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Research Article

EFFECT OF DIFFERENT COMBINATIONS OF FEED MATERIAL OF CATTLE DUNG WITH KITCHEN WASTE ON GROWTH RATE OF EARTHWORM *EUTYPHOEUS WALTONI* MICHAELSEN

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ABSTRACT

In this study the effect of different combinations of animal dung (buffalo, cow, and goat) with kitchen wastes (vegetable wastes and banana peels) on the growth rate of *Eutyphoeus waltoni* during vermicomposting has been investigated. To identify the most potential feed material combination for enhancement of earthworm growth, the experiment was conducted using different combination of animal dung with kitchen waste as well as dung alone. Significant growth rate of *Eutyphoeus waltoni* was observed in all the binary combinations of animal dung with vegetable waste and banana peels whereas; the maximum growth rate was observed in the combination of buffalo dung and vegetable waste present in (1:1) ratio. It may be due to the balanced nutrient profile provided by the mixture, which enhances the decomposition process and creates an ideal environment for earthworm growth. The feed material combination of buffalo dung and vegetable waste in (1:1) ratio is suitable for better growth and development of earthworm *Eutyphoeus waltoni* which not only enhances the growth rate of earthworm but also contribute to efficient waste management by converting organic waste into nutrient-rich vermicompost.

Keywords: Banana peel, Buffalo dung, Cow dung, *Eutyphoeus waltoni*, Goat dung, Growth rate, Kitchen waste.

INTRODUCTION

Chemical fertilizers which are used as a tool for increasing the crop yields can lead to several harmful effects on soil health, environmental quality and human health. These problems include soil degradation, nutrient imbalances, water pollution, and adverse impacts on biodiversity. Continuous application of chemical fertilizers can degrade soil structure and reduce microbial activity, leading to soil compaction, erosion and loss of organic matter (Lal, 2003). Vermicompost, derived from earthworm-mediated decomposition of organic matter offers a sustainable alternative to chemical fertilizers, addressing these issues while promoting soil fertility by enhancing its physical, chemical and biological properties as well as ecosystem resilience and human well being (Singh *et al*., 2021; Siddiqui *et al*., 2022; Singh *et al*., 2022). The use of organic waste for vermiculture is an emerging area of sustainable agriculture, aimed at producing nutrient-rich compost while managing waste. Vermicomposting is an environmentally friendly and effective technique for transforming organic waste into nutrient-dense compost, offering a sustainable approach to waste management and improving soil fertility (Bhat *et al*., 2018; Siddiqui *et al*., 2022). This method involves the use of earthworms to break down organic matter, resulting in vermicompost that is abundant in essential nutrients like nitrogen, phosphorus, and potassium along with beneficial microorganisms that boost soil health (Tiwari and Yadav, 2023; Edwards and Bohlen, 1996; Singh and Singh, 2023 a,b,c). Earthworms, often termed "ecosystem engineers," play a vital role in this process by converting organic waste into vermicompost, a highly valuable organic fertilizer. A critical factor influencing the efficiency of vermicomposting is the type and combination of feed material provided to the earthworms. Organic waste, which includes agricultural residues, kitchen scraps, yard waste, and animal manure, constitutes a significant portion of the global waste stream. Proper management of organic wastes is crucial for

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reducing landfill use, minimizing greenhouse gas emissions, and creating valuable resources through recycling processes. With the increasing emphasis on sustainable waste management practices, the recycling of organic waste through vermicomposting has gained considerable attention (Bouhia *et al*., 2023; Naseem *et al*., 2023). Household kitchen waste is a major source of organic waste, with a large amount produced every year in India (Mohite *et al*., 2024). These kitchen wastes can have negative effects on health and the environment if not properly decomposed (Kaviraj and Sharma, 2003). Every household creates a lot of food scraps in the kitchen. Throwing these scraps in the trash can lead to bad smells and increase the amount of waste in landfills. Although using a garbage disposal is easy, it puts extra pressure on waste treatment systems and discards the potentially valuable resource that could be useful (Chavan *et al*., 2017). India produces million tonnes of agricultural waste each year, with vegetable waste representing a significant portion (Suthar *et al*., 2005). The disposal of vegetable scraps from markets into municipal landfills presents environmental challenges due to their high biodegradability (Bouallagui *et al*., 2004). Vegetable waste is particularly suited for vermicomposting because it is fully organic and decomposes more readily compared to other waste types. Bananas, which rank as the second-largest fruit crop globally after citrus fruits, constitute about 16% of global fruit production. Bananas are highly nutritious, rich in potassium and calcium (Mohapatra *et al*., 2010; Siddiqui and Singh, 2023a). Animal manure, a valuable substrate in vermicomposting, is rich in nutrients and organic matter, promoting earthworm growth and activity. Animal manures comprises of many necessary nutrients needed by crops such as nitrogen, phosphorus, and potassium. These manures provide a balanced source of carbon and nitrogen, essential for the growth and activity of earthworms and microorganisms involved in decomposition. It is an abundant and renewable resource, making it a cost-effective choice for compost production (Kale *et al*., 1992). Studies indicate that cattle dung can be used alone or mixed with other organic materials as a bulking agent to produce vermicompost that is both stable and nutrient-dense (Yadav *et al*., 2013; Yuvraj *et al*., 2020; Singh and Singh, 2024; Kinigopoulou *et al*., 2023). Animal dung typically contains high level of nitrogen content (Kale *et al*., 1992), which is essential for protein synthesis and critical for earthworm growth, reproduction, and enzyme production. This nitrogen content boosts microbial activity, facilitating the decomposition of organic matter in vermicomposting. Additionally, kitchen waste, which is rich in organic matter, provides a crucial carbon source, maintaining a balanced carbon-to-nitrogen (C/N) ratio in the compost substrate (Suthar, 2009). Vermicomposting of kitchen wastes with other organic materials, demonstrated improvements in compost quality and nutrient content in a recent study (Yadav and Garg, 2019). The combination of these materials creates a nutrient-rich environment that supports optimal earthworm growth and accelerates its development. *Eutyphoeus waltoni* is commonly found across India, inhabiting various environments including forests, agricultural lands, plant nurseries, gardens, manure heaps, and cultivated fields (Singh *et al*., 2015). This species, known for its anecic behavior, is particularly well-suited for processing organic waste from diverse sources such as canteens, homes, towns, and farms (Gergs *et al*., 2022; Singh and Singh, 2024). Anecic species have been shown not only to produce vermicompost efficiently but also to generate more offspring during six-month trials (Gajalakshmi *et al*., 2000). However, there is limited research on using *Eutyphoeus waltoni* with specific combinations of organic waste, especially involving mixtures of animal dung and kitchen waste. This study aims to improve the growth rate of *Eutyphoeus waltoni* by using the specific combinations of animal dung with kitchen wastes, which is beneficial for enhancing the conversion of organic waste into high-quality vermicompost.

MATERIALS AND METHODS

Collection and rearing of the earthworm *Eutyphoeus waltoni*

The cultured earthworm *Eutyphoeus waltoni* from the Vermibiotechnology Laboratory, Department of Zoology, Deen Dayal Upadhyaya, Gorakhpur University, Gorakhpur were used for the experiment. For this, vermibed were prepared by using garden litter with cow dung on a cemented surface in the laboratory. Young cultured earthworms were used for the experiment.

Collection of animal dung and kitchen wastes

Animal dung was collected from the local farm houses and vegetable wastes (VW) as well as banana peels (BP) were procured from the local area of the Gorakhpur district. Buffalo dung (BD), Cow dung (CD) and Goat dung (GD) were spread in a layer and exposed to sunlight for 20 days to remove various harmful organisms and noxious gases. After pre treatment these biological wastes were used in the experiment as feed material in vermicomposting (Garg *et al*., 2005).

Experimental setup

The experiment was conducted on cemented surface. Two kilograms (Kg) of each five different combinations of buffalo dung i.e. BD+VW (1:1), BD+VW (2:1), BD+BP (1:1), BD+BP (2:1), BD+VW+BP (1:1:1) and BD alone; Cow dung i.e. CD+VW (1:1), CD+VW (2:1), CD+BP (1:1), CD+BP (2:1), CD+VW+BP (1:1:1) and CD alone as well as goat dung i.e. GD+VW (1:1), GD+VW (2:1), GD+BP (1:1), GD+BP (2:1), GD+VW+BP (1:1:1) and GD alone were prepared in beds of (30 x 30 x10 cm^3) at room temperature (27±2 ^{0}C) in the dark. The experiment to study the growth and development of earthworm *Eutyphoeus waltoni* was performed by the method of (Garg and Kaushik 2005). The vermicomposting beds were turned over manually every 24 hours for 2 weeks in order to eliminate volatile substances. Thereafter 20 young *Eutyphoeus waltoni* were inoculated into each bed. In order to provide optimal environmental conditions for earthworms, the moisture of all the treatments were maintained at 60-70% by sprinkling water during the experiment. Each experiment was replicated six times.

Growth rate of the earthworm *Eutyphoeus waltoni*

Every week, cocoons were collected using a 0.5 mm mesh sieve and gently washed, and their numbers were recorded on an individual basis. Before weighing, the cocoons were lightly washed in distilled water to eliminate any debris stuck to the sticky hull. The culture sets were carefully observed daily for cocoons, if any. The cocoons were immediately isolated and incubated. In the experiment old cultural media was replaced with the same amount of fresh media on a weekly basis, thus food was not a limiting factor. After isolation, each cocoon was freshly put in a petri dish containing moist filtered paper at 30±2 ^{0}C and 70±5% RH. The growth rate (GR) was calculated for complementary growth measure, for each 15-day growth interval. Their values are obtained by calculating the change in individual's growth during an infinitely short time interval. The growth rate was calculated as, GR= $(W_f - W_i)/\Delta t$, where, W_i= initial earthworm mass (mg), W_f= final earthworm mass (mg), respectively, and Δt=time interval measured in days. Biomass gained was recorded after 15 days interval up to 90 days in each bed.

Statistical Analysis

All the experiments were replicated six times to ensure consistency in the results and figure out the mean with standard error. Analysis of variance was used to analyze the significant difference between the combinations and *t* test (P< 0.05) used to identify the homogeneous type of bedding in terms of reproduction and growth compared to the control (Sokal and Rohlf, 1973).

RESULTS AND DISCUSSION

The result deals with the growth rate of *Eutyphoeus waltoni* in binary and tertiary combination of different animal dung with vegetable waste and banana peels during vermicomposting. Different combinations of animal dung with vegetable waste and banana peels have their influence on the growth rate of *Eutyphoeus waltoni*. The significant higher growth rate (9.19±0.55 mg/worm/day) was observed in the binary combination of buffalo dung and vegetable waste in (1:1) ratio with respect to dung alone (7.15±0.24 mg/worm/day) (Table1; Figure 1, 4). The tertiary combination of buffalo dung with banana peel and vegetable waste has less growth (6.80±0.41 mg/worm/day) than the dung alone (7.15±0.24 mg/worm/day) (Table 1; Figure 1, 4). The significant higher growth rate (8.94±0.28 mg/worm/day) of *Eutyphoeus waltoni* was observed in the binary combination of cow dung and vegetable waste in (1:1) ratio with respect to the dung alone (6.77±0.45 mg/worm/day) (Table 2; Figure 2, 5). The growth rate in the tertiary combination of cow dung, vegetable waste and banana peel was less (6.23±0.44 mg/worm/day) than the dung alone (6.77±0.45 mg/worm/day) (Table 2, Figure 2, 5). The significant higher growth rate (7.55±0.40 mg/worm/day) was observed in the binary combination of goat dung and banana peel (2:1) ratio with respect to the dung alone (5.81±0.28 mg/worm/day) (Table 3; Figure 3, 6). The growth rate in the tertiary combination of goat dung, vegetable waste and banana peel was less (5.51±0.28 mg/worm/day) than the dung alone (5.81±0.28 mg/worm/day) (Table 3; Figure 3, 6). The significant earlier growth rate of earthworm *Eutyphoeus waltoni* was observed in combination of feed material of animal dung (buffalo, cow, goat) mixed with vegetable wastes and banana peels in comparison of the animal dung alone as a feed material (Figure 4-6).

Table 1. Effect of different combinations of buffalo dung with kitchen wastes on the growth rate of *Eutyphoeus waltoni.*

Combination	Initial weight (mg)	Max. weight (mg)	Net weight (mg)	Growth rate (mg/worm/day)
BD	218.03 ± 2.42	863.34 ± 5.34d	644.02 ± 7.3c	7.15 ± 0.24
BD + VW (1:1)	252.04 ± 7.49	1075.64 ± 12.1a	823.39 ±10.09a	9.19 ± 0.55
BD + VW (2:1)	242.51 ± 6.13	898.70 ± 6.70c	656.07 ± 7.9c	7.29 ± 0.61
BD + BP (1:1)	237.10 ± 5.89	1042.57 ± 2.58b	805.50 ± 4.9a	8.92 ± 0.36
BD + BP (2:1)	248.12 ± 5.01	1026.32 ± 6.12b	778.50 ± 6.42b	8.65 ± 0.25
BD + BP + VW (1:1:1)	243.03 ± 5.46	855.60 ± 6.64d	612.00 ± 7.57d	6.80± 0.41

Each value is the mean ± SE of six replicates. BD=Buffalo dung, BP= Banana Peel, VW= Vegetable Waste

*Mean differences in column followed by common letter are not significant at P<0.05 (DMRT) in 30.0 x 30.0 x10 cm^3area of vermicompost bed.

Table 2. Effect of different combinations of cow dung with kitchen waste on the growth rate of *Eutyphoeus waltoni.*

Combination	Initial weight (mg)	Max. weight (mg)	Net weight (mg)	Growth rate (mg/worm/day)
CD	222.23 ± 3.34	831.65 ± 15.98d	609.30 ± 9.17d	6.77 ± 0.45
CD + VW (1:1)	258.66 ± 10.50	1063.28 ± 5.68a	804.60 ±15.8a	8.94 ± 0.28
CD + VW (2:1)	226.61 ± 3.53	883.58 ± 8.8c	656.10 ± 8.31c	7.28 ± 0.47
CD + BP (1:1)	243.22 ± 2.61	982.03 ± 8.04b	738.81 ± 6.07b	8.21 ± 0.33
CD + BP (2:1)	237.40 ± 3.38	913.31 ± 9.13c	675.90 ±3.83c	7.51 ± 0.53
CD+BP+VW (1:1:1)	217.61 ± 3.27	778.32 ± 16.68d	560.70 ±5.20e	6.23 ± 0.44

Each value is the mean ± SE of six replicates. CD= Cow Dung, BP= Banana Peel, VW= Vegetable Waste

*Mean differences in column followed by common letter are not significant at P<0.05 (DMRT) in 30.0 x 30.0 x10 cm^3area of vermicompost bed.

Table 3. Effect of different combinations of goat dung with kitchen waste on the growth rate of *Eutyphoeus waltoni.*

Combination	Initial weight (mg)	Max. weight (mg)	Net weight (mg)	Growth rate (mg/worm/day)
GD	234.50 ± 5.78	756.77 ± 5.24d	522.27 ± 9.97c	5.81 ± 0.28
GD + VW(1:1)	247.03 ± 7.16	793.98 ± 4.73c	546.95 ± 8.42c	6.07 ± 0.46
GD + VW(2:1)	251.87 ± 6.76	821.18 ± 10.31c	569.31 ± 11.39c	6.33 ± 0.32
GD + BP(1:1)	240.07 ± 6.79	876.28 ± 6.69b	636.21 ± 7.81b	7.07 ± 0.41
GD + BP(2:1)	263.83 ± 5.06	940.48 ± 7.97a	676.65 ± 9.39a	7.55 ± 0.40
GD + BP+VW (1:1:1)	227.15 ± 3.48	723.78 ± 4.86e	496.63 ± 7.60c	5.51 ± 0.28

Each value is the mean ± SE of six replicates. GD= Goat Dung, BP= Banana Peel, VW= Vegetable Waste

*Mean differences in column followed by common letter are not significant at P<0.05 (DMRT) in 30.0 x 30.0 x 10 cm^3area of vermicompost bed.

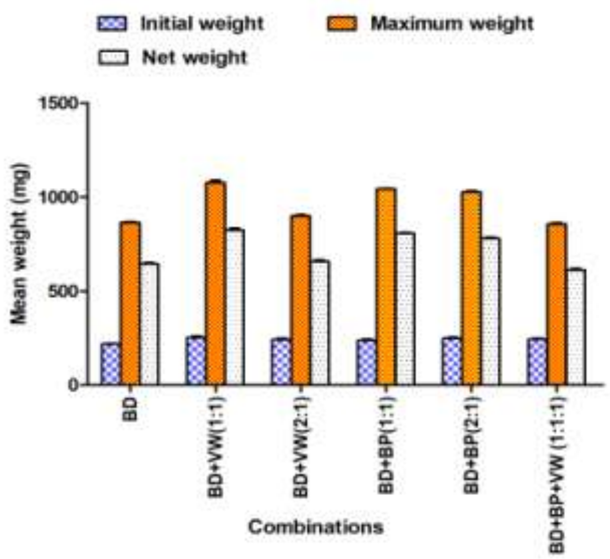

Figure 1. Effect of different combinations of buffalo dung with kitchen wastes on the growth of *Eutyphoeus waltoni*. BD= Buffalo dung, VW= Vegetable waste, BP= Banana peel.

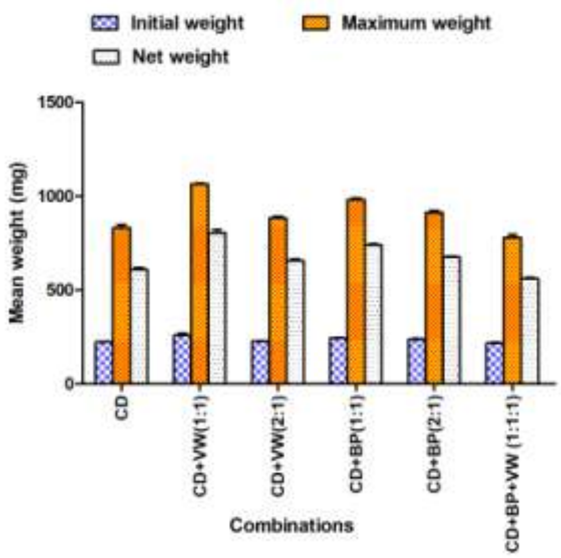

Figure 2. Effect of different combinations of cow dung with kitchen wastes on the growth of *Eutyphoeus waltoni*. CD= Cow dung, VW= Vegetable waste, BP= Banana peel.

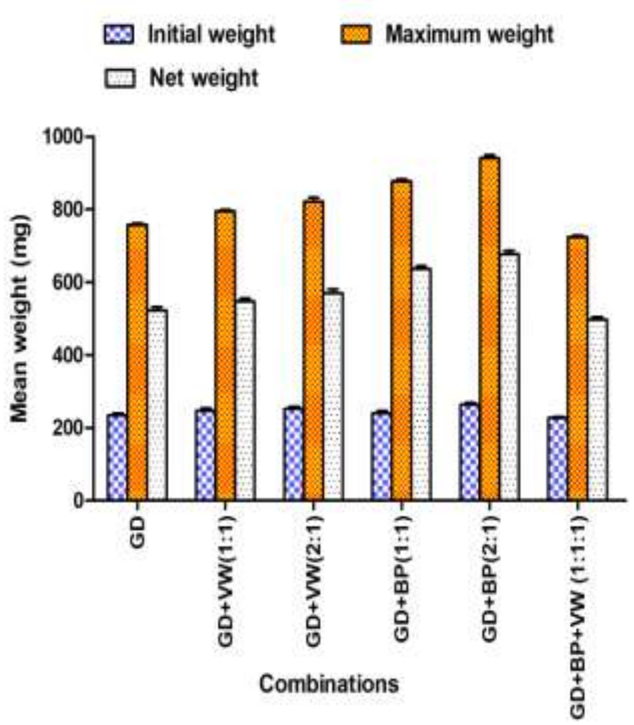

Figure 3. Effect of different combinations of goat dung with kitchen wastes on the growth of *Eutyphoeus waltoni*. GD= Goat dung, VW= Vegetable waste, BP= Banana peel.

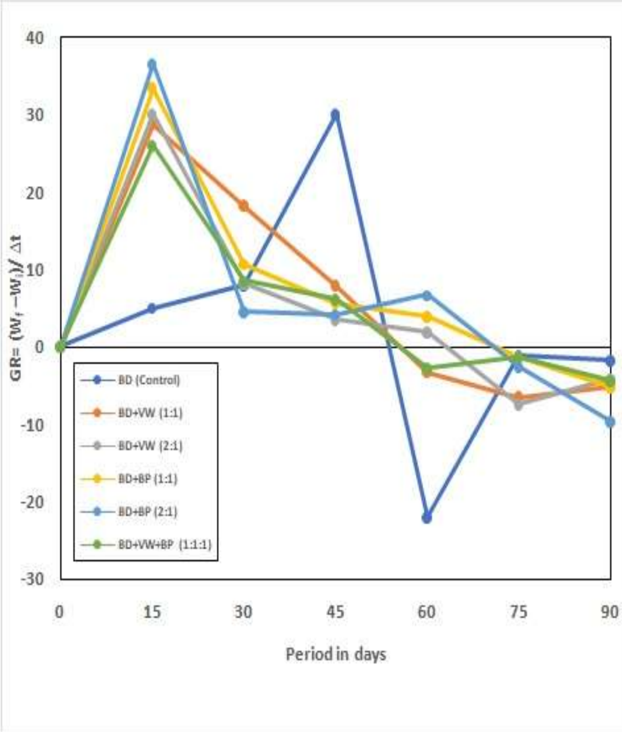

Figure 4. Growth curve of *Eutyphoeus waltoni* in different combinations of buffalo dung with kitchen wastes. GR= Growth rate, BD= Buffalo dung, VW= Vegetable waste, BP= Banana peel.

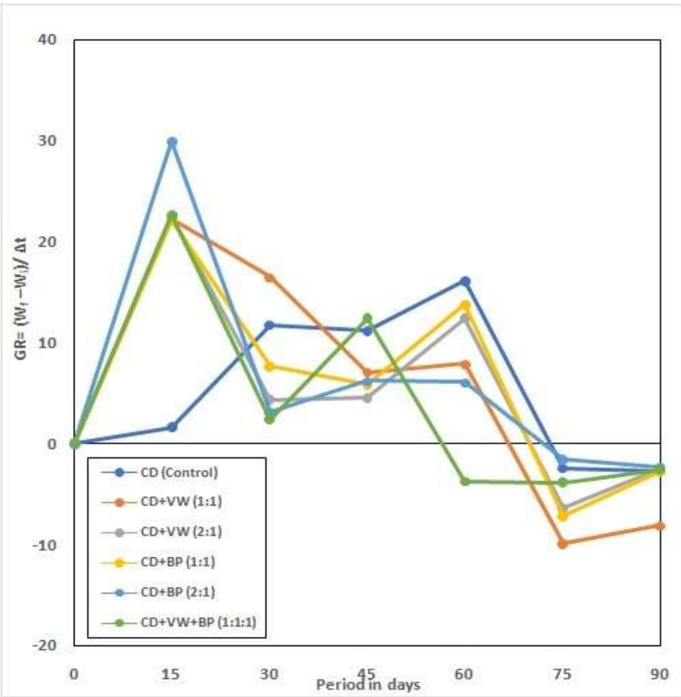

Figure 5. Growth curve of *Eutyphoeus waltoni* in different combinations of cow dung with kitchen wastes. GR= Growth rate, CD= Cow dung, VW= Vegetable waste, BP= Banana peel.

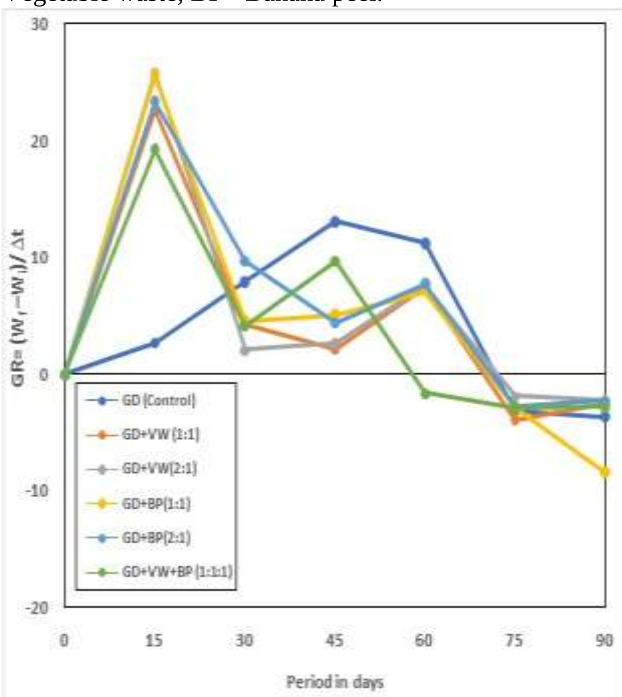

Figure 6. Growth curve of *Eutyphoeus waltoni* in different combinations of goat dung with kitchen wastes. GR= Growth rate, GD= Goat dung, VW= Vegetable waste, BP= Banana peel.

In the present study the significant growth rate of *Eutyphoeus waltoni* in binary and tertiary combination of different animal dung (buffalo, cow, goat) with kitchen wastes (vegetable waste, banana peels) as feed material during vermicomposting was observed which demonstrated that the combinations of animal dung with vegetable waste and banana peel have influenced the growth rate of *Eutyphoeus waltoni*. The binary combination of buffalo dung and vegetable waste present in the ratio of 1:1 obtained maximum growth rate in *Eutyphoeus waltoni* among all the binary and tertiary combinations of buffalo dung with kitchen wastes. Buffalo dung is rich in nutrients and provides a balanced diet with essential nitrogen, phosphorus, and potassium, which are beneficial for the growth of earthworms (Kale and Bano, 1986; Suthar, 2008). It also provides a favourable texture and moisture content that supports vermic activity and reproduction. Vegetable waste, on the other hand, is abundant in organic matter and provides a carbon-rich environment. The combination of buffalo dung and vegetable waste offers an optimal C/N ratio, enhancing the decomposition process and facilitating earthworm growth (Tripathi and Bhardwaj, 2004). Recent research has shown that incorporating vegetable waste into the feed can boost the total number of earthworms, increase their overall weight, and promote better growth (Merta and Raksun, 2024). The moisture-retentive quality of the dung, combined with the fibrous nature of vegetable waste, supports earthworm burrowing and feeding activities, leading to increased biomass production (Singh *et al*., 2010). This mixture also supplies a diverse range of microorganisms, which earthworms can utilize as a food source, further promoting their growth and reproduction.

Different combinations of cow dung with kitchen wastes enhanced the growth rate of *Eutyphoeus waltoni*. The maximum growth of *Eutyphoeus waltoni* was observed in the combination of cow dung with vegetable waste present in the ratio of 1:1 between all the combinations of cow dung and kitchen wastes may be due to high edible nitrogenous substrate in feed material. It is also suggested here that the feeding rate of earthworms is directly related to the food availability (Nath *et al*., 2009) and resources allocated competition among earthworms in vermibeds. The growth rate was significantly higher in binary combination of goat dung and banana peel present in the ratio of 2:1 among all the combinations of goat dung and kitchen wastes. This may be due to high decrease of C/N ratio (Chauhan and Singh, 2012). Degradation of substrate slows down due to higher C/N ratio (Haug, 1993). The potassium from banana peels enhances enzyme activation and growth processes, while phosphorus supports energy transfer and reproductive processes (Arvanitoyannis and Mavromatis, 2009). Cattle dung is a preferred substrate for earthworms which has been successfully used to produce nutrient-rich vermicompost, either alone or in combination with other organic waste materials. A variation in the growth of worm and reproduction was observed in parallel vermicomposting investigations and these variations are dependent on the original feed material (Ananthavalli, 2019; Devi and Khwairakpam, 2020). The nutrient-rich environment, optimal moisture and temperature conditions, enhanced microbial activity in the substrate combination contribute to the successful growth rate in *Eutyphoeus waltoni*. This research underscores the importance of selecting the appropriate feed materials for vermicomposting and suggests that buffalo dung mixed with vegetable waste in (1:1) ratio is best feed material combination for maximizing earthworm growth rate. The results provide valuable insights for sustainable organic waste management practices and the development of efficient vermicomposting systems.

CONCLUSION

The (1:1) ratio of buffalo dung with vegetable waste creates the most favourable conditions for earthworm growth. This mixture provides a balanced nutrient profile that boosts microbial activity and accelerates decomposition. The high nitrogen content in buffalo dung, combined with the rich organic carbon from vegetable waste, creates an optimal environment for *Eutyphoeus waltoni*. Earthworms gained the highest growth rates with this combination. These results suggest that using a (1:1) ratio of buffalo dung and vegetable waste is an effective method for managing organic waste and producing high-quality vermicompost. Additionally, the study highlights the advantages of adding kitchen wastes into vermicomposting systems to improve soil fertility and promote sustainable agricultural practices.

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