



THE ROLE OF ORGANIC FERTILIZER PREPARED FROM PLANT AND ANIMAL RESIDUES AT THE COLLEGE OF EDUCATION FOR PURE SCIENCES / UNIVERSITY OF DIYALA AND THE STUDY OF ITS EFFECT ON THE GERMINATION AND MORPHOLOGICAL CHARACTERISTICS OF SWISS CHARD (*BETA VULGARIS* L)

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Abstract. A study was carried out to demonstrate how the college of education for Pure Sciences of the University of Diyala converts its organic food waste and plant waste into organic compost and what the effects are of the use of this compost in different concentrations (0%, 25%, 50%, 75% and 100%) on the germination and the growth of Swiss chard (*Beta vulgaris* L). The compost was prepared by combining fresh green residues, cattle manure, and dry brown materials at a ratio of 3:1:1, respectively. The mixture was stored in a sealed container and subjected to periodic turning over a three-month decomposition period. Subsequent chemical analysis of the resulting compost confirmed its considerable richness in both macro- and micronutrients essential for plant development. We began cultivating Swiss chard seedlings in plastic pots, using a completely randomized block design with three distinct treatment categories. First, a control soil lacking any compost was used. The second treatment involved mixing 50 g compost per 5 kg of soil. The third treatment used 200 g of compost per 5 kg of soil. There were four replicates for each category. The trial has demonstrated that the 200 g rate showed a statistical significant advantage in all studied indicators of vegetative growth and biomass production, where the area of leaves rose to 74.62 cm² and the fresh weight of roots was measured as 19 g. Both indicators improved 530% and 850%, respectively, Compared to the control treatment. The germination percentage wasn't statistically influenced among all trials. Using compost at the rate of 200 g per 5 kg of soil favors growing the Swiss chard according to the study. The application rate of this type of fertilizer led to high productivity. Moreover, the use of organic compost derived from university waste as organic matter significantly improves yield and provides an alternative to chemical fertilizers.

Keywords: Organic fertilizer, Organic waste, *Beta vulgaris* L., Vegetative growth.

1. Introduction

University environments are considered to be expensive resources with a high consumption of food and plant waste producing a significant amount of waste, which is seen as a load in the environment and a lack of natural resource utilization. The majority of this waste is created from food meals eaten by students and staff members in campus cafeterias, as well as residues of plant refuse that are generated by pruning trees and the natural falling of leaves in campus gardens. These items build up, but are thrown away without any sort of formalized waste management plan. Ineffective disposal not only embodies the waste of potentially precious organic matter that may improve the soil fertility and agricultural productivity, but also loses potential use in processing feed and natural organic fertiliser industries, as a replacement to the use of chemical fertilizers. In addition, such a poor handling undermines larger environmental protection purposes. Fruit and vegetable waste fractions are very rich in long-chain polyunsaturated fatty acids, vitamins, peptides and carotenoids, but failing to recycle them is a significant wastage of food (Georganas et al., 2020). Therefore, efficient management of biodegradable agricultural and food organic waste, i.e., converting biodegradable agricultural and food organic waste into organic compost by aerobic and anaerobic biological decomposition and anaerobic fermentation at enclosed (a building-remote) site, is essential. Such solutions are far better than traditional methods of disposal outside campus (landfilling, dump, incineration). The latter need extensive plots of land and, without sound planning, have effectively converted desert landscapes into open waste dumping areas, negatively impacting the aesthetics of natural environments, which leads to air and environmental pollution, and presents serious psychological and public health risks (Laso et al., 2024). *Conocarpus* sp. and *Dodonaea viscosa* L. are endemic in large areas of the world, and in Iraq, for example, with their use among parks, sports centres, university campuses, and commonplaces. Because of their outstanding resistance to drought, soil salinity and higher temperatures, these are found in afforestation plants, and also in landscaping plants and areas whose sites are reclaimed. Easily to prune, and moldable into a variety of aesthetic shapes, they are more pleasing enough to the eye and also act as an environmental signal to maintain a good structure and balanced canopy to produce a more elegant and visually pleasing look (Rehman et al., 2019). But regular trimming and seasonal leaves fall produce large amounts of branches and green foliage, which are meaningful sources of nitrogen, phosphorus, and other useful nutrients. They are currently being burned or dumped away in the wilderness, where they contribute to the propagation of disease vectors, rodents, and insect infestations (Navarro-Pedreño et al., 2023). Research has consistently demonstrated that the organic residues of these tree species possess a nutrient-rich composition that renders them promising raw materials for the production of compound organic fertilizers, particularly when combined with animal manure to yield a nutritionally balanced amendment rich in both macro- and micronutrients essential for plant growth (Drózdź et al., 2023). Animal manure is not only an abundant but also a cheap and readily accessible organic source with a wide range of microorganisms known to solubilize phosphate (including *Bacillus* and *Pseudomonas* species) (Hashim et al., 2022). In addition to its various biochar composition, animal manure naturally contains nutrients like nitrogen, phosphorus and potassium to a wide range of trace elements, which is the basis for using as an amendment to plant-derived residues in compound organic fertilizer composition. It hosts helpful microorganisms that actively stimulate biological decomposition and improve bioavailability of soil nutrients (Drózdź et al., 2023). Thus integrated use of both plant and animal waste

is regarded as one of the most powerful processes in creating ecological sustainable agricultural production system (Drózdź et al., 2023). Swiss chard (*Beta vulgaris* L.), being from the family Chenopodiaceae, is also the most widely grown green leafy vegetables in Iraq and one of the most produced in the world. From this composition is derived the nutritional value of the plant in that the plant has an astonishingly diverse flora, represented including upwards of 192 known chemical compounds in 23 categories, including lipids, flavonoids, phenolics, terpenes and their derivatives, carbohydrates and minerals as well as sugars (with a rich mineral status). The leaf section of the leaves is also among the highest with dietary fiber, magnesium and vitamins (especially vitamin C), whereas the petioles possess a high potassium content. These characteristics give specific medical, economic, and nutritional significance as the crop plays an important medical, economic, and nutritional role as a component of many traditional foods and ingredients, e.g., the prominent preparation of dolma, that would have been native to Iraqi food. And indeed, seed germination is one of the most critical and sensitive phases in plant life cycle, as it decides about the ability of a seed to grow to become a germinating seedling. Morphological plant features (e.g., plant height, leaf amount, leaf area, and petiole length) provide a direct and unbiased estimate of the plant's potential response to an array of fertilisation treatments (Finch-Savage & Leubner-Metzger, 2006). It is thus necessary to adopt contemporary agronomic practices that are capable of improving leaf yield and quality, and also of reducing the environment pollution (Gamba et al., 2021). Hence, this study was performed to explore the possibility of environmental saving with respect to the repurposed of agricultural and plant waste materials and to minimize rates of environmental pollution through transforming waste and organic fertilizers into valuable long-term soil-benefiting fertilizers. Such transformation fosters the development of a range of soil microbial cultures, increase the soil biodiversity and reduction in use of chemical fertilizers like urea, promoting clean agriculture promotion, environmental pollution avoidance, increase of soil structure by means of nutrient enrichment through natural soil nutrients, crop yield enhancement, and sustainability to environment (Vezzani et al., 2022). More specifically, the study aimed to generate a compound organic fertilizer made from the pruning residues of *Conocarpus* and *Dodonaea* trees distributed as organic fertilizer seeds in its home-grown form in the campus grounds of College of Education for Pure Sciences, University of Diyala, the product of the college will also be combined with animal manure, the effects of different rates of application to germination rates on germination percentage, morphological characteristics of Swiss chard (*Beta vulgaris* L.), as a leafy crop of outstanding nutritional significance (medical and economical significance) was investigated — with an objective to optimize the environmental resource of the college and a more sustainable agriculture principle (Grzanka et al., 2024).

2. Materials and Methods

2.1. Experimental Site

The experiment was conducted at the nursery of the Department of Life Sciences, College of Education for Pure Sciences, University of Diyala, over a three-month period commencing on November 18, 2024.

2.2. Collection and Preparation of Raw Materials

The raw materials for the experiment were sourced from various locations within the university campus. Nitrogen-rich green waste, consisting of potato and cucumber peels along with lettuce leaves, was collected from the college cafeteria. Carbon-rich materials included green foliage and dry brown matter obtained after pruning *Conocarpus* and *Dodonea* trees in the college garden, as well as naturally fallen leaf litter. Additionally, cow manure was procured from the College of Veterinary Medicine. The experimental mixture was formulated at a ratio of 1:1:3 (green waste: cow manure: brown waste) in appropriate containers as illustrated in Figure (1)



Figure 1: Illustrates the preparation phase of the composting process at the college nursery; (a) the prepared composting bins, (b) manual mixing steps of organic materials according to the specified ratios.

2.3. Compost Preparation

Following the collection of the aforementioned materials, 1 kg of green waste, 1 kg of cow manure, and 3 kg of dry brown waste were weighed using a standard scale, as shown in Table 1.

Table (1): Raw materials used in compost preparation.

No.	Compost Components	Quantities in kilograms
1	Fresh waste	1 kilogram
2	Cow manure	1 kilogram
3	Dry waste (Brown leaves of <i>Conocarpus</i> and <i>Dodonea</i>)	3 kilograms

The measured quantities were then placed in an opaque, sealed container for two weeks to undergo anaerobic fermentation by microorganisms. This initial phase aimed to break down the mixture into simpler compounds while preventing putrefaction. The first turning of the compost was performed after 14 days of fermentation. This aeration process was repeated at 7 to 14-day intervals over a three-month period to enhance oxygen availability and ensure complete decomposition of the organic matter. Upon completion, the final product was

crushed to remove large impurities and sieved to obtain a fine, homogeneous organic fertilizer resembling commercial compost, ready for agricultural use. These steps are visually illustrated in Figure 2, which displays the fermentation container, the sieving process to remove large impurities, and the final dark organic fertilizer product.

Figure (2): Stages of organic fertilizer preparation



2.4. Chemical analysis

A pot experiment with chard seeds (*Beta vulgaris* var. *cicla*) sold at the local market, in sandy loam soil taken from the college nursery (yellowish in colour indicating nutrient deficiency). 12 plastic pots (5 kg capacity, 20 cm diameter, 18 cm height) were developed as a Randomized Complete Block Design (RCBD) in four replications, eight seeds per pot were planted followed by thinning to 4 plants per pot. The experiment consisted of three treatments: T1 (Control): seeds planted in unamended soil at a depth of 4 cm, T2: seeds with 200 g of organic fertilizer mixture in 5 kg of soil at a depth of 4 cm, and T3: seeds planted with 50 g of organic fertilizer mixture in 5 kg soil at a depth of 1 cm. The pots were all watered evenly during the entire experiment. Seeds were planted 26/2/2025, and germination percentage and germination speed were measured 2 weeks after planting based on Maguire (1962). At manual harvest, 40 days after sowing, the following attributes were recorded: height of plants (cm), number of leaves per plant, flag leaf area (cm²), radicle length (cm), length of plumules (cm), fresh weight (g), dry weight (g) and vegetative dry weight (g). The organic fertilizer chemical analysis was performed in solid and liquid samples to investigate the organic matter (O.M.) content, as well as mineral elements (Ca, Mg, Fe, Zn, Cu and Mn) by the Atomic Absorption Spectrophotometer (AAS) (Rezaei Kahkha et al., 2022; Latimer, 2023), in addition to the pH and electrical conductivity (EC) measured with pH meter and EC meter, respectively (Mylavarapu & Kennelley, 2020).

2.5. Statistical analysis

The data were statistically analyzed using the IBM Statistical Package for the Social Sciences (IBM SPSS Statistics, Version 30, 2024). Analysis of variance (ANOVA) was performed according to the Randomized Complete Block Design (RCBD), and means were compared using Duncan's Multiple Range Test (DMRT) at a probability level of $P \leq 0.05$. Non-significant differences between treatments are indicated by the abbreviation NS.

3. Results

3.1. Chemical Composition of the Prepared Organic Fertilizer

The chemical analysis of the solid sample of the organic fertilizer is presented in Table (2). The total carbon content was 58% and organic matter (O.M.) recorded 29.5%. Total nitrogen (N) reached 3.13%, available phosphorus (P) was 0.25%, and sulfur (S) was 0.14%. Calcium (Ca) and magnesium (Mg) were 5.56% and 1.58% respectively, while iron (Fe) recorded 0.21%. Among the microelements, zinc (Zn) recorded the highest value at 940 PPM, followed by manganese (Mn) at 223 PPM, and copper (Cu) at 35 PPM. The chemical analysis of the liquid sample is presented in Table (3). Magnesium (Mg) recorded the highest concentration at 1000 PPM, followed by potassium (K) at 300 PPM, phosphorus (P) at 272 PPM, and nitrogen (N) at 212 PPM. Calcium (Ca) was 121 PPM, iron (Fe) was 9.0 PPM, zinc (Zn) was 62 PPM, manganese (Mn) was 5.5 PPM, copper (Cu) was 0.1 PPM, and sulfur (S) constituted 0.31%.

Table (2): Elements available in the fertilizer for the solid sample.

No	Zn PPM	Mn PPM	Cu PPM	Ca	Mg	Fe	Total N	Avelable P	S %	O.M	Total carbon
1	940	223	35	5.56%	1.58%	0.21%	3.13%	0.25%	0.14%	29.5%	58%

Table (3): Available Elements in the Liquid Fertilizer Sample.

No	Zn PPM	Mn PPM	Cu PPM	Ca PPM	Mg PPM	Fe PPM	K PPM	N PPM	P PPM	S %
1	62	5.5	0.1	121	1000	9.0	300	212	272	0.31 %

3.2. Vegetative Growth and Morphological Response to Organic Fertilizer Treatments

A comparison of germination percentage between the three treatments (Table (4)) indicated no significant differences from 90.62% of treatment (control) to 96.88% of treatment (50 g and 200 g) of germination percentage. But the 200 g fertilizer treatment was significantly greater than the control and 50 g treatment with respect to all the remaining vegetative growth parameters. The mean leaf area obtained by this treatment was 74.62 cm² (about five times higher than the previous control treatment of 11.84 cm²). Moreover, it produced the maximum significant values in petiole length (21.00 cm), root length (16.12 cm), and stem length (9.75 cm). In branch number, the 200 g treatment offered an advantage as well, with a mean number of around 7.25 branches per plant, greater than both the control and 50 g treatment.

Table (4): Effect of Fertilizer Treatments on Vegetative Growth and Morphological Traits

Trait	Unit	Treatment (Mean ± SD)			% Change vs. Control		LSD _{0.05}
		Control	Fertilizer 50 g	Fertilizer 200 g	Fertilizer 50 g	Fertilizer 200 g	
Germination	%	90.62	96.88 ±	96.88 ±	+6.90%	+6.90%	<i>NS</i>

Trait	Unit	Treatment (Mean ± SD)			% Change vs. Control		LSD _{0.05}
		Control	Fertilizer 50 g	Fertilizer 200 g	Fertilizer 50 g	Fertilizer 200 g	
percentage (%)		± 11.97 ^a	6.25 ^a	6.25 ^a			
Petiole length (cm)	cm	9.50 ± 2.65 ^b	9.06 ± 1.56 ^b	21.00 ± 2.12 ^a	-4.61%	+121.05%	3.45
Leaf area (cm ²)	cm ²	11.84 ± 3.39 ^b	12.25 ± 3.57 ^b	74.62 ± 15.25 ^a	+3.44%	+530.15%	14.8
Number of branches	count	5.25 ± 0.50 ^b	5.75 ± 0.50 ^b	7.25 ± 0.50 ^a	+9.52%	+38.10%	0.8
Root length (cm)	cm	10.88 ± 1.38 ^b	11.75 ± 1.44 ^b	16.12 ± 3.01 ^a	+8.05%	+48.28%	3.34
Stem length (cm)	cm	4.75 ± 1.02 ^b	4.62 ± 1.20 ^b	9.75 ± 1.50 ^a	-2.63%	+105.26%	2.01

* Different letters (a, b, c) following each value indicate significant differences between treatments according to Duncan's Multiple Range Test at $P \leq 0.05$. NS = no significant difference.

3.3. Effect of Organic Fertilizer Rates on Fresh and Dry Weight of Shoot and Root Systems:

In addition to their respective treatments, Table (5) shows that biomass accumulation significantly and statistically increased after comparison with each other for the 200 g treatment, indicating that the 200 g fertilizer treatment significantly outperformed the control and 50 g treatment on all measured parameters. Fresh weight of the shoot system was recorded highest for this treatment at 19.00 g which is an exceptional eight-fold increase relative to both control and 50 g treatment. This increase was also reflected in the dry weight of the shoot system, which increased to 2.09 g, more than five times higher than other methods. The superiority of 200-g treatment was not found only to be limited to the shoot system, but also applied fairly well to the root system, where both fresh and dry root weights were also found to be 10.75 g and 1.29 g, respectively, which showed an increase of 681.82% compared to the other two treatments. Application of organic fertilizer at the 50 g rate did not differ significantly, however, compared with control treatment in all the fresh weight and dry weight calculations.

Table (5): Effect of fertilizer treatments on biomass characteristics.

Trait	Unit	Treatment (Mean ± SD)			% Change vs. Control		LSD _{0.05}
		Control	Fertilizer 50 g	Fertilizer 200 g	Fertilizer 50 g	Fertilizer 200 g	
Fresh weight of	g	2.00 ±	2.50 ±	19.00 ±	+25.00%	+850.00%	4.97

Trait	Unit	Treatment (Mean ± SD)			% Change vs. Control		LSD _{0.05}
		Control	Fertilizer 50 g	Fertilizer 200 g	Fertilizer 50 g	Fertilizer 200 g	
shoot system (g)		0.82 ^b	1.00 ^b	5.23 ^a			
Dry weight of shoot system (g)	g	0.33 ± 0.27 ^b	0.31 ± 0.05 ^b	2.09 ± 0.54 ^a	-4.55%	+533.33%	0.56
Fresh weight of root system (g)	g	1.38 ± 0.75 ^b	1.75 ± 0.50 ^b	10.75 ± 2.87 ^a	+27.27%	+681.82%	2.78
Dry weight of root system (g)	g	0.16 ± 0.07 ^b	0.22 ± 0.03 ^b	1.29 ± 0.34 ^a	+33.33%	+681.82%	0.33

* Different letters (a, b, c) following each value indicate significant differences between treatments according to Duncan's Multiple Range Test at $P \leq 0.05$. NS = no significant difference.

3.4. Total Dry Biomass and Production Efficiency in Response to Organic Fertilizer Rates:

Table (6) confirmed the sustained and statistically significant superiority of the 200 g fertilizer technique in total dry biomass of 3.38 g, which is almost a six-fold increase with respect to the control and the 50 g fertilizer treatment. In addition, 200 g treatment showed the highest production efficiency, namely 0.47 g/branch, higher than control and 50 g treatments, where the efficiency of 0.10 and 0.09 g/branch were observed. As for the physiological distribution and the stability of water indices, such as the root-to-shoot ratio, shoot and root dry matter percentages, and the relative water content of the shoot, the results showed that no significant differences were found among any treatments tested.

Table (6): Calculated growth indices from different fertilizer treatments

Trait	Unit	Treatment (Mean ± SD)			% Change vs. Control		LSD _{0.05}
		Control	Fertilizer 50 g	Fertilizer 200 g	Fertilizer 50 g	Fertilizer 200 g	
Root-to-shoot ratio	-	0.63 ± 0.25 ^a	0.71 ± 0.11 ^a	0.63 ± 0.15 ^a	+13.45%	+0.81%	NS
Shoot dry matter percentage (%)	%	15.00 ± 6.00 ^a	14.50 ± 6.37 ^a	11.17 ± 1.65 ^a	-3.33%	-25.51%	NS
Root dry matter percentage (%)	%	13.50 ± 4.43 ^a	13.38 ± 3.90 ^a	12.00 ± 0.00 ^a	-0.93%	-11.11%	NS
Relative water content of	%	85.00 ± 6.00 ^a	85.50 ± 6.37 ^a	88.83 ± 1.65 ^a	+0.59%	+4.50%	NS

Trait	Unit	Treatment (Mean ± SD)			% Change vs. Control		LSD _{0.05}
		Control	Fertilizer 50 g	Fertilizer 200 g	Fertilizer 50 g	Fertilizer 200 g	
shoot (%)							
Total dry biomass (g)	g	0.50 ± 0.32 ^b	0.54 ± 0.07 ^b	3.38 ± 0.75 ^a	+8.08%	+582.83%	0.76
Production efficiency (g/branch)	g/branch	0.10 ± 0.07 ^b	0.09 ± 0.01 ^b	0.47 ± 0.11 ^a	-3.39%	+386.42%	0.12

* Different letters (a, b, c) following each value indicate significant differences between treatments according to Duncan's Multiple Range Test at $P \leq 0.05$. NS = no significant difference.

4. Discussion

Analyzing the organic fertilizer made from college waste, we see the components mature into a balanced nutrient profile (58% total carbon, 3.13% total nitrogen, and 0.25% available phosphorus) and a solid and liquid form of other essential macro and micronutrients. Supporting this, Sienkiewicz et al. (2024) demonstrated that compost from organic waste contains plant growth hormones, like auxins and gibberellins. These plant growth hormones stimulate cell division and the growth of the plants. In terms of seed germination, treatments had no significant difference (90.62% in the control vs. 96.88% in fertilizers). This proves alignment with Kelley et al. (2022), which verifies that seed germination is primarily reliant on internal seed reserves, and that the plant's actual response to compost manifests during the later vegetative stages rather than the initial germination stage. In the vegetative stage of growth, the 200 g treatment significantly surpassed both the control and the 50 g treatment across the board ($P \leq 0.05$). Leaf area increased by 530.15%, and shoot fresh weight improved by 850.00% relative to the control. This is consistent with Lin et al. (2024), who reported that organic fertilizers increase net photosynthesis as well as positively contributing to overall biomass. Additionally, the profound increase in leaf area is the result of enhanced nutrient mineralization. In this context, Lucchetta et al. (2023) stated that compost has a positive impact on the soil microbial community, enhancing biological activity to a level where rapid plant nutrient uptake and vegetative growth are heavily stimulated. Outstanding increases even occurred in the elongation of the root and overall biomass. Highlighting this mechanism, (Guo et al., 2023) stated that improved phosphorus availability in the rhizosphere is directly involved in nucleic acid synthesis, cell division, and elongation, which enhances overall plant productivity. These outcomes perfectly mirror the findings of Carnimeo & Gelsomino (2022), who observed that root elongation and leaf expansion are directly correlated with escalating rates of compost application. Conversely, the 50 g treatment failed to show significant differences from the control in most growth metrics. Reinforcing this, Smith et al. (2024) confirmed that low application rates of organic amendments may not release sufficient nutrients to surpass the minimum threshold required for a significant growth response. Despite the significant increase in biomass in the 200 g treatment, the physiological indicators (relative water content and root-to-shoot ratio) remained statistically non-significant. This suggests real physiological stability; Bondi et al.

(2024) explained this as the effect of organic fertilizers on the water retention capacity of the soil as well as the water balance within plant tissues. In the end, the 200 g treatment had the best production efficiency (0.47 g/branch) and a total dry biomass increase of 582.83%. According to Tananuwong & Wattanasirmkit (2023), organic fertilizers, in the presence of nutrients, hormones, and plant growth regulators, improve the productivity of plants per unit of vegetative growth. Moreover, the authors emphasized that soil biota are essential for the transformation of nutrients in the soil into plant-accessible forms. These positive effects are even more pronounced in compost when compared with mineral fertilizers, as pointed out by Choudhary et al. (2024). The available macronutrients and micronutrients in the compost made it more effective in providing nourishment to the plants. Overall, these findings confirm the results of Bai et al. (2024), who attributed the increase in plant parameters and total yield to improved soil characteristics resulting from compost application, thereby reinforcing the value of the locally produced organic fertilizer.

5. Conclusion

This research demonstrates the successful transformation of organic waste generated at university into a highly nutritious compost. Experimental findings indicate that using 200 g of this compost as a treatment is the optimum approach to induce Swiss chard productivity development. In particular, this rate generated a 530% increase in leaf area and an 850% increase in root fresh weight as compared to the control group. Despite the fact that germination rates of seeds have statistically not changed, reflecting that early development relies heavily on internal seed reserves, this favourable effect of compost seemed particularly apparent at later vegetative growth and biomass accumulation stages. In the grand scheme of things, the present study points to the practicality of replacing chemical fertilizers with sustainable organic ones which can better utilize resources and reduce environmental pollution in academic facilities that would enable cleaner agriculture.

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