International Journal of Applied Environmental Sciences
ISSN 0973-6077 Volume 14, Number 3 (2019), pp. 249-258

http://www.ripublication.com

The Roles of Mercury Nitrate in Soil: Effects and Impacts on the Growth of Okra

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ABSTRACT

Pollution due to contaminants released into the environment (soil, air, water) has been associated has resulted to decreasing soil microbial activity, fertility, reduced crop yield and losses. Therefore, the need to evaluate the roles of mercury nitrate in soil as it affects the growth and survival of okra (*Abelmoschus esculentus*) is necessary as it's a staple economic crop usually consumed as vegetable and in soup preparation in many parts of the world. Okra seedlings were subjected to varying concentrations (30ppm, 50ppm, 70ppm and 00ppm (control)) of mercury nitrate ($Hg(NO_3)_2$) in both field and laboratory trials. Parameters such as germination, growth, fresh and dry weight were determined. The results obtained from the study showed that $Hg(NO_3)_2$ had little or no effects on the percentage germination of the plant with after 14 days of planting in field trial. There were observed effects on laboratory trial. Plant growth parameters showed insignificant effects in both the control and the different $Hg(NO_3)_2$ treatment concentration (30ppm, 50ppm and 70ppm). The result obtained shows that the higher the concentration of mercury (ii) nitrate the higher the biomass of okra plants. The biomass for control, 30ppm, 50ppm and 70ppm were recorded to be 3.48g, 3.83g, 4.10g and 4.38g and 0.73g, 0.89g, 1.50g and 1.53g respectively for fresh and dry weight. However, there is possibilities that increase in concentration could alter negatively the growth of the plant.

Keywords: Mercury nitrate toxicity, *Abelmoschus esculentus,* plant growth parameters

INTRODUCTION

The advent of industries and urban expansion has resulted in soil, air and water pollution which affects humans, plants and animals. Pollution from human activities results to the generation of metals such as lead, copper, cadmium, nickel among others which causes several effects on crop growth [1]. Pollution and contamination of soil, air and water has been a major issue responsible for severe environmental problems causing risks to both human and environmental health as well as decreasing soil microbial activity, fertility, reduced crop yield and losses [2]. Soil contamination with heavy metals at varying concentrations has been a major challenge lead to losses in agricultural yield and hazardous health effects as they enter into the food chain [3]. Over the years, there has been a great deal of attention channelled towards the effects of heavy metals on cellular system by researchers as a result of the increasing rate exposure faced by living organisms to these metals in the environment.

Mercury (Hg) is one of the major soil pollutants due to the annual import of toxic mercury into agricultural lands [4] usually as waste materials and in the control of pests and diseases of plant as herbicides The interaction between Hg and plant systems is very important because mercury has largely been employed in seed disinfectants, in fertilizers and in herbicides. The disposal, application and use of mercury in the environment have been termed to be an issue of global concern because of its persistent and non-biodegradable nature [3]. Research has shown that mercury greatly reduced germination, elongation of root, hypocotyl as well as coleoptiles growth in wheat when compared with Cd, Co, Cu, Pb, and Zn [5]. Also, it has been reported that when mercury is released to soils, it remains mainly in the solid phase through adsorption onto sulfides, clay particles and organic matters. It was found that mercuric ions are able to induce oxidative stress by triggering generation of reactive oxygen species (RO S), e.g. superoxide radical, hydrogen peroxide, and hydroxyl radical in plants [4][6]. Based on the toxic and persistent nature of mercury nitrate in soil and the rate of deposition of these substances on both agricultural and residential areas, there is need to evaluate their roles in soil as its relate the growth and survival of economic crops. Therefore, this study was to determine the role of mercury nitrate in soil and its impacts and effects on the growth of Okra.

MATERIALS AND METHOD

Clemson spineless variety of okra was purchased from Accredited Salesman/Farmer of Premier Seeds Company, Ibadan, whose office is located in Benin City, Edo State and were subjected to analytical grade chemical bottle of mercury nitrate monohydrate ($Hg(NO_3)_2.H_2O$) at different treatment levels (0ppm, 30ppm, 50ppm and 70ppm). Mercury nitrate solutions were applied to soil samples every four days. For the field experiment, 200ml of Hg treatment were applied to each experiment every four days, up to six weeks after planting. The field experiment was laid out as a complete randomized design (CRD) in the field, consisting of four different levels according to the mercury ion treatments and replicated five times. Also, the *in vitro* experiment was also carried using petri dishes. Whatman no. 1 filter papers were used

as inner lining material to hold the mercury ion solution for seed germination [7]. The petri dishes were lined with filter paper and 5 mL each of the different concentrations (0ppm, 30ppm, 50ppm and 70ppm) of mercury nitrate were applied to petri dishes. Each of the four mercury ion treatment concentrations had five replicates. For the *in vitro* experiment, seven (7) seeds of okra were placed on the filter paper inside one petri dish and moistened with treatments. They petri dishes were left on the laboratory bench for observation. The petri dishes were kept moist by watering with the treatments daily as needed. The data collected for the *in vitro* experiment were percent germination, radicle and plumule lengths. Germination was recorded if the protrusion of radicle is greater than 2 mm.

The number of seeds that germinated per pot were counted and recorded and the percentage germination (G.P) was computed using:

$$\text{G.P (\%)} = \frac{\text{Seed Germinated}}{\text{Total Seed Sown}} * \frac{100}{1}$$

The germination was recorded for fourteen (14) days. A seed has germinated if the plumule appears above the soil surface. Measurement of plant height was taken by obtaining the length from the terminal bud to soil level. The number of leaves formed per plant was done by counting the leaves on the plant. Stem girth (circumference) was measured using a thin thread wound around the base of the stem and afterwards, the thread is stretched on a ruler to record the length. The number of flower buds formed per plant in each pot was recorded by counting. The biomasses consist of both fresh and dry weights were determined. The fresh weight was determined immediately after which samples were oven dried at 80^0C for 48 hours to obtain dry weight using the method of Wu *et al.* [8].

Statistical Analysis

Data obtained from both laboratory and field research was subjected to analysis of variance using the SPSS software.

RESULTS AND DISCUSSION

Results obtained from the study showed that mercury nitrate has negative effects on the germination and growth activities of okra plant in both laboratory and field trials. Percentage germination recorded for both trials showed variations in relation to other studies on the effects of mercury and other metals on germination. The control plants recorded higher percentage germination as high as 100% after 12 day and 14 days of planting with 90% and 98.67% recorded after 6 days and 9 days of planting. However, 30ppm and 70ppm concentrations also recorded as high as 100% 14 days after planting with 50ppm concentrations recording the least (77%) 14 days after planting for field trial (Figure 1). Laboratory (*in vitro*) experiment observed for eleven days (11 Days) after initiating Hg treatments suggests that mercury (II) nitrate did not have significant effects on the germination of okra (P>0.05).

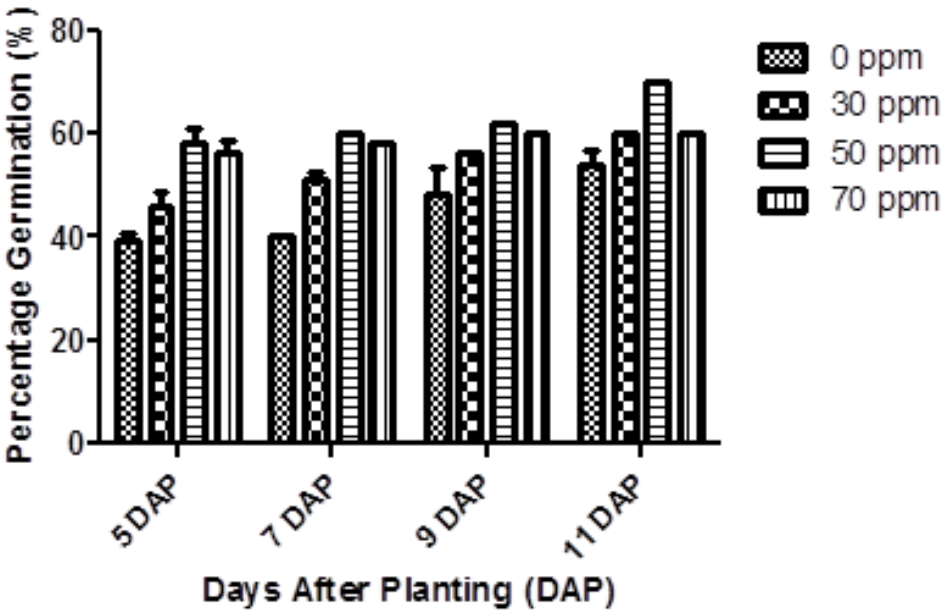

Figure 1: Effect of mercury nitrate on percent germination of okra seeds for field work

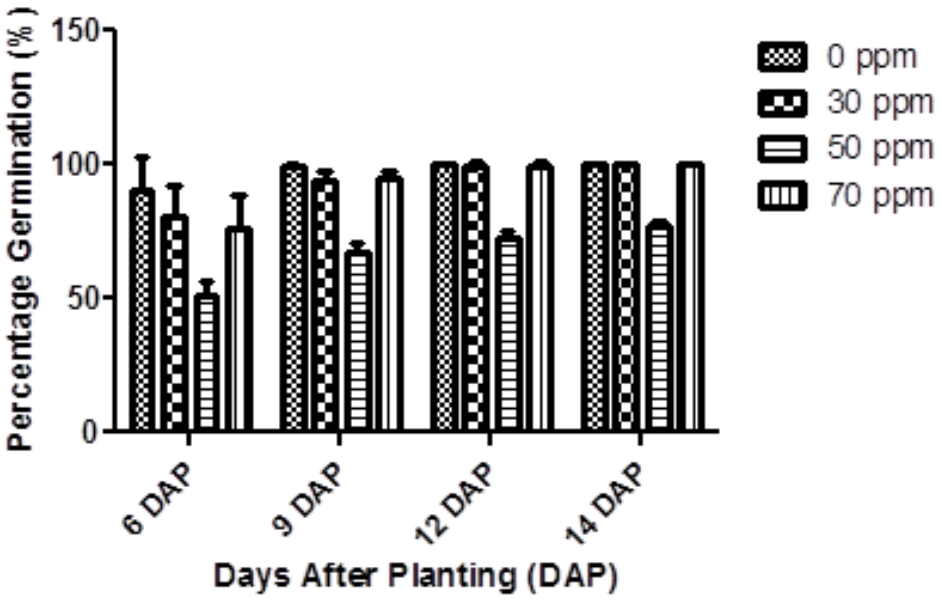

Figure 2: Germination percentage of okra seeds treated with mercury ions *in vitro* experiment

Table Figure 3 shows the effect of mercury (ii) nitrate on the radicle length of the germinating okra seeds during the *in vitro* experiment. Ten day (10) days after applying the treatments, it was observed the seed treated with 50ppm had more radicle followed by 70ppm and 30ppm, the control had lesser radicle as seen from the table. Figure shows the effect of mercury (ii) nitrate on plumule length germinating okra seeds during the *in vitro* experiment.

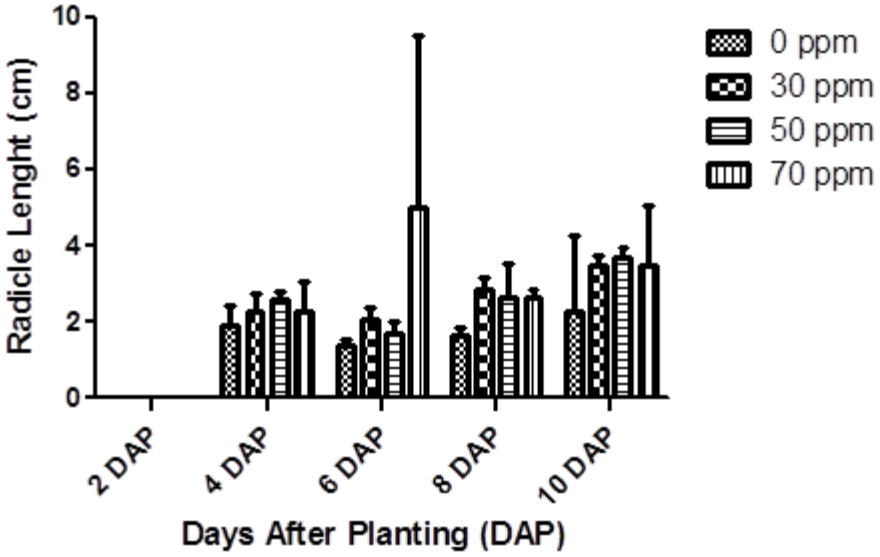

Figure 3: Radicle length (cm) of germinating okra seeds treated with mercury ions *in vitro* experiment

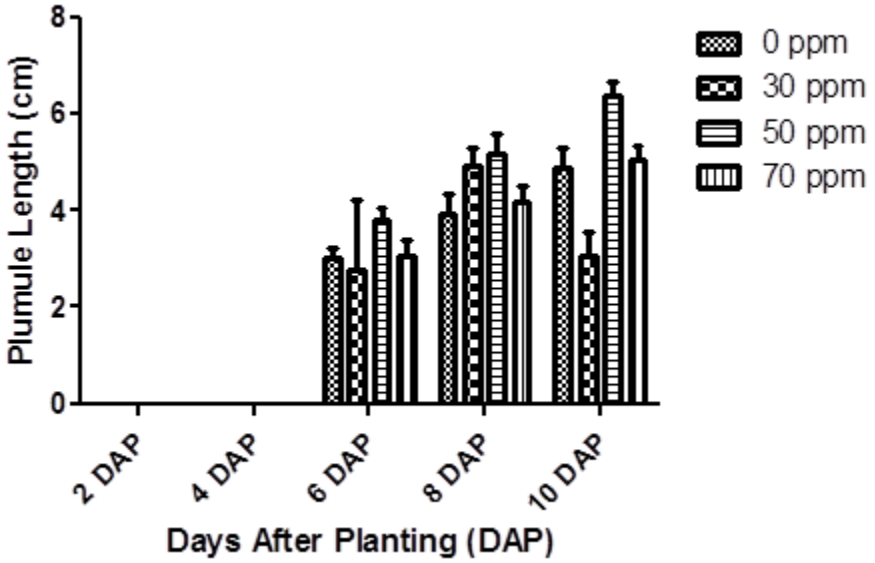

Figure 4: Plumule length (cm) of germinating okra seeds treated with mercury ions *in vitro* experiment

Plant height is a major determinant in the determination of effects of pollutants and toxic metals in plants and soil. The result of the study showed that there were variations in the response of okra plant to different concentrations of mercury nitrate. However, it was observed that mercury nitrate treatments were higher in terms of plant height compared to the control (non-treated soil) (Figure 5).

Figure 6 shows the effects of mercury (ii) nitrate on the stem girth of Okra after 6 weeks of growth. From the result, the highest mean for stem girth was observed in 70ppm while lowest stem girth value was observed in 30ppm. The stem girth of okra plants varied proportionally with mercury (II) nitrate concentrations applied to soil. The higher the concentration of mercury (II) nitrate applied to soil, the higher the stem girth values of okra plants. The highest values were recorded for plants grown in 50 and 70 ppm Hg treated soils. For the number of leaves formed by okra plants, the highest value recorded was for plants grown in 70 ppm Hg treated soils as compared with the control which can be viewed as a form of beneficial factor for the growth of okra plants.

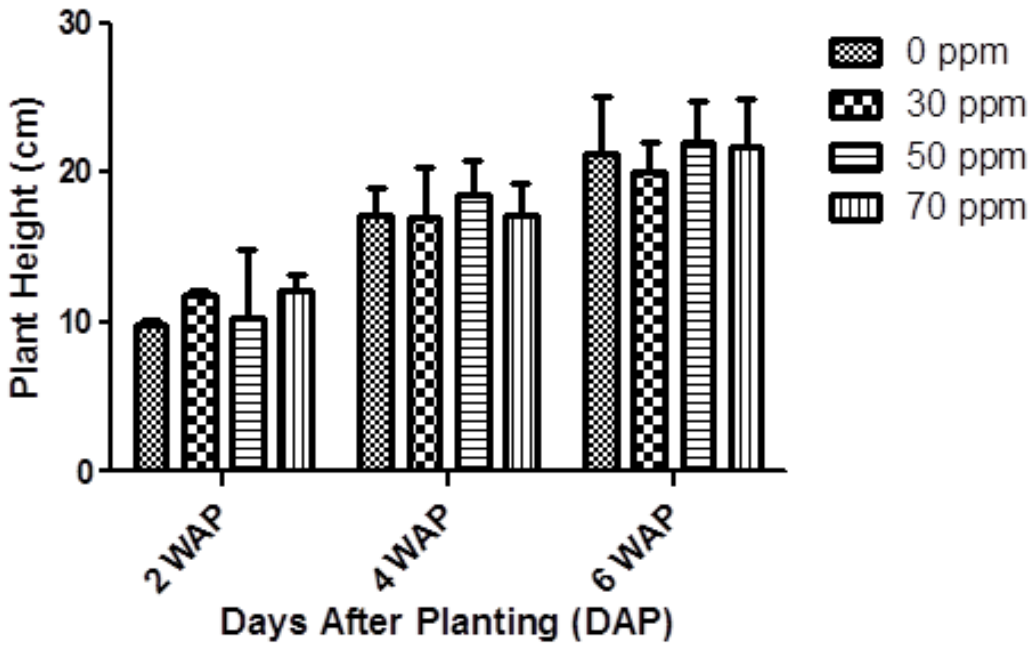

Figure 5: Effect of mercury nitrate on the height of Okra plants grown in mercury treated soil

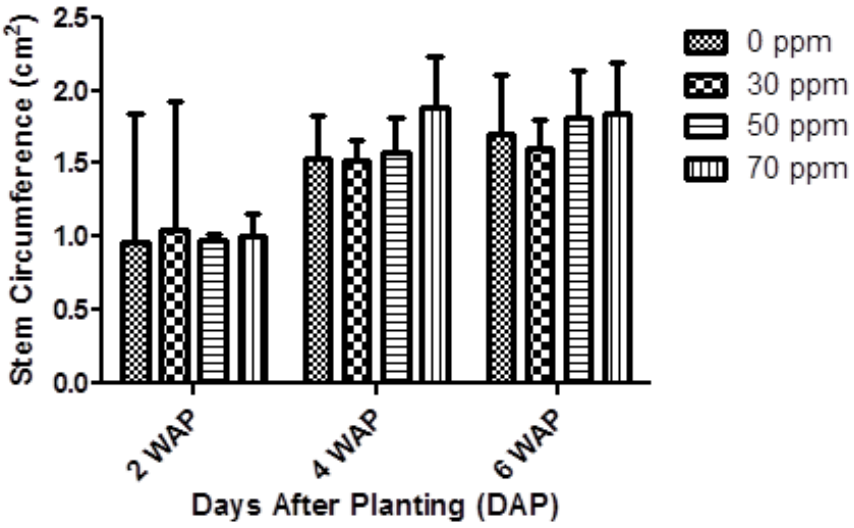

Figure 6: Effect of mercury nitrate on stem girth of Okra plants grown in mercury treated soil

Figure 7 shows the effects of mercury (ii) nitrate on the number of leaves produced per okra plant after 6 weeks of growth. From the figure, the highest number of leaves formed per plant was recorded for plants grown in 70 ppm Hg treated soils. The least was observed in 30 ppm Hg treated soils. The number of bud formed per plant recorded for okra in both the control and mercury nitrate contaminated soil in field trial are presented in Figure 8. The highest value of 5.60 was recorded in 30ppm concentration 50 days after planting which was followed by the control with 4.60 while 50ppm and 70ppm recorded values of 3.40 and 3.25 respectively. The result showed that 30ppm treatment had higher bud formation as the days increased.

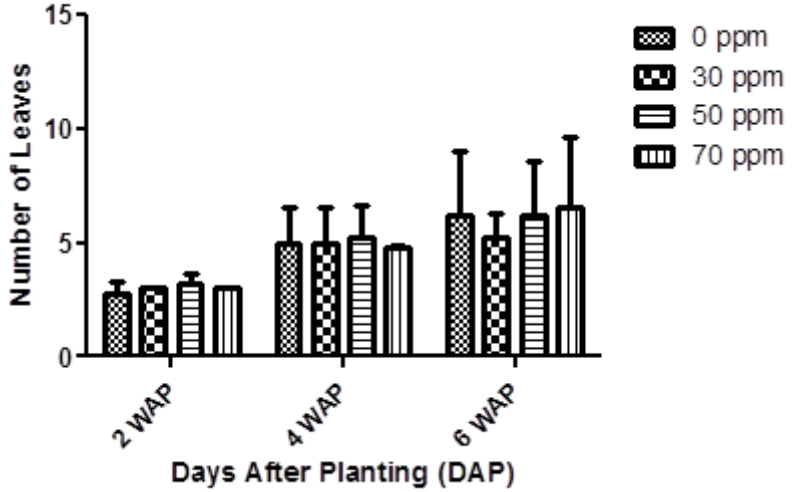

Figure 7: Effect of mercury nitrate treated soils on the number of leaves formed per okra plant

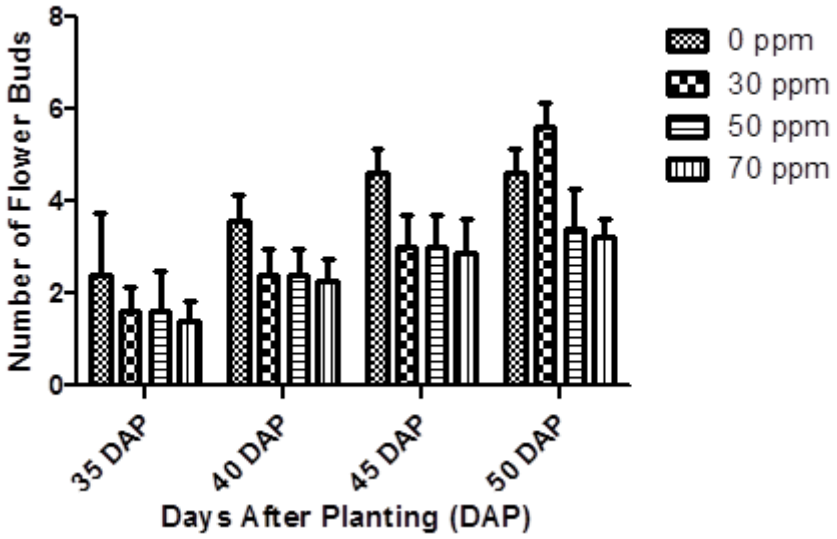

Figure 8: Number of flower buds per plant recorded for okra plants grown in Hg treated soils

Figure 9 shows the biomass (fresh and dry weights) of okra plants grown in soils treated with different concentrations of mercury (ii) nitrate. The result obtained shows that the higher the concentration of mercury (ii) nitrate the higher the biomass of okra plants. The biomass for control, 30ppm, 50ppm and 70ppm were recorded to be 3.48g, 3.83g, 4.10g and 4.38g and 0.73g, 0.89g, 1.50g and 1.53g respectively for fresh and dry weight.

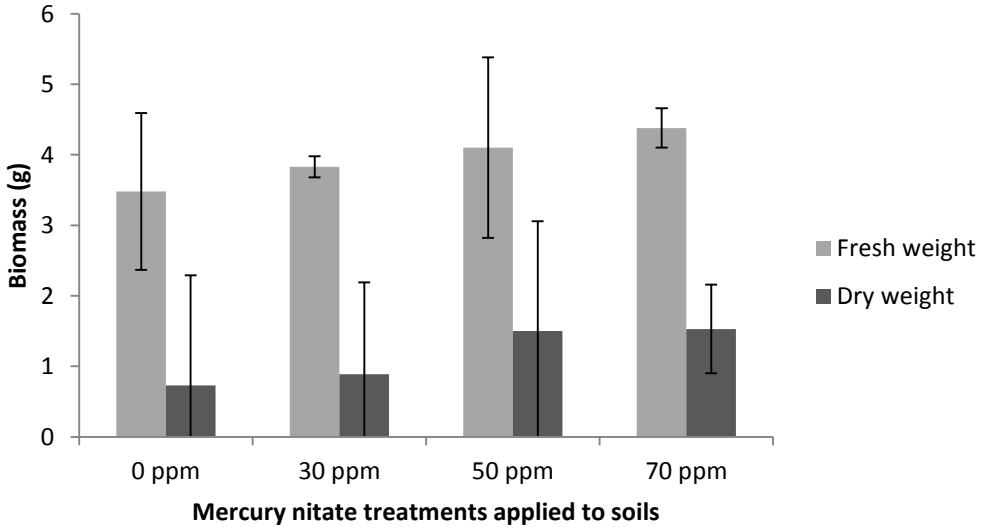

Figure 9: Biomass of okra plants grown in mercury nitrate treated soils after 9 weeks of growth

DISCUSSION

The effects of mercury (II) nitrate on the germination of *Abelmoschus esculentum* were investigated. The results obtained indicated that the increase in the concentration of mercury (II) nitrate led to a decrease in the number of buds and flowers formed by the plant. The result also show that increase in the concentration of mercury (II) nitrate (50ppm and 70ppm) led to increase in plant height, stem girth, number of leaves, fresh and dry weights of the plant. Therefore it is confirmed that vegetative growth and biomass of *Abelmoschus esculentum* is favoured between 50 and 70ppm, while reproductive growth is hindered with the increase in the concentration of mercury (II) nitrate applied to soils.

The result shows that the higher the concentration of mercury (ii) nitrate the higher the percentage germination, with 0ppm having lowest percentage germination and 50ppm having the highest percentage germination (Figure 2). Studies of Srinivas *et al.* [9] on germination has shown that in field experiment has shown that growth was consistently reduced with increased concentration of both metals and maximum suppression of plant growth was recorded at the highest concentration of heavy metals (Ni and Pb) at 500 ppm whose growth was reduced up to 65% as compared to control. Also, Mohammad *et al.* [10] reported that increase in concentration of mercury produced significant reduction in seed germination.

Ten (10) days after applying treatments, it was observed that the highest mean plumule length was recorded in seeds treated with 50 ppm and 70 ppm Hg solutions, and lower values were observed in seeds treated with 0 and 30 ppm Hg solutions. The plumule and radicle length of germinating okra seeds varied proportionally with mercury (II) nitrate concentrations applied to soils. At 50ppm of mercury (II) nitrate, highest values were recorded for the length of plumule and radicle. This result contradicts the study of Bhanumath and Jayabalan [11] which concluded that "increase in the concentrations of mercury ions leads to decrease in the length plumule and radicle. From the result, increase in the concentration of mercury (II) nitrate led to delay in the formation of flower buds and increase in number of days to first flower formation.

The result shows that 50ppm of mercury (ii) nitrate has the highest height while lowest height was observed in 30ppm. Similar effects has also been reported by Chandra *et al.* [12] who recorded that little or no difference in plant height of tomato plant in mercury contaminated soil. For the plant height of okra grown under different concentration of mercury (II) nitrate, the height of okra varied proportionally with the concentration of mercury (II) nitrate. The higher the concentration of mercury nitrate applied to soils, the higher the mean height of okra plants. The mercury treatment seems to have supported the growth of okra plants in this study. This result suggests that okra plants benefited from the applications of mercury nitrate to the soil medium.

ACKNOWLEDGEMENT:

The authors wish to acknowledge the Department of Botany, Delta State University for their contribution and support towards the success of this research.

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