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EVALUATION OF MILLICOMPOST AMONG THE TWO DIFFERENT MILLIPEDE SPECIES

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Abstract

Millicomposting is an effective modern technique than vermicomposting which is used to produce unwanted organic waste into wanted useful manure with assistance of millipede species. It is an important approach that is both economical and environmentally friendly. One recently popular organic solid waste management technique is millicomposting. The current study was conducted with the aim of examining the millicomposting process. In this investigation, wastes of vegetable market were processed by two different millipede species, *Trigoniulus corallinus* and *Arthrosphaera magna*. *Trigoniulus corallines* processed millicompost showed rich in macronutrients such as carbon, nitrogen, phosphorus, potassium, calcium, an ideal C/N ratio and the growth efficiency of plant *Abelmoschus esculentus* than millicompost processed by *Arthrosphaera magna*. The current study highlighted that *Trigoniulus corallinus* are more environmentally friendly than other millipede species. It also suggested that millicomposting is a sustainable way to address the pressing issue of solid waste.

Keywords: Millicomposting, millipede, *Arthrosphaera magna*, *Trigoniulus corallines, Abelmoschus esculentus*

Introduction:

According to projections, the amount of municipal solid wastes generated will increase from 2.1 billion tonnes in 2023 to 3.8 billion tonnes by 2050. An estimated USD 252 billion was spent on waste management directly worldwide in 2020. The cost increases to USD 361 billion when the hidden costs of pollution, bad health, and climate change due to improper waste disposal methods are taken into account. If waste management is not addressed immediately, this yearly global cost might nearly treble to an astounding USD 640.3 billion by 2050 (Global Waste Management Outlooks, 2024). However, with the world population predicted to increase to 8 billion by 2025 and 9.3 billion by 2050, with about 70% of them residing in urban areas, cities worldwide will continue to face an overwhelming challenge of solid waste management despite economic growth, improved lifestyles and consumerism (FAOSTAT, 2021; OECD, 2021). Most cities in underdeveloped nations only collect 50–80% of the waste that is created after allocating 20–50% of their budgets, of which 80–95% are allocated to rubbish collection and transportation (Guerrero, 2013; World Bank, 2018). Furthermore, only 10% of the waste produced in suburban areas is collected in many low-income nations, which increases the risk to the environment and public health by increasing the incidence of acute respiratory infections and diarrhea in those who live close to garbage dumps, especially children (UN-Habitat, 2010). Effective municipal solid waste management is hampered by a lack of knowledge, technology, funding, and sound governance (Hettiarachchi, 2018; Abubakar, 2017).

Particularly in metropolitan regions overrun by the rapid rate of population expansion and waste production, solid waste management remains a significant socioeconomic and governance concern. Several worldwide development agendas, charters, and visions place a strong emphasis on the role that solid waste management plays in attaining sustainable development. Even though, several methods to dispose the solid waste, biocomposting is an effective and environmentally friendly methods to convert waste in to manure. Biocomposting is an environmentally sound technology (EST), according to the United Nations Environmental Program (UNEP). EST reduces pollution, uses resources sustainably, recycles garbage, and treats waste in an environmentally responsible manner (Sharma and Agarwal, 2004). Unfavorable waste disposal is transformed into commercially valuable manure through the biocomposting process. Additionally, biocomposting enhances the soil aeration, structure, and texture while also increasing its capacity to hold water. According to Appelhop and Garbage (2003), biocompost provided organic matter provides microorganisms with nutrition, keeps soil healthy, and organically produces nitrogen, potassium, and phosphorus.

Natural waste is frequently unsuitable for direct use due to phytotoxicity, nitrogen immobilization, excessive salinity, and fundamental inconsistency. By composting the organic waste, either vermicomposting or millicomposting, these drawbacks can be avoided. Vermicomposting is a popular method that uses earthworms to turn organic waste into beneficial manure. Earthworms are essential to vermicomposting because they break down partially eaten organic materials into usable components. Because earthworms lack the mouth parts necessary to shatter organic waste, they can only eat partially digested material. In contrast, millipedes have developed mouth features that allow them to break down organic waste. As a result, millipedes rely directly on organic waste as food. According to taxonomy, millipedes are Arthropods, which descended from annelids and have more traits than earthworms, while earthworms are classified as Annelids.

The term "millicomposting," which uses millipedes to turn organic waste into beneficial manure, was first used in the recent few decades by Alagesan and Ramanathan (2012). When compared to more conventional methods such as landfilling, burning, producing biogas, and so on, millicomposting is the most sensible way to convert natural waste materials because it is an environmentally beneficial process that does not involve adulteration. According to Kania and Klapec (2012), millipedes are essential soil arthropod and, in certain ecosystems, they have a more substantial role as agents of soil and nutrient turnover than earthworms. According to Martens *et al*., (2002) both millipedes and earthworms use manure as a food source and have been shown to be significant components of the detritus food web in the agricultural ecosystem. The millipede *Arthrosphaera magna* effectively composted cocoa and acacia leaves for organic farming, according to Ashwini and Sridhar (2006b), Compost made from millipedes has the potential to significantly contribute to soil enrichment in terms of soil microbiology and nutrition, according to Karthigeyen and Alagesan (2011). Because they convert cellulose to simple sugar, gut microbes are essential to millipede's ability to digest food. Furthermore, it has been revealed that the microorganisms in millipedes' guts promote the breakdown of organic matter and the recycling of trash energy (Alagesan *et al*., 2003).

The biochemical components of soil showed significant enrichment in millipede compost made from different organic waste (Ramanathan and Gnanamani, 2022). Although millipede species are important saprophagous animals, there is currently insufficient information available about using millipedes to produce millicompost. Millipede humus (millicompost), a stable organic compound with a C/N ratio less than 30, is the end product of millicomposting and has the qualities to be used as a substrate. Despite the lack of knowledge in the scientific and rural communities about millicompost, some findings indicate that it produces high-quality seedlings because of its physical and chemical properties that are appropriate for plant development, including fruit trees (dragon fruit) and vegetables (lettuce, arugula) (Antunes *et al*., 2021a; Bugni *et al*., 2021).

Although millipede species are significant macro-arthropods animals, there is currently insufficient information available about using millipedes to produce compost. Thus, the current experiment aims to determine how well millipedes gathered from Sirumalai Hills can turn vegetable waste into beneficial manure and evaluate how plant growth of *Abelmoschus esculentus* is affected by millicompost made from two distinct millipede species.

2. Materials and Methods:

2.1. Collection of Compost Materials:

The source materials for this study were vegetable wastes of radish and cabbage that were gathered from Madurai Mattuthavani vegetable market. They underwent predigestion after being torn into tiny bits and allowed to dry for a week.

2.2. Predigestion of Compost Materials:

In separate plastic troughs, the processed vegetable wastes were combined with an equal amount of fresh cow dung and given water to help them predigest. The predigested contents were composted using millipedes after 45 days.

2.3. Collection and Maintenance of Experimental Animal:

Arthrosphaera magna and *Trigoniulus corallinus*, two adult millipede species, were collected from the Sirumalai Hills reserve forest in Dindigul District. One month before to the commencement of experiment, they were acclimated to the lab environment.

2.4. Preparation of Millibed:

50 individual millipedes of the species *Arthrosphaera magna* and *Trigoniulus corallines* were placed in each of two rectangular culture troughs of identical size (47 x 32 x 16 cm) containing five kilograms of the predigested vegetable waste of cabbage. Similarly, 50 individuals

of the millipede species *Arthrosphaera magna* and *Trigoniulus corallines* were placed into each of the two additional troughs containing the predigested radish waste. For sixty days, the biocomposting procedure was carried out. Water spraying was halted two days prior to harvest. Three duplicates of the composting experiment were carried out. Samples of millicompost were collected for biochemical examination prior to the millipedes being placed in the troughs, namely on the first day and after the twentieth, forty, and sixty days.

2.5. Biochemical Estimations:

The fast titration method developed by Jackson (1973) method of Walkley and Black was used to measure the amount of organic carbon in the compost. Umbreit *et al.,* (1974) used the MicroKjeldhal technique to determine total nitrogen. Vogel's (1963) method was used to estimate phosphorus. The Flame photometer (Elico; Model CL 378) was used to detect the amount of potassium and calcium that was available.

2.6. Designing of Pot Experiment to Assess Quality of Compost:

The effectiveness of various composts on plant development was evaluated through a pot experiment. We bought seeds of *Abelmoschus esculentus* from Tamil Nadu Agriculture College and Research Institute in Madurai. After being surface sterilized with 0.1% mercuric chloride, they were each seeded in a separate earthenware pot (9 cm in diameter). *T. corallines* processed 60 day old millicompost from cabbage and radish waste was placed in the first two pots, whereas *A. magna* processed 60 day old millicompost from cabbage and radish waste was placed in the last two pots. Three duplicates of each compost were kept. Growth metrics, including the plant's height, leaf area and number, and fruit weight and number, were measured after the forty fifth day. The Arnon method (1949) was used to calculate the total chlorophyll content of the leaves.

3. Results:

The nutrient composition data of millicompost from vegetable wastes processed by *T. corallines* and *A. magna* (Table. 1 &2) shows the changes in key nutrient parameters across different stages of composting for two types of vegetable waste: cabbage waste and radish waste. All biochemical components of vegetable wastes handled by millipede species showed a substantial difference from traditional compost at the conclusion of the 20th, 40th, and 60th days of composting.

A significant decrease in organic carbon was noticed in the composts worked with millipede, *T. corallines* and the decrease was comparatively higher than in the compost processed by millipede, *A. magna*. The organic carbon content of the compost produced from cabbage waste processed by *T. corallines* decreased from 40.08 to 35.02% at the end of 60th day of the experiment and it was decreased from 42.00 to 36.80 % at the end of 60th day of the experiment in the compost content produced from the radish waste. The similar trend was observed in the compost produced from cabbage waste processed by *A. magna* decreased from, 42.06 to 38.84 % at the end of 60th day of the experiment and it was decreased from 42.88 to 39.33 % at the end of 60th day of the experiment in the compost content produced from the radish waste. In both millipede processed compost contain significant reduced carbon content in cabbage waste when compare to radish waste. Statistical analysis of correlation showed that a significant negative correlation was obtained between the different days millicompost and the organic carbon of the two different vegetable waste worked with two different millipedes. The nitrogen content was gradually increased from 1.02 to 1.22 % in the compost of cabbage waste processed by millipede, *T. corallines* at the end of 60 days and it was increased from 0.90 to 1.06% in radish waste compost. The similar trend was observed in the nitrogen content (0.94 to 1.08%; 0.91 to 0.98%) of the both waste (cabbage and radish) processed by *A. magna*. Among the two species of millipede and two waste, the millipede *T. corallines* was very efficient species to increase the nitrogen content in the cabbage waste. Statistically significant positive correlation was observed between the duration of composting and the nitrogen content.

At the initial stage, the C/N ratio was maximum and it was found to be decreased with increased the duration of both millipede processed composting. From the data, it is clear that the C/N ratio of cabbage (39.29 to 29.62) and radish waste (43.75 to 39.00) worked with millipede, *T. corallines* had been reduced significantly. The similar trend was observed in the C/N ratio of compost from millipede *A. mangna* in both vegetable waste. Analysis of correlation showed that a significant negative correlation was obtained between the duration of millicomposting processed by two distinct millipede with two different vegetable waste and C/N ratio.The level of phosphorus at the commencement of composting on the initial day was (0.35%) and at the end of 20th, 40th and 60th day, it was 0.46%, 0.48% and 0.51% in the cabbage waste compost processed by *T. corallines* respectively. It was lower in the compost handled in radish waste. At the end of 60th day, the amount of phosphorus increased in compost processed by millipede, *A. magna* in cabbage waste (0.51%) than (0.38%) radish waste. A remarkably high level of phosphorus (0.51%) was noticed in compost worked with *T. corallines*. The relationship between the phosphorus and duration of millicomposting of two vegetables wastes are statistically significant.

With respect to the quantity of potassium and calcium, the minimum was observed in compost from cabbage waste processed by both millipede species, it was increased in the compost from cabbage waste processed by both millipedes. Table 1. (*T. corallines*): Potassium levels also increased during composting, with CW compost rising from 0.62% to 0.88% and RW from 0.61% to 0.82%. Table. 2 (*A. magna*): The increase in potassium was more gradual, with CW rising from

0.62% to 0.76% and RW from 0.61% to 0.68%. Similarly, Table.1. (*T. corallines*) Calcium content fluctuated, with CW initially at 0.88% and decreasing to 1.20%, while RW started at 0.80% and increased to 1.09%. Table.2. (*A. magna*): Calcium showed a more stable increase, with CW increasing from 0.88% to 1.08% and RW from 0.80% to 1.00%. Among the two waste, cabbage is suitable waste for potassium and calcium source than radish waste. Similarly, two distinct millipede species *T. corallines* is an efficient species to increase the both potassium and calcium form the vegetable wastes. A modest correlation and positively significant statistical results were obtained for the potassium and calcium content in the different days of millicompost from the two vegetable wastes. Two way ANOVA indicates the significant variation ($P < 0.05$) in biochemical components of the initial day (0 day), 20th, 40th and 60th day samples of millicompost produces from two distinct vegetable waste processed by two millipede species.

Data related to the effect of vegetable waste composts processed by two different millipede species on the growth parameters of *Abelmoschus esculentus* are presented in Table 3. The results revealed that the plant grown on cabbage waste processed by *T. corallines* showed maximum height (45.22cm), number of leaves (10.58), leaf area (158.73cm2), number of fruits (10.28), fruit weight (17.29 gm) and chlorophyll content (4.19 mg/g fresh wt.) compared to radish waste processed by *T. corallines* (height 38.85 cm; number of leaves 10.53; leaf area 122.30cm^2; number of fruit 8.65; fruit weight 14.28gm and chlorophyll content 23.25 mg/g fresh wt.) (Fig. 1 & 2). Minimum bionomics were observed in *A. esculentus* grown in millicompost processed from *A. magna* in both waste of cabbage (height 42.49 cm; number of leaves 10.76; leaf area 121.86cm2; number of fruit 9.33; fruit weight 15.48 gm and chlorophyll content 3.86 mg/g fresh wt.) and radish (height 36.12 cm; number of leaves 9.49; leaf area 118.32cm2; number of fruit 17.58; fruit weight 12.75 gm and chlorophyll content 3.10mg/g fresh wt.) waste. One way ANOVA indicates the significant variation (P < 0.05) between the millicompost processed by two distinct millipedes and two different vegetable waste on the growth parameters of *A. esculentus*.

Fig 1: Effect of two vegetable wastes composted with by *T. corallines* millipede on the biomics of *Abelmoschus esculentus*

A **B**

A: Cabbage Waste B: Radish Waste

Fig 2: Effect of two vegetable wastes composted with by *A.magna* millipede on the biomics of *Abelmoschus esculentus*

A **B**

A: Cabbage Waste B: Radish Waste

Discussion:

Every step of waste collection, handling, treatment, and disposal results in serious direct and indirect environmental and public health problems, which are frequently linked to a weak or insufficient solid waste management system in the cities of the global south (Menikpura, 2012; Vidanaarachchi *et al*., 2006; Miezah *et al*., 2015; Hoornweg, and Bhada-Tata, 2012; Giusti, 2009). Waste is carelessly dumped on roadways, open areas, and water bodies as a result of poor and insufficient solid waste management in Pakistan (Batool and Chuadhry, 2009; Akmal and Jamil, 2021), India (Ramachandra, 2018), Nepal (Pokhrel and Viraraghavan, 2005), Brazil (de Morais Lima, P.; Paulo, 2018), Kenya (Dianati *et al*., 2021), and other countries have also reported such practices. A biological approach to trash management, composting involves the breakdown of organic waste into simpler forms by naturally existing microbes like fungi and bacteria. Certain macro-fauna are crucial to the decomposition and disintegration of organic matter in terrestrial ecosystems, ultimately contributing to soil enrichment through the addition of minerals (Wolters, 2000). By aerating and thoroughly mixing the litter in the soil, saprophagous invertebrates change the micro-environmental conditions of the litter. Certain earthworm species are used in vermicomposting technology to enhance waste modification, harvest healthy end products, and mix and air litter in the soil.

Vermicomposting is a straightforward biotechnological composting method that uses specific earthworm species to improve waste conversion and yield a superior final product by severely mixing and airing litter in the soil (Maraun and Scheu, 1996). Likewise, millicomposting is a new method that uses millipedes to break down organic waste. Earthworms consume a lot of organic trash and reduce it by 40–60%. Mature millipedes eat organic waste around five times their weight, whereas earthworms typically eat organic waste equal to their body weight and produce cast from roughly half of the trash they consume in a day (Drago *et al*., 2011). Similar results have been observed in species of temperate millipedes (Hopkin and Read, 1992). Throughout the year, diplopods in temperate climates exhibit bimodal activity. There is a decreased activity period during the summer in addition to the spring and fall activity peaks (Stojałowska and Krocionogi, 1996). In certain tropical areas, millipedes are more important than earthworms for soil recycling (Costaneto, 2007). Crushed litter, significant minerals, and a high microbial load are all found in millipede feces (Berg and McClaugherty, 2003). Rich organominerals found in millipede fecal pellets hasten the humification of the litter layer (Loranger *et al*., 2003). It has been determined that millipede feces differ from those of the initial litter in the following ways (Zhang *et al*., 2021): (i) higher quantities of amino acids and carbohydrates; (ii) higher levels of nitrogen; (iii) adequate moisture, whether via pellet compaction or otherwise; (iv) a pH of 6.5; and (v) changes in the physical structure of the pellet in comparison to the parent litter.

There are currently very few published studies on compost made from millipedes. Thus, the current study is an attempt. According to our findings, millicompost had lower levels of carbon and higher levels of nitrogen, phosphorus, potassium, and calcium. The carbon-nitrogen ratio in the fecal pellets is lowered when millipedes break down organic waste. The primary cause of this is the rise in nitrogen compounds accompanied by relative shifts in the quantity of carbon compounds. Numerous researchers have discovered a declining tendency for C and an increasing trend for N, P, K, and Ca (Ramanathan and alagesan, 2012; Kania and Klapec, 2012).

The increased level of nitrogen in the millicompost may be due to the excretory products of the millipede (Alagesan *et al*., 2003) and nitrogen, phosphorous, ash contents were found to be high in millicompost than vermicompost (Webb, 1977). Moreover, nitrogen level also increased may be due to faecal pellets of millipedes and by the microorganisms present in the excretory products. High degree of breakdown and mineralization increase the nitrogen content of soil which may fix atmospheric nitrogen in significant amounts and also act as important source of nitrogen for the growth of plant (Hair *et al*., 2004). According to Means *et al*., (2015), millipede fecal pellets also increased pH, humidity, and bacterial count while lowering carbon and fungal count in comparison to undigested leaf litter. Millipede feces had a lower C/N ratio than the consumed litter, according to David and Gillon (2002). Between eaten leaf litter and feces produced by Glomeris Spp., a decrease in the C/N ratio was observed (Doris *et al*., 2016). According to Sousa Anutnes *et al*., (2016) millicompost raised the amount of nutrients like calcium, phosphorus, potassium, and nitrogen, respectively.

The present study unequivocally demonstrates the effectiveness of *T. corallines* and *A. magana* millipede species in composting waste of vegetables, including cabbage and radish. Additionally, among the two millipede species, *T. corallines* millicompost from processed vegetable waste had a greater potassium and calcium content, a lower carbon content, a higher nitrogen content, and an optimal C/N ratio than millicompost produced from *A. magana*. Significant support for this can be found in the strong correlation between our current work and the study by Senthilkumar, 2018; Autunes *et al*., (2022) which discovered that the activity of the *Trigoniulus corallines* individuals was successful in increasing the digestion and fragmentation of the plant components.

The results of the pot experiment indicate that, in comparison to millicomposts processed by millipede, *Trigoniulus corallines* increased the growth parameters of the vegetable plant *A. esculentus*. than millicompost processed by other millipede, *A. magna*. Autunes *et al*., (2022) recorded that millipede, *Trigoniulus corallines* processed compost from vegetable waste provide sufficient opportunities to examine their efficiency as potting mixtures for lettuce seedlings. From the current study it is evident that the role of millipedes is organic waste degradation has been amply explored and it is suitable for sustainable organic farming as in the millicompost production essential macro and micro nutrients for the growth of plants are generated.

Conclusion:

An alternate and promising strategy to get rid of environmental threats that affect both the environment and human health is the composting method. One encouraging method for getting rid of organic waste is millicomposting. Vegetable waste can be successfully millicompost utilizing millipede species. Significant amounts of plant nutrients were present in the final millicompost, demonstrating the efficacy of producing nutrient-rich, environmentally acceptable manure for agricultural crops. Future studies should also examine the potential for producing millicompost from various waste materials and compost.

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Table.1.1. Nutrient composition (%) of millicompost of vegetable wastes processed by *T. corallines.* Each value represents the mean of (X ± SD) of 5 estimates.

Parameters	Initial (0 day)		20^{th} day		40^{th} day		60^{th} day	
	CW	RW	Compost from CW	compost from RW	Compos from CW	compost from RW	Compos from CW	compost from RW
Organic Carbon	43.24 ± 3.45	44.32 ± 3.54	40.08 ± 3.26	42.00 ±3 3.36	36.84 ± 2.64	37.09 ± 2.59	35.02 ± 2.80	36.80 ± 2.94
Nitrogen	0.88 ± 0.06	0.90 ± 0.06	1.02 ± 0.08	0.96 ± 0.08	1.08 ± 0.08	1.01 ± 0.08	1.22 ± 0.09	1.06 ± 0.08
Phosphorus	0.35 ± 0.02	0.31 ± 0.02	0.46 ± 0.03	0.32 ± 0.02	0.48 ± 0.03	0.34 ± 0.02	0.51 ± 0.04	0.38 ± 0.03
Potassium	0.62 ± 0.04	0.61 ± 0.04	0.72 ± 0.05	0.69 ± 0.04	0.79 ± 0.05	0.76 ± 0.06	0.88 ± 0.07	0.82 ± 0.06
Calcium	0.88 ± 0.07	0.80 ± 0.06	0.99 ± 0.06	0.84 ± 0.05	0.16 ± 0.01	0.97 ± 0.06	1.20 ± 0.09	1.09 ± 0.08
C / N Ratio	49.13 ± 3.43	49.24 ± 3.93	39.29 ± 3.53	43.75 ± 3.93	33.33 ± 2.99	36.72 ± 3.30	29.62 ± 2.36	39.00 ± 3.51

CW: Cabbage Waste, RW: Radish Waste

Table.1.2. Nutrient composition (%) of millicompost of vegetable wastes processed by *A. magna.* Each value represents the mean of (X ± SD) of 5 estimates.

Parameters	Initial (0 day)		20^{th} day		40^{th} day		60^{th} day	
	CW	RW	Compost from CW	compost from RW	Compos from CW	compost from RW	Compos from CW	compost from RW
Organic Carbon	43.24 ± 3.89	44.32 ± 3.98	42.06 ± 3.78	42.88 ± 3.43	41.33 ± 3.30	42.02 ± 3.78	38.84 ± 3.49	39.33 ± 3.53
Nitrogen	0.88 ± 0.07	0.90 ± 0.07	0.94 ± 0.05	0.91 ± 0.07	0.99 ± 0.07	0.93 ± 0.06	1.08 ± 0.08	0.98 ± 0.06
Phosphorus	0.35 ± 0.02	0.31 ± 0.02	0.36 ± 0.02	0.35 ± 0.22	0.38 ± 0.03	0.36 ± 0.02	0.48 ± 0.03	0.42 ± 0.03
Potassium	0.62 ± 0.04	0.61 ± 0.04	0.63 ± 0.05	0.62 ± 0.04	0.69 ± 0.05	0.64 ± 0.05	0.76 ± 0.06	0.68 ± 0.05
Calcium	0.88 ± 0.07	0.80 ± 0.06	0.94 ± 0.07	0.90 ± 0.07	0.98 ± 0.07	0.93 ± 0.07	1.08 ± 0.08	1.00 ± 0.08
C / N Ratio	49.13 ± 3.93	49.24 ± 3.93	42.06 ± 3.36	47.12 ± 3.12	41.74 ± 3.33	45.02 ± 3.60	35.96 ± 2.87	40.13 ± 3.21

CW: Cabbage Waste, RW: Radish Waste

Table 3. Effect of two vegetable wastes composted with two different millipedes on the biomics of *Abelmoschus esculentus*. Each value represents as mean (X ± SD) of 5estimates

Parameters	Millipede species			
	T. corallines		*A. magna*	
	CW	RW	CW	RW
Height of the plant (cm)	45.22 ± 3.66	38.85 ± 3.10	42.49 ± 3.39	36.12 ± 2.88
No. of leaves	12.58 ± 1.00	10.53 ± 0.08	10.76 ± 0.08	9.49 ± 0.07
Leaf area (cm^2)	158.73 ± 12.69	122.30 ± 9.78	121.86 ± 9.74	118.32 ± 9.46
No. of fruit	10.28 ± 0.08	8.65 ± 0.06	9.33 ± 0.07	7.58 ± 0.60
Fruit weight (gm)	17.29 ± 1.38	14.28 ± 1.14	15.48 ± 1.22	12.75 ± 1.02
Chlorophyll (mg/g fresh. wt)	4.19 ± 0.33	3.25 ± 0.26	3.86 ± 0.30	3.10 ± 0.24

CW: Cabbage Waste, RW: Radish Waste