ISSN: 2347-4688, Vol. 11, No.(1) 2023, pg. 297-305

Current Agriculture Research Journal

www.agriculturejournal.org

Groundnut Shells and Toddy Palm Shells Recycling through Vermicomposting Technology and its Efficacy on Growth and Yield Attributes of Cluster Bean (*Cyamopsis Tetragonoloba* L.) Taub

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Abstract

Farming generates numerous types of agricultural wastes to the environment such as crop residues, animal waste, poultry waste etc,. those are landfilled or burning creates environmental pollutions. The aim of the study was to determining the growth and yield performance of cluster bean (*Cyamopsis tetragonoloba* L.) Taub on groundnut shells and toddy palm shells based vermicompost with *Trichoderma asperelloides*, microbial consortium and *Eisenia fetida* assistance. Pot experiments of plants were grown on six different combination of groundnut shells and toddy palm shells composts and one control treatment. During 25, 50 and 75 DAS (Days After Sowing) growth parameters and 90 DAS yield characters of cluster bean was carried out under pot culture respectively. The combined application of toddy palm shells composted with consortium of microorganisms and earthworm (T_6) achieved the maximum growth parameters such as root length (21.9cm), shoot length (84.8cm), number of leaves (46.3), number of nodules (4.6), number of flowers (24.6), number of pods (6.6), fresh weight (17.912g) and dry weight (2.684g) of plant on 75 DAS of cluster bean (*Cyamopsis tetragonoloba* L.) Taub. During the 90th day the same treatment achieved the yield characters like number of pods (8.0), length of pod (16.6cm), number of seeds/pod (10.3), yield/plant (45.384g), fresh weight (5.673g) and dry weight (1.496g) of pod compared to the control. Based on the results T_6 more suitable for growth and yield characters of cluster bean followed by T_3 respectively. The study suggested that, the organic fertilizer prepared from groundnut shells and toddy palm shells with microbial consortium and *Eisenia fetida* assistance promotes the plant development and yield attributes of *Cyamopsis tetragonoloba* (L.) Taub. simultaneously, reduce the usage of chemical fertilizers.

Article History
Received: 07 January 2023
Accepted: 24 March 2023

Keywords
Plant Growth;
Recycling;
Toddy Palm Shells;
Vermicomposting;
Waste Management.

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Doi: http://dx.doi.org/10.12944/CARJ.11.1.26

Introduction

India generates approximately 350 million tonnes of agricultural waste per year. Agricultural wastes are leaf litters, crop residues, livestock, animal waste etc, those wastes are leftover product after harvesting which are landfilling or buried in the open field causing environmental pollutions. Hence, recycling is one of the best ways to reduce and use the leftover.[1] The reduction and recycling of agricultural waste in suitable and systematic ways is composting, energy production, animal fodder, mushroom production etc.,[2] In the current study, the groundnut shells and toddy palm shells recycled by composting technology. Composting is an environment friendly method converts waste into organic fertilizer with the help of animal manure (cow dung) through biological processes[3] which improving fertility of soil and crop production.[4] Animal manure is rich source of organic matter and nutrients (phosphorus and nitrogen).[5] Vermicomposting is an eco-friendly sustainable technology that involves stabilization of organic matter by dual action of microorganisms and earthworms[6] which is a peat like material used as soil conditioner, contains macro and micronutrients available in the form that are easily absorbed by plants.[7,8] Vermicompost retains water holding capacity, high porosity and humidity produced by the activity of earthworms in the composting unit which improves the plant growth, yield and soil physical and chemical parameters.[9] Vermicomposting of groundnut shells and toddy palm shells with consortium of microorganisms, *Trichoderma asperelloides* and earthworm assistance. Groundnut shells are waste material after separation of groundnut seeds and toddy palm shells are discarded material after removal of sweet jelly sockets. Both wastes are degrading very slow in the natural environmental conditions due to high level of moisture content. However, both waste material contains substantial amount of plant nutrients such as NPK.[1]

The pit composting of groundnut shells and toddy palm shells were done at Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, Tamil Nadu, India which is coolest method for bio-composting and low-priced. The cluster bean (*Cyamopsis tetragonoloba* L.) Taub variety MDU 1 was used as an experimental crop under pot culture studies which is an economical important and edible crop cultivated throughout India, particularly north parts.[10] Cluster bean has been considerably valued for its galactomannan content gained from the endosperm of seeds.[11] In this study, we aim to investigate the influence of six different organic fertilizer made from two different substrates on growth and yield of cluster bean respectively.

Materials and Methods

Experimental Setup

Groundnut shells was collected from groundnut field and toddy palm shells was collected from roadside vendor shops around Coimbatore located at 11.0168ºN latitude and 76.9558ºE longitude. Microorganisms, *Trichoderma asperelloides* and cluster bean seeds were collected from Tamil Nadu Agricultural University, Coimbatore. Approximately, 100ml of consortium of microorganisms such as *Streptomyces lavendulae* (MTCC-6821), *Paecilomyces variotti* (MTCC-6581), *Bacillus licheniformis* (MTCC-10498), and *Pleurotus florida* (MTCC-9194) were mixed with 10 L of water contains one kilogram of cow dung respectively. Six pits were dug in equal size measured at 50×45×60cm (length, width, depth) and named as T_1-T_6 5kg of samples (groundnut shells and toddy palm shells) transferred into respective pits along with microorganisms and cow dung in the following manner.

T_1 - Groundnut shells + *Trichoderma asperelloides* + *Eisenia fetida*
T_2 - Groundnut shell + microbial consortium
T_3 - Groundnut shells + microbial consortium + *Eisenia fetida*
T_4 - Toddy palm shells + *Trichoderma asperelloides* + *Eisenia fetida*
T_5 - Toddy palm shell + microbial consortium
T_6 - Toddy palm shells + microbial consortium + *Eisenia fetida*

After 30 days of pre-digestion process approximately 50 g of tiger worm *Eisenia fetida* was inoculated into the respective composts (T_1, T_3, T_4 and T_6) for two months and retaining moisture level around 50 percent respectively. After 90 days of complete composting process the compost was matured turn dark brown to black colour, which is used for pot culture studies. 100g of respective compost mixed

in a cement pot contains 20kg of red clay loam soil prepared having following combination and arranged in randomized block design with three replications.

C - 20kg soil
T_1 - 20kg soil + 100g (Groundnut shells + *Trichoderma asperelloides* + *Eisenia fetida*)
T_2 - 20kg soil + 100g (Groundnut shell + microbial consortium)
T_3 - 20kg soil + 100g (Groundnut shells + microbial consortium + *Eisenia fetida*)
T_4 - 20kg soil + 100g (Toddy palm shells + *Trichoderma asperelloides* + *Eisenia fetida*)
T_5 - 20kg soil + 100g (Toddy palm shell + microbial consortium)
T_6- 20kg soil + 100g (Toddy palm shells + microbial consortium + *Eisenia fetida*)

Three seeds were sowed in each pot at 3cm depth and irrigated necessary of water two days once.

Growth and Yield Characters

After germination three healthy plants were taken for analysis. On 25, 50 and 75 DAS root length, shoot length, number of leaves, flowers, nodules, fresh weight and dry weight of plant were analyzed. On 90 DAS yield parameters like number of pods, length of pod, number of seeds/pod, yield/plant, fresh and dry weight of pod were analyzed. Root length was measured from ground level to tip of the root and shoot length was measured from ground level to the shoot apex. Number of leaves, flowers, nodules, pods, seeds/pod were count manually and fresh & dry weight of plant and pods were weighted in grams by digital balance.

Statistical Analysis

The data obtained from 25, 50, 75 and 90 DAS were subjected to statistically analyzed by one way and two-way anova and based on the results inference were drawn.

Table 1: Growth parameters of (*Cyamopsis tetragonoloba* L.) Taub on 25, 50 and 75 DAS

Treatments	Root length (cm)			Shoot length (cm)		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	3.2	8.9	10.5	17.2	42.4	60.2
T_1	5.3	11.3	12.5	19.3	48.9	69.9
T_2	6.3	13.4	13.9	20.3	54.6	66.4
T_3	7.2	20.2	21.4	22.4	66.4	83.0
T_4	5.9	14.9	15.6	18.2	59.4	68.3
T_5	6.9	10.3	13.2	20.4	63.6	80.2
T_6	9.1	20.8	21.9	24.6	78.2	84.8
SEd		0.16441			0.20902	
Cd(p<0.05)		0.33186			0.42191	
Cd(p<0.01)		0.44361			0.56398	

Results and Discussions

Root Length (cm)

The data presented in table 1 shows that the root length and shoot length of cluster bean on 25, 50 and 75 DAS respectively. The maximum root length was observed in T_6 (9.1 cm, 20.8 cm and 21.9 cm) followed by T_3 (7.2 cm, 20.2 cm and 21.4 cm) compared to the C (3.2 cm, 8.9 cm and 10.5 cm) on 25, 50 and 75 days after sowing. This is may be due to the combined action of consortium of microorganisms and earthworms promotes maximum plant growth such as root and shoot length. The vermicompost promotes availability of macro & micronutrients and phytohormones that stimulates the plant growth.[12] In addition, the presence of PGPM in the consortium of microorganism (B. *licheniformis* and *P. variotii*) helps growth of root and shoot. These microbes are able to produce auxin which plays a vital role in elongation of root consequence plant growth.[13] Several reports have revealed that the plant inoculated with two or more organisms (microbial consortium) significantly improved the growth of plant than single source.[14,15] Likewise, the plant height significantly improved by the plant inoculated

with the dual application of recommended dose of N, P, K and microbial consortium[16] and plant growth promoting rhizobacterial strains treated *Amaranthus* crop enhanced the maximum root and shoot length compared to the control.[17]

Shoot Length (cm)

The maximum shoot length was observed in toddy palm shell composted with consortium of microorganisms and earthworm (24.6 cm, 78.2 cm and 84.8 cm) compared to the other treatments as shown in table 1. This is may be due to the obtainability of vital nutrients from consortium of microorganisms enhanced the plant growth. The supplement of macro nutrients (N, P, K) availability in T_6 promotes vigorous production of crop increase the shoot length. Particularly, P plays an important role in development of plant and multiplication of cells resulting enhanced the length of shoot.[18] The joint action of vermicompost and microbial consortium promotes maximum length of shoot. Similarly, the joint action of 75% vermicompost and 100% soil increased the growth parameters of okra. In the present study, the PGPM such as *P. variotii* and B. *licheniformis* in the consortium of microorganisms ability to produce gibberellins, responsible for the elongation of shoot.[19]

Number of leaves

On 25, 50 and 75 DAS the higher count of leaves was observed in the combined application of toddy palm shells + microbial consortium + *Eisenia fetida* (9.0, 43.3 and 46.3) followed by groundnut shells + microbial consortium + *Eisenia fetida* (8.3, 40.6 and 44.3) as given in table 2. The dual action of two or more microorganisms with vermicompost revealed the vigorous production of plant growth and also the availability of micro and macro nutrients in the vermicompost improved the growth parameters. Similarly, the mutual action of *Bacillus* sp and *Pseudomonas* sp. increased the root length, height of plant, number of leaves and yield of zea mays[20] and also vermicompost of 60% municipal solid waste enhanced the number of leaves and diameter of leaf in bhendi.[21] The application of 20% rumen blood with 80% coir pith enhanced the number of leaves of okra (*Abelmoschus esculentus*).[22]

Table 2: Growth parameters of (*Cyamopsis tetragonoloba* L.) Taub on 25, 50 and 75 DAS

Treatments	Number of leaves			Number of nodules		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	3.0	28.0	29.3	5.3	7.3	1.3
T_1	3.6	29.6	31.6	6.0	8.0	1.6
T_2	5.3	30.3	36.6	6.3	10.3	2.6
T_3	8.3	40.6	44.3	8.0	13.6	4.0
T_4	5.6	37.0	39.0	7.0	11.6	3.0
T_5	6.0	32.3	35.0	7.6	12.6	3.6
T_6	9.0	43.3	46.3	8.6	14.0	4.6
SEd		0.27208			0.15908	
Cd(p<0.05)		0.54921			0.32111	
Cd(p<0.01)		0.73414			0.42923	

Number of Nodules

The maximum count of root nodules presents in T_6 (8.6, 14.0 and 4.6) followed by T_3 (8.0, 13.6 and 4.0), T_5 (7.6, 12.6 and 3.6), T_4 (7.0, 11.6 and 3.0) and minimum in C (5.3, 7.3 and 1.3) on 25, 50 and 75 DAS respectively. The count of nodules reach peak on 50 DAS of plant growth which may be due the better nutrients supply enhanced the propagation and development of roots consequence better formation of nodules and fixation of nitrogen.[23] The joined action of consortium of microorganisms and earthworms promotes the highest number of nodules in both (toddy palm shell and groundnut shell) composts. Further, the application of 75%

recommended dose of fertilizer + rhizobium + pressmud increased the height of plant, number of nodules and a diameter of cluster bean under alley cropping system[15] and the combination of Brevi *bacillus* MP4 + *Pseudomonas* MP5 + Rhizobium MP7 enhanced the root nodules of *Vicia faba* plant.[24]

Number of Flowers

Higher number of flowers was observed from T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) followed by T_3 (groundnut shell + microbial consortium + *Eisenia fetida*) than C (Table 3). This might be due to the essential amount of micro and macronutrients from the consortium of microorganisms enhanced the flowering attributes of cluster bean. The recommended level of P, N, K from inorganic and organic substrate promotes maximum count of flowers.[25] The presence of PGPR in microbial consortium ability to produce auxin, gibberellins and cytokinin which plays a key role in initiation of flowering.[26]

Number of Pods

Table 3: Growth parameters of (*Cyamopsis tetragonoloba* L.) Taub on 50 and 75 DAS

Treatments	Number of flowers		Number of pods
	50 DAS	75 DAS	75 DAS
C	8.3	9.0	2.3
T_1	11.3	14.0	3.0
T_2	13.6	16.3	2.6
T_3	15.0	18.6	5.6
T_4	12.0	15.0	4.6
T_5	14.3	16.0	5.3
T_6	15.6	24.6	6.6
SEd	1.35111		0.3324
Cd(p<0.05)	2.76771		0.7130
Cd(p<0.01)	3.73404		0.9895

The maximum number of pods recorded in T_6 (6.6) followed by T_3 (5.6), T_5 (5.3), T_4 (4.6), T_1 (3.0), T_2 (2.6) and minimum in C (2.3) on 75 days after sowing which may be due to the availability of nitrogen leads to increase number of pods in cluster bean. Similarly, accumulation of nitrogen level enhanced the number of pods in mungbean.[27] In addition, the consortium of microorganisms accelerates the growth of plant and yield. The application of 100% recommended dose of fertilizer + zinc + phosphate solubilizing bacteria significantly registered maximum number of pods in *Cyamopsis tetragonoloba* (L.).[28]

Fresh Weight of the Plant (g)

On 25 DAS the maximum fresh weight was observed in T6 (4.881 g) which was gradually increased more than double fold (9.658 g and 17.912 g) on 50 and 75 DAS as shown in table 4 respectively. The plant growth promoting microorganisms present in compost enhanced the soil fertility thereby, increased the height of plant resulting increased the fresh weight. Okra inoculated with 25% urea + 75% jeewamirta enhanced the fresh weight of root and shoot.[29] In the current study, the application of microbial consortium and earthworms which have growth regulars such as gibberellins and cytokines, helps in producing more biomass of plant.[30] The isolation of rhizobium enhanced the seedling growth parameters (shoot length, root length, plant height, fresh and dry weight) of green gram[31] and different concentration of Na_2SO_4 enhanced the length and fresh weight of sesame seedling after 96 and 144 hours.[32]

Dry Weight of the Plant (g)

The maximum plant dry weight (0.894 g, 1.829 g and 2.684 g) was observed from the treatment of toddy palm shells degraded with consortium of microorganisms and earthworms assistance on 25, 50 and 75 DAS. The absorption of K+ ions and

H_2O from soil transported all parts of plant by xylem through root hairs promotes plant biomass and growth. The plant contains 70% of water content promotes fresh weight and loss of water improved the dry mass of plant. Likewise, the usage of water in plants directly related to increasing or decreasing dry weight of plant.[33]

Yield

Table 4: Fresh and dry weight of (*Cyamopsis tetragonoloba* L.) Taub on 25, 50 and 75 DAS

Treatments	Fresh weight (g)			Dry weight (g)		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
C	3.052	8.081	12.529	0.145	0.475	0.725
T1	3.296	8.984	13.021	0.255	0.845	0.986
T2	3.652	8.672	14.527	0.481	0.924	1.328
T3	4.051	9.241	17.170	0.852	1.570	2.082
T4	4.011	9.024	16.926	0.523	0.862	1.296
T5	3.958	9.052	16.098	0.686	1.224	1.841
T6	4.881	9.658	17.912	0.894	1.829	2.684
SEd		0.19268			0.17792	
Cd(p<0.05)		0.38894			0.35914	
Cd(p<0.01)		0.51991			0.48007	

The yield attributing characteristics of cluster bean like number of pods, number of seeds/pod, length of pod (cm), yield/plant (g), fresh and dry weight of plant (g) are presented in Figure 1.

The plant treated with toddy palm shells + microbial

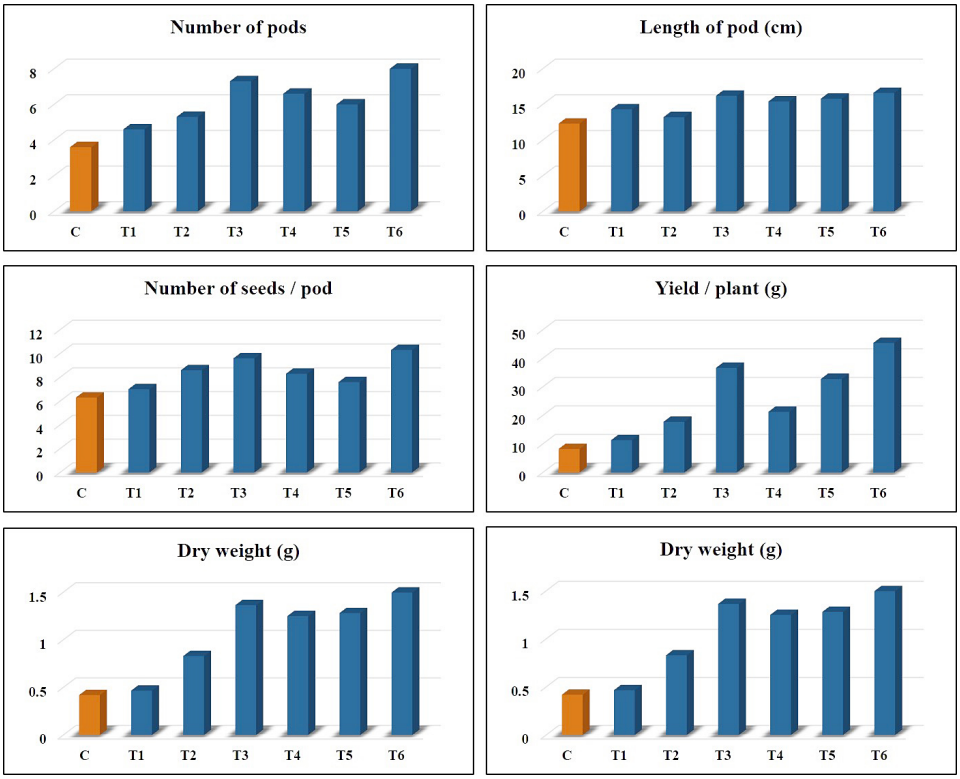

Fig. 1: Yield characters of (*Cyamopsis tetragonoloba* L.) Taub on 90 DAS

consortium + *Eisenia fetida* (8.0, 16.6 cm, 10.3, 45.384 g, 5.673 g and 1.496 g) registered maximum yield parameters of cluster bean on 90 DAS followed by T_3 (7.3, 16.2 cm, 9.6, 36.646 g, 5.020 g and 1.363 g) compared to the C (3.6, 12.3 cm, 6.3, 8.247 g, 2.291 g and 0.419 g) respectively. This might be due to better translocation of photosynthesis from leaves to pods caused higher yield in cluster bean. The joint application of organic and chemical fertilizer enhanced the yield attributing characters of cucumber.[34] The organic fertilizers like compost and vermicompost retains growth promoting substances like micro and macronutrients, bacteria, fungi, actinomycetes and vitamins.[35] The compost prepared from toddy palm shells have higher amount of essential nutrients like nitrogen, phosphorus and potassium promotes maximum yield.[1] Particularly, phosphorus is essential for initiation of flowering and fruiting. In the current study, T_6 achieved higher count of flowers promotes maximum number of pods consequence higher yield. Different combination of organic briquettes (20% rumen blood with 80% coir pith promotes maximum length of fruit, weight of fruit and fruit yield per plant in okra was reported by.[22]

Conclusions

Vermicompost with microbial consortium had positive impact on vegetative growth particularly root and shoot development promotes the growth of plant. Based on the observations, the combined application of toddy palm shells and groundnut shells degraded with consortium of microorganisms and earthworm (T_6 and T_3) is recommended for enhancement of growth characters and yield attributes of (*Cyamopsis tetragonoloba* L.) Taub. The usage of organic fertilizers enhanced the fertility of soil and higher yield simultaneously, reduce the usage of chemical fertilizers and avoids pollutions, retains water holding capacity. Hopefully this information will encourage small scale farmers to do organically and environmentally friendly ways.

Acknowledgement

The authors sincerely thank the Department of Botany, Avinashilingam Institute for Home Science and Higher Education for Women, for providing necessary facilities to carry out the present study.

Funding

There are no funding sources.

Conflict of Interest

The authors declare no conflict of interest.

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