

## Utilization of Paddy Straw Waste in the Culture Practices of Earthworm and Cultivation of Radish Plant

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### Abstract

The rates of cocoon production, incubation time and hatching success of cocoons of *Eudrilus eugeniae* kept in 0, 10, 25, 50, 75 and 100 PSR (per cent substrate ratio) of partly decomposed paddy straw waste (DPSW) for 30 days were determined. The worms kept in soil alone (0 PSR) for 30 days though showed 100% survival value with 21% weight loss, only 2 cocoons were laid during the course of study. But the worms kept in 75 PSR of DPSW produced relatively more cocoons than the worms kept in control or other PSR media. The incubation time and hatching success of cocoons collected from different PSR media of partly DPSW ranged from 10—17 days and from 74.1—86.6% respectively. Though the hatchlings cultured in different PSR of DPSW showed a gradual increase in their total length and weight, only the hatchlings grown in 100 and 75 PSR attained sexual maturity within 50 days. But the hatchlings grown in lower PSR attained sexual maturity only after 60 days of exposure. The pH levels measured in the samples of partly DPSW showed a basic pH with  $8.2 \pm 0.1$ . But the samples of vermicast and unused residual compost showed pH levels respectively as  $7.7 \pm 0.4$  and  $7.5 \pm 0.4$ . Of the three macro- (N, P and K) and four micronutrients (Fe, Mn, Zn and Cu) analyzed in the samples of partly DPSW, the levels of K in macronutrients and Mn in micronutrients were relatively high when compared to other nutrients. While vermicomposting this earthworm drastically decreased the levels of K, Fe, Mn and Cu present in the partly DPSW. Radish plants raised in different doses (25, 50, 75, 100 and 125 g/pot) of earthworm unused residual compost showed relatively lesser values of root weight than the plants raised in vermicast and DPSW. The lesser shoot weight observed in the current study was due to lesser amount of N present in DPSW as revealed in its macronutrients analysis.

**Key words :** *Eudrilus eugeniae*, Cocoon, Hatchlings, Paddy straw waste, Radish cultivation.

The epigeic earthworm, *Eudrilus eugeniae* has been effectively used in India for vermicomposting of various organic wastes due to its large size, high rates of growth and reproduction and capable of rapid decomposing ability (1—4). To understand the full potentiality of this compost worm as waste decomposer and protein producer, it is essential to study the growth, reproduction and life cycle of the same cultured under different organic wastes. In view of enormous amount of paddy straw wastes dumped in the vicinity of harvesting area, the present study was aimed to use these wastes for vermiculture (production of cocoon) and vermicomposting practices.

Land application of vermicompost obtained from diverse organic wastes could be one of the most economical and attractive methods of solving wastes disposal problem and increasing the nutrient contents of soil simultaneously. However, evaluation of

the actual nutrient status of vermicomposts is a necessary preliminary task to establish the real advantages of their use in agriculture. Further, it is well established that the nutrient status of vermicomposts mainly depends upon the quality (nutrient status) of organic wastes that are used as feed material for earthworms (5). Vermicompost and vermicast utilization in horticulture have been proposed for several years (6). The study of vermicompost effect on plant growth is essential to determine its manurial quality and nutrients status. Such study would be an important prerequisite for large scale planning of high quality vermicompost production from a specific organic waste, thereby achieving cost effective agricultural crop production. Hence to establish the quality of vermicompost obtained from paddy straw waste after using it by *Eudrilus eugeniae*, a pot cultivation was undertaken using radish plant.

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**Table 1.** Rate of cocoon production, incubation time and hatching success of cocoons of *Eudrilus eugeniae* kept in different per cent substrate ratios (PSR) of partly DPSW. \*Produced by 60 earthworms and collected for 30 days.

PSR	Total cocoons*	Rate of cocoon production Cocoon/ worm	Cocoon/ worm/day	Incubation time (days)	Total hatchlings obtained	Hatchling cocoon	Hatching success (%)
0	2	0.03	0.001	12	1	0.50	50.0
10	31	0.52	0.017	10—15	23	0.74	74.1
25	60	1.00	0.033	10—17	52	0.87	86.6
50	93	1.55	0.052	10—16	79	0.85	84.9
75	125	2.08	0.069	10—17	107	0.86	85.6
100	63	1.05	0.035	12—17	54	0.86	85.7

### Methods

#### *Procurement and Maintenance of Eudrilus eugeniae*

Specimens of adult *Eudrilus eugeniae* were purchased from a vermiculture farmer at Chidambaram. The worms were kept in large trays with a substrate containing 50% partly decomposed cowdung and 50% soil and maintained under the laboratory condition (31—36 C) for 30 days. The worms with the size of 19.7—27.2 cm in length and 1.800—2.900 g in weight were used for the present study.

#### *Collection of Soil and Paddy Straw Waste*

Dry soil taken from the Cauvery riverbank at Government Arts College (Autonomous), Kumbakonam was manually powdered using stone mortar. The paddy straw wastes were collected from Keelamanjeri village, Papanasam Taluk, Thanjavur district.

#### *Partial Decomposition of Paddy Straw Waste*

Two rectangular brick work cement tanks each

with 180 × 75 × 90 cm size were used for the decomposition of paddy straw waste. The tanks were filled with dry paddy straw waste and poured with sufficient water. They were closed with polythene sheets to avoid water evaporation and a possible release of foul smell during decomposition. Water was poured regularly in the tanks after removing the polythene sheets and closed again for proper decomposition. Once in three days, the decomposing materials were thoroughly mixed with the help of a wooden rod to ensure uniform decomposition. Ideal semi-decomposed paddy straw waste (DPSW) in the form of wet powder can be obtained only after 50 days of decomposition and was air dried. The dried powder was sieved using a sieve with a size of 1 mm<sup>2</sup> to obtain a medium with a particle size less than 1 mm as suggested by Reinecke and Venter (7) to promote microbial activities and moisture availability.

#### *Preparation of Substrates for Cocoon Production Study*

Six sets of five media with per cent substrate ratios (PSR), 100, 75, 50, 25 and 10 were prepared using dry soil and powdered DPSW on the basis of volume by volume and mixed well. Four liters of each

**Table 2.** Changes of body weight (g) during cocoon production of 60 *Eudrilus eugeniae* kept in different PSR media of partly DPSW for one month. Total of 30 pairs were kept in each PSR.

PSR	0	6	On day 12	18	24	30	Percent change
0	80.4	69.2	66.3	64.7	64.2	63.7	- 20.7
10	87.0	84.5	79.0	76.2	73.3	70.7	- 18.7
25	115.9	110.0	106.2	103.0	101.5	94.9	- 18.1
50	131.1	136.3	140.6	145.7	139.8	132.7	+ 1.22
75	145.0	153.8	160.9	166.3	163.7	154.0	+ 8.48
100	128.2	144.2	152.7	157.4	144.8	144.0	+ 12.3

**Table 3.** Measurements of the length (cm) and weight (mg) of hatchlings of *Eudrilus eugeniae* obtained from different PSR of partly DPSW and cultured in the respective PSR under laboratory condition. Values in parenthesis indicate number of hatchlings cultured ; \*indicates the time of clitellum formation ; upper and lower row values indicate the average length and weight of hatchlings ; hatchling kept in 0 PSR shows no sign of any movement from 30 days onwards but get itself coiled all the times.

Age (day)	PSR					
	100 (54)	75 (107)	50 (79)	25 (52)	10 (23)	0 (1)
0	0.90	0.99	0.82	0.74	0.61	0.70
	05	06	05	03	03	04
10	2.89	2.97	2.58	2.40	2.25	1.30
	61	67	54	43	47	35
20	4.64	4.74	4.42	4.24	4.11	2.50
	243	220	200	125	167	80
30	6.70	7.00	6.31	6.75	6.02	2.50
	494	414	387	349	386	50
40	10.22	10.51	9.89	8.35	8.33	2.50
	862	623	660	676	949	10
50	14.01*	14.34*	11.92	10.03	9.95	2.50
	1387*	909*	853	1005	1490	10
60	—	—	14.03*	12.00	11.78	2.50
	—	—	1145*	1290	1919	10
70	—	—	—	13.96*	13.93*	2.50
	—	—	—	2582*	2411*	10

substrate was taken in an earthen pot and added sufficient water to ensure optimum moisture condition as suggested by Martin (8). To assess the rate of cocoon production in the above media, 10 adult earthworms were introduced into each pot. Six sets of control (soil alone as substrate) experiments having 10 adult earthworms in each were also maintained simultaneously along with these media. Regular watering is a must for this culture study to provide optimum moisture to the earthworms. Cocoons produced by earthworms were collected and recorded once in six days for one month. Survival of earthworms was also observed in the media during the course of study. Rate of cocoon production was calculated at daily and monthly basis.

#### *Collection of Vermicasts and Earthworm Unused Residual Compost*

Vermicasts released by earthworms in 100 PSR medium alone were collected from the upper surface at every 6-day intervals and stored in polythene bag separately. At the end of cocoon production study, the substrate unused by earthworms as residual compost was collected and stored in another polythene bag.

#### *Hatchlings Growth Study*

All the media used in the above study after one month were renewed with fresh partly DPSW to ascertain the incubation time, hatching success and hatchling growth rate. Cocoons collected from the above study were placed separately in plastic cups containing the same PSR medium and observed their hatching time until all the cocoons hatched out into hatchlings. The hatchlings collected from these cups were placed in the respective earthen pots and measured their length and weight at 10-day intervals until the worms developed into clitellum. Incubation time and hatching ability of all cocoons were also assessed.

#### *Macro and Micronutrients Analysis*

The levels of pH and electrical conductivity (EC) were measured in the samples of partly DPSW (before vermicomposting), vermicast and unused residual compost (after vermicomposting by *Eudrilus eugeniae*). Macronutrients such as nitrogen (N), phosphorus (P) and potassium (K) and micronutrients such as zinc, iron, copper and manganese were also estimated in the above samples at Soil Testing

**Table 4.** Values showing the levels of pH, EC (dS/m), macro and micronutrients present in the samples of partly DPSW (before vermicomposting), vermicast and unused residual compost (URC) (after vermicomposting by earthworm) obtained from paddy straw waste. Values are mean  $\pm$  SD of six samples. \*Statistically significant ( $P < 0.05$ ) over partly DPSW ; \*\*Statistically not significant ( $P > 0.05$ ) over partly DPSW.

Parameters	Partly DPSW	Vermicast	URC
<b>Sample Nature</b>			
pH	8.2 $\pm$ 0.1	7.7 $\pm$ 0.4	7.5 $\pm$ 0.4
EC	2.85 $\pm$ 0.25	2.45 $\pm$ 0.20*	2.01 $\pm$ 0.34*
<b>Macronutrients (ppm)</b>			
N	131.6 $\pm$ 17.4	132.2 $\pm$ 14.8**	116.8 $\pm$ 17.1*
P	53.2 $\pm$ 11.0	60.1 $\pm$ 6.0**	57.7 $\pm$ 6.0**
K	3475 $\pm$ 246	2029 $\pm$ 318*	1521 $\pm$ 193*
<b>Micronutrients (ppm)</b>			
Fe	4.20 $\pm$ 0.22	1.80 $\pm$ 0.11*	2.54 $\pm$ 0.29*
Mn	12.06 $\pm$ 1.17	1.39 $\pm$ 0.30*	2.98 $\pm$ 0.71*
Zn	2.03 $\pm$ 0.55	2.57 $\pm$ 0.72*	1.71 $\pm$ 0.66*
Cu	0.19 $\pm$ 0.06	0.11 $\pm$ 0.05*	0.12 $\pm$ 0.02*

Laboratory, Soil Research Institute, Aduthurai. The contents of macro and micronutrients were expressed as ppm.

#### *Effect of DPSW on the Growth of Radish Plant*

Two sets of 15 circular pots with size, 22 cm diameter and 23 cm height were taken and to each, 7 kg of dry soil was transferred. Five doses (25, 50, 75, 100 and 125 g) in each of partly DPSW, vermicast and unused residual compost of DPSW were selected and mixed well in the pot soil. Control experiment was also carried out in duplicate along with this experiment using soil alone as culture medium. Radish seeds were purchased from the local seed farm at Kumbakonam. Three seeds were placed in each pot at a depth of 2.5 cm and sufficient water was poured in all the pots for proper germination of seeds. The experimental pots were kept at open terrace for direct sun light. The pots were regularly poured with sufficient water to ensure proper growth until the plants get harvested (42 days). Care was taken to see that the plants growing in the pots must be protected from predation, if any. Number of leaves present in the plants was counted at regular week intervals. At the end of week 6, all plants were uprooted and mea-

sured their leaf and root weight.

#### *Statistical Analysis*

The rate of cocoon production by earthworms (cocoon/worm per month or day) was calculated in each medium. Statistical comparisons were also made in macro and micro nutrient levels between the samples of partly DPSW and vermicast/unused residual compost using Students *t*-test.

### **Results and Discussion**

#### *Reproductive Study*

The rate of cocoon production, incubation time and hatching success of cocoons of *Eudrilus eugeniae* kept in 0, 10, 25, 50, 75 and 100 PSR media prepared from partly DPSW with soil for 30 days were given in Table 1. The worms kept in soil alone for 30 days though showed 100% survival value, only two cocoons were laid during the course of study due to poor nutrient status of the medium. Though the worms kept in other PSR media produced relatively more cocoons than the control, the cocoons produced in 75 PSR medium were relatively more (0.069 cocoon/worm per day) when compared to the cocoons produced in other PSR media (0.017 to 0.052 cocoon/worm per day). The cocoons collected from the earth-

**Table 5.** Values showing the root, shoot and total weight (g) of radish plant raised through pot cultivation for 42 days under different paddy straw media. Values are the average of 2 pots ; upper, middle and lower row values indicate the plants cultivated in partly DPSW, vermicast and earthworm unused residual compost obtained from paddy straw waste respectively.

Dose (g/pot)	Root weight	Shoot weight	Total weight
25	37.7	18.9	56.6
	53.7	28.1	81.8
	32.8	14.0	46.8
50	40.4	19.6	60.0
	61.6	30.2	91.8
	38.1	14.1	52.2
75	51.7	31.7	83.4
	54.9	32.0	86.9
	41.1	16.7	57.8
100	56.6	26.9	83.5
	58.1	33.5	91.6
	45.0	19.3	64.3
125	59.5	34.7	94.2
	62.6	35.6	98.2
	48.8	20.5	69.3
0	32.3	14.1	46.4
	27.7	12.1	39.8
	22.1	8.2	30.3

worms living in 75 PSR medium were hatched out into young ones at the rate of 0.86 hatchling / cocoon with 85.6% hatching success after a period of 10 to 17 days of incubation time. A maximum hatching success of 86.6% was noticed in the cocoons of earthworms collected from 25 PSR medium. The hatching ability of cocoons (0.50 to 0.87 hatchling / cocoon) collected from the study did not follow the findings of Dash and Senapati (9) and Bakthavathsalam and Ramakrishnan (10), where they observed usually one or rarely two juveniles from each cocoon on hatching. But it follows the findings of Bakthavathsalam and Geetha (11), where they found 0.9–1.0 and 0.7–1.0 hatchling / cocoon on hatching while using the earthworm, *Lampito mauritii* exposed to decomposed paddy chaff and weed plants material respectively. A contradictory report was noticed in the incubation time of cocoons collected from *Eudrilus eugeniae* as observed by Reinecke et al. (12), Ramalingam (13) and Bakthavathsalam and Geetha (11), where they found  $\pm 23$  days,  $27.33 \pm 0.42$  days and 26–54 days respectively for *Eisenia fetida*, *Lampito mauritii* and

*Lampito mauritii*. In spite of good health and 100% survival observed in the adult earthworms kept in DPSW it is important to note here that the production of cocoons from lower PSR to higher PSR showed an increasing trend, but it was relatively less when compared to the studies made by Ramalingam (13) in *Lampito mauritii* cultured in pressmud where he found  $\pm 0.4$  cocoon/worm per day. This result along with the study made by Bakthavathsalam and Ramakrishnan (10) and Bakthavathsalam and Geetha (11) revealed that the organic substrates prepared from paddy products such as fresh paddy chaff powder, decomposed paddy chaff powder and DPSW are not considered as good medium for viable culture practices of earthworm under laboratory condition, though they contain high amount of carbon and potassium as reported by Jena et al. (14). From these results, it is suggested that if at all any culture medium prepared from paddy products for vermiculture, the waste materials may be used after microbial decomposition mixed along with nitrogen and phosphorus rich organic waste materials to raise earthworms or any other crops of human interest. Further the weight loss observed in 10 and 25 PSR media may be the reason for low nitrogen level observed in the present study and also as reported by Jena et al. (14) since the earthworms need nitrogen for their cellular protein synthesis and the production of cocoons.

Weight changes during cocoon production of 60 adult earthworms kept in different PSR media of partly DPSW for one month were given in Table 2. The worms kept in 50, 75 and 100 PSR media for 30 days showed a gradual increase in their body weight upto 18 days and a gradual decline thereafter but above their initial weight. In contrast, the worms kept in 0, 10 and 25 PSR media showed a gradual decrease in their body weight right from the beginning till the end having the weight loss values of 20.7, 18.7 and 18.1% respectively.

#### Hatchlings Growth

Measurements of length and weight of *Eudrilus eugeniae* hatchlings cultured in 100, 75, 50, 25 and 10 PSR of DPSW at laboratory condition for 70 days were given in Table 3. The hatchlings showed a gradual increase in their total length and weight throughout the study period. The hatchlings grown

in 100 and 75 PSR attained sexual maturity after 50 days of exposure after reaching a mean length of 14.01 and 14.34 cm and a mean weight of 1387 and 909 mg respectively. On the contrary, the hatchlings placed in 25 and 10 PSR media attained sexual maturity only after 70 days of exposure after reaching a mean length of 13.96 and 13.93 cm and a mean weight of 2582 and 2411 mg respectively. But the hatchlings grown in 50 PSR medium attained sexual maturity only after 60 days of exposure. The hatchling kept in control medium (soil alone) showed no sign of any movement from 30 days onwards but get itself coiled all the times, though showed a slight improvement in its length and weight upto 20 days. Although, lower values were noted in cocoon production and hatching ability (Table 1), practically no adverse effect was noticed in any of the hatchlings growth parameters (Table 3). Similar results were also reported in the culture study made by Bakthavathsalam and Ramakrishnan (10) and Bakthavathsalam and Geetha (11) using *Lampito mauritii* cultured in the medium containing neem products and weed plants materials respectively. Over all, the time of sexual maturity and the length values observed in hatchlings growth study were followed strictly in accordance with PSR values, where there is a high PSR, the worm length value is also high and vice versa. An important observation noted in the culture study was that irrespective of total weight or the age it may have, the worm after reaching a length of  $\pm 14$  cm showed a positive sign at its anterior region to develop a thick clitellum. The results though showed relatively lower rate of cocoon production and hatching success over other species such as *Lampito mauritii* cultured in farmyard manure (15) and *Perionyx excavatus* cultured in different organic wastes (16), the length and weight gain values observed (Table 3) were relatively high when compared to the results reported by Bakthavathsalam and Ramakrishnan (10) and Bakthavathsalam and Geetha (11) in *Lampito mauritii* cultured in different substrates. From the present result (Table 3) it was concluded that the DPSW may be considered as a good material for the culture practices of *Eudrilus eugeniae* at least for the production of biomass to meet the protein requirements of food industry pertaining to fish, poultry and pigs though it exerts certain adverse effect on the reproductive biology of this earth-worm.

#### *Analysis of Macro and Micro nutrients in Paddy Straw Waste*

The levels of soil parameters such as pH, electrical conductivity, macronutrients (nitrogen, phosphorus and potassium) and micronutrients (iron, manganese, zinc and copper) present in the samples of partly DPSW (before vermicomposting), vermicast and unused residual compost (after vermicomposting by *Eudrilus eugeniae* for one month) of DPSW are given in Table 4. The samples of partly DPSW showed a basic pH with  $8.2 \pm 0.1$ . But the samples of vermicast and unused residual compost obtained after one month of vermicomposting showed relatively lesser pH with  $7.7 \pm 0.4$  and  $7.5 \pm 0.4$  respectively over partly DPSW. The levels of electrical conductivity measured in the samples of partly DPSW showed relatively more values ( $2.85 \pm 0.25$ ) than the samples of vermi-cast and unused residual compost which indicate that the soluble salts level was reduced during vermicomposting and it also revealed by their pH level. The availability of several plant nutrients and elements present in any soil depends upon the pH value of the organic manure. The pH value at neutral level should be considered important in retaining nitrogen since it is lost as volatile ammonia at high pH (17) and the pH range 6—7 seems to promote the availability of plant nutrients (18). In the present analysis though there are changes in pH during vermicomposting but their pH observed were above the safe range ( $> 7$ ) as suggested against by Brady (18). Hence it could be concluded that the observed pH is not safe for the plants to get available free nutrients for their better growth as revealed by poor growth of radish plant raised in the present study. The high pH value and lesser amount of nitrogen observed in the partly DPSW supported the views that the nitrogen level is lost at high pH (17).

Of the three macronutrients (N, P and K) and four micronutrients (Fe, Mn, Zn and Cu) analyzed in the samples of partly DPSW, the levels of potassium in macronutrients and magnesium in micronutrients were relatively high when compared to other macro and micronutrients. Further, the partly DPSW while vermicomposting drastically decreased the levels of potassium, iron, magnesium and copper over their levels prevailed in the partly DPSW samples. This result was not in conformation with the reported re-

sults of increased levels of N, P, K and Mg (19), macro and micronutrients (20), N, P, K, Ca and Mg (13), N, P, K, Ca, Mg, Zn, Fe, Cu and Mn (21) and N, P, Fe, Zn and Cu (22) due to the effective action of earthworm and microbial activity on waste material during vermicomposting. Thus it is inferred that the quality of any vermicompost depends upon the quality of organic waste used by earthworms.

#### *Effect of Vermicompost on the Yield of Radish Plant*

Measurements of root and shoot weight of 42 days old radish plant raised through pot cultivation using different doses (25, 50, 75, 100 and 125 g/pot) of partly DPSW, vermicast and earthworm unused residual compost of DPSW are given in Table 5. The results revealed a differential effect on the growth of radish plant raised in different doses of DPSW. The plants raised in different doses of earthworm unused residual compost showed relatively lesser values of root weight than the plants raised in vermicasts and partly DPSW. The values of root weight obtained were relatively high when compared to shoot weight and this lesser shoot weight was due to meager amount of nitrogen present in the DPSW (Table 4). Another important observation noted in this study was that the measurements of root weight are strictly followed in accordance with the doses of DPSW. This observation falls in line with many reports already made in other plants with vermicomposts obtained from different sources.

There have been numerous experiments in which plants have been grown in pots with earthworms or their cast or vermicompost, where an increase in plant growth has occurred. Kale and Bano (23) found that the vegetative growth of plants was influenced by *Eudrilus eugeniae* worm cast in a better way than the chemical fertilizers. Line (24) reported that vermicomposted mixture of wood waste and sea star waste showed an excellent growth of tomatoes and lettuces. Ramalingam (13) has also reported a differential effect on the growth parameters of tomato raised in organic manures (cattle dung, farmyard manure and pressmud) and vermicomposts (obtained from farmwaste + pressmud, water hyacinth + pressmud and water hyacinth + pressmud slurry). Similarly Uthayakumar and Bakthavathsalam (21)

and Jayaseelan (22) have also reported a differential effect on the growth and yield of black gram and radish plant respectively raised in different ratios of vermicompost obtained from vegetable market wastes and green gram wastes.

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