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Impact of various Organic Wastes based Vermicompost on Physiological Growth of Rice (*Oryza sativa* L.)

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ABSTRACT: A field experiment was conducted to study the effect of various organic wastes based vermicompost on physiological growth of rice (*Oryza sativa* L.) during the year 2019-20 and 2021. The experiment was carried out at the Wetland farms, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The study was carried out with various organic wastes based vermicompost. The treatments includes the earthworm *Eudrillus eugeniae* species with organic wastes paddy straw (T_1), coconut wastes (T_2), vegetable wastes (T_3), farm wastes (T_4) and FYM (T_5) and *Eisenia foetida* with paddy straw (T_6), coconut wastes (T_7), vegetable wastes (T_8), farm wastes (T_9) and FYM (T_{10}) and absolute control (T_{11}). The result showed that the treatment *Eudrillus eugeniae* + coconut wastes (T_2) was found significantly superior on drymatter production and other physiological growth rates during both the years. The study revealed that the vermicompost from coconut wastes along with earthworm species *Eudrillus eugeniae* influenced positively the drymatter production and growth rates of rice. The current study was designed to see how vermicomposts generated from various organic residues and earthworm species affected rice growth rates.

Keywords: Vermicompost, Drymatter production, Crop growth rate, Relative growth rate, Net assimilation rate.

INTRODUCTION

Rice (*Oryza sativa* L.) is the worlds most significant and dependable food crop, supplying over half of the world's population and being widely produced. It delivers 50-60% of a person's daily calories to 2.7 billion people (Metwally *et al*., 2011). Rice accounts for around 11% of global agricultural land and ranks second in terms of farmed area (Tumrani *et al*., 2015). The rice soil system is critical to the long-term viability of wetland rice systems, since it helps to protect soil fertility and build up organic matter (Sahrawat, 2004). Continuous use of chemical fertilizers without organic sources produces a steady drop in organic matter content and a change in soil native N status, resulting in low rice productivity (Pei *et al*., 2015).

Organic farming is one of the strategies that can help make a production system more sustainable without harming the environment or natural resources (Ram *et al*., 2011). Organic manures gradually release a controlled amount of plant nutrients, increasing rice yield and nitrogen efficiency (Sharma *et al*., 2002). Furthermore, organic manure nutrients are released more slowly and kept in the soil for a longer period of time, ensuring a long residual effect (Ge *et al*., 2010).

Organic wastes, farm yard manure (FYM), compost, vermicompost, and poultry manures are now being emphasised as the most effective means of increasing soil fertility and, as a result, crop productivity (Hossaen *et al*., 2011). Vermicompost contains a high concentration of humic acids, which improves the crop's morphological traits by boosting plant height, leaf area index, and shortening the slow-growing period (Atarzadeh *et al*., 2013).

In India, organic waste is substantial, with rice alone contributing 100 mt (Bhor *et al*., 2013) and coconut farms contributing roughly 6-8 tonnes ha^{-1} annually (Thomas *et al*., 2012). Vegetable wastes are abandoned along roadsides, polluting rural regions in large quantities, and other plant residues after harvest are also available at a higher rate in India. As a result, vermicomposting will be advantageous in recycling these organic wastes and enhancing their nutritious content. With these factors in mind, the current study was designed to see how vermicomposts generated from various organic residues and earthworm species affected rice growth rates.

MATERIAL AND METHODS

Experimental location. During December-March 2019-20 and March-June 2021, the experiment was done in the Tamil Nadu Agricultural University's Wetland Farms in Coimbatore, Tamil Nadu. For both years, the soil texture was clay loam, and the initial soil samples were taken at random before the crop was transplanted. The samples were dried in the shade, processed, and analyzed for physical qualities and nutrients. Table 1 shows the sample values at the start.

Table 1: Initial physical and chemical properties of the soil.

Particulars	2019-20	2021
pH (Jackson, 1973)	8.56	8.34
EC (Jackson, 1973)	0.28	0.64
Organic carbon (g kg^{-1}) (Walkley and Black, 1934)	0.34	1.36
Available nitrogen (kg ha^{-1}) (Subbiah and Asija, 1956)	134.4	179.2
Available phosphorus (kg ha^{-1}) (Olsen *et al*., 1954)	22.0	33.0
Available potassium (kg ha^{-1}) (Jackson, 1973)	364	431

Treatment details. The experiment was carried out in the randomized complete block design with 11 treatments and three replications. By utilizing the wastes available, two species of earthworms were released for decomposition and preparation of vermicompost. The prepared vermicompost was used for rice cultivation. The treatment details were T_1 – *Eudrillus eugeniae* + paddy straw, T_2 - *Eudrillus eugeniae* + coconut wastes, T_3 - *Eudrillus eugeniae* + vegetable wastes, T_4- *Eudrillus eugeniae* + farm wastes, T_5 - *Eudrillus eugeniae* + FYM, T_6 – *Eisenia foetida* + paddy straw, T_7- *Eisenia foetida* + coconut wastes, T_8 – *Eisenia foetida* + vegetable wastes, T_9 – *Eisenia foetida* + farm wastes, T_{10} – *Eisenia foetida* + FYM and T_{11} - Absolute control (without application of vermicompost). Plot size used was 8 m × 3 m.

Cultivation practices. The rice variety grown was CO (Rice) 51 with the duration of 110 days (short duration). The experiment was conducted at the organic field which was maintained organically for the past thirteen years (since 2007). Before transplanting, the field was grown with green manure (*Daincha*) and incorporated. Vermicompost was applied as a basal application to each plot based on their N content as per recommended dosage (150:50:50 NPK kg ha^{-1}). The nursery was maintained for 21 days. Transplanting was carried out at a spacing of 20 cm × 15 cm. The other cultivation practices were followed as per the CPG (2020).

Observations recorded. The observations were made by randomly picking five plants from the net plot from each experimental plot. Drymatter production (kg ha^{-1}), Crop Growth Rate (CGR), Relative Growth Rate (RGR), and Net Assimilation Rate (NAR) were estimated and monitored.

Drymatter production. The plants were collected from border rows of each plot as destructive sampling at active tillering, panicle initiation and flowering stages and the plants were dried in hot air oven at 65 ± 5°C to obtain constant weight. The dried plants were then weighed and expressed in kg ha^{-1}.

Crop growth rate (CGR). The rate of accumulation of drymatter per unit land area per unit time is known as crop growth rate (Peng *et al*., 1993). It was estimated using the formula below and expressed as g m^{-2} day^{-1} during the active tillering, panicle initiation, and flowering periods of the crop.

$$CGR = \frac{W_2 - W_1}{P\,(t_2 - t_1)}$$

Where,
W_2 and W_1 – Total plant dry weight,
t_2 and t_1 - Time interval in days, and
P – Land area (spacing).

Relative growth rate (RGR)

It's a measure of how much growth material there is per unit dry weight of plant per unit time. The mean RGR is derived using Blackman's proposed dry weight measurements at time t_1 and t_2 (1919).

$$RGR = \frac{\text{Log}_e\ W_2 - \text{Log}_e\ W_1}{(t_2 - t_1)}$$

Where,
W_2 and W_1 – Natural logarithm of the total plant dry weight, and
t_2 and t_1 – Time interval in days.

Net assimilation rate (NAR). The term NAR was used by Williams, (1946). NAR is defined as dry matter increment per unit leaf area or per unit leaf dry weight per unit of time. It was calculated by the following formula and expressed as mg cm^{-2} day^{-1}.

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\text{Log}_e\ L_2 - \text{Log}_e L_1}{L_2 - L_1}$$

Where,
W_1 and W_2 - Whole plant dry weight at time t_1 and t_2, respectively,
t_1 and t_2 - Time intervals in days, and
L_1 and L_2 – Leaf area of the plants.

Statistical analysis. The observed data were statistically analyzed as per the procedures given by Gomez and Gomez, (2010) for randomized complete block design. The critical differences were worked out at five per cent probability level.

RESULTS AND DISCUSSION

Drymatter production. During the years 2019-20 and 2021, drymatter output was strongly influenced at all stages of the crop's growth, including active tillering, panicle initiation, and maturity (Table 2). During both years, the treatment *Eudrillus eugeniae* + coconut wastes (T_2) accumulated the most drymatter compared to the other treatments. This was followed by the treatment *Eisenia foetida* + coconut wastes (T_7). It's possible that the higher drymatter generation in treatment T_2 is related to enhanced enzyme activity and plant growth hormones. According to Gopal *et al.*, (2010), coconut leaf vermicompost is a bulky stable manure with high organic content, which is the best source of growth for plants and microorganisms. Maheswarappa *et al.* (2014) also discovered similar results. The treatment Absolute control (T_{11}) produced significantly less drymatter than the other treatment plots, owing to a lack of appropriate nutrients.

Table 2: Effect of various organic wastes based vermicompost on drymatter production of rice (kg ha^{-1}).

Treatments	2019-20			2021		
	Active tillering	Panicle initiation	Maturity	Active tillering	Panicle initiation	Maturity
T_1- *Eudrillus eugeniae* + Paddy straw	1886	4177	7860	1812	4125	8015
T_2 - *Eudrillus eugeniae* + Coconut wastes	2410	5514	9745	2650	5557	9987
T_3- *Eudrillus eugeniae* + Vegetable wastes	1474	3573	7213	1552	3858	7350
T_4 - *Eudrillus eugeniae*+ Farm wastes	1254	3167	6877	1325	3310	6885
T_5 - *Eudrillus eugeniae* + FYM	1733	3951	7907	1752	4074	7898
T_6 - *Eisenia foetida* + Paddy straw	1593	3704	7646	1650	3987	7652
T_7 - *Eisenia foetida* + Coconut wastes	2171	4720	8844	2264	4836	9047
T_8 - *Eisenia foetida* + Vegetable wastes	1400	3321	7172	1473	3558	7111
T_9- *Eisenia foetida* + Farm wastes	1238	2998	6583	1289	3266	6593
T_{10}- *Eisenia foetida* + FYM	1944	4278	7983	2038	4356	8178
T_{11}- Absolute control	1039	2474	5996	1154	2792	6095
S.Ed	89	191	334	95	263	388
CD (5%)	187	390	698	198	550	810

Physiological growth rates. The results revealed that crop growth rate, relative growth rate and net assimilation rate showed significant difference among the treatments and influenced by drymatter production (Table 3 and 4).

Crop growth rate (CGR). During the years 2019-20 and 2021, drymatter output was strongly influenced at all stages of the crop's growth, including active tillering, panicle initiation, and maturity stage (Table 3). During both years, the treatment *Eudrillus eugeniae* + coconut wastes (T_2) accumulated the most drymatter compared to the other treatments. The treatment *Eisenia foetida* + coconut wastes (T_7) was followed. It's possible that the higher drymatter generation in treatment T_2 is related to enhanced enzyme activity and plant growth hormones. According to Gopal *et al.* (2010), coconut leaf vermicompost is bulky stable manure with high organic content, which is the best source of growth for plants and microorganisms. Maheswarappa *et al.*, (2014) also discovered similar results. The treatment Absolute control (T_{11}) produced significantly less drymatter than the other treatment plots, owing to a lack of appropriate nutrients.

Relative growth rate (RGR). The relative growth rate was significantly affected with the drymatter production at active tillering, panicle initiation and at maturity stage of the crop. Maximum relative growth rate was found with the treatment Absolute control (T_{11}) at all the stages of both the years. This was followed by the treatment *Eisenia foetida* + farm wastes (T_9). As the crop matures, the relative growth rate showed gradual decrease at all the stages of the crop, due to lower plant growth and drymatter accumulation. This was in line with the findings of Sarker *et al*. (2017). Minimum relative crop growth rate was obtained with the treatment *Eudrillus eugeniae* + coconut wastes (T_2).

Net assimilation rate (NAR). The net assimilation rate is inversely proportional to crop drymatter production and leaf area. When compared to all other treatments, the treatment *Eudrillus eugeniae* + coconut wastes (T_2) had the highest net assimilation rate, followed by the treatment *Eisenia foetida* + coconut wastes (T_7). The treatment Absolute control (T_{11}) had the lowest net assimilation rate. At all stages of the crop, the net assimilation rate was higher in the T_2 treatment. This was owing to the increased leaf area and number of leaves generated per unit area, as well as the increased number of tillers per unit area. The enhanced drymatter buildup in this treatment resulted in a higher net assimilation rate in the current investigation. Sunil kumar *et al*., (2017) also stated that nutrient availability and translocation enhanced the plant's metabolic and physiological activities, as well as facilitated the photosynthetic process.

Table 3: Effect of various organic wastes based vermicompost on physiological growth rates of rice during 2019-20.

Treatments	CGR (g $m^{-2}day^{-1}$)		RGR (mg $g^{-1}day^{-1}$)		NAR (mg $cm^{-2}day^{-1}$)	
	Active tillering-Panicle initiation	**Panicle initiation-Maturity**	**Active tillering-Panicle initiation**	**Panicle initiation-Maturity**	**Active tillering-Panicle initiation**	**Panicle initiation-Maturity**
T_1- *Eudrillus eugeniae* + Paddy straw	7.63	12.28	494	248	9.50	15.90
T_2 - *Eudrillus eugeniae* + Coconut wastes	10.34	14.10	386	194	13.40	18.30
T_3- *Eudrillus eugeniae* + Vegetable wastes	7.00	12.84	611	279	9.10	15.70
T_4 - *Eudrillus eugeniae*+ Farm wastes	6.38	12.13	700	302	8.20	16.10
T_5 - *Eudrillus eugeniae* + FYM	7.39	13.19	536	254	9.50	17.10
T_6 - *Eisenia foetida* + Paddy straw	7.04	13.14	578	266	9.10	17.10
T_7 - *Eisenia foetida* + Coconut wastes	8.50	13.75	441	219	11.00	17.80
T_8 - *Eisenia foetida* + Vegetable wastes	6.40	12.37	651	288	8.30	16.60
T_9- *Eisenia foetida* + Farm wastes	5.87	11.95	727	317	7.60	15.40
T_{10}- *Eisenia foetida* + FYM	7.78	12.35	489	243	10.10	16.00
T_{11}- Absolute control	4.79	11.74	874	364	6.20	15.30
S.Ed	0.38	0.67	37	09	0.40	0.57
CD (5%)	0.80	1.40	77	20	0.81	1.17

Table 4: Effect of various organic wastes based vermicompost on physiological growth rates of rice during 2021.

Treatments	CGR (g $m^{-2}day^{-1}$)		RGR (mg $g^{-1}day^{-1}$)		NAR (mg $cm^{-2}day^{-1}$)	
	Active tillering-Panicle initiation	**Panicle initiation-Maturity**	**Active tillering-Panicle initiation**	**Panicle initiation-Maturity**	**Active tillering-Panicle initiation**	**Panicle initiation-Maturity**
T_1- *Eudrillus eugeniae* + paddy straw	7.71	12.97	514	247	10.02	16.80
T_2 - *Eudrillus eugeniae* + coconut wastes	9.69	14.77	368	191	12.60	23.40
T_3- *Eudrillus eugeniae* + vegetable wastes	7.69	11.64	570	267	10.02	15.00
T_4 - *Eudrillus eugeniae*+ farm wastes	6.62	11.92	667	297	8.50	15.40
T_5 - *Eudrillus eugeniae* + FYM	7.74	12.75	527	250	10.06	16.50
T_6 - *Eisenia foetida* + paddy straw	7.79	12.22	546	257	10.50	15.80
T_7 - *Eisenia foetida* + coconut wastes	8.57	14.04	427	215	11.50	18.20
T_8 - *Eisenia foetida* + vegetable wastes	6.95	11.84	611	281	9.00	15.30
T_9- *Eisenia foetida* + farm wastes	6.59	11.09	681	305	8.50	14.40
T_{10}- *Eisenia foetida* + FYM	7.73	12.74	474	238	10.06	16.50
T_{11}- Absolute control	5.46	11.01	780	342	7.10	14.30
S.Ed	0.39	0.65	31	14	0.26	0.64
CD (5%)	0.83	1.37	64	29	0.54	1.31

CONCLUSION

The present study concluded that the use of vermicompost produced from coconut residues along with the earthworm species *Eudrillus eugeniae* performed well and had influenced the drymatter production and growth rates of rice. Hence, it can be inferred that *Eudrillus eugeniae* can be utilized well for preparation of vermicompost in coconut gardens.

FUTURE SCOPE

As now the trend is going back to the organic farm, vermicomposting with the available resources in the farm will be helpful for the sustainability and environmental conditions.

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Conflict of Interest. None.

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