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Composts Prepared from Roadside Weeds as Potential Source of Soil NPK: A Pro-Environmental Solution for Restoration of Degraded Lands

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ABSTRACT

The management of weeds and replenishment of soil is a relevant issue. This study investigates the potential of composts prepared from roadside weeds as a sustainable solution for soil nutrient replenishment and weed management. Compost prepared from four common roadside weeds of NE India —*Ageratum conyzoides, Galinsoga parviflora, Mikania micrantha, and Tithonia diversifolia* — were added to degraded soils and the changes in Nitrogen (N), Phosphorus (P), and Potassium (K) levels were measured using Kjeldahl method, Bray No. 1 Extract method and Flame Photometer respectively with results demonstrating a significant increase in soil NPK levels upon higher compost application. *Tithonia diversifolia* exhibits the highest nutrient enrichment followed by *Mikania micrantha, Ageratum conyzoides and Galinsoga parviflora*. This study highlights the effectiveness of composts from roadside weeds in enhancing soil fertility and presents a pro-environmental strategy for restoring degraded lands while managing invasive plant species.

Keywords Roadside weeds, Compost, Soil nutrient replenishment, Degraded lands, Invasive plant species.

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INTRODUCTION

Composting as a strategy for weed management

The best method for managing weeds is composting (Kumar *et al*. 2023, Taneja *et al.* 2023) through which weed biomass may be safely disposed of and converted into extremely rich manure supporting sustainable development (Yadav 2015). Composting has, therefore, been suggested as a useful approach for reducing weed biomass while also maintaining soil fertility using organic additions (Evans 1997). This method of management is considered the most effective, environmentally friendly and agronomically sound since the resulting compost can be utilized as a natural, organic fertilizer and soil nutrient source (Karak *et al.* 2013). However, the performance depends on the properties of the waste (Aruna *et al.* 2018).

Composting process

Composting being an environmentally friendly method that turns organic material into a product with high humic acid and plant-available nutrients with very low population of pathogenic bacteria serves as a sustainable method for recovering nutrients and other components from weed biomass (Himanshi *et al.* 2023, Meng *et al.* 2017, Soobhany 2018). Composting has been defined by Ayilara *et al.* (2020) as a form of recycling in which organic waste is digested by microbial activity under regulated conditions to create valuable, ecofriendly, and environmentally friendly goods. The biological process involves the conversion of solid organic waste materials into fertile form through numerous micro-organisms which includes actinomycetes, bacteria, and fungi, in the presence of oxygen (Dróżdż *et al.* 2020, Żukowska *et al.* 2019) and the process is initiated and managed under regulated environmental conditions, distinguishing it from decomposition by its controlled process (Qasim *et al.* 2018).

Historical context and modern applications

Historically, ancient civilizations like the pre-Columbian Indians of Amazonia and the Egyptians practiced composting to improve soil quality. Over the past four decades, composting techniques have advanced significantly, with scientific research highlighting their benefits and the complexity of the factors involved in the composting process (Avidov *et al.* 2017, Ren *et al.* 2018). At present day, it is favored as it is a low-cost method, influencing the physical–chemical parameters of heat, aeration, water content, C:N ratio, and pH (Cogger *et al.* 2008, Ventorino *et al*. 2019), boosting the soil's organic carbon content, revitalizing degraded soils, improving soil structure, water retention capacity, and tilth (Azim *et al.* 2018). Composting at home is necessary to facilitate decentralized solid waste management system (Mahapatra *et al.* 2022).

Compost as replacement of chemical fertilizers

Soil fertilizers may be replaced by compost as they too are rich in different nutrients which helps in increasing the crop yield, reduces soil erosion, increasing soil workability and also contributes to lowering the greenhouse gas emissions from landfills, garbage dumps, (Walling and Vaneeckhaute 2020, Bernal *et al.* 2017). By blending compost and soil, it improves the hydrological properties of soil further increasing the infiltration of water into the soil (Kranz *et al*. 2020). Additionally, the content of nutrients in the compost ensures the growth and development of plants over long periods of time, negating the need to apply another type of fertilizer for a period of 2–3 years, thereby reducing the number of chemical fertilizers (Goldan *et al.* 2023). The potential of North East India's weeds as a viable source of compost for enhancing soil nutrients remains uncertain. This study, therefore, offers insight into the potential of compost from four common weeds for potential source of NPK.

MATERIALS AND METHODS

Collection and composting of selected weeds

An *ex-situ* field survey was conducted using line-quadrat method (Kent 1992) to identify weeds with highest frequency and abundance along roadsides. The highest four species were selected and identified for this study namely *Ageratum conyzoides* (Billygoat weed), *Galinsoga parviflora* (Gallant soldier), *Mikania micrantha* (Bitter vine) and *Tithonia diversifolia* (Mexican sunflower). A thorough local survey was carried out with sampling fraction < 0.05 to make sure that the selected species are unwanted, slashed, burnt or eradicated with herbicides.

The above-ground biomass of selected weeds was manually collected and cleared of diseased or necrotic parts while fresh parts were shredded into smaller pieces to facilitate faster decomposition. Plastic closed-bins (20 L) were used as plastics are most preferred for composting (Samal *et al.* 2017) with no external additives introduced. The process was monitored periodically by aeration, turning, watering (Lleó *et al.* 2013) and assessing the breakdown of organic material, allowing the compost to mature under natural conditions. The compost was evaluated on-site for phytotoxicity, temperature, color, odor and moisture (Forster *et al.* 1993, Ponsá *et al.* 2008) and was deemed mature and stable.

Soil collection and Analysis

Soil samples were collected from agriculturally degraded lands with high compactness due to heavy machinery or overgrazing, characterized by reduced pore space, limited water infiltration, increased susceptibility to erosion, topsoil loss, surface crusts and nutrient depletion (Hamza & Anderson 2005, Valentin & Bresson 1992, Morgan 2005, Håkansson & Lipiec 2000). Prior to the addition of compost, the initial levels of Nitrogen (N), Phosphorus (P), and Potassium (K) in the degraded soil were analyzed using Kjeldahl Method (Kjeldahl 1883, Bremner 1960), Bray No. 1 Extract method (Bray & Kurtz 1945, Menage & Pridmore 1973, Bartlett *et al.* 1994), and Flame Photometer method (Gammon and Nathan 1951) respectively.

Compost application & soil analysis

The matured compost was added to the degraded soil samples and mixed thoroughly to ensure even distribution. The addition of compost samples to soil sample was done in the following values: C_1+S = 125g compost + 875g soil, C_2+S = 150g compost + 850g soil, C_3+S = 175g compost + 825g soil, C_4+S = 200g compost + 800g soil. After the addition of compost, the soil samples were allowed a set period for integration of nutrients in natural condition under sunlight. Subsequently, the soil was re-analyzed for Nitrogen (N), Phosphorus (P), and Potassium (K) levels using the same testing procedures as the initial analysis. Differences before and after addition of compost was analyzed.

Data analysis

The data from the pre- and post-compost soil analysis were analyzed on One-Way ANOVA with ±SD using SPSS 16. Statistical significance at $p \leq 0.05$ was considered. Data visualization in parallel coordinate plots by Matplotlib and pandas 2.2.2 via Python 3.12.0.

RESULTS AND DISCUSSION

Readings of soil NPK (kg/ha) for different compost treatments

Phosphorus and potassium values below 13.65 kg/ha and 68.25 kg/ha in soil are considered to be deficient (Siatwiinda *et al.* 2024) as observed in the degraded soil, however, addition of compost increases the value above said values resulting in medium soil fertility. It is observed that the values of N, P and K increased significantly upon addition of compost prepared from *Galinsoga parviflora* (Gallant soldier), *Mikania micrantha* (Bitter vine), *Tithonia diversifolia* (Mexican sunflower) and *Ageratum conyzoides* (Billygoat weed). It is also shown that the levels of N, P and K increased along with increasing amount of added compost (C_4>C_3>C_2>C_1) for each of the selected plants and among the four selected weeds, compost from *Tithonia* emerged to have the highest value of NPK. The NPK values (kg/ha) in soil after treatment with compost from 4 selected plants are given in Table 1.

Comparison of soil NPK among treatments

A comparison of Nitrogen (kg/ha) showed that in C1+S (125g compost + 875g soil): *Tithonia* > *Mikania* > *Ageratum* > *Galinsoga*, in C_2+S (150g compost + 850g soil): *Tithonia* > *Mikania* > *Ageratum*

Table 1. NPK values (kg/ha) with SD± in soil after treatment with compost from 4 selected plants.

Treatment	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
Blank Soil (S)	100.32±5.18	7.1±2.32	21.05±4.51
Ageratum C_1+S	119.78±7.42	22.4±5.18	79.02±10.22
Ageratum C_2+S	122.89±8.93	51.05±6.92	114.83±12.67
Ageratum C_3+S	160.52±10.59	78.73±8.76	218.77±15.15
Ageratum C_4+S	231.29±12.86	90.66±10.43	318.64±18.38
Galinsoga C_1+S	120.58±8.42	33.52±7.19	130.72±14.22
Galinsoga C_2+S	131.29±10.91	54.43±9.55	202.05±17.66
Galinsoga C_3+S	149.87±12.58	84.17±11.76	327.8±22.17
Galinsoga C_4+S	175.56±14.83	111.82±13.43	559.01±29.37
Mikania C_1+S	159.7±9.89	18.21±5.29	93.46±12.71
Mikania C_2+S	200.23±12.92	53.14±8.97	168.01±15.34
Mikania C_3+S	223.81±14.75	89.71±11.67	244.9±18.23
Mikania C_4+S	338.58±16.37	127.28±13.75	321.55±22.17
Tithonia C_1+S	211.55±11.57	40.78±7.99	190.03±14.29
Tithonia C_2+S	389.01±14.75	101.71±10.81	305.95±18.46
Tithonia C_3+S	462.28±17.11	183.07±13.65	522.9±22.63
Tithonia C_4+S	588.26±19.38	245.42±16.4	703.16±25.33

C_1+S = 125g compost + 875g soil, C_2+S = 150g compost + 850g soil, C_3+S = 175g compost + 825g soil, C_4+S = 200g compost + 800g soil, kg/h = Kilogram per hectare, SD± = Standard deviation.

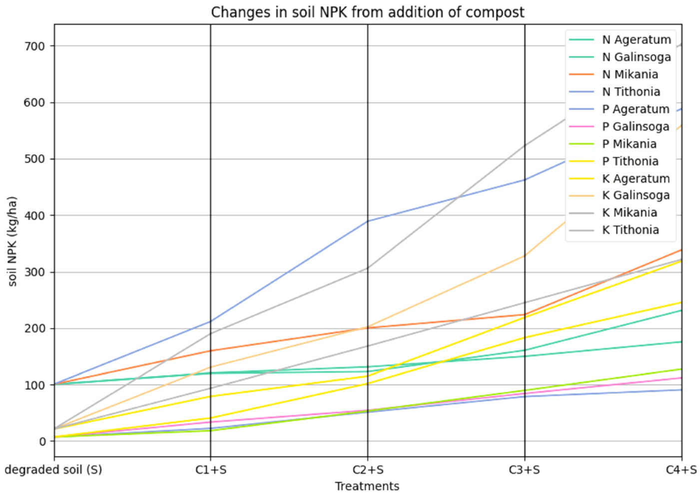

Fig. 1. Soil NPK (kg/ha) under different compost treatments.

> *Galinsoga,* in C_3+S (175g compost + 825g soil): *Tithonia* > *Mikania* > *Ageratum* > *Galinsoga*, and also for C_4+S (200g compost + 800g soil): *Tithonia* > *Mikania* > *Ageratum* > *Galinsoga*.

A comparison of Phosphorus (kg/ha) showed that in C_1+S (125g compost + 875g soil): *Tithonia* > *Galinsoga* > *Mikania* > *Ageratum*, C_2+S (150g compost + 850g soil): *Tithonia* > *Galinsoga* > *Mikania* > *Ageratum*, C_3+S (175g compost + 825g soil): *Tithonia* > *Galinsoga* > *Mikania* > *Ageratum*, and C_4+S (200g compost + 800g soil): *Tithonia* > *Galinsoga* > *Mikania* > *Ageratum.*

A comparison of Potassium (kg/ha) showed that in C_1+S (125g compost + 875g soil): *Tithonia* > *Galinsoga* > *Mikania* > *Ageratum,* C_2+S (150g compost + 850g soil): *Tithonia* > *Galinsoga* > *Mikania* > *Ageratum*, C_3+S (175g compost + 825g soil): *Tithonia* > *Galinsoga* > *Mikania* > *Ageratum*, similarly for C_4+S (200g compost + 800g soil): *Tithonia* > *Galinsoga* > *Mikania* > *Ageratum.*

The changes in soil NPK (kg/ha) under different compost treatments are given in Fig. 1.

CONCLUSION

Weeds need management and soil needs replenishment, as noticed by the United Nations focusing on land restoration for the theme of World Environment Day 2024 (Andersen 2024). Composting is an answer as it is proven to be an effective form of weed management while also offering sustainable soil rejuvenation (Kumar *et al*. 2023, Taneja *et al.* 2023, Yadav 2015). Through this work, the slashed, burnt and eradicated roadside weeds of NE India are studied for their potential to serve as effective compost.

According to the Govt. of India (RKVY 2024), soil nitrogen values under 280 kg/ha is considered low, 280-560 kg/ha as medium while values above 560 kg/ha is deemed high, and it is observed that the application of compost prepared from *Tithonia diversifolia* increases soil from low (100.32±5.18 kg/ha) to high nitrogen content (588.26±19.38 kg/ha), thereby, emphasizing the role of roadside weeds for pro-environmental soil replenishment. *Tithonia,* in particular, has gained a foothold in serving as a prominent source of compost followed by *Mikania micrantha, Ageratum conyzoides* and *Galinsoga parviflora*. It can, therefore, be concluded that composts prepared from unwanted roadside weeds of NE India, particularly *Tithonia diversifolia*, can serve as a potential source of Nitrogen, Phosphorus and Potassium for degraded soils.

Further studies can focus on the allelopathic effect of specific weeds and the soil dynamics that come along with it.

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