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Comparative germination profiles of some arable crops in ballast water

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ABSTRACT

Lack of enforced regulations on the exchange of ballast water has led to the indiscriminate manner of its discharge in the environment with the perceived attendant consequences on both animal and plant life. In this study, the effect of different concentrations [5, 10, 25, 40, 50, 75, 100% (v/v)] of ballast water on the germination of Zea mays L., Arachis hypogaea L., and Abelmoselus esculentus L. were found to vary from one plant to another. The ballast water was observed to inhibit the germination of all seed types used which was concentration-dependent. The length of radicle and plumule of the seedlings decreased with increase in ballast water concentration. A. esculentus was found to be the least tolerant to the ballast water while Z. mays was the most tolerant.

Key words : *Abelmoselus esculentus, Arachis hypogaea., Ballast water, Germination, Zea mays L.,*

INTRODUCTION

Ballast water is mostly sea water taken on board for stability, often in one country and discharged before loading. It is a heavy material placed in the hold of a ship to gain stability. In Nigeria, ballast water is indiscriminately discharged into the environment, due to lack of enforced IHS regulations. There is reason to believe that periodic discharges of this ballast water from oil tankers could constitute a significant portion of the oil and other impurities introduced into our environment each year with perceived consequences on both animal and plant life. Results obtained from physicochemical parameters revealed that ballast water was basic with high electrical conductivity and total dissolved solids (Duru and Okieimen, 2011).

The concentration of COD was appreciably high indicating that the water is polluted with oxidizable organic and inorganic pollutants, however, majority of the heavy metals, except lead, were within permissible limits. We are not aware of any published data available on the effects of ballast water on germination in plants.

The objective of this study was therefore, to ascertain the level of toxicity or otherwise and perceived consequences, if any, on the germination of three arable crops of economic importance: *Abelmoschus esculentus, Zea mays,* and *Arachis hypogea*.

MATERIALS AND METHODS

The ballast water used for the study was collected from “M/V Thelka” (a multipurpose vessel carrying dry cargo, 6301 gross tonnage 132,2m long, IMO number 9259020, built March 2003, Flag; Antigua & Barbuda). The vessel was berthed at canal in Warri Port on the 24th March 2011. Total ballast water capacity was 3313m^3 and it was having 700m^3 ballast water on board. Total number of ballast tanks on board was 23 while the number of tanks in ballast was 7 and none of the tanks was exchanged. Also, at the port, the vessel did not deballast. Sample was obtained from Tank DB8 (DB = Double Bottom) which it took from Amboin in Angola on 24th of January 2011 while ballasting.

The seeds of *Zea mays, Arachis hypogea* and *Abelmoschus esculentus* were used in this study. The seeds were obtained from Okere market, Warri, Delta State. The same batch of seeds was used throughout. This is because the seeds were assumed to be o the same age, variety and stock. The seeds were sorted, cleaned and stored in polythene bags in the laboratory and used within a few days of collection. Serial dilutions of the stock sample (100%) were made to obtain the various test solutions at lower concentrations of 5, 10, 25, 40, 50, and 75% from the stock using a measuring flask with distilled water. The floating method was used, where the seeds were put in bowls of water and left for 5

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minutes. Submerged seeds were collected and used while the ones that remained afloat were discarded (Idu and Olorunfemi, 1988).

Thirty seeds were placed in Petri dishes and kept moist by a layer of cotton wool and coarse filter paper in triplicates. 20 ml portion of each concentration of the ballast water (5, 10, 25, 40, 50, and 75%) was added to each Petri dish. The Petri dishes were placed on a bench in the laboratory in light condition at room temperature and kept under plastic covers to reduce water loss by evaporation. Test solutions were added when necessary to keep the filter papers moist. Filter papers were examined daily for fungal infection and seeds so affected were removed to avoid contamination of other seeds.

According to Freeland (1976), the normal criterion for germination is the emergence of the radical from the testa. Germination experiments were continued until germination ceased. The Petri dishes were examined daily for germination. Radicle and plumule lengths were measured following the methods used by Olorunfemi *et al*., (2007).

Data were expressed as Mean ± Standard Error of Mean (SEM). Differences between the control and the different concentrations of the leachates were analyzed by means of the Student's unpaired *t*-test. P values of <0.05 were considered to be statistically significant. All statistical analyses were carried out using SPSS®14.0 statistical packages.

RESULTS AND DISCUSSION

The germination profiles of seeds of three arable crops, *Abelmoschus esculentus, Zea mays,* and *Arachis hypogea* at different time periods and ballast water concentrations are presented in Figs. 1-6. Germination percentage decreased with increased effluent concentration. *Zea mays* seeds treated with ballast water did not germinate until the 36h. Seeds of *A. esculentus* recorded 60, 33, and 1% germination in 5, 10 and 25% ballast water concentration respectively at the 18 h. *A. hypogea* seeds recorded 5, 0, 0% germination at the same wastewater conc. and time period respectively. On the contrary, seeds of *Z. mays* did not germinate until the 36 h with germination percentages of 20, 20, and 8 at 5, 10 and 25% ballast water concentrations respectively.

A comparison of percentage germination of seeds of *Abelmoschus esculentus, Zea mays,* and *Arachis hypogea* in ballast water concentrations at 50, 75 and 100% show that seeds of *A. esculentus* recorded 4% germination at 50% while there was no germination at 75 and 100% ballast water concentration for these seeds up till the 96 h. Seeds of *A. hypogea* at the same time period recorded 8%, 2% and no germination at the same ballast water concentrations respectively. Seeds of *Z. mays,* on the other hand recorded 68, 38 and 26% germination respectively at the same wastewater concentrations at 96 h (Figs. 7-9).

The radicle and plumule lengths of germinating seeds of *Abelmoschus esculentus, Zea mays,* and *Arachis hypogea* at different time periods and ballast water concentrations are presented in Tables 1-2. As the concentration of the wastewater increased there was a corresponding decrease in radicle and plumule lengths of all seedlings.

Germination marks the resumption of metabolic activities following imbibition, cell division and enlargement. The mechanism of resistance to toxic chemicals is relatively unclear but may be due to the ability of different plants to detoxify substances, particularly heavy metals or exclude them from the roots. As evident from the results, the effects of a wastewater on seed germination vary from one crop to another. Compared to *Zea mays*, seeds of *A. esculentus* and *A. hypogea* were faster at germinating but interestingly, *Z. mays* which had delayed germination, later recorded the highest germination percentage at the same wastewater concentrations at 96 h while seeds of *A. esculentus* and *A. hypogea* did not germinate at all at 100% ballast water concentration.

The physicochemical properties of the ballast water sample used in this study (Duru and Okieimen, 2011) contain anions which can be beneficial for plant growth but which at excessive levels could be toxic and retard the growth of the plants. There is no published data available on the effects of ballast water on germination in plants. Industrial effluents, from manufacturing or chemical processes have been found to contribute to water pollution, which significantly affect the entire food chain (Agarwal, *et al*., 1996).

Sofia *et al*. (2006) have opined that certain physical, chemical and biological properties of water up to an adequate level are good for health but became toxic at excessive level. Our results are consistent with this opinion and are in agreement with earlier studies (Olorunfemi *et al*., 2007). Rodger *et al*. (1957) reported that high osmotic pressure of the germination solution makes imbibition more difficult and retard germination. Richards (1968) on the other hand observed that it is the total concentration of the solute particles in the solution rather than their chemical nature that is mainly responsible for the inhibitory effects of saline solutions on the growth of crops. All these factors are in conformity with the present study indicating that untreated ballast water was responsible for the inhibition of germination while flooding would support germination.

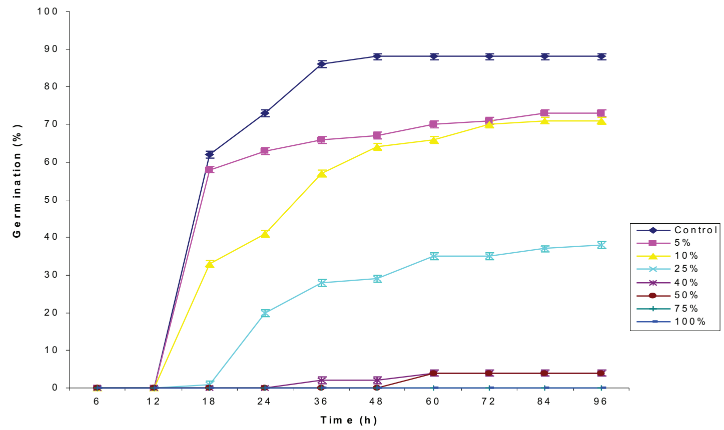
Inhibition of germination at higher concentrations (50% and above) of the ballast water may be due to high levels of total dissolved solids which enhance the salinity and conductivity of the solute absorbed by the seeds before germination. The decreasing trend of germination value of the plants with increasing effluent concentrations may be attributed to the lesser uptake of nutrients and increase in osmotic potential of the soils irrigated with higher effluent concentrations. Therefore, plants irrigated with higher concentrations of effluents have lower germination rates.

Table 1 : Effect of Ballast water on the radicle length of 4 days (96 h) old seedlings

Concentration of Ballast water (%)	*Zea mays*	*A. esculentus*	*Arachis hypogaea*
0 (Control)	74.6 ± 0.93	0.0 ± 0.00	19.0 ± 0.59
5	61.0 ± 0.99	30.4 ± 1.00	18.4 ± 0.59
10	64.0 ± 1.00	31.0 ± 0.27	12.0 ± 1.00
25	46.4 ± 0.81	14.4 ± 0.17	9.0 ± 0.76
40	29.4 ± 0.83	3.0 ± 0.35	2.3 ± 0.17
50	21.6 ± 0.38	1.4 ± 0.38	1.1 ± 0.10
75	20.0 ± 0.61	0.0 ± 0.00	0.3 ± 0.06
100	4.6 ± 0.17	0.0 ± 0.00	0.0 ± 0.00

Table 2 : Effect of Ballast water on the plumule length of 4 days (96 h) old seedlings

Concentration of Ballast water (%)	*Zea mays*	*A. esculentus*	*Arachis hypogaea*
Control	38.4 ± 0.49	2.1 ± 0.56	0.0 ± 0.00
5	26.8 ± 0.55	4.1 ± 0.40	0.0 ± 0.00
10	32.2 ± 0.52	3.4 ± 0.51	0.0 ± 0.00
25	19.6 ± 0.43	1.8 ± 0.49	0.0 ± 0.00
40	11.0.4 ± 0.23	0.0 ± 0.00	0.0 ± 0.00
50	4.9 ± 0.07	0.0 ± 0.00	0.0 ± 0.00
75	1.8 ± 1.00	0.0 ± 0.00	0.0 ± 0.00
100	0.0 ± 0.00	0.0 ± 0.00	0.0 ± 0.00



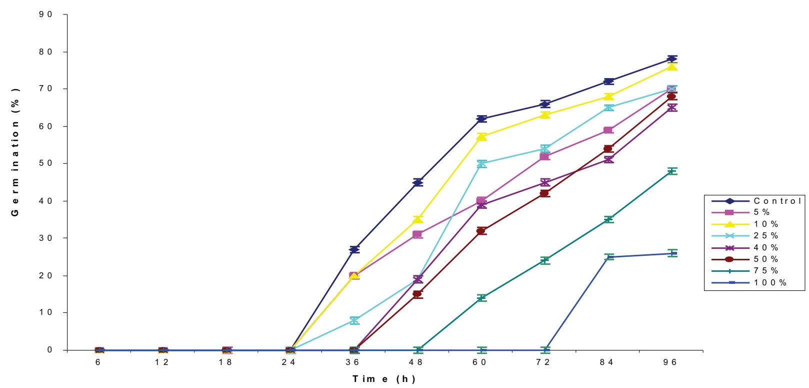


Fig. 2 : Percentage germination of seeds of *Zea mays* at different time periods and ballast water concentration

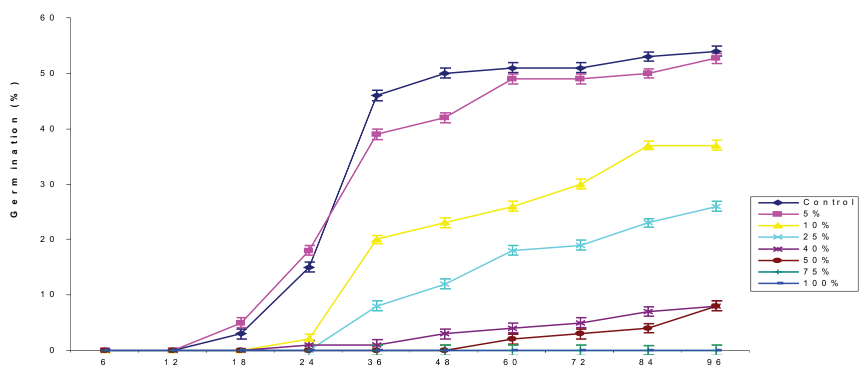


Fig. 3 : Percentage germination of seeds of *Arachis hypogea* at different time periods and ballast water concentration

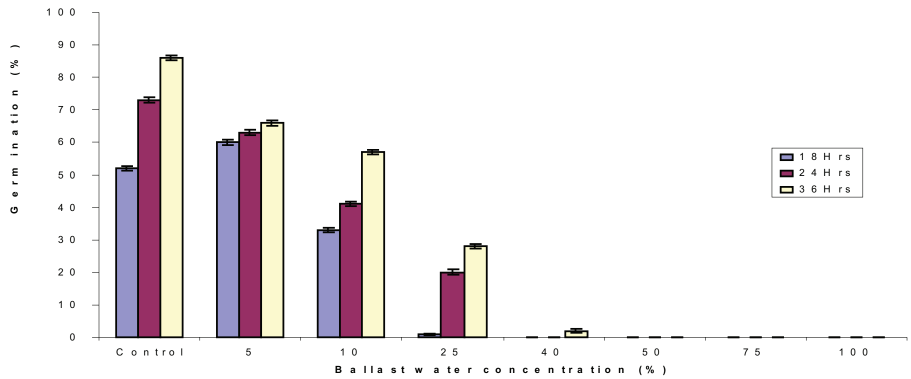


Fig. 4 : Percentage Germination of seeds of *Abelmoschus esculentus* at 18h, 24h and

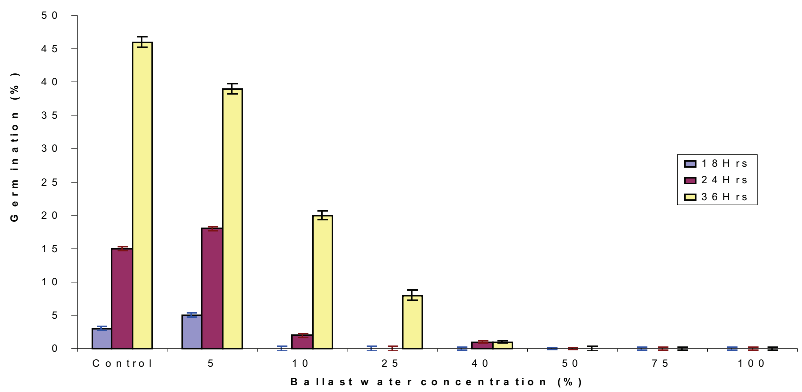


Fig. 5 : Percentage Germination of seeds of *Arachis hypogea* at 18h, 24h and 36h

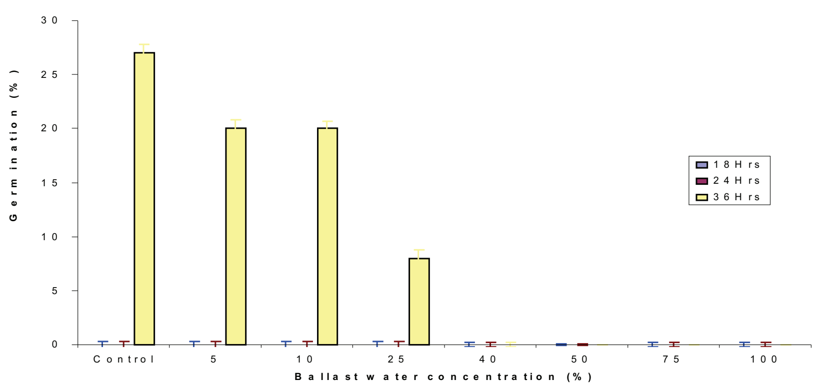


Fig. 6 : Percentage Germination of seeds of *Zea mays* at 18h, 24h and 36h.

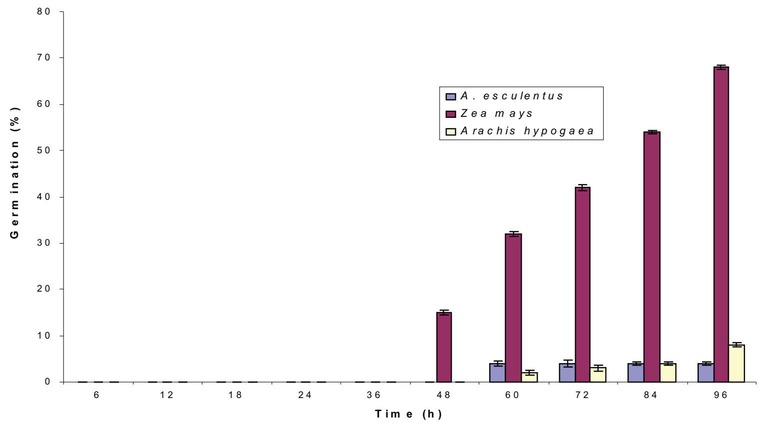


Fig. 7 : Comparison of percentage of germination of seeds Abelmoschus esculentus, Zea mays and Arachis hypogaea in 50% ballast water concentration

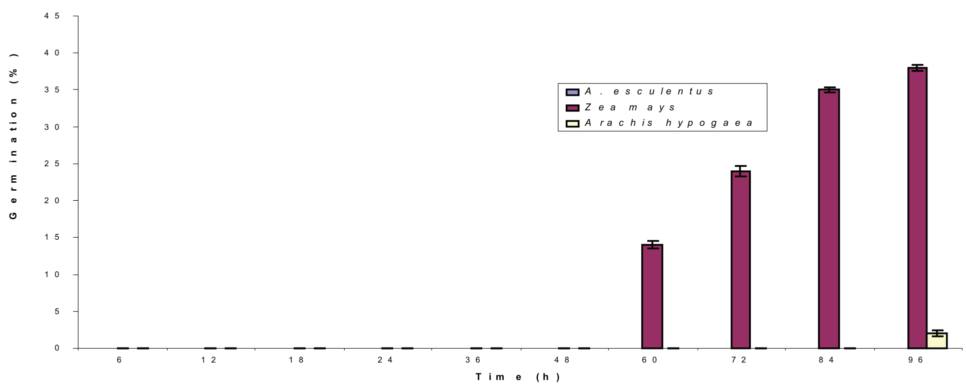


Fig. 8 : Comparison of percentage of germination of seeds *Abelmoschus esculentus, Zea mays* and *Arachis hypogaea* in 75% ballast water concentration.

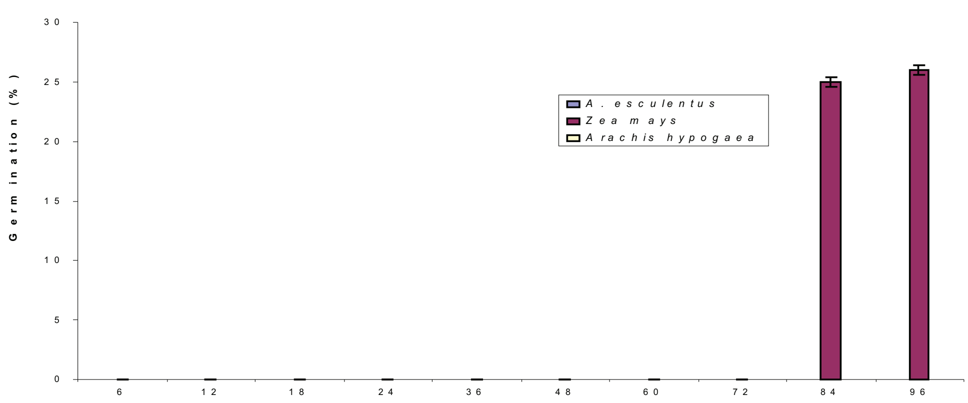


Fig. 9: Comparison of percentage of germination of seeds *Abelmoschus esculentus, Zea mays* and *Arachis hypogaea* in 100% ballast water concentration.

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