micro nutrients needed for the growth of the plants are available only at low pH (Angelova et al., 2013). Use of coir pith as a potting medium for the orchid vanda rothschildiana resulted in higher production of flowers (Srinivasan et al., 2005). The unique structure of lignin requiring depolymerization by extracellular oxidative mechanisms accounts for the recalcitrance of lignin towards degradation by most microorganisms (Ververis et al., 2006).

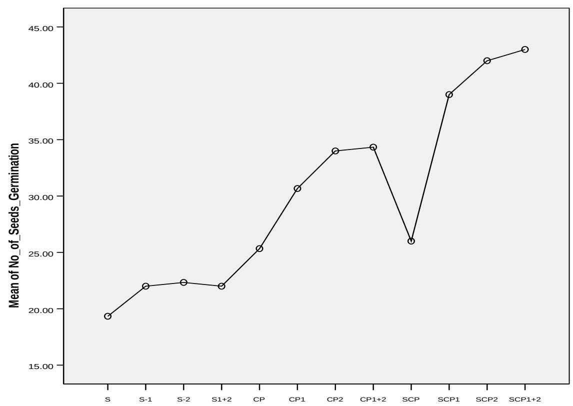
Plant Analysis: 20 days-50seeds - 100gm of culture per kg of growing media

Table 1

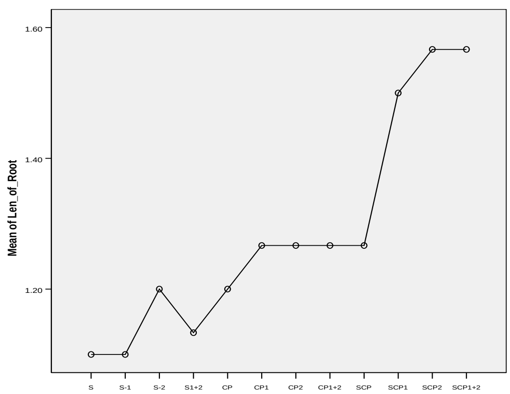
Samples	No of Seeds Germinated (in numbers)			Root Length (cm)			Bio Mass (gm)			Shoot Length (cm)			Chlorophyll (OD value at 630nm)			Protein (OD value at 630nm)			Carbohydrate (OD value at 630nm)		
S	17	21	20	0.9	1.1	1.3	9.6	9.8	9.9	1.8	2.0	2.4	0.07	0.07	0.07	0.8	1.0	1.0	0.4	0.4	0.4
S-1	23	20	23	1.1	1.0	1.2	14	14	15	2.0	1.8	2.5	0.07	0.07	0.07	1.0	1.0	1.0	0.4	0.4	0.4
S-2	22	23	22	1.0	1.2	1.4	15	16	16	1.9	2.0	2.4	0.07	0.07	0.07	1.0	1.0	1.1	0.4	0.4	0.4
S1+2	23	20	23	1.1	1.0	1.3	13	15	17	1.8	1.9	2.2	0.07	0.07	0.07	1.0	1.1	1.1	0.4	0.4	0.5
CP	24	26	26	1.0	1.2	1.4	10	12	14	1.9	2.0	2.3	0.07	0.07	0.07	1.0	1.0	1.0	0.4	0.4	0.4
CP1	29	31	32	1.1	1.3	1.4	14	14	14	1.9	2.1	2.3	0.07	0.07	0.07	1.4	1.6	1.8	0.4	0.4	0.5
CP2	32	34	36	1.2	1.1	1.5	14	14	14	2.0	2.1	2.4	0.08	0.08	0.08	1.6	1.8	1.1	0.5	0.5	0.5
CP1+2	33	34	36	1.1	1.3	1.4	16	17	17	2.0	2.1	2.3	0.08	0.08	0.08	1.8	2.0	2.2	0.5	0.5	0.5
SCP	24	26	28	1.2	1.1	1.5	14	14	14	1.8	2.0	2.2	0.08	0.08	0.08	1.6	1.7	1.9	0.4	0.4	0.5
SCP1	37	39	41	1.3	1.5	1.7	17	17	16	2.2	2.3	2.6	0.1	0.1	0.1	1.9	2.0	2.2	0.4	0.4	0.4
SCP2	40	42	44	1.3	1.6	1.8	21	21	21	2.4	2.5	2.6	0.2	0.2	0.2	2.2	2.4	2.6	0.6	0.6	0.7
SCP1+2	41	43	45	1.4	1.5	1.8	19	20	20	2.3	2.5	2.8	0.2	0.2	0.2	2.3	2.4	2.5	0.7	0.7	0.7

From Table 1, the analysis of plant was observed for number of seeds, shoot length , Root length , Biomass, Chlorophyll, Protein and carbohydrate. From the results, we observed that 17 seeds to 45 seeds were grown in various growing media. Maximum number of seeds germinated in SCP1+2(45 seeds) and SCP2 (44 seeds). Rootlength was 1.8 cm maximum in SCp1+2 and SCP2. Biomass was 20gm and 21 gm in SCP1+2 &SCP2 respectively. Shoot length was 2.8cm and 2.6 cm maximum in SCP1+2 and SCP2 cholrophyll was 0.2 in both SCP2 and SCP1+2.Protein was 2.6gm, and carbohydrate was 0.7 gm inSCP2 which is the maximum. All the values are statistically significant at 0.01%, Influence of biodegraded coir pith in plant growth is statistically significant P<0.01.Graph 1 to graph7 shows statistically analysed graphs for Table.1.

Graph 1: Seeds Germination

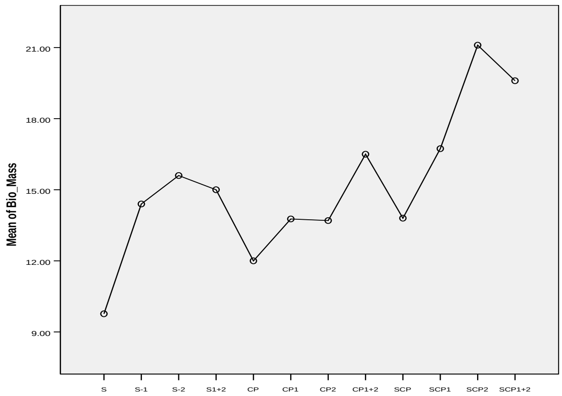


Graph 2: Length of root

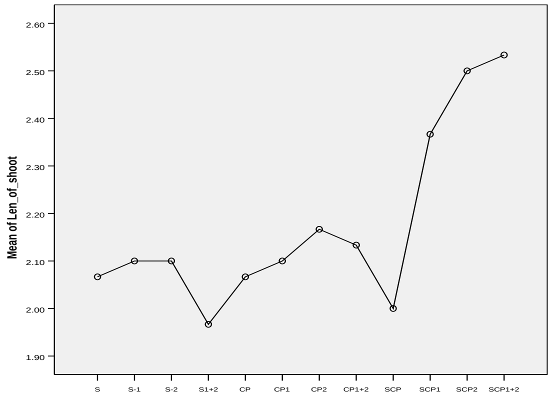


Growing Media **Growing Media**

Graph 3: Bio-Mass

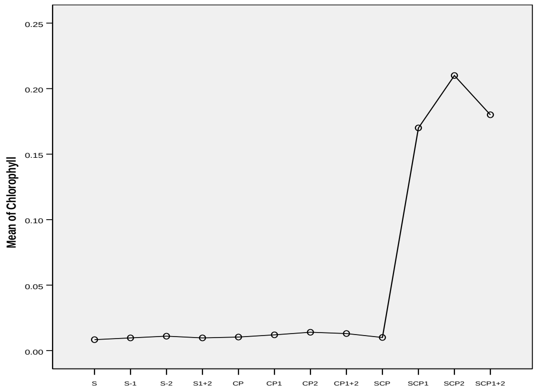


Graph 4: Length of shoot

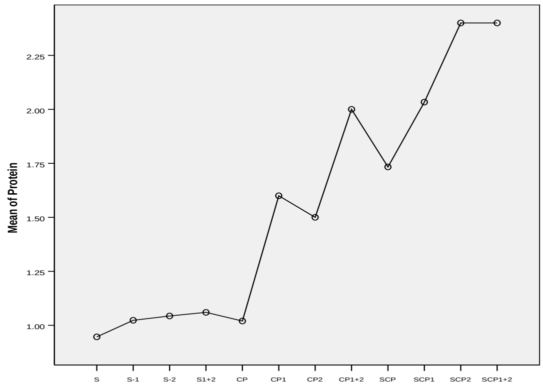


Growing Media **Growing Media**

Graph 5: Chlorophyll

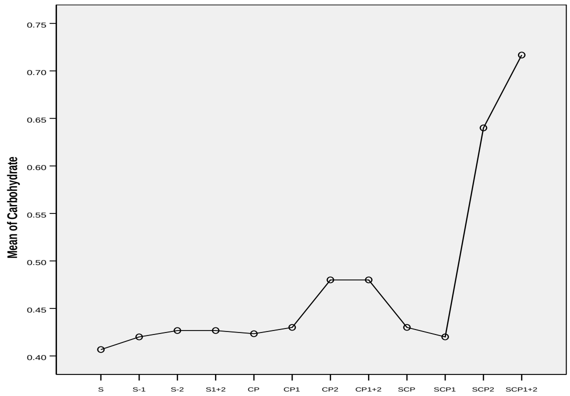


Graph 6: Protein



Growing Media **Growing Media**

Graph 7: Carbohydrate



Growing Media

Datas were collected from morphometric and biochemical analysis of plants and growing media. Number of seeds germinated, root length, shoot length, chlorophyll, total protein, biomass and carbohydrate in the plant were analysed. Growing media was analysed for various parameters such as sodium, calcium, magnisium, chlorine, sulphur, iron, manganese, bulk density, water holding capacity, P^H potassium, electrical conductivity, moisture and phosphorus. Compost2 (Aspergillus tubingensis) Shows more efficiency than compost 1(Aspergillus flavus).In combination both compost shows good result.

Growth media analysis: 20 days-50seeds - 100gm of culture per kg of growing media

Table 2

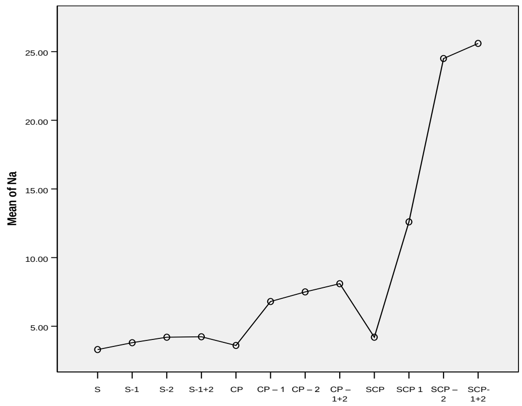
Samples	**Na (mg/kg)**			**Ca (mg/kg)**			**Mg (mg/kg)**			**Cl (mg/kg)**		
S	3.1	3.3	3.5	49	51	52	4.9	5.1	5.3	118	120	122
S-1	3.6	3.8	4.0	26	28	60	12	12.2	12.4	134	136	138

S-2	4.0	4.2	4.4	60	62	64	14	16	18	141	143	145
S-1+2	4.1	4.2	4.4	64	66	68	19	21	23	142	143	144
CP	3.4	3.6	3.8	50	52	54	11	13	15	130	132	134
CP – 1	6.6	6.8	7.0	69	71	73	30	32	34	174	176	178
CP – 2	7.3	7.5	7.7	94	96	98	39	41	43	181	183	185
CP – 1+2	7.9	8.1	8.3	97	99	101	44	46	48	187	189	191
SCP	4.0	4.2	4.4	69	71	73	29	31	33	130	132	134
SCP 1	12.4	12.6	12.8	131	132	135	79	81	83	264	266	268
SCP – 2	24.3	24.5	24.7	154	156	158	93	95	97	513	515	517
SCP- 1+2	25.4	25.6	25.8	149	150	152	94	96	98	493	495	497

S (mg/kg)			Fe (mg/kg)			Mn (mg/kg)		
1.1	1.3	1.5	2.3	2.5	2.7	1.5	1.7	1.9
1.7	1.9	2.1	3.0	3.2	3.4	2.0	2.2	2.4
1.8	1.9	2.0	3.9	4.1	4.3	2.0	2.2	2.3
2.0	2.2	2.4	4.0	4.2	4.4	2.0	2.2	2.3
1.4	1.6	1.8	1.5	1.7	1.9	1.6	1.8	2.0
3.0	3.2	3.4	4.6	4.8	5.0	2.0	2.2	2.4
3.9	4.1	4.3	5.0	5.2	5.4	3.0	3.2	3.4
4.0	4.2	4.4	5.1	5.2	5.4	3.6	3.8	4.0
1.7	1.9	2.1	2.2	2.4	2.6	1.9	2.1	2.3
4.3	4.5	4.7	5.0	5.2	5.4	4.7	4.9	5.1
7.0	7.2	7.4	5.6	5.8	6.0	6.6	6.8	7.0
7.6	7.8	8.0	5.7	5.8	6.1	6.1	6.3	6.5

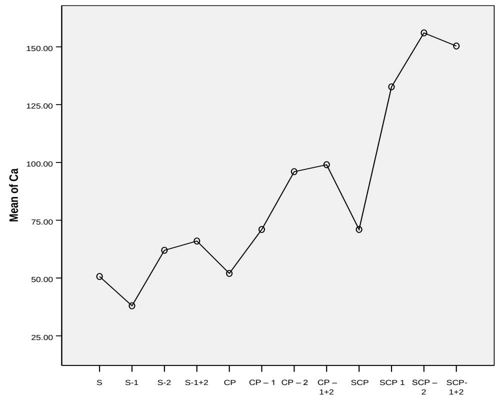
In table 2, results of the growth media analysis was observed. Various parameters such as sodium, calcium, magnesium, chlorine, sulphur, Iron and manganese were sorted out. Maximum values were read in SCP1+2 and SCP2. Maximum values of sodium was 25.8 and 24.7 in SCP1+2 and SCP2 respectively. Maximum value of calcium was 158 in SCP2.Maximum value of magnesium was 98 & 97 in scp1+2 andscp2 respectively. Maximum value of chlorine was 517 in scp2 maximum value of sulphur was 8 in scp1+2 and 7.4 in scp2 maximum value of Iron is 6.1 and 6 in Scp1+2 and scp2 maximum value of manganese. All the values are statistically significant at 0.01%, Influence of biodegraded coir pith in plant growth is statistically significant P<0.01.Graph 8 to 14 shows the statistically analysed graphs of Table 2.

Graph 8: Sodium



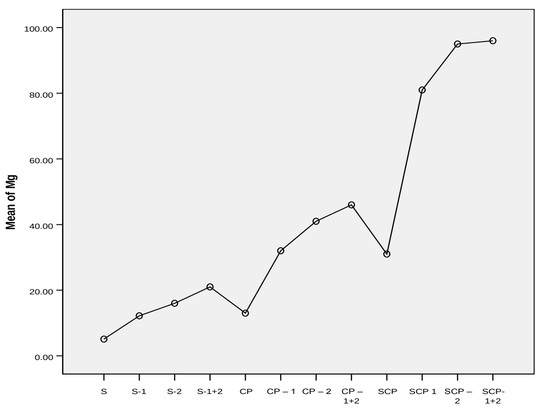
Growing Media

Graph 9: Calcium

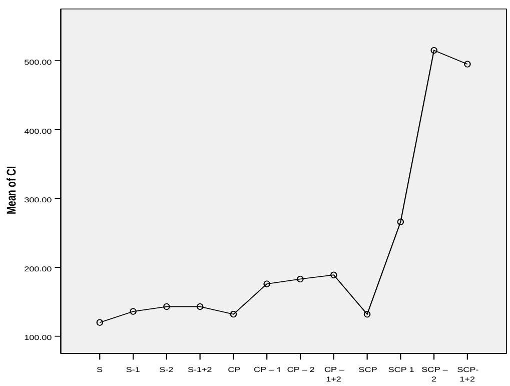


Growing Media

Graph 10: Magnesium

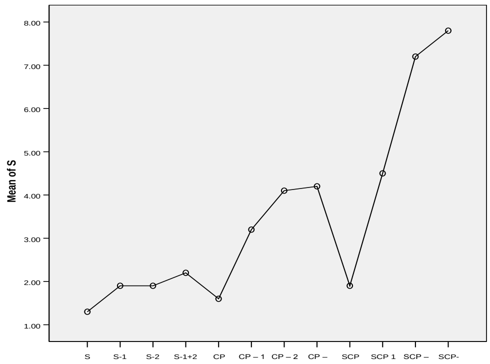


Graph 11: Chlorine



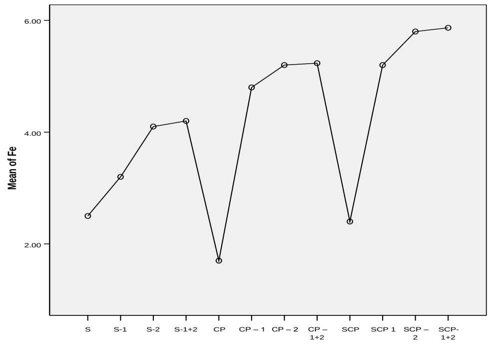
Growing Media

Graph 12: Sulphur



Growing Media

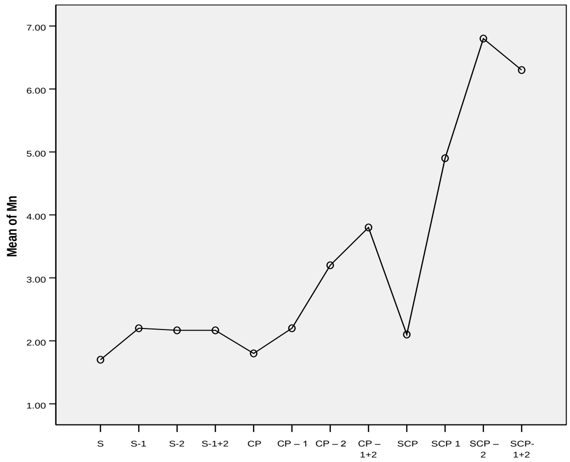
Graph 13: Iron



Growing Media

Growing Media

Graph 14: Manganese



Growing Media

Analysis of growing media: 20 days-50seeds - 100gm of culture per kg of growing media

Table 3

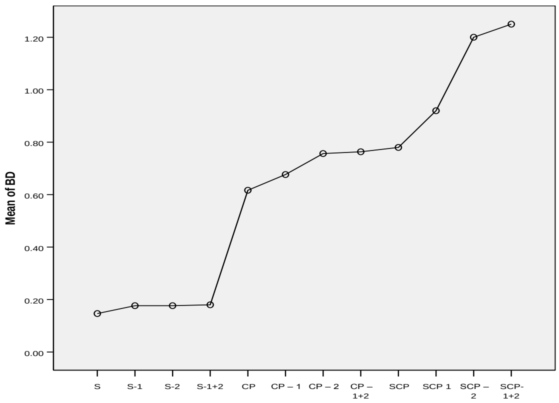
Samples	BD (g/cm^3)			WHC			Moisture %			PH		
S	0.13	0.15	0.16	40	42	44	0.8	1	1.2	6.7	6.9	7.1
S-1	0.16	0.18	0.19	44	46	48	0.8	1	1.2	6.7	6.9	7.1
S-2	0.17	0.18	0.18	45	46	47	1	1.2	1.4	6.7	6.8	7
S-1+2	0.17	0.18	0.19	45	47	49	0.9	1.2	1.4	6.8	6.9	7.1
CP	0.6	0.61	0.64	43	44	46	0.8	0.9	1.3	6.7	6.9	7.2
CP – 1	0.66	0.67	0.7	47	49	52	1.1	1.3	1.5	6.8	6.7	7.1
CP – 2	0.74	0.75	0.78	48	50	52	1.2	1.4	1.6	6.7	6.9	7.2
CP – 1+2	0.75	0.76	0.78	48	50	52	1.3	1.4	1.6	6.8	7	7.2
SCP	0.76	0.78	0.8	47	49	52	1.3	1.4	1.5	6.6	6.8	7
SCP 1	0.9	0.92	0.94	59	61	63	1.8	2	2.2	6.9	7	7.2
SCP – 2	1	1.2	1.4	61	63	65	2.4	2.6	2.8	6.9	7.1	7.3
SCP- 1+2	1.23	1.25	1.27	64	63	66	2.4	2.6	2.7	6.8	7.1	7.2

EC (us/cm)			Total Nitrogen%			K(mg/kg)			P (mg/kg)		
92.4	92.6	92.8	14	15	18	1.4	1.6	1.8	7.2	7.4	7.6
92.6	92.8	92.8	9	9	11	29	31	33	8	8.2	8.4
92.6	92.8	93	122	122	124	28	31	32	8.4	8.6	8.8
121	122	124	125	125	127	40	42	44	8.5	8.6	8.7
123	125	127	102	102	104	34	36	38	7.9	8.1	8.3
100	102	104	126	126	128	41	43	45	12	14	16
124	126	128	126	126	127	59	61	63	14.6	14.8	14.9
158	160	162	160	160	162	64	66	68	15	15.2	15.4

140	142	144	142	142	144	54	56	58	14.4	14.6	14.8
167	169	171	169	169	171	79	81	83	17.6	17.8	17.9
170	172	174	172	172	174	94	96	98	18	18.2	18.4
168	170	172	170	170	172	95	96	97	18.1	18.2	18.4

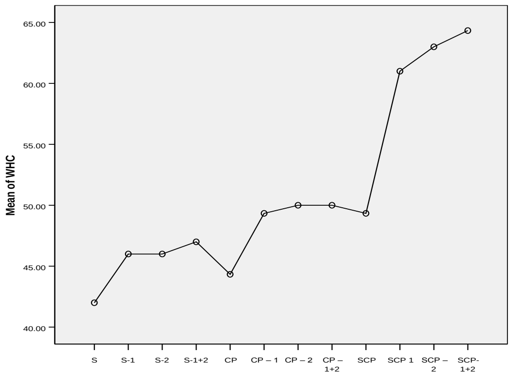
In table 3 the results of growth media analysed were shown. Various parameters such as Bulk density, water holding capacity, moisture, P^H total nitrogen, potassium and phosphorus were tabulated with the results. Maximum value of bulk density was 1.4 in scp2 and 1.27 in scp1. WHC was 66 in scp1+2 and 65 in scp2, moisture capacity was 2.7and 2.8in scp1+2 and scp2 respectively. P^H was normal in all growing media. Electrical conductivity was read as 172 in scp1+2 and 174 in scp2. Total nitrogen was 172 and 174 in scp1+2 & scp2 respectively. Potassium showed 97 in scp1+2 and 98 in scp2, phosphorus was maximum as18.2 in scp2. All the values are statistically significant at 0.01%, Influence of biodegraded coir pith in plant growth is statistically significant P<0.01.Graph 15 to 22, shows the statistically analysed graphs for Table 3.Coir pith application also increases yields of a number of cereals, millets, pulses, oil seeds and fruit crops (Fuangworawong et al., 2008).

Graph 15: Bulk Density



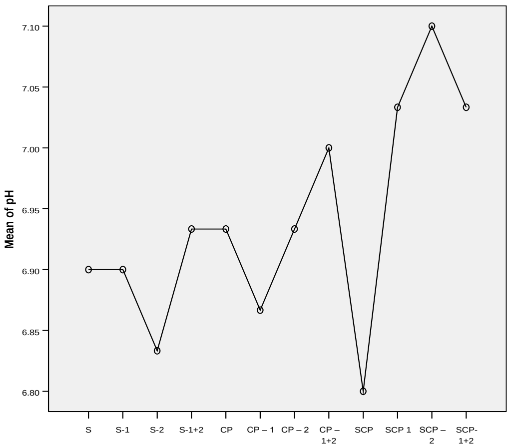
Growing Media

Graph 16: Water Holding Capacity



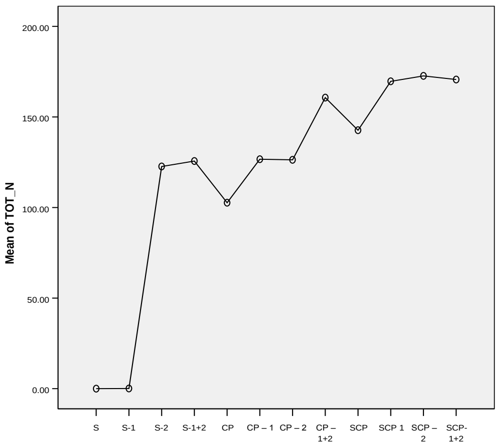
Growing Media

Graph 17: P^H



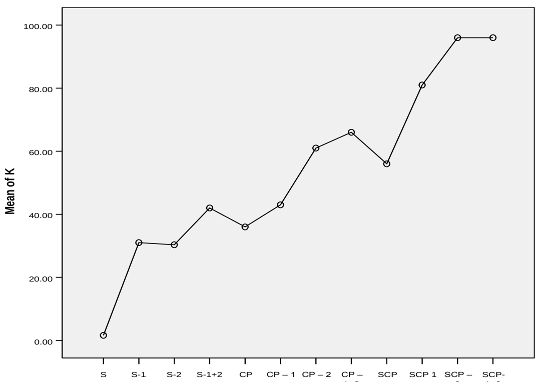
Growing Media

Graph 18: Total Nitrogen

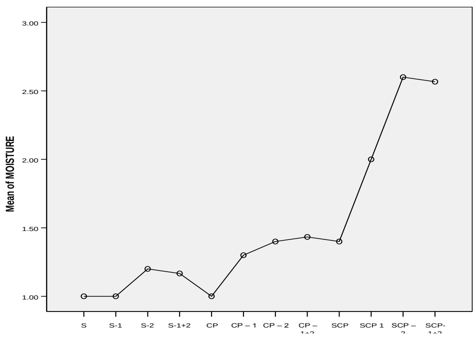


Growing Media

Graph 19: Electrical Conductivity

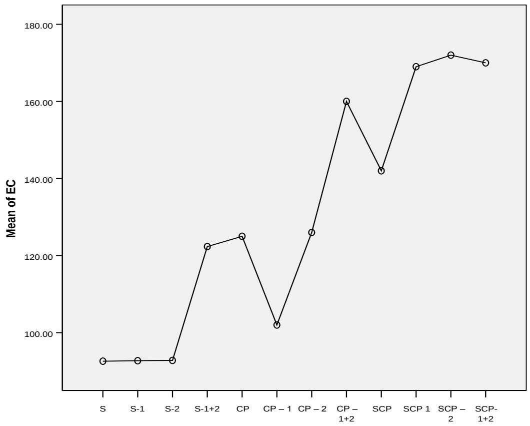


Graph 20: Moisture %



Growing Media

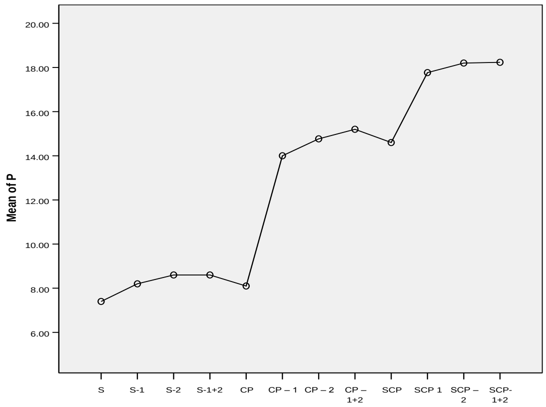
Graph 21: Potassium



Growing Media

Growing Media

Graph 22: Phosphorus



Growing Media

Conclusion:

The results indicated that the biodegraded coirpith was statistically significant P<0.01.From the results of plant analysis and growth media analysis, conclusion is made that coir pith & soil in combination shows good results. Compost 2is more efficient than compost 1, more or less compost 2 and compost 1+ 2 shows same results. Above all plant was grown in the same soil. Fertility of the soil is increased when compost was added. From the soil analysis results. we conclude that soil fertility is increased and from plant analysis increased efficiency of plant growth was observed. The results indicated that the biodegraded coirpith was statistically significant P<0.01. According to Tiquia et al., (2002) coir pith having a C:N ratio of 24 : 1 or less could be used as a good source of organic matter for agricultural use. Lignin degrading fungi Aspergillus has been proved to degrade coir pith and covert it into organic manure in this study on the application of lignin degrading fungal species of Aspergillus tubingensis and Aspergillus flavus on the coir pith. From the study it could be concluded that the fungal species could degrade the lignin in coir pith or enhance its nutrient status. Aspergillus tubingensis was observed to be more efficient in lignin degradation as compared to others. The study could emphasize the fact that lignin degrading fungal species could be used for finding a solution to the problem of accumulation of the biological waste coir pith and also convert it into a value added eco-friendly fertilizer for different types of plants.

References:

1. Abhijith Bhat, D. and Prashanth Narayan. 2003. Chromatographic Analysis of Phenolics and study of Klason lignin biodegraded coir pith using "Pleurotus sajor caju". B.Sc, Dissertation,University of Kerala, Alappuzha.
2. Abraham Christopher. P, Viswajith, V.Prabha. S, Sundhar. K, and Malliga. P, 2007. Effect of coirpith based cynobacterial basal and foliar biofertilizer on Basella rubra L. Acta agriculturae Slovenica, 89-1.
3. Angelova. V.R, Akova . V.I, Artinova, N.S and Ivanov, K.I. The Effect of Organic Amendments on soil Chemical Characteristics, Bulgarian Journal of Agricultural science, 19, 2013, 958-971.
4. Atiyeh, R.M, Jorge Dominguez, Scott Subler and Clive A. Edwards, 2000. Changes in biochemical properties of cow manure during processing by earthworms (Eisenia Andrei, Bouche) and the effects on seedling growth. Pedobiologia 44,709-724.
5. Fuangworawong,P. Influence of Nitrogen sources, Molasses Addition and Aeration Schemes on Composting of Coir Pith. Dissertation, king Mongkut's University of Technology, Thonburi; 2008.
6. Ladwani kiran D., Ladwani Krishna D., Manik Vivek S. And Ramteke Dilip S., Impact of Industrial Effluent Discharge on Physico –Chemical Characteristics of Agricultural Soil, International Research Journal of Environmental Sciences, 1(3), 32-36(2012).
7. Leishipem Ningshen and Thilagavathy Daniel,2013, A Study on biodegradation of coir pith using microbial consortium.5(6) ,2319 - 2399
8. Mahmoud E.K and Ibrahim M.M, 2012. Effect of vermicompost and its mixtures with water treatment residuals on soil chemical properties and barley growth. Journal of Soil Science and Plant Nutrition, 12(3), 431-440.
9. Meerow, A.1995. Growth of two tropical foliage plants using coir dusts as a container medium amendment. Hort . Technology. 5(3):237[13].
10. Nedegwa, P.M and Thompson, S.A 2000. Effects of C to N ratio on Vermicomposting of biosolids. Bio resource technology. 75:7-12[15].

11. Prabhu, S.R. and Thomas, G.V.2001. Composted coir pith as a resource in agri-horticulture. Coir news 30(8) 13-18.
12. Ramalingam, A., Gangatharan, M., Kasturi, R.2005. Solid state bio-treatment of coir pith and paddy straw. Asian Journal of Microbiology, Biotechnology and Environmental Science.6:141-142.
13. Richard, M.P.2006. Effect of nursery media particle size distribution on container- grown woody ornamental production. M.Sc., thesis. B.S., Louisiana state University.
14. Shozeb Javed and Aruna Panwar, (2013) Effect of biofertilizer, vermicompost and chemical fertilizer on different biochemical parameters of Glycine max and Vigna Mungo, Recent Research in Science and Technology, 5(1): 40, 44.
15. Srinivasan V, Hamza S, Sadanandan K: Evaluation of composted coir pith with chemical and biofertilizers on nutrient availability yield and quality of black pepper. J.Spices Aromatic Crop 2005, 14(1):15-20.
16. Thampan, P.K.2000. Recycling of coconut biomass for sustainable production Indian coconut Journal, 7:5-6.
17. Tiquia, S.M, Wan, J.H.C. and Tam, N.F.Y., Microbial population dynamics and enzyme activities during composting. Compost. Sci. Util., 2002, 10,150-161.
18. Unnithan K.B. 2001. Survey of coir industry in india, Central coir research institute (CCRI)
19. S.Umesha, M.Srikantaiah, K.S.Prasanna,K.R. Sreeramulu, M.Divya and R.NLakshmipathi, 2014. Comparative Effect of Organics and Biofertilizers on Growth and Yield of Maize (Zea mays.L) vol.2 (1), 55-62(2014).
20. Ververis, C., Geoghior K., Danielidies, D.Hatzinikolau, D.G., Santas, P.,Santas, R. and Corteti, V.(2006) Cellulose, hemicelluloses, lignin and ash content of same organic materials and their suitability for use as paper supplements. Bio resource Technology, 98,296-301
21. Zakaria Sharifian, Ali Akbar Maghsoudi Mood and Neda Mohamadi., 2014 Effect of different ratios of municipal solid waste compost on growth parameters and yield of Marigold and Daisy. Inter. Jour.of Advanced Biological and Biomedical Research: 43-50.