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Assessment of the Growth Performance of Two Tropical Weeds Cultivated on the Dumpsite

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***Abstract*—** *This study examined the growth response of Tithonia diversifolia (Mexican Sunflower) and Chromolaena Odorata (Siamweed) grown on the dumpsite in order to learn about the features of dumpsite soil and how they affect the growth response of the two tropical weeds. Viable seedlings of T. diversifolia and C. odorata were gathered in a brewery dumpsite on Ibadan Road in Ilesa, Nigeria, and identified at the Ife Herbarium. The experiment was conducted in three repetitions using Randomized Complete Block Design (RCBD), with three treatments: T. diversifolia, C. odorata, and a control plot with no weed plant. Core surface soil samples were taken using a soil auger and then blended together. Composite samples were taken before and after the weeds were planted to determine the physicochemical parameters of the seeds. The plots were manually weeded at weekly intervals beginning two weeks following planting. For 12 weeks, growth indices such as leaf number, stem girth, plant height, and leaf area were measured every fortnight. The data was examined using analysis of variance, and means were separated using Duncan's Multiple Range Test at 5% significance level. The results revealed that the pH of the pre-cropped soil was 7.7, indicating a somewhat alkaline soil state. The soil particle sizes for sand, silt, and clay were 92, 114, and 794/kg, indicating a clayey nature. The pre-cropped soil had 188.50, 1.85, 99.88, and 37.80 mg/kg of Pb, Cd, Cu, and Hg, respectively. These levels were within the Food and Agricultural Organisation of the United Nations' permitted limit in cultivable soils, with the exception of Cu, which was above. At six weeks after planting, C. odorata had 35.91 leaves, 47.09 cm plant height, 1.47 cm stem girth, and 20.15 leaf area, while T. diversifolia had 20.39 leaves, 21.02 cm plant height, 1.56 stem girth, and 16.20 leaf area. From the results obtained this study showed a remarkable increase in the growth parameters examined, though, more in C. odorata and probably due to high pH and clay contents of the soil.*

***Keywords*—** *Dumpsite soils, Tithonia diversifolia, Chromolaena odorata, growth response.*

I. INTRODUCTION

In Nigeria and many other third-world countries, families and small businesses dispose of their domestic garbage in refuse dumps. The local population's characteristics determine the content of the dumps, which varies by location. A typical garbage dumpsite contains leaves, plastics, abandoned cans, tins, pails, motor and machine components in various states of corrosion, rags and fabrics, dry cells, and plants (Ulakpaa and Eyankwareb, 2021). Many of the locations include a substantial amount of ash as a result of ash dumping and waste burning on the dumpsite. In addition to the periodic burning of dumpsites, the land's shape and composition also contribute to erosion, potentially lowering the fertility of the dumpsite soil. Some farmers cultivate the dumpsite soils into edible plants. These plants take up heavy metals alongside the nutrients in the soil. Globally, there has been significant awareness and efforts focused on using specific plants to absorb heavy metals in contaminated soils (Rajendran et al., 2022). One of the most promising ways of reclaiming contaminated soil is phytoremediation, which involves the use of some plants with special hyperaccumulation attributes (Ogundola et al., 2022). Yan et al. (2020) state that the plants utilized needs to generate a significant amount of biomass and possess the capacity to hyperaccumulate trace elements. Rai et al. (2023) and Ayesa (2021) have reported the effectiveness of *Tithonia diversifolia* in remediating heavy metals.

Assessing the growth response of tropical weeds involves evaluating how these plants behave and adapt to various environmental factors and management practices. In the analysis of how temperature, rainfall, and height conditions affect weed growth, tropical weeds often thrive in warm, humid conditions, so variations in these factors can influence their development and spread. In the assessment of the impact of soil type, pH, and nutrient availability on weed growth, tropical soils can vary widely, and understanding these variations helps in managing weed populations effectively. In the evaluation of how tropical weeds interact with crops and other plants, competition for resources like water, nutrients, and light can affect both weed growth and crop yields. Considering how different control methods—such as herbicides, mechanical removal, and cultural practices—impact weed growth, effectiveness can vary based on the specific weed species and the applied method. The role of pests and diseases is also important in assessing the growth response of tropical weeds. Some tropical weeds can be more susceptible or resistant to specific biotic stressors. Understanding these factors can help in developing effective weed management strategies tailored to tropical environments.

Due to the scarcity of fertile soils, the developing world is increasingly cultivating edible crops on dumpsites. The dumping of waste substances has rendered most soils, intended for agricultural use, infertile or contaminated. We have adopted a series of technologies to remediate contaminated sites. The cultivation of dumpsites for arable and vegetable crops is increasing on a daily basis, particularly in

Nigeria. These actions are putting human health at high risk. However, there is a lack of information regarding the use of *T. diversifolia* and *C. odorata* as test plants on dumpsites, which is why this study was conducted.

II. Methods

The aim of this research work is to determine the physico-chemical properties of the soil of the dumpsite and assess the growth performance of the two tropical weeds cultivated on the dumpsites. The experiment took place on a 10 m × 13 m dumpsite, and the treatments were set up in a randomized complete block design. There were three treatments: T1 (Treatment 1, Seedlings of *Tithonia diversifolia*), T2 (Treatment 2, Seedlings of *Chromolaena odorata*), and T3 (control, no treatment). We replicated each of these treatments three times to create nine plots measuring 40 cm x 60 cm, with a 1 m inter- and inter-row spacing. We transplanted 36 seedlings per treatment on each plot. We randomly collected core soil samples from different locations on the experimental field, down to a depth of 15 cm. We collected the composite soil samples, air-dried them for seven days, and then sieved them through a 2 mm sieve, followed by a 0.5 mm sieve. We conducted a pre-planting soil analysis and determined the physico-chemical properties. We collected viable seedlings of both *Tithonia diversifolia* and *Chromolaena odorata* from an open field at the Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria, where there is minimal traffic, and authenticated them at the IFE Herbarium. We transplanted two seedlings per hole, leaving 36 plant stands on each plot to grow. We carried out weeding every two-week interval to minimize interference from weeds of interest. We conducted the experiment for 12 weeks, collecting growth parameters such as stem girth, number of leaves, plant height, and leaf area at two-week intervals.

We determined the stem girth by tying a rope around the plants' stems, marking them, and placing them on a measuring tape. We read the measurements from the tape and recorded them. We measured each plant's height from the base to the apex (the last leaf up) using a tape. We determined the leaf area using a de-structure method. We achieved this by plucking three leaves (the widest), placing the leaves on a millimeter graph sheet, counting the grids covered by the leaves, and calculating the mean to determine the plant's leaf area. We manually counted the leaves on each plant stand to determine the number of leaves. We carried out pre-planting and post-harvest testing of the experimental soil using laboratory procedures from the IITA (1979) manual series No 1. These include soil pH, particle size, organic carbon, exchangeable cations (Na^+, K^+, Ca^{2+}, and Mg^{2+}), total nitrogen, available phosphorus, and exchangeable acidity.

We subjected the collected data to descriptive analysis and analyses of variance (ANOVA), following the general mode procedure of the Statistical Analysis System (SAS) statistical package. Means were separated using Duncan`s Multiple Range Test ($p<0.05$).

III. Results

Soil Physico-chemical Characteristics

Table 1 presents the physical and chemical characteristics of the experiment's soil. The pH in the 1.1 soil-to-water ratio was 7.7, indicating a slightly alkaline soil condition. The organic carbon content of the soil was 35.82 kJ/kg, while the total nitrogen was 3.65 kJ/kg. The available phosphorus was 245 mg/kg. The available phosphorus was 245 mg/kg. The results for the micronutrients (manganese, iron, copper, and zinc) in mg/kg are 104, 696, 181, and 8.60, respectively. The proportion of sand (92 g/kg), silt (114 g/kg), and clay (794 g/kg) indicates that the soil textural class is clay. The selected heavy metals in the soil of the dumpsite before planting had values of 188.5, 1.85, 99.88, and 37.80 mgkg-1 for lead (Pb), cadmium (Cd), copper (Cu), and mercury (Hg), respectively.

TABLE 1: Physicochemical Properties of the Soil of the Dumpsite used in the Study

Soil Property	Value
pH (H_2O)	7.7
Organic Carbon (g kg^{-1})	35.8
Total Nitrogen (g kg^{-1})	3.65
Available Phosphorus (mg kg^{-1})	245.17
Exchangeable Acidity (cmol kg^{-1})	0.3
Calcium ($cmolkg^{-1}$)	25.45
Magnesium ($cmolkg^{-1}$)	4.14
Potassium ($cmolkg^{-1}$)	1
Sodium ($cmolkg^{-1}$)	0.32
Manganese ($mgkg^{-1}$)	104
Iron($mgkg^{-1}$)	696
Copper ($mgkg^{-1}$)	181.1
Zinc ($mgkg^{-1}$)	8.6
Sand (gkg^{-1})	92
Silt (gkg^{-1})	114
Clay (gkg^{-1})	794
Lead ($mgkg^{-1}$)	188.5
Cadmium ($mgkg^{-1}$)	1.85
Copper ($mgkg^{-1}$)	99.88
Mercury (mg kg^{-1})	37.8

Growth Parameters

The growth parameters examined for the two selected tropical weeds planted on the dumpsite are number of leaves, stem girth, leaf area, and plant height. We took these parameters to identify how the two selected weeds responded to the absorption of contaminants as their growth progressed. Figure 1 presents the results of counting the leaves of the two test weeds at two-week intervals during the 12-week post-planting (WAP) season. From 2 WAP to 10 WAP, *C. odorata* (treatment B) showed the highest number of leaves, approximately 20, 28, 36, 46, and 67, respectively, whereas at 12 WAP, *T. diversifolia* (treatment A) displayed the highest number of leaves (88). Figure 2 presented the stem girths of the two test plants. We observed that the stem of *C. odorata* had a wider girth at 2 and 10 WAP (1.3 and 2.1 cm), whereas *T. diversifolia* had a slightly wider stem girth at 4, 6, 8, and 12 WAP (1.43, 1.56, 1.73, and 2.3 cm), respectively. Figure 3 presents the height results for the two test plants. Throughout the growing period, we observed that *C. odorata* consistently outgrew *T. diversifolia*, reaching heights of 23.77, 32.22, 47.09, 63.47, 77.71, and 88.53 cm from 2WAP to 12 WAP, respectively. Figure 4 presents the leaf area results for the two test weeds. At 2 and 4 WAP (15.85, 18.42 cm2, and 15.87 and 18.80 cm^2 for *C. odorata* and *T. diversifolia*, respectively), there was little difference in the leaf areas of the two test weeds. However, at 6 to 12 WAP (20.15, 30.75, 32.13, 31.17 cm^2, and 16.22, 12.92, 15.97, and 16.67 cm^2), there was a significant difference. The leaf area of *C. odorata* exceeded that of *T. diversifolia*, and this trend continued as the weeds grew until the end of the experiment.

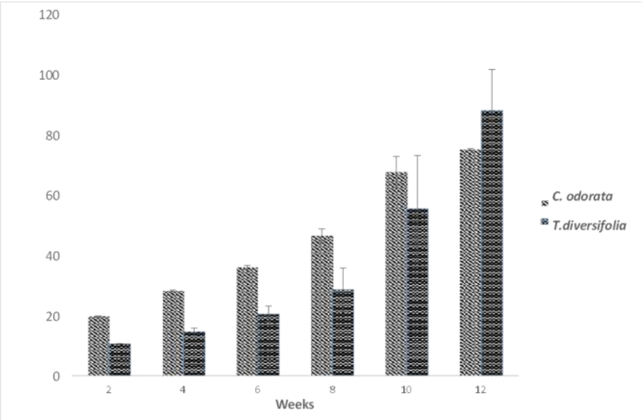

Fig. 1: Mean number of leaves of cultivated plant species studied at different dumpsite at different weeks after planting. Bars indicate standard error

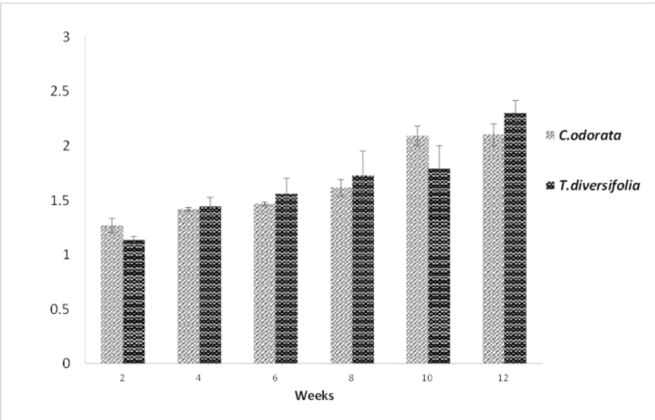

Fig. 2: Mean of cultivated plant stem girth species studied at different dumpsite at different weeks after transplanting. Bars indicate standard error

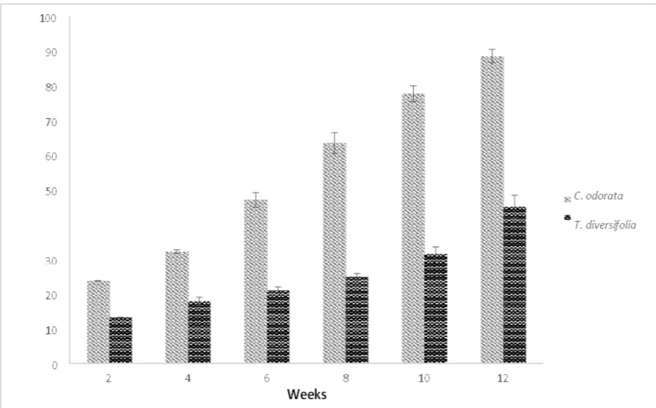

Fig. 3: Mean plant height of cultivated plant species studied at different dumpsite at different weeks after transplanting. Bars indicate standard error

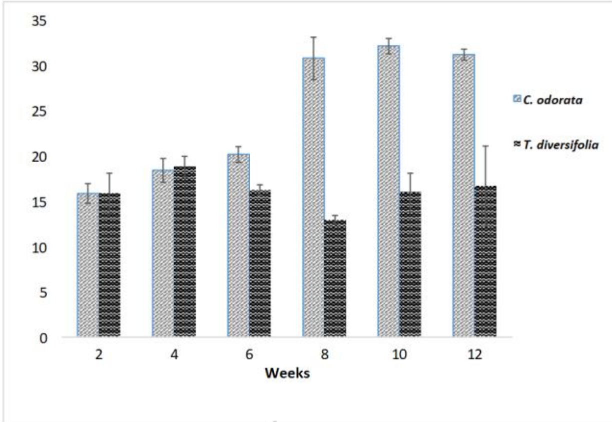

Fig. 4: Mean leaf area of cultivated plant species studied at different dumpsite at different weeks after transplanting. Bars indicate standard error

Statistical Analysis of The Growth Parameters (Plant height, Number of leaves, Stem Girth and Leaf Area)

Table 2 presents the growth parameters obtained for the two test weeds at a two-week interval. For plant height, significant differences at P<0.05 between the treatments were observed: treatment A, *T. diversifolia*, with mean heights of 13.22, 17.89, 21.02, 24.89, 31.47, and 45.15 cm. Twelve (12) weeks after planting, respectively. While treatment B with heights of 23.77, 32.22, 47.09, 63.47, 77.71, and 88.51 cm for the 12 weeks of planting respectively was observed. This indicated that the height of the weeds remained consistent throughout their growth. We observed that the stem girths of the two weeds did not significantly differ throughout the planting season. Treatment A, *T. diversifolia,* had stem girths of 1.13, 1.44, 1.56, 1.73, 1.79, and 2.3 cm for 12 weeks of planting, respectively, while treatment B, *C. odorata,* had girths of 1.27, 1.42, 1.47, 1.61, 2.10, and 2.1 cm for 12 weeks of planting, respectively. Within the first six weeks of planting the test weeds, we observed no significant difference in the leaf area between treatment B and treatment A. Treatment B had a mean leaf area of 15.85, 18.42, and 20.15 cm^2, while treatment A had 15.84, 18.82, and 16.23 cm^2. However, at the 8th and 10th weeks, we observed a significant difference in their leaf areas, with treatment B having 30.75 and 32.12 cm^2 and treatment A having 12.92 and 15.97 cm^2, respectively.

TABLE 2: Mean Growth Parameters of the two treatments in weeks after planting

Growth Parameters	Treatment	Weeks after Planting					
		2	4	6	8	10	12
Mean Plant Height (cm)	A	13.22^b	17.89^b	21.02^b	24.89^b	31.74^b	45.15^b
	B	23.77^a	32.22^a	47.09^a	63.47^a	77.71^a	88.53^a
Mean Stem Girth (cm)	A	1.13^a	1.44^a	1.56^a	1.73^a	1.79^a	2.30^a
	B	1.27^a	1.42^a	1.47^a	1.61^a	2.09^a	2.10^a
Mean Leaf Area (cm^2)	A	15.84^a	18.82^a	16.23^a	12.92^b	15.97^b	16.67^a
	B	15.85^a	18.43^a	20.15^a	30.75^a	32.12^a	31.17^a
Mean number of leaves	A	10.56^b	14.53^b	20.39^b	28.49^a	55.30^a	87.93^a
	B	19.67^a	28.14^a	35.91^a	46.37^a	67.49^a	79.97^a

Mean value with same superscript are not significantly (p<0.05) different from each other.
Legend: Treatment A: *Chromolaena odorata* ; Treatment B: *Tithonia diversifolia*

For the first 6 weeks of planting, there was a significant difference in the number of leaves between the two plants.

Treatment B, C. odorata, had 19.67, 28.14, and 35.91 mean number of leaves, while treatment A, T. diversifolia, had 10.56, 14.53, and 20.39 mean number of leaves. However, from week 8 to week 12, there was no significant difference, with treatment B having 46.37, 67.49, 74.97 mean number of leaves, and treatment A having 28.49, 55.30, and 87.93 mean number of leaves, respectively.

IV. Discussion

Municipal waste collection sites such as open dumpsites are usually characterized by different compositions; consequently, their physicochemical compositions could vary (Osim et al., 2020). The pH values of the study location were moderately alkaline. This finding is in agreement with independent studies in dumpsites by Eze et al. (2021) and Osim et al. (2020) in Abia/Imo and Bayelsa, respectively. High concentrations of basic cations could be the cause of the dumpsite's alkalinity. Furthermore, Harirchi et al. (2022) suggest that the reason for the alkalinity could be the reduction in free volatile acid concentrations caused by anaerobic decompositions, as well as the accumulation of minerals from waste on the dumpsite. Al-Yaqout and Hamoda (2020) reported that the alkalinity of soil is peculiar to landfills even after 10 years of continuous disposal, which also resonates with pH observations from the study site. However, findings on pH in this study were slightly different from the reports from Obianefo et al. (2016), where the pH of soil around dumpsites in their study ranged between moderately acidic and slightly above neutral. According to Nyiramigisha & Sajidan's 2021 report, most soils within the pH range of 6.0–9.0 contain metals that are not always in their free form, making them less likely to be bioavailable.

Soil organic carbon; its quantity and quality are reliable assessments of soil fertility, a measure of the extent of nutrient depletion (Aleminew & Alemayehu, 2020), as well as the usefulness of soil for agricultural purposes. Typically, we use the quantity of organic matter in the soil as an indicator of the soil system's potential sustainability (Gerke, 2022). There was no significant difference in organic carbon among the pre-harvest soil samples. According to Kooch et al. (2020) and Sofo et al. (2022), the removal of biomass or biota for agricultural purposes leads to a decrease in soil biota, which in turn affects soil organic matter and soil fertility. Researchers have found that solid waste dumpsites are rich in organic matter, which serves as the primary source of nitrogen and phosphorus content, thereby enhancing soil fertility and fostering plant growth (Hiranmai et al., 2024). The high levels of organic matter may be attributed to the composition of the wastes, primarily derived from agricultural and farmyard sources. Also, the activities of soil organisms in the decomposition of these wastes may have accounted for the rich nutrient contents of the soil (Prasad et al., 2021). The critical value of soil organic matter for tropical soil is between 15-20 gkg-1 (Feller et al., 2020). In this study, the organic matter content slightly exceeds the critical values provided by Feller et al. (2020), but it still falls within the range of 30 g kg-1 for tropical soils according to FAO standards, with the exception of the pre-planting soil, which has significantly higher organic matter content. The high organic matter of the soil before planting may be a result of the decomposition of materials over a long time. A high content of organic matter favors increases in moisture content, water holding capacity, and permeability (Seyedsadr et al., 2022). The organic matter content depends on a number of factors, such as the level of microbial activity and proportion of organic refuse on the dumpsite.

The soil of the dumpsite had a clayey texture both before and after planting. Frequent erosion on the sloppy dumpsite land, which frequently removes loose sand particles from the soil surface, may have contributed to the higher level of clay. The soils from the dumpsites consisted of high clay fractions; thus, they exhibit plasticity and encourage surface water flooding and erosion. This clayey texture of the soils also favors low permeability of water and leachates (Yonli et al., 2022). This textural class result aligned with that of organic matter, as soils with a high clay content typically have higher levels of organic matter. (Islam et al., 2022).

We found that the test weeds performed better in terms of height, number of leaves, leaf area, and stem girth as the planting period increased. The study's findings demonstrated that an increase in the plants' planting period boosted the test's growth parameters and metal accumulation capabilities, exhibiting a consistent upward trend. These findings align with those reported by Abiloro et al. (2020). As plants reach the maturity stage, they tend to have higher capability for metal absorption. The overall results showed that *C. odorata* grew faster in almost all of the growth parameters that were looked at. The only ones that favored *T. diversifolia* were the number of leaves and the girth of the stems at the height of the growing season. This was also supported by statistical analyses, which showed significant differences at $p<0.05$. The differences in their growth performance may be due to some unfavorable external and atmospheric factors that affected T. diversifolia, such as the absence of rainfall during the growing period, which can affect the solubility and availability of nutrients for the weeds; excessive sunlight and very harsh weather conditions; and frequent burning and grazing by cattle. *C. odorata* outperformed *T. diversifolia* in terms of growth performance.

We also found that *T. diversifolia* germinated scantly during the growing period, indicating the need to extend the harvesting period. On the contrary, a higher number of leaves was also recorded in *T. diversifolia* at 12 weeks after planting with a mean value that was not significantly different from that of *C. odorata* at $p<0.05$.

V. Conclusion

Open dumpsites are common occurrences in several developing countries, including Nigeria. Activities within the surrounding environment can influence the heterogeneous chemical and physical properties of soil, even within the same vicinity. Municipal waste collection sites, such as open dumpsites, are usually characterized by different compositions; consequently, their physical and chemical compositions could vary.

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The study specifically selected *Chromolaena odorata* (siam weed) and *Tithonia diversifolia* (Mexican sunflower) for their invasiveness, survival in extreme harsh conditions in almost all soils, and seemingly non-vegetative use in the Nigerian environment. These plants showed a remarkable increase in the growth parameters examined, with *C. odorata* showing a greater increase, likely due to the higher pH and clay contents of the soil.

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