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A Comparative Study on the Nutrients in Organic Fertilizers and Garden Soil in Tirunelveli

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Organic fertilizers are natural compounds made from waste or by-products and human assistance is limited to physical extraction or processing steps. Examples of commonly used organic matter include sewage sludge, food processing waste, composted animal manure, and urban biosolids. In this study, an attempt was made to examine the nutritional value of *Lyroderma lyra* (giant pseudo-vampire bat) bat guano, garden soil, and earthworm compost. Essential elements (macro elements - N, P, K, NO_3, NO_2, Pi, PO_3), trace elements (Na, C, Fe, Mn, Zn, Cl), meso elements (Mg, Ca, SO4)) from this study The identified non-essential elements (Al), toxic elements (Ba) and pH were analysed and compared. Earthworm compost is rich in No_3, No_2, Pi, PO_3, Ca, Mg, SO_4, C, Fe, Zn, Mn and Cl. On the other hand, bat guano is rich in N, K and Na. The garden soil was rich in Cl, Mg, Ca, N. No toxic element was found in the garden soil but found in very low levels in both vermicompost and bat guano. In summary, these elements improve soil health and gradually

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release necessary nutrients into the soil as essential elements. This study suggests the need for prior soil studies and the need to better balance the effects of different organic matter on plant growth.

Keywords: Organic fertilizers; bat guano; vermicompost; Lyroderma lyra.

1. INTRODUCTION

Plant growth and development are largely determined by nutrient availability; therefore, to ensure better productivity of crop plants, it becomes essential to understand the dynamics of nutrients uptake and their biological interactions [1]. A wealth of information has been generated during the last two decades on morphological and physiological adaptations of plants in response to the changes in the availability of mineral nutrients [2,3,4,5,6,7], Yet, there is still a dearth of understanding among agriculturalists regarding the types of minerals required for plant growth, whether a loss is caused by a mineral deficiency or by microorganisms, etc.

Organic fertilizers are substances having a well-defined chemical make-up and high in nutritional value that can offer sufficient nutrients for plant growth [8,9]. Plant material composting (such as straw and garden waste), animal manure, human excrement with microorganisms are fermenting at high temperatures is used to create organic fertilizers [10]. Organic fertilizers help the soil's structure, offer a variety of plant nutrients, and enrich the soil with healthy microbes. Because organic fertilizers improve soil quality and crop productivity, they are frequently employed in agriculture [11,12].

Bats are common and essential to maintaining ecological harmony, cycling nutrients, and redistributing forests. The nitrogen and mineral budgets of insectivorous bats have not been the focus of many investigations [13,14]. Nutritional studies of bats have focused on energy or water demands [15]. Due to high nitrogen content and nematocidal properties, bat guano is frequently utilized as a natural fertilizer in western countries [16]. As it includes all the necessary nutrients for plant growth, bat guano is also crucial for the development of microflora. Unfortunately, chemical fertilizers replaced bat guano as the plant's primary source of sustenance. The use of chemical pesticides and fertilizers in modern agriculture enhanced food production but also harmed the environment and soil, having an adverse effect on ecosystem health as well as human health. as a result of the fact that it contains benevolent microorganisms, macro and micronutrients, enzymes, and hormones.

Vermicompost is crucial for sustainable agriculture. Vermicompost has appealing characteristics like lower levels of pollutants [17]. Vermicomposting technology is the decomposition of organic waste into nutrient-rich vermicasts through the combined action of earthworms and microorganisms by which the earthworms also increase in number, size, and weight [18,19]. Vermicompost made from earthworms is proving to be a more effective "growth promoter" than traditional composts as well as a "protective" farm input. It serves as an excellent "organic " as well. It increases the physical, chemical & biological properties of soil, restoring & improve its natural fertility against the ‘destructive’ chemical fertilizer which has destroyed the soil properties and decreased its natural fertility over the years [20]. Although bat guano and vermicompost have been utilized as organic manures in various parts of the world for a long time, research on the nutrients compounds found in bat guano is still in its infancy. Therefore, this study aimed to investigate the mineral nutrients of bat guano of *Lyroderma lyra* bat with vermicompost and garden soil in Tirunelveli.

2. MATERIALS AND METHODS

The present study was carried out from November 2021 to April 2022. The bat guano samples were collected from Murapandu (8.714208 N, 77.831300 E), vermicompost samples from Vermiculture Unit at Sarah Tucker College (8.699526 N, 77.743088 E) and garden soil samples from Ramayanpatti (8.776518 N, 77.677780 E). The fine power was made with mortar and pestle and were stored in separate zipper bags of 500g each and then placed in foil covers and then transferred to Life Tech Research Centre, Arumbakkam, Chennai for analysis.

The samples were analysed by atomic absorption spectroscopy for Nitrogen (N), Nitrate (NO_3), Nitrite (NO_2), In. Phosphate (Pi), Phosphate (PO_3), Potassium (K), Calcium (Ca),

Magnesium (Mg), Sulphate (SO_4), Sodium (Na), Copper (C), Iron (Fe), Zinc (Zn), Manganese (Mn), and by titration method for Chloride (Cl), Aluminium (Al) Barium (Ba), pH (2%), colour of the samples was absorbed visually.

3. RESULTS AND DISCUSSION

In order to grow and develop plants like all other living things, require sustenance. The 16 necessary components are needed for plants. The air and water in the soil are the sources of carbon, hydrogen, and oxygen. The remaining 13 important elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, zinc, manganese, copper, boron, molybdenum, and chlorine) are either supplied by soil minerals and soil organic matter or by organic or inorganic fertilizers [21]. The colour and texture of the garden soil are red colour granules, vermicompost is a dark black powder and bat guano is greyish black granules. The samples were transferred to the Life Teck Research Centre, Arumpakam for analysis and the results were tabulated in Table – 1. The concentrations of essential elements in plants may be higher than the critical concentrations, which are the minimal concentrations needed for growth, and they may differ slightly between species [22]. Macro, meso, and microelements are the three major types of soil nutrients. There is a distinction made between macronutrients, which are needed in bigger amounts, and micronutrients, which are needed in lesser amounts. This split just indicates that they are needed in various amounts and concentrations and does not imply that one nutrient component is more crucial than another.

Table 1. Elemental composition of GS - garden soil, VC – vermicompost and BG – bat guano

PROPERTIES				Method	GS	VC	BG
					(mg / 100 g)		
Essential Elements	Macroelements	Nitrogen	N	Absorption at 190 - 250 nm	209.50	1545.60	6280.00
		Nitrate	NO_3	Absorption at 220 - 275 nm	45.55	456.70	10.54
		Nitrite	NO_2	Absorption at 190 - 250 nm	12.89	122.89	2.35
		In. phosphate	Pi	Absorption at 650 nm	50.45	293.40	15.74
		Phosphate	PO_3	Absorption at 420 - 450 nm	80.55	709.76	20.24
		Potassium	K	Absorption at 766.5nm	100.40	786.50	2245.60
	Mesoelements	Calcium	Ca	Absorption at 422.7nm	489.60	3378.80	403.02
		Magnesium	Mg	Absorption at 285.2nm	509.60	6078.00	141.05
		Sulphate	SO_4	Absorption at 420 nm	190.60	2298.80	10.33
	Microelements	Sodium	Na	Absorption at 589 nm	156.70	1560.90	3356.70
		Copper	C	Absorption at 324.7nm	0.56	26.03	0.56
		Iron	Fe	Absorption at 248.3nm	90.50	1098.67	15.33
		Zinc	Zn	Absorption at 213.8nm	10.56	78.78	5.89
		Manganese	Mn	Absorption at 279.5nm	2.45	25.45	2.05
		Chloride	Cl	Titration	784.60	1876.78	12.15
Nonessential Element		Aluminium	Al	Titration	0.00	0.20	1.00
Toxic Element		Barium	Ba	Titration	1.89	10.23	25.22
pH (2% Sample Solution)			pH	pH Meter	9.03	8.68	8.02
Colour				Visual	Red	Dark black	Greyish black

3.1 Macroelements

The macroelements are the primary nutrients required for plant growth are nitrogen (N), phosphorus (P), and potassium (K). The table values of macroelements are plotted in Fig. 1. The presence of nitrogen can be in the form of nitrogen itself or in the form of nitrates and nitrites. Nitrogen content was high in Bat guano (6280.00mg) and low in garden soil (209.50 mg). Pure, "elemental" phosphorus (P) is rare. Phosphorus typically occurs in nature as a component of the phosphate (PO_4) molecule. Inorganic and organic phosphate are the two forms of phosphorus that are present in aquatic systems [23]. The high concentration of inorganic phosphate (293.40 mg) and phosphate (709.76 mg) was knotted in vermicompost. Potassium level was high in bat guano, low in garden soil, and moderate in vermicompost and the values are 2245.60 mg, 100.40 mg, and 786.50 mg respectively. Sridhar et al. [24] the highest ratio of NPK is present in bat guano. Pawan et al. [25] reported that the highest ratio of P and K is present in bat guano when compared to vermicompost. The elements present in vermicompost varies based on the types of substratum we use for the process of vermicomposting. Likewise, the elements in bat guano also varies based on their diet they follow.

3.2 Mesoelements

Mesoelements are calcium (Ca), magnesium (Mg), and sulphur (S). The mesoelements are often grouped with macro elements or with nonessential elements for plant growth as they are required in very low quantities. The deficiency diseases in plants can also be knotted due to deficiency of the mesoelements [21]. The highest concentration of Mg (3378.80 mg) and Ca (6078.00 mg) was found in vermicompost. Sulphur is essential for many growth functions in plants including nitrogen metabolism, enzyme activity and protein and oil synthesis. The elemental sulphur is different from sulphate both the sulphur and sulphate are dependent on each other for plant growth based on time, temperature and moisture needed [26]. The highest level of 2298.80 mg of sulphate is found in vermicompost, 190.60 mg in soil and 10.33 mg in bat guano and depicted in Fig. 2.

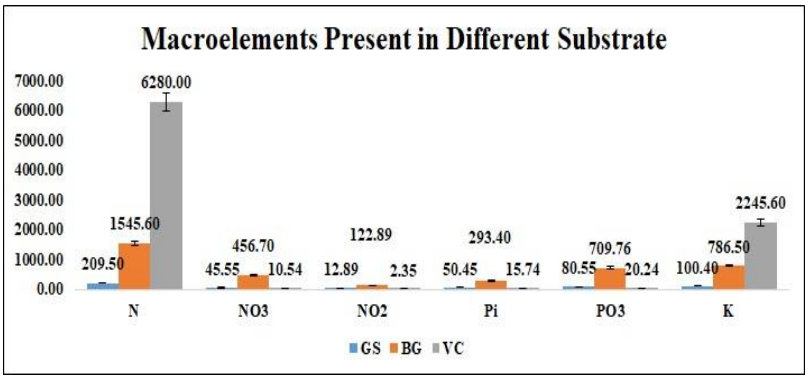

Fig. 1. Macroelements present in garden soil (GS) and in organic fertilizers (BG- Bat guano & VC – Vermicompost).

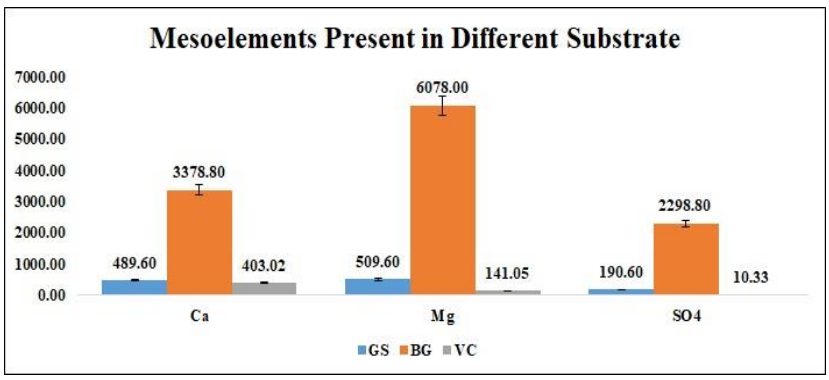

Fig. 2. Mesoelements present in garden soil (GS) and in organic fertilizers (BG- Bat guano & VC – Vermicompost)

3.3 Microelements

Micronutrients are essential for plant growth in low level, hence, the term "micro". They include boron (B), zinc (Zn), chlorine (Cl), copper (Cu), manganese (Mn), iron (Fe), Molybdenum (Mo), and silicon (Si). These elements may be referred to as minor or trace elements, but micronutrients are the preferred term. The desk standards are strategized in Fig.- 3. The highest level of Sodium 3356.70 mg was found in bat guano. The highest level of copper 26.03 mg, iron 1098.67 mg, zinc 78.78 mg, manganese 25.45 mg and chloride 1876.78 mg was recorded in vermicompost, moderately in garden soil (0.56 mg, 90.50 mg, 10.56 mg, 2.45 mg, and 784.60 mg respectively) and very low (0.56 mg, 15.33 mg, 5.89 mg, 2.05 mg, 12.15 mg) correspondingly in bat guano. The microelements are also called as trace elements or tracer elements [25].

3.4 Nonessential and Toxic Elements

The nonessential metal aluminium (Al) was not present in Garden soil but found in low concentration in vermicompost and high in bat guano. The toxic metal barium (Ba) was also high in bat guano when compared to vermicompost and garden soil. The presence of nonessential (Al) and toxic elements (Ba) was high in Bat guano and moderately in vermicompost and this is given in Fig. 4. The increased levels might be due to decomposing nature (i.e.) the leaf foliage and other substrates for the preparation of the vermicompost manure or due to the intake of toxic fishes from the environment that are eaten by bats. Amanda [27] observed the presence of Mercury, cadmium, and lead was also present in bat guano of *Myotis grisescens* in USA. The elimination of these elements can be done with proper guidance from the agricultural society. Bats, like humans, play a top role in the food chain. The more concentrated the metals tend to get accumulate, because these metals bioaccumulate, which means they become more concentrated as they move up the chain. A reliable estimate of these harmful elements in the environment can be obtained by researching on the species specific manures.

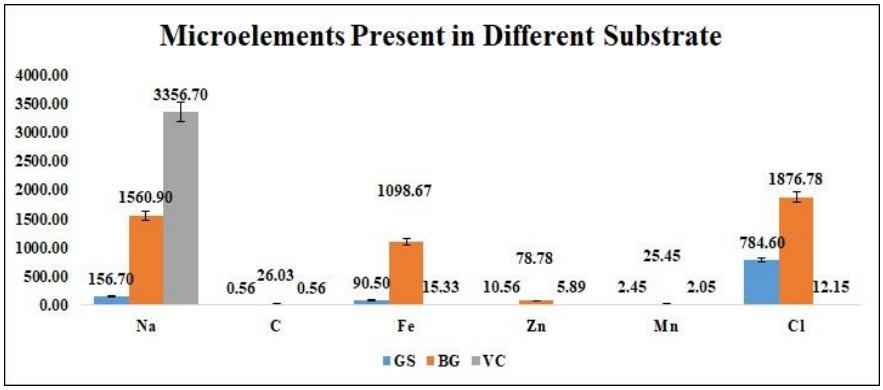

Fig. 3. Microelements present in garden soil (GS) and in organic fertilizers (BG- Bat guano & VC – Vermicompost)

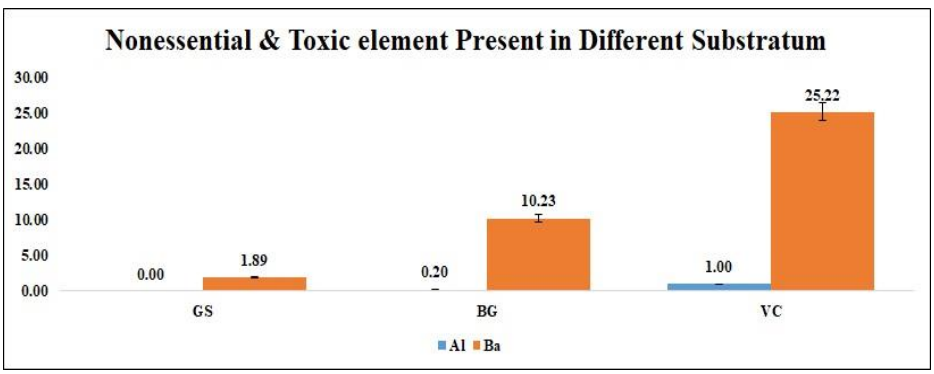

Fig. 4. Nonessential & Toxic elements present in garden soil (GS) and in organic fertilizers (BG- Bat guano & VC – Vermicompost)

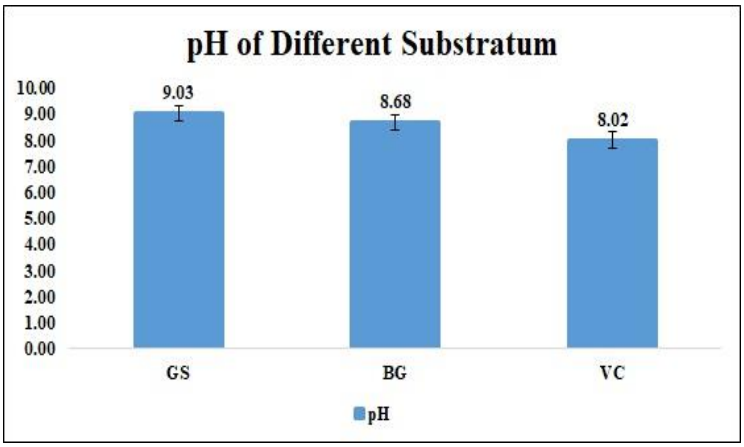

Fig. 5. pH of garden soil (GS) and organic fertilizers (BG- Bat guano & VC – Vermicompost)

3.5 pH of the Substrates

The pH of all the substrate is slightly alkaline in nature and the values are graphed in Fig. 5. Application of bat guano to the soil decreases the soil pH (H_2O) an also, it markedly reduces exchangeable aluminum in the soil [28].

In addition to enhancing soil fertility and structure, organic fertilizers can also boost soil nutrients. Combining organic and inorganic fertilizers was thought to be an efficient way to maintain the sustainability of crop ecosystems. Organic fertilisation practises can increase crop yields and soil quality [29]. In addition to increasing soil organic carbon and other nutrients, the use of organic fertilizers can also improve soil structure and fertility [30,31]. Nutrient shortages often occur because sufficient levels are not soluble and available to the crop, rather than because there are not enough nutrients in the soil [32]. The use of organic fertilizers aids in the formation and stability of earthworm communities because the more stable nutrients in organic manure that result from aerobic fermentation [33].

Numerous studies have demonstrated that adding organic fertilizers to the soil surface can give microorganisms a rich food source and considerably boost the composition and diversity of microbial communities when compared to not applying [34,35]. Applying organic fertilizers also alters Cation Exchange Capacity (CEC) significantly and raises soil moisture content, changing the structure and composition of the soil's fauna species in acidic soils [35,36].

The broad application of mineral fertilizers is crucial to the achievement of sustainable food production. However, a variety of trace metals are added to the commercially available fertilizers, which are applied to the soil at the same time as the fertilizers. Given the growing environmental concerns, interest in environmentally friendly organic fertilizer soil amendments has grown [37].

Lack of access to groundwater in some locations has led to another issue: water shortages. It demonstrated that foliar spraying with a tiny amount of nutrients—in particular, Zn, Fe, and Mn—significantly boosts crop output [38]. People are becoming more environmentally conscious, and plant leaves are absorbing nutrients [39]. It should be emphasised that, in addition to crop yields, crop quality is another factor that requires careful consideration because it impacts both the nutritional value of crops and the commercial viability of crop products [40].

According to Manyuchi *et al.* [41] study of the NPK ratio in vermicompost and vermiwash, the vermicompost contains a significant level of nitrogen and iron. Vermicast is a rich source of the micro- and macronutrients necessary for plant growth [42,41,20]. The elemental makeup of bat guano, according to Pawan et al. [25] study, is the nutrient supply for the microbiota's growth in the cave environment. The bat *Lyroderma lyra* use to dwell in cervices of the buildings, well, tunnels located nearer to agricultural field and water bodies [43,44]. During monsoon the increase in the water level directly outhouse the guano from the roost to the agricultural land. Vermicompost and bat guano are examples of animal waste. Nevertheless, vermicompost still raises environmental concerns because, in contrast to bat guano, it speeds up plant development. However, vermicomposting

takes a long time. A readily available natural material that can be utilised in very small concentrations or as a substitute for panchagavya or fish amino acid is bat guano.

4. CONCLUSION AND SUGGESTIONS

There is a global demand for organic food as a result of the perceived negative effects of synthetic and chemical fertilizers, herbicides, and pesticides on human health. This emphasises the need for a better balancing of the impact of fertilizer with diverse organic fertilizer absorption rates. Crop waste could be added to the soil to boost its organic content, but burning crop waste defeats the purpose of this strategy and worsens environmental pollution. It is advised that research on plant nutrition and soil fertility adopt a multidisciplinary strategy where soil scientists, breeders, and nutritionists collaborate to develop a research agenda. It is necessary to compare the effects of bat guano and other organic fertilizers on crop growth and yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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