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Differential tolerance of spinach (*Spinaceae olearacae* L.) cultivars to waste water

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ABSTRACT

The differential tolerance of Spinach (*Spinaceae olearecea* L) cultivars was examined for a period of five weeks (April-June) using different concentrations of waste water - majorly washed plate residues, collected from food vendors and restaurants within Keffi Metropolis of Nasarawa State. The parameters examined included the height and numbers of sprouted leaves of the cultivars after treatment with series of waste water Concentrations (WWC) (10%, 50%, and 100%), obtained as a percentage of the waste water diluted in a given volume of clean water. A Randomized Complete Block Design (RCDB) technique was used to set the experiment. Analysis of the results showed that waste water has some effects on the growth and development of Spinach Cultivars. This was shown by a mean coefficient of three percent (3%) increase in height from sixty five percent (65%) to sixty eight percent (68%) on days ten and twenty one respectively. Similarly the analysis of the sprouted leaves was found to be highly significant with an F. calculated value of 8.56 as against 3.38 value of the F. Tabulated at 5% d. f. The calculations on the Least Significant Difference (LSD) to deduce which treatment had a major influence over the others had the treatment designated M_2 showing very high superiority over M_1, followed by J_1 and P_1 respectively. Varying growth, small leaf size, yellowing of leaves and poor performance on cultivars were observed mostly in plots treated with higher concentrations of waste water. It is however necessary to imbibe the culture of waste water management for irrigation through appropriate guidelines and legislations by individuals, homes, communities and industrialist

Key words: Tolerance, Spinach, Waste Water, Management.

INTRODUCTION

Spinach (*Spinacea Olearacea L*) is a wide range of leafy vegetables, whose origin is traced to Iran and currently distributed through out temperate world (Russel, 1988). Spinach is commonly called Amaranthus and includes such species as *Amarantus hybridus, Amarantus cruentus,* and *Amarantus Viridus.* Like in every other plant, the cultivars require sufficient water for growth so as to maintain balance, resilience and to attain turgidity. Hence about 70% of the tissue contains water (Kelvin & lewis, 1995).

However as essential as water is, its supply is a peculiar problem not only in the developing countries but in the advanced world, thereby resulting in serious looming water supply crisis which often necessitates the use of waste water by most homes to irrigate spinach gardens (Daniel, 1980).

Waste water originates from domestic, Industrial and Meteorological waste sources. It is formed from industrial pollution and unwanted materials or substances which are discharged into the environment. (Niel and Galloway, 1991) Domestic waste water is however obtained from the day to day activities of people such as washing plates, cloths, house keeping and other forms, averaging about sixty gallons per day or more in congested Metropolitan areas (Daniel, 1980), and contains detergents, sulphates, and oil (Eniayeju *et al.,* 1983).

These discharges disallow proper percolation and infiltration into the soil, resulting in the accumulation of toxic materials and high salinity (Niel and Galloway, 1991). The disposition of waste water could therefore affect both terrestrial and wetland ecosystem, by constituting a major cause of environmental pollutants that could impede the growth and population of some Plants (Crook *et al.,* 1987).

Amaranthus can be grown during wet and dry seasons. In dry season cropping, the practice of irrigation is normally required to replenish the fairly high rate of transpiration by the leaves, taking into cognizance the stages of growth of the crop and the moisture retaining capacity of the soil (Tindal, 1986).

Soil with high organic content and adequate mineral reserve is necessary for optimum yield. However, some species of plants are tolerant to fairly wide range of soil conditions, ranging from a pH of between 5.5 - 7.5(even though some species can tolerate more alkaline conditions) and a relatively high temperature range of 22- 30^{oc} (Kelvin *et al.,* 1995).

The effect of waste water on soil invariably affects the growth and development of plants, for instance Odeigah *et al.,* (1998) posited that Oil concentration in the soil tends to block the pores completely from air, thereby reducing percolation and infiltration. In addition, high salt concentration in saline soil prevents the absorption of adequate moisture and nutrient element by plants, just as excessive amount of calcium carbonate reduces the availability of phosphorus uptake due to the formation of relatively insoluble calcium phosphate (Daniel, 1980). Salt produced alkaline soil, are harmful to plant tissues as a result of the formation of Sodium Hydroxide. Sodium inhibits the absorption of Calcium and Magnesium by plant roots, while Sodium ions disperse the soil and consequently reduces drainage aeration and water movement (Kelvin *et al.,* 1995).

Foth and Tork (1972) concisely described high concentration of neutral salt (Sodium Chloride and Sodium Sulphate) as detrimental to plants, as it may interfere with the absorption of water through the development of high osmotic pressure capable of raising the wilting coefficient of the soil, thereby reducing the availability of water needed by the plants. According to Parrand *et al.,* (1978) high salinity affects plant growth either osmotic ally by direct toxicity or by creating nutrient imbalance. Similarly, Pezeshki *et al.,* (1987), observed that a common grass in fresh water marshes, *penicum homitomen* for example will die within four days after exposure to 10 parts per thousand (ppt) salinity. Earlier, Pezeshki *et al., (*1986), found that baldcypress *Taxodium distichum* seedling can tolerate and recover from short-term exposure to salinity less than 3 ppt, they maintained that above that level, they cannot acclimate and will ultimately die from reduced photosynthesis and metabolic stress and that a slight increase in salinity can cause leafy injury and root damage to bald seedling.

However, De Beer *et al.,* (1985), see wastewater as beneficial constituent, as their reclamation would not only conserve potable water supplies, but will help to protect the quality of the environment, enhance plant growth and development. Agriculturally, however, the use of wastewater includes; water conservation, ease of disposal, nutrient utilization and avoidance of surface water pollution (Buwer and Chaney , 1974) This work is therefore aimed at assessing the tolerance rate of Spinach *Spinacea Olearacea* L cultivar to waste water and to extrapolate the effect on growth and development of the plant.

Methodology

Materials

Soil Media, seed boxes, clean water, spinach seeds, plastic containers, 1000cm^3 graduated measuring cylinder, watering can, plastic plates (for dilution), Hoe, meter rule, pen and exercise book.

Assay procedure

Produced waste water was collected from

Table 1: Analysis of Variance of the heights of the cultivars on day 10

Variation	DF	SS	MS	F.CAL	F.TAB 5%	0.1%
Treatment	3	2.55	0.085	0.086	3.86	2.81
Block	3	1.14	0.38	0.038		
Error	9	89.09	9.89			
Total	15	92.78				

Table 2: Analysis of Variance of the heights of the cultivars on day 21

Variation	DF	SS	MS	F.CAL	F.TAB 5%	0.1%
Treatment	3	6.38	2.13	0.084	3.86	2.81
Block	3	2.41	0.80	0.032		
Error	9	227.24	25.25			
Total	15	236.03				

Table 3: Mean values of height of cultivars and percentage of the coefficient of variation for the 10th & 21st day

Treatment	10TH Day(cm)	21ST Day (cm)
J_1	4.35	6.88
P_1	4.98	5.17
M_1	5.43	7.15
M_2	4.65	8.45
	CV = 65%	CV = 68%

Restaurants in Keffi Metropolis. The effluents were residues collected on daily basis from washed plates after meals, and stored in plastic containers under room temperature pending when used. The effluent was diluted with clean water to produce the series of concentrations of solutions (10%, 50%, 100% and undiluted aliquot) to be investigated. The various concentrations were obtained by diluting known volumes of the effluent in a given volume of water (Odeigah *et al.,* 1998).

Table 4: The Analysis of variance of the spouted leaves on the 10th day

Variation	DF	SS	MS	F.CAL	F.TAB 0.05%	0.10%
Treatment	3	0.25	0.083	0.036	3.86	2.81
Block	3	0.25	0.083	0.066		
Error	9	20.70	2.30			
Total	15	21.20				

Table 4: The Analysis of variance of the spouted leaves on the 21st day

Variation	DF	SS	MS	F.CAL	F.TAB 0.05%	0.10%
Treatment	3	461.12	153.71	8.56	3.86	2.81
Block	3	451.51	151.00	8.41		
Error	9	161.58	17.95			
Total	15	1074.22				

Table 6: The Mean values of the sprouted leaves and the coefficient of variation on the 10th day

Treatment	10^{th} Day(cm)
J_1	3.80
P_1	3.70
M_1	3.50
M_2	3.70

Application of test effluent

Four square wooden boxes measuring 10cm × 17cm in length and 10cm depth were constructed and used as seed trays. The seed trays numbering sixteen were arranged in four treatments, numbered I-IV and labeled J_1, P_1, M_1 and M_2 as in Figure 1. A tent was constructed with white transparent Polythene in place of a green house to prevent splashing and interference by rain water and other variables. A Randomization Complete Block Design (RCBD) method was used. The method involves dividing the experimental boxes into blocks and treatment. Each replicate (in the treatment) was treated with various concentration of waste water and planted with equal quantity of spinach seed. The following percentages of aliquot were used. J_1 = 10%, P_1 = 50%, M_1 = Clean water (control) M_2 = 100% (undiluted aliquot).

The replicates in each treatment were located or arranged randomly and labeled with the percentage of the effluent used. This was aimed at minimizing avoidable errors during application of the aliquot as above.

Data collection

The following parameters were used to obtain information during the collection of data in the experimental site.

Plant height (cm)

After 10 days of planting, the seedling height was measured with a meter rule. Five plants were sampled randomly in each box and their average heights recorded.

Number of leaves

Five plants were randomly sampled and the leaves counted. The average number of leaves of each plant was recorded.

Data analysis

The results were subjected to Analysis of Variance (ANOVA) to determine whether the differences were statistically significant. On this note:-

Tables 1-6 show the tolerance ability and the relationship of the spinach cultivars to waste

(i)		(ii)		(iii)		(iv)	
J1	10 %	P1	50%	M1	0%	M2	100%
M2	100%	M1	0%	P1	50%	J1	10%
M1	0%	J1	10%	M2	100 %	P1	50%
P1	50%	M2	100%	J1	10%	M1	0%

Fig. 1.

Water. While Figures 2A-D show observed Morphological Variations owing to treatment with the various concentrations of waste water

The result of the height of cultivars obtained on the 10th day showed no significant growth index (GI) in height owing to an F.cal value of 0.086 and 0.084 on the tenth and twenty first days respectively, when compared with the F.tab value of 3.86 at 5% degree of freedom (Table 1&2). However the mean coefficient value of the height measured in centimeters (Table 3) indicates a three percent (3%) increase from sixty five percent (65%) on the tenth day to sixty eight percent (68%) on the twenty first day.

Pictures from addendum to be inserted here

The analysis of the results on the size and numbers of sprouted leaves and the coefficient of variation as shown above, indicates that the numbers of sprouted leaves is insignificant with an F. calculated value of 0.036 compared to F. tabulated value of 3.86 at 5% degree of freedom, and a forty one (41%) percent coefficient of variation on the tenth day.

However on the twenty first (21st) day, a high significant statistical inference was drawn with a greater F. Calculated value of 8.56 over the F. Tabulated value of 3.86 at 5% degree of freedom. Owing to this significance, the Least Significant Difference (LSD) of the sprouted leaves was calculated on the twenty first day to ascertain the treatment that had greater superiority. Analysis of the results (LSD) therefore showed that M_2 treatments topped the ranking with a greater superiority over M_1. This was followed by J_1 and P_1 in that order.

DISCUSSION

Whereas the height of a plant enhances adequate exposure of the leaves to light for food synthesis, the retarded growth tendency as observed in this work could lead to reduced photosynthetic potentials of the cultivars and possibly an abrupt significant decline in the energy gain and transfer or distribution within the food chain and ecosystem.

A possible explanation for such retardation in height could be attributed to the plants inability to recover from continuous exposure to waste water, hence can hardly acclimate. This may lead to ultimate death from reduced photosynthesis and metabolic stress. Or possibly too, an inhibitory effect on the cell division process, could consequently deter or hinder apical differentiation, elongation and growth as a result of induced genotoxic effect of the waste water on the roots of the cultivars Odeigah *et al.,* 1998), which must have suffered osmotic ally by direct toxicity of the waste water and consequently a nutrient imbalance effect.

The result of this work indicates that though waste water has some effects on the growth of the cultivars, this effect may not be absolute. Morphological observations were however made. Worst hit by these observations are cultivars treated with 50% and 100% waste water (Fig 2C and D) where such morphological effects in the form of stunted growth, tiny leaf sizes, yellowing of leaves, perforations and scanty or sparse distribution of the cultivars featured prominently when compared to Fig 2A and B treated with no or minimal concentration of waste water.

This work has undoubtedly exposed the vulnerability of waste water on the environment (especially the plant biota) with the findings that the use of waste water could cause appreciable effect on the growth and morphological development of spinach cultivar. However, since there was no work done on the physiology of the cultivars, it is difficult to state whether or not there was any induced effect on the conductive ability of the vascular tissue.

More importantly too, deciding whether growth retardation or inhibition of the cultivar is concentration dependent requires further studies. Above all, the impact all these would have on the genetic load of the subsequent progeny of the cultivars is left to be desired. Finally, it is adequate that waste water management, through appropriate guidelines and legislation be imbibed by individuals, homes, communities, industrialist and irrigators to minimize the potential effects of same on the biota.

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