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Effect of Dye and Drainage Waste Water on Growth of Some *Amaranthus Species* in Gashua, Yobe State.

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ABSTRACT

The textile industry plays a significant role in the economic development of African countries, including Nigeria. With its major contribution to the source of employment, foreign exchange earnings, and industrial output, hence considered a crucial component of the national economy. However, the growth of the textile industry has been accompanied by environmental challenges, precisely the management of wastewater generated during textile manufacturing processes. The arid and semi-arid zone of Nigeria, where irrigation practices are widely adopted, faces the most serious ecological and environmental problems arising from a shortage of water (drought) and many more, this study intend to use waste water from local textile industries and other places to test its effect on growth of some varieties of plants to ensure recycling and practice of zero waste. The experiment was carried out at the Department of Biological Science, Botanical Garden, Federal University Gashua, located at latitude 12°52'5" N and Longitude 11°2'47" E, Yobe State, Nigeria, to evaluate the effect of textile dye waste and drainage water on the growth of some Amaranthus species. The experiment was laid out in a completely randomized block design with two treatments and replicated three 3 times. Three (3) varieties of Amaranthus spp. were used: Amaranthus caudatus, Amaranthus tricolor and one Local check, Amaranthus doguwa. Varieties were screened using plastic pots. The parameters evaluated were: vegetative, physiological and growth. Finding reveals that a higher concentration of dye waste with a pH of 10.93 significantly inhibited growth, causing stunted development. The result of different concentrations of dye waste and drainage water on the growth parameters of plants, i. e plant height, number of leaves, and stem diameter across the weeks, shows that Amaranthus caudatus spp. has the highest plant height, Amaranthus caudatus produces the highest number of leaves, 10, while tricolor spp has the lowest number of leaves with 6. In stem diameter, Amaranthus Caudatus has the highest stem diameter of 1.2cm of while tricolor has the stem diameter of 0.6cm. The germination success of Amaranthus species indicated that Amaranthus caudatus has the highest percentage of 66% while Local check Amaranthus spp (Doguwa) has the lowest percentage of 53%. These findings highlight the need for proper waste management practices and water quality monitoring to safeguard crop production and food security in the area.

Keywords: Dye waste, Drainage waste, Drought, Recycling, and Zero Waste**.**

INTRODUCTION

Amaranthus species, commonly known as amaranths or pigweeds, are a group of plants cultivated for their fresh edible leaves and grains. These plants are valued for their nutritional content, adaptability to various environmental conditions, and relatively high tolerance to stress factors such as drought and poor soil quality (Akinola et al., 2020). In regions where agricultural land is limited or degraded due to industrial activities, amaranths offer a viable option for food production and soil remediation. However, the growth and productivity of amaranth plants can be adversely affected by several factors of environmental pollutants, ranging from those present in wastewater and industrial sources. Studies investigating the impact of industrial pollution on crops have reported reduced growth, yield losses, and physiological disorders in plants exposed to contaminated water and soil (Adekiya et al., 2018). Therefore, understanding the effects of dye waste and drainage water from textile industries on the growth of amaranths in Gashua, Yobe State, is crucial for assessing the risks to agricultural productivity and food security in the region.

The textile industry plays a crucial role in the economic development of many countries, including Nigeria. With its significant contribution to employment generation, foreign exchange earnings, and industrial output, the sector is considered a vital component of the national economy (Onuoha, 2020). However, the growth of the textile industry has been accompanied by environmental challenges, particularly concerning the management of wastewater generated during textile manufacturing processes.

Textile manufacturing involves various stages, including dyeing, printing, and finishing, all of which require substantial amounts of water. According to estimates, the textile industry is one of the largest consumers of water globally, with an average water consumption of 100-150 liters per kilogram of textile produced (UNIDO, 2018). Along with water, the industry also consumes a wide range of chemicals, including dyes, detergents, and auxiliary agents, many of which end up in wastewater effluents discharged into water bodies (Nasir et al., 2021).

One of the most significant pollutants in textile wastewater is synthetic dyes. These dyes impart color to textiles but can pose serious environmental hazards if not properly managed. Synthetic dyes are complex organic compounds that are often resistant to degradation, making them persistent in the environment (Singh et al., 2019). When textile wastewater containing these dyes is discharged into water bodies without adequate treatment, it can lead to water pollution, affecting aquatic ecosystems and posing risks to human health (Okonkwo et al., 2019).

Nigeria, like many other developing countries, faces challenges related to the management of industrial wastewater, including textile effluents. The textile industry in Nigeria is concentrated in certain regions, such as Lagos, Kano, and Kaduna, where textile manufacturing clusters have emerged over the years (Nweze et al., 2018). However, the environmental impacts of textile industry activities, particularly concerning wastewater pollution, extend beyond these industrial clusters, affecting water resources and agricultural lands downstream (Singh et al., 2019).

Gashua, a town located in Yobe State, Nigeria, is home to several textile industries that discharge their effluents into nearby water bodies, including rivers and streams. The indiscriminate discharge of untreated wastewater containing dye residues and other pollutants raises concerns about the environmental and public health implications in the region. Studies conducted in similar settings have documented elevated levels of heavy metals, organic pollutants, and other contaminants in soil and water samples collected near textile industrial areas (Okonkwo et al., 2019).

MATERIALS AND METHODS

Study Area

This study was conducted in the Department of Biological Sciences Biological Garden, which is located in the Central Laboratory Complex of Federal University Gashua, Yobe State, Nigeria. Gashua is located in the northern part of Nigeria, with geographical coordinates of 12°52'5" N and 11°2'47" E, with an average elevation of about 299 mm above the sea level (Saleh and Ahmed, 2019; Yuguda et al., 2020). The area experiences a semi-arid climate characterized by high temperatures and low rainfall. The study site was selected based on its significant presence of dyeing industries and accessibility for research purposes.

Sample Collection and Preparation

Dyeing waste and drainage water samples were collected from AISARA (Local Dyeing Industry) located at Sabon Gari Ward, Opposite Mass Transit, while the drainage water was collected at Gashua's largest gutter channel located at Katuzu ward toward the river Katuzu, Bade Local Government, Gashua, Yobe State. Samples were collected in clean, sterilized containers to prevent contamination. Care was taken in collecting representative samples from different sources to ensure the reliability of the analysis.

Before analysis, the collected samples were transported to the laboratory in coolers to maintain their integrity. Upon arrival at the laboratory, samples were stored at appropriate temperatures and subjected to preliminary analysis within 24 hours of collection.

Seeds of the Amaranthus species were obtained from the Bauchi State Agricultural Development Programme (BSADP) and subjected to surface sterilization to remove any external contaminants. The seeds were then germinated in petri dishes lined with filter paper moistened with distilled water, as the control, dyeing waste, and drainage water samples.

Treatment combination

A pot experiment was conducted to evaluate the effect of dyeing waste and drainage water on the growth and yield parameters of Amaranthus species. Plastic pots filled with a soil ratio of 2:1 of Sandy loam soil were used for the experiment.

15 seeds of the Amaranthus species were sown in the plastic rubber pots of 18cm length, and treatments were applied using different concentrations of dyeing waste, drainage water, and control (distilled water). The pots were arranged in a completely randomized design (CRD) with three replicates per treatment. The local dyeing wastewater was mixed with soil at four ratios (0, 0.5, 1, and 1.5 liters) with 500g of soil, respectively, and each pot was loaded with an equal percentage of soil/wastewater mixture. The 0% wastewater containing pot, i.e. pot filled with only soil, was used as a positive control to compare the impact of different ratios of wastewater on the growth of amaranthus. For irrigation, an equal volume of freshwater was applied twice to each pot in the morning and late evening. Under these controlled conditions, plants were grown for 42 days until their harvest. During this period, no additional wastewater was applied. After 42 days, the plants were harvested carefully and taken to the laboratory for further analysis.

DATA COLLECTION

Germination success for different Amaranthus species was counted and recorded using a relationship: x 100

Germination was monitored daily until no further germination was observed.

Plant height at maturity (cm)

Plant heights were measured for each variety every week with the help of a measuring tape, and the height was recorded.

Leaf number

The number of leaves was counted every week and recorded accordingly.

Stem diameter (cm)

The diameters of the stems were measured using thick sewing thread and a meter rule. The average values were recorded accordingly.

Statistical Analysis

Data obtained from the experiments were subjected to analysis of variance

(ANOVA) using appropriate statistical software. Mean separation was done using Duncan's multiple range test at $p < 0.05$. Results were presented as means ± standard error of the mean (SEM) or standard deviation (SD) as applicable.

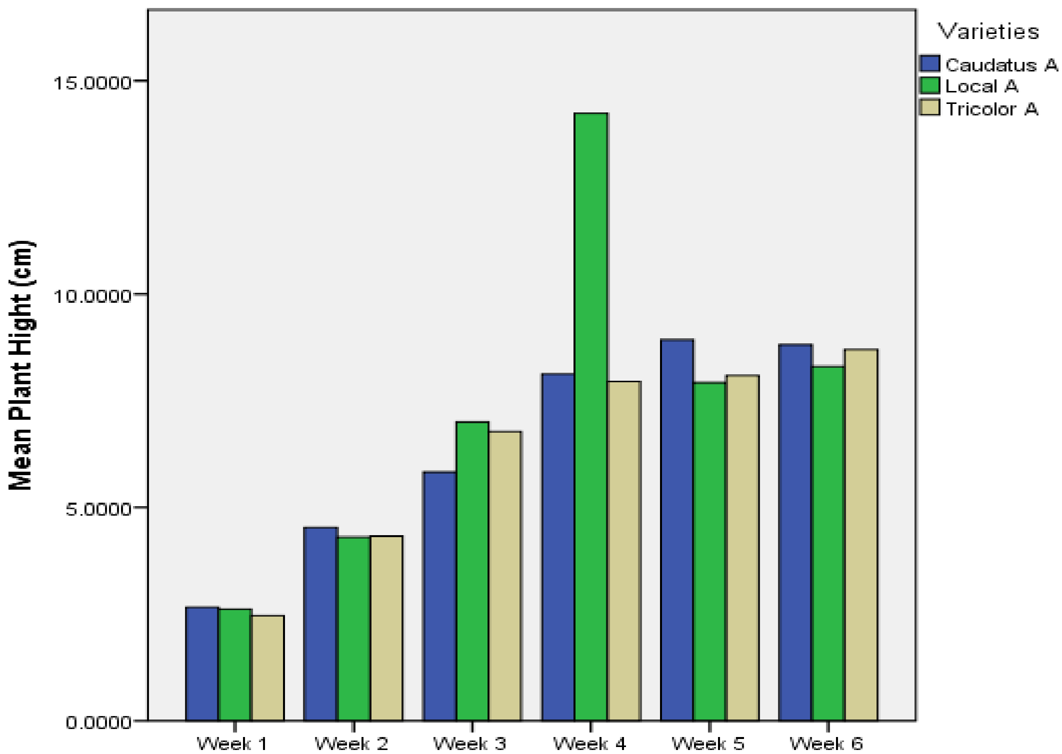
RESULT

The result of the physicochemical properties of dye waste and drainage water was presented in Table 1: about eight different parameters were measured. The result indicated that high pH was 10. 93 in dye waste, which is highly alkaline and 6.15 in drainage water, which is mildly acidic in nature. The water temperature was 28 °C in the drainage water and 27 °C in the dye waste. The salinity was 8330ppm in dye waste and 119ppm in drainage water. Dissolved oxygen level was 8.20ppm in drainage water and 5.30ppm in dye waste. The electrical conductivity was 239cm in drainage water and 5.05cm in dye waste. Biochemical dissolved phosphate (PO4) was 2.0ppm in drainage water and 0.18ppm in dye waste. Nitrate was not detected, and the chlorine was 35.5ppm in drainage water and 4.5ppm in dye waste.

Germination Success of Amaranthus species

The result of the germination success of Amaranthus species was presented in Table 2. below were counted and recorded. The result indicated that Caudatus amaranthus has the highest percentage of seed germination with 66% while the Local amaranthus has the lowest seed germination with 53%. The result of the effect of plant height in (cm) was presented in Figure 1, indicating that at week 1, Caudatus A. recorded the highest height of 3cm, while Tricolor A. had the lowest of 2.6cm. In week 2, Caudatus A. has the highest height of 4.8cm, while Local A. has the lowest of 4.6cm. In week 3, Local A. has the highest height of 7.5cm, while Caudatus A. has the lowest of 6cm. In week 4, Local A. has the highest height of 14.8cm, while Tricolor A. has the lowest of 7cm. In week 5, Caudatus A. has the highest height of 8.7cm, while Local A. has the lowest of 7cm. In week 6, Caudatus A. has the highest height of 8.6cm, while Local A. has the lowest of 7.3cm.

Figure 1: Effect of Plant Height (cm) on growth of some *Amaranthus species* under two different treatment (drainage and dyeing waste water)



The result of the effect of the number of leaves on the growth of Amaranthus species is presented in Figure 2: below. The result indicated that in week 1, Amarantus caudatus has the highest number of leaves recorded, with 3 different leaves, while Local A. has the lowest leaf number of 2. In week 2, Local A. has the highest number of 4 leaves, while Tricolor has the lowest number of 3 leaves. In week 3, Local A. has the highest number of 6 leaves, while Caudatus A. has the lowest number of 4 leaves. In week 4, Local A. has the highest number of 7 leaves, while Caudatus A. has the lowest number of 6 leaves. In week 6, Tricolor has the highest number of 6 leaves, while Caudatus A. has the lowest number of 5 leaves

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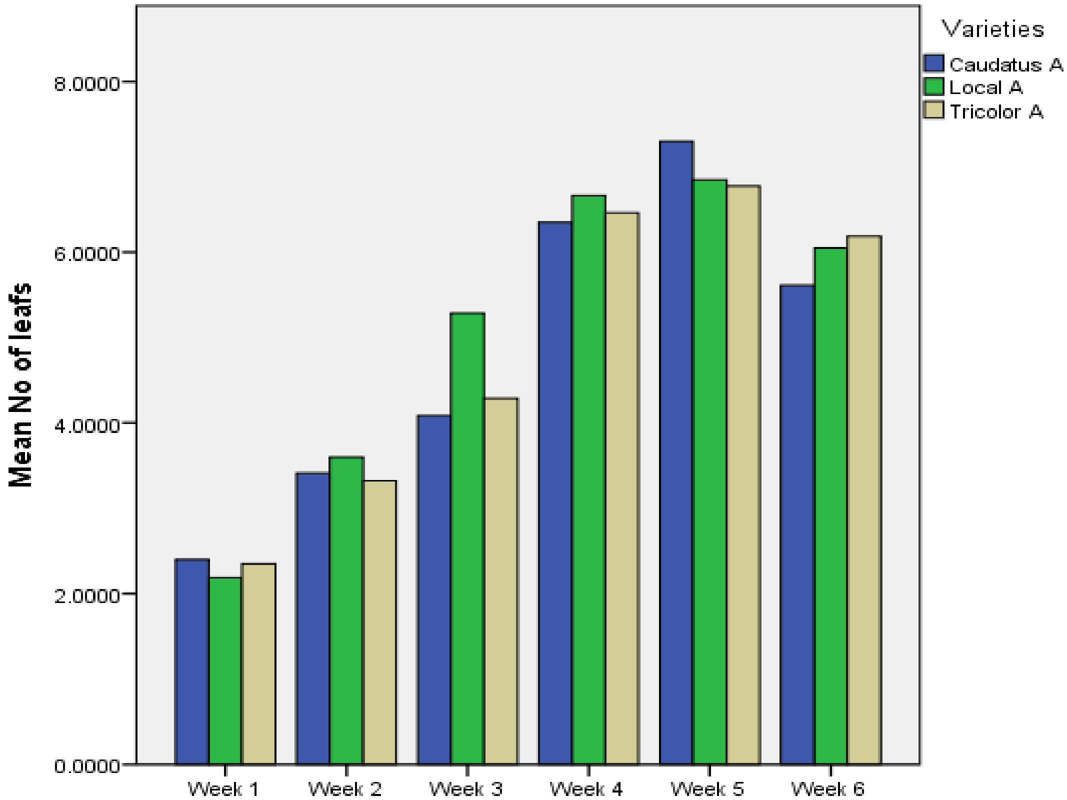
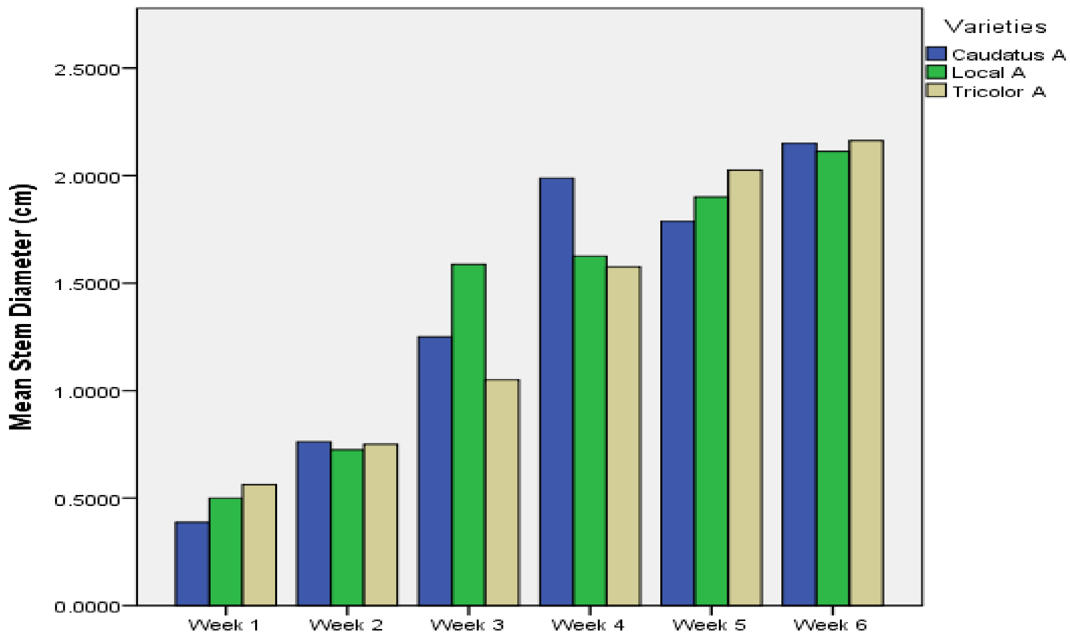
Figure 4.4: Effect of Plant Leaf Number on growth of some *Amaranthus species* under two different treatment (drainage and dyeing waste water)



The result of the effect of stem diameter on the growth of Amaranthus species was presented in Figure 4.5 above. The result shows that in week 1, Tricolor A. has the highest stem diameter of 0.6cm, while Caudatus A. has the lowest of 0.4cm. In week 2, Caudatus A. has the highest of 0.8cm while Local A. has the lowest of 0.7cm. In week 3, local A. has the highest of 1.3cm while Tricolor A. has the lowest of 1.0cm. In week 4, Caudatus A. has the highest of 2.0cm while Tricolor A. has the lowest of 1.5cm. In week 5, Tricolor A. has the highest of 2.0cm, while Caudatus A. has the lowest of 1.7cm. In week 6, Caudatus A. and Tricolor A have the same increase of 2.3cm while Local A has the lowest of 2.1c cm

Figure 4.5: Effect of Plant Stem Diameter (Cm) on growth of some *Amaranthus species* under two different treatment (drainage and dyeing waste water



A one-way Analysis of variance (a one-way ANOVA) was conducted to compare the effect of dyeing water and drainage water on the growth and development of Amaranthus species. There's a significant difference at $p<0.05$ in the plant height, number of leaves, and the development of stem diameter with $F(119,24) = 1.781$, $P = 0.025$, $F(119,24) = 11.787$, $P = 0.000$, and $F(79,64) = 6.859$, $P = 0.000$, respectively

DISCUSSION

The effect of dye waste and drainage water on the growth of Amaranthus species was studied using growth parameters such as height, number of leaves and stem diameter. The result of different concentrations in weeks 1 to 6 on the height of Amaranthus plant (Figure 4.3) indicated that Caudatus Amaranthus had a better height because there was no stress from wastewater. This agrees with the earlier work done by Murtaza et al. (2019), use of saline-sodic water for sustainable irrigation and is different from the work earlier done by Akbar et al. (2007) effect of marble industry effluence on seed germination. The number of leaves per plant is one of the good parameters for indicating the successful growth of a plant or not. Here, the result shows that the Local Amaranthus has the highest number of leaves across the weeks. This study agrees with the work of Adegbile et al. (2021), who work on the impact of heavy metals on soil and Amaranthus species growth in contaminated soil and is different from the work done by Judd et al. (2008), who work on plant systematics. Stem diameter also indicates the growth performance of the plant. The result of the study indicated that there is a significant increase in stem diameter across the week, where Caudatus and Tricolor Amaranthus had a better increase in stem diameter than the Local Amaranthus, which agrees with the finding of Sairam et al. (2002). Differential response of wheat genotype to long-term salinity stress in relation to oxidative stress, which is different from the work in Singh et al. (2015), who work on toxicity assessment of textile industry effluent and its possible bioremediation options. Further, the lack of nitrate detection in both water sources could suggest limited nitrogen availability, which is essential for plant growth, particularly leaf development (Sharma et al., 2016). However, the better growth performance of Amaranthus species under drainage water irrigation, despite the absence of nitrates, highlights the relative importance of other factors like salinity, pH, and dissolved oxygen in determining plant growth outcome. These findings suggest that high levels of salinity and alkaline pH in dye wastewater are primary growth inhibitors, corroborating the work of Singh et al. (2015), who also reported reduced growth in plants irrigated with effluent from the textile industry due to elevated salinity and pH levels. Therefore, while drainage water offers more favorable conditions for the growth of Amaranthus species, the dye wastewater hinders growth due to its adverse chemical composition

Plate 1: Different of Amaranthus Spp before sowing.

CONCLUSION

The study indicated that the Amaranthus plant in the nursery stage demonstrated a growth pattern that is potentially related to the number of weeks it was planted; this was the same for height, number of leaves, and stem diameter. The controls for both the number of leaves, height, and stem diameter were uncharacteristically higher than those with dyeing wastewater applied. This probably could be due to the limited number of weeks sampled (six weeks) for this study, and the concentration of some physicochemical parameters in the dyeing wastewater that are above the maximum permitted or allowable limits, which can hinder the development of plants. However, there was no significant statistical variation observed in growth performance in terms of height, number of leaves, and stem diameter of the remaining treatments that had concentrations of dyeing waste water.

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Table 1: Physicochemical properties of Dye waste and Drainage water

	DYE WASTE WATER		DRAINAGE WATER
S/N	**PARAMETER**	**RESULT**	**RESULT**
1	P.H	10.93	6.15
2	Temperature	27	28
3	Salinity	8330ppm	119ppm
4	Dissolved Oxygen	5.30ppm	8.20ppm
5	Electrical Conductivity	5.05cm	339cm
6	Biochemical Dissolved Phosphate (PO_4)	0.18 ppm	2.20ppm
7	Nitrate	Not Detected	Note Detected
8	Chlorine	4.5ppm	35.5ppm

Table 2: Germination Success of *Amaranthus species*

Varieties	Week 1	Week 2	Week 3	Total % of Germination
Caudatus *Amaranthus*	10	10	10	66%
Tricolor *Amarathus*	10	9	8	60%
Local *Amaranthus*	8	9	8	53%