



Journal of Biological Sciences

ISSN 1727-3048

science
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Effects of Brewery, Textile and Paint Effluent on Seed Germination of Leafy Vegetables-*Amaranthus hybridus* and *Celosia argentea* (Amaranthaceae)

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Abstract: Effluent-laden water bodies have increasingly been used as sources of irrigation for arable crops to ensuring year round food production and sufficiency. Toxicity of living tissues may result from substances accumulated in the growth medium through the food chain. In order to assess the suitability or otherwise of some industrial wastewater for irrigation purposes, germination experiment was performed on seeds of *Amaranthus hybridus* and *Celosia argentea* presoaked in 50 and 100% concentration of brewery, textile and paint effluent for 30 min to 3 h. Longer duration of seeds in presoaked medium (3 h) increased germination rate (0.92) and percentage (95%) of *A. hybridus* significantly ($p < 0.05$) to optimum level in 50% diluted brewery effluent. Though, the effluent generated gradual increase in germination of *C. argentea* with increasing presoaking period, the maximum germination (25 and 35%) was below the control untreated seeds (45%). Fifty percent textile effluent favoured germination in *A. hybridus* up to the control level (70%) at 2 h with higher rate (0.63). Germination decreased (45%) significantly ($p < 0.05$) beyond 2 h. One hundred percent and 50% textile effluent significantly decreased ($p < 0.05$) germination in *A. hybridus* (5-20%) and *C. argentea* (5-10%), respectively and totally toxic to *C. argentea* at 100%. The rate and percentage seed germination of *A. hybridus* and *C. argentea* decreased significantly ($p < 0.05$) as the presoaking period increased in paint effluent becoming toxic beyond 1 and 1½ h, respectively. Industrial effluent may be environmentally harmful if not properly treated or diluted.

Key words: *Amaranthus hybridus*, *Celosia argentea*, industrial effluent, seed germination, toxicity

INTRODUCTION

Environmental pollution constitutes a great health hazard to human, animals and plants with local, regional and global implications (Irshad *et al.*, 1997). Pollution has adverse effects on land, water or air and its biotic and abiotic components. Water pollution may result from municipal, agricultural or industrial wastes containing organic and inorganic chemical substances, dissolved or suspended solids (Terry, 1996; Nebel and Wright, 1998; Moeller, 2004). Industrial waste effluents are discharged into water bodies with multiple effects and changes to water physicochemical parameters (pH, temperature, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Total Suspended Solids (TSS), heavy metals, turbidity etc.) (Nebel and Wright, 1998) supporting aquatic life and organisms that depend on them. Organic wastes contain heavy metals, ammonia, salts

and low molecular weight organic acids which may be toxic to plants (Fuentes *et al.*, 2004).

Increasing population and consequent increase in food demand had necessitated intensive year round food production. Hence, irrigation of arable land and crops from water bodies is indispensable to ensuring food sufficiency. Increasingly, effluent-laden water bodies have become sources for crop irrigation systems sometimes preferred for added nutrients from municipal wastes, distillery or agro-based industries (Veer and Lata, 1987; Pathak *et al.*, 1999; Subramani *et al.*, 1999; Ramana *et al.*, 2002a; Shrestha and Niroula, 2003). Nevertheless, pollutants may also change the properties and composition of soil and micro-flora (Kisku *et al.*, 2000; Shrestha and Niroula, 2003). More so, plants respond to pollution stress and metabolize pollutants differently (Zhu, 2001; Ramana *et al.*, 2002b) by varying mechanisms of uptake, translocation and accumulation (Salt *et al.*, 1998; Rehman *et al.*, 2008).

Phytotoxicity results from intoxication of living tissues by substances accumulated from the growth medium (Chang *et al.*, 1992). The toxic substance may be further bio-accumulated and magnified in the food chain with dire consequences for human. Therefore, it is imperative to evaluate the toxic effects of wastewater and their suitability for irrigation of crop plants. The transition between dormancy and germination represents a critical stage in the life cycle of crop plants which controls population dynamics and productivity (Radosevich *et al.*, 1997; Keller and Kollmann, 1999) constituting an important ecological and commercial trait (Holdsworth *et al.*, 2008).

Thus, seed germination bioassay of two leafy vegetables (*Amaranthus hybridus* L. and *Celosia argentea* L. (Amaranthaceae) was performed in three industrial wastewater (brewery, textile and paint). These plants are popular vegetables widely cultivated in domestic gardens and farms both in rural and urban areas of Nigeria (Maynard, 1983). *Amaranthus hybridus* is a robust annual herb (Olorode, 1984; Epenhuijsen, 1974) popularly cultivated throughout the world (Rehm and Gustav, 1991; Lehman, 1989) for its nutritional value (Oguntona, 1998; Ifon and Bassir, 1979). *Celosia argentea* is a short lived annual herb, slow growing and more drought resistant than *A. hybridus*. It is mostly cultivated in the South-Western part of Nigeria (Oguntona, 1998; Rehm and Gustav, 1991; Epenhuijsen, 1974).

This study was conducted to assess the effects and toxicity levels of brewery, textile and paint effluent on seed germination of *A. hybridus* and *C. argentea* with a view to determining their suitability for crop irrigation.

MATERIALS AND METHODS

Seeds of *A. hybridus* and *C. argentea* were obtained from the Institute of Agricultural Research and Training (IAR and T) Ibadan, Oyo State, Nigeria in March 2006.

Untreated effluents (100%) were collected from Brewery, Textile and Paint Industries at Ikeja and Ogba, Lagos in March 2006 and analyzed for physicochemical parameters at the Analytical Research Laboratory, Babcock University. They were diluted with water to make 20, 50 and 80%.

Germination studies: Four hundred viable seeds of each species were randomly selected from the stock. Preliminary tests were performed with 20, 50, 80 and 100% effluent concentration before 50 and 100% were selected for the bioassay. A set of 20 seeds of *A. hybridus* and *C. argentea* was presoaked in 50 and 100% brewery, textile and paint effluent concentrations for 30 min, 1, 1½,

2 and 3 h. Each was carried out in duplicates. At the end of each time-treatment, the seeds were placed between folds of moistened filter paper in glass Petri dish at room temperature, 28±2°C in the Biology Research Laboratory, Babcock University. The preparation was moistened with effluent every 12 h and observed for radicle emergence every 24 h as indicative of germination.

Control: A set of 20 untreated, intact seeds of *A. hybridus* and *C. argentea* was soaked in tap water for 30 min, 1, 1½, 2 and 3 h, respectively. At the end of each soaking period, the seeds were sown in regularly moistened filter paper in Petri dish at room temperature, 28±2°C. The preparations were watered every 12 h and the emergence of radicle was observed every 24 h as indicative of germination.

Computation and statistical analysis: The rate and percentage of seed germination were calculated for each species from the formula:

$$\text{Rate (coefficient velocity of germination), } r = \frac{x_1 - x_0}{n \times t_1} + \frac{x_2 - x_1}{n \times t_2} + \frac{x_3 - x_2}{n \times t_3} + \dots + \frac{x_n - x_{n-1}}{n \times t_n}$$

where, x is the number of seeds germinated per total number of seeds, n, emerged on a particular number of day t₁ and x_n - x_y is the difference between present and last germination (not necessarily previous, where, [†]x₂ = 0, r = x₃ - x₁/n × t₃) at t_n; r ranges from 0-1.

$$\text{Percentage seed germination (\%)} = \frac{x}{n} \times 100$$

The values were subjected to one-way Analysis of Variance (ANOVA) to determine statistical significance. Statistical analysis were performed using SPSS for Windows, version 14.0. (SPSS Inc. Chicago, IL. USA).

RESULTS

Germination increased significantly (p<0.05) above the control level (70%) with increase in presoaking period of seeds of *A. hybridus* in 50 and 100% brewery effluent concentration. The highest percentage (95%) and rate (0.92) of germination was obtained at 3 h with 50% diluted effluent. There was significant decrease (p<0.05) in the percentage and rate of germination of *C. argentea* in 50 and 100% brewery effluent. The highest percentage (35%) of germination occurred at 3 h in 100% effluent below the control level (45%) at 2 h (Figs. 1a-c and 2a-c).

Germination increased in *A. hybridus* with increasing presoaking period up to control levels (70%) at 2 h in 50% textile effluent with a considerable higher rate (0.63).

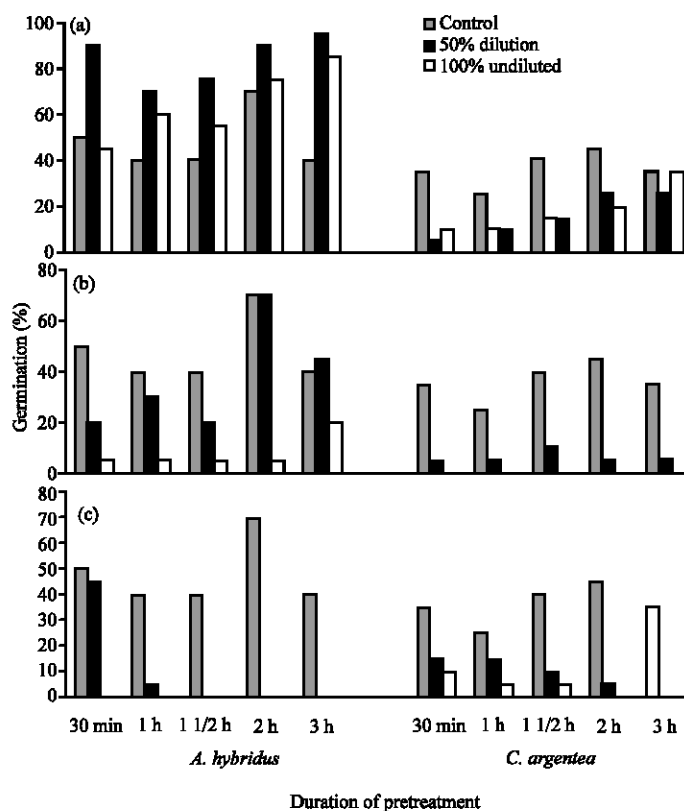


Fig. 1: Percentage germination of *Amaranthus hybridus* and *Celosia argentea* treated with brewery, textile and paint effluent (a) brewery, (b) textile and (c) paint

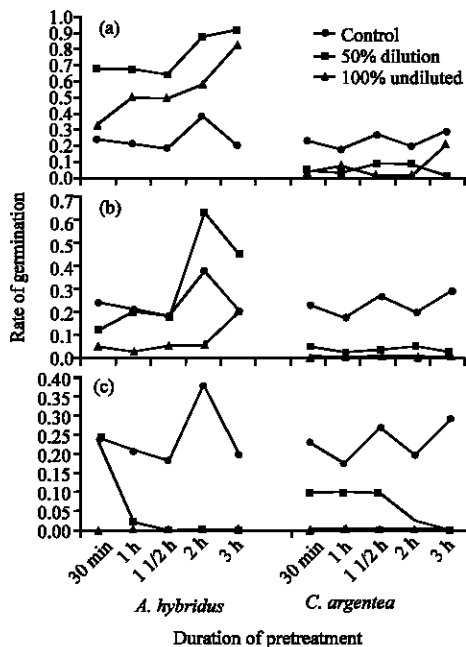


Fig. 2: Rate of germination of *Amaranthus hybridus* and *Celosia argentea* treated with brewery, textile and paint effluent (a) brewery, (b) textile and (c) paint

Germination decreased (45%) significantly ($p < 0.05$) beyond 2 h. One hundred percent and 50% effluent treatments significantly decreased germination ($p < 0.05$) in *A. hybridus* (5-20%) and *C. argentea* (5-10%), respectively. One hundred percent textile effluent was completely toxic to *C. argentea* (Fig. 1, 2).

Paint effluent inhibited seed germination with increasing presoaking period. It was completely toxic at 100% effluent concentration in *A. hybridus* and beyond 1 h in 50% effluent. Germination was very low in *C. argentea* (5-15%) and toxicity resulted beyond 1½ and 2 h seed treatment in 100 and 50% paint effluent, respectively (Fig. 1, 2).

The analysis of physicochemical parameters of the effluents is shown in Table 1.

DISCUSSION

Transcriptional and post-transcriptional processes take place in dry seeds following desiccation. After-ripening processes and post-after-ripening hormone-signaling as well as hormone-independent environmental signals (light, temperature) determine germination potentials (Holdsworth *et al.*, 2008).

Table 1: The Physico-chemical analysis of brewery, textile and paint effluent

Parameters	Brewery	Textile	Paint
Color	Colorless	Red	Blue
Total suspended solid (TSS) (mg L ⁻¹)	20	7.2	30
Total dissolved solids (TDS) (mg L ⁻¹)	200	120	200
Biochemical oxygen demand (BOD) (mg L ⁻¹)	-	7.2	30
Chemical oxygen demand (COD) (mg L ⁻¹)	80	158.4	80
Copper (mg L ⁻¹)	0.1	-	1
Phosphate (mg L ⁻¹)	2	-	5
Sulphate (mg L ⁻¹)	300	-	500
Nitrates (mg L ⁻¹)	15	-	20
Chlorine (mg L ⁻¹)	-	100	600
Sulphide (mg L ⁻¹)	-	241.91	-
Oil and grease (mg L ⁻¹)	-	1.9	10
Iron (mg L ⁻¹)	-	1.26	20
Lead (mg L ⁻¹)	-	-	1
Arsenic (mg L ⁻¹)	-	-	0.1
Nickel (mg L ⁻¹)	-	-	0.1
Magnesium (mg L ⁻¹)	-	-	5
Chromium (mg L ⁻¹)	-	-	1
Cadmium (mg L ⁻¹)	-	-	1
Phenol (mg L ⁻¹)	-	-	0.2
Cyanide (mg L ⁻¹)	-	-	0.1

Germination marks the resumption of metabolic activities following imbibition, cell division and enlargement. Such activities include hydration of sub-cellular organelles, enzyme, protein and RNA syntheses, hormone (abscisic acid) and enzyme (endo-B-mannanases) controlled degradation of embryo surrounding tissues and the endosperm, mobilization of reserves from cotyledons and/or endosperm, protein kinases activated signal cascades, activation or redistribution of metabolites within the embryonic axis and hormone (gibberellins) dependent embryo axial elongation (Black *et al.*, 2000; Noggle, 2002). These activities involve increased water and oxygen uptake. Hence, the growth medium containing water and dissolved chemical substances impacts significantly on the success of seed germination. More so, plants absorb, transport and accumulate these chemical substances differently. Similarly, duration of seed presoaking period in medium influence germination rates positively or negatively and requires effective monitoring (Ugborogho and Ogunwenmo, 1999).

Whereas the seed coat of *A. hybridus* permits increased germination with increasing presoaking period up to 2 h under natural conditions, *C. argentea* affords only marginal increase. Consequently, diluted brewery wastewater enhanced seed germination in *A. hybridus* maximally between 30 min and 3 h presoaking. Generally, distillery effluent had been found to enhance seed germination and / or yield in groundnut (Ramana *et al.*, 2002a), different vegetables (Ramana *et al.*, 2002b), wheat, rice, pea and lady finger (Pathak *et al.*, 1999; Pandey *et al.*, 2007), due to presence of essential nutrients

(copper, sulphates and nitrates) and absence of toxic elements. Conversely, brewery wastewater retarded germination below control in *C. argentea*. Impregnable seed coat seemed to prevent nutrient enrichment of germination from brewery wastewater in *C. argentea*. Naturally, *C. argentea* was generally more resistant to drought than *A. hybridus*.

Two hour presoaking period in diluted textile mill was critical for effective seed germination in *A. hybridus* while higher concentration up to 100% in textile effluent inhibited it. Whereas *A. hybridus* selectively permitted seed germination in textile mill wastewater, *C. argentea* was inhibited by diluted textile wastewater becoming toxic at higher concentration. The mechanism of resistance to toxic chemicals is relatively unclear but may be due to the ability of different plants to detoxify toxic substances, particularly heavy metals or exclude them from the roots. Textile mill wastewater enhanced germination with increasing concentration in *Cicer arietinum* while at the same time, it decreased root, shoot and seedling lengths, fresh and dry weights and to some extent dry matter accumulation (Nawaz *et al.*, 2006). Untreated textile wastewater decreased the germination of Turnip and Brassica with increasing concentration while it had no adverse effects on Radish. Similarly, the fresh and dry weights of the three vegetables decreased significantly though Brassica weighs more than the control in almost all concentrations except 100% (Rehman *et al.*, 2008). Heavy metals (e.g. Pb²⁺, Cd²⁺, Cr²⁺, Ni²⁺) even at low concentrations may result in phytotoxicity by impairing a range of cellular activities and reducing the uptake of other essential nutrients (Palacios *et al.*, 1998; Kadar and Kastori, 2003). Oil and grease may act jointly with other salts and organic compounds to increase the osmotic potential thus, reducing the amount of water and oxygen available in the medium for maximum imbibition critical to onset of germination.

Paint effluent generally inhibited germination in both species. These may be due to presence of some salts (-Cl⁻¹), oil and grease and toxic heavy metals (Pb, Cd, Cr and Ni) which retard germination and growth. Unlike textile mill, *C. argentea* slightly permitted germination in 2 and 1½ h presoaking period in 50 and 100% paint effluent. On the other hand, *A. hybridus* could only afford germination up to 1 h in 50% paint effluent while 100% was completely toxic. Plants response to effluent stress and their uptake, translocation and accumulation of the metabolites vary (Salt *et al.*, 1998; Ramana *et al.*, 2002b) depending on their genetic make-up and eco-physiology. Even closely related cultivars (P-91 and P-2000) of the same species (*C. arietinum*) responded differently to the same effluent (Nawaz *et al.*, 2006).

Overall, brewery effluent improved seed germination in *A. hybridus* while textile mill was only effective at lower concentrations up to 50% at 2 h presoaking period. Paint would require clean-up, maximum dilution and short presoaking period below 30 min to yield any appreciable result in *A. hybridus*. None of the effluents was suitable for *C. argentea* but may be slightly tolerant to paint diluted effluent where water is scarce. Generally, paint and textile wastewater inhibited seed germination and became toxic at higher concentrations.

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