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EFFECT OF MERCURY-TREATED SOIL ON GERMINATION AND GROWTH OF PAPAYA (*CARICA PAPAYA* L.)

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ABSTRACT

The aim of this study was to investigate the stress of mercury-treated soils on the germination and growth of papaya (Carica papaya L.). The research was carried out in the field as a potted experiment where 10 kg soils were treated with mercury concentrations of 0, 30, 50, 70 and 100 ppm. The soils were supplemented with poultry manure before seeding, and then mercury solution treatments were administered. Up to the fourth week after planting, the mercury solutions were administered every fourth day. Germination, plant height, stem girth, and number of leaves generated were all examined using standard procedures. Carica papaya germinated twenty-five days after sowing. Thirty-four days after planting, the control had the highest rate of germination (about 53%). The presence of Hg reduced the duration of seedling emergence in contaminated soil, lowering the proportion of seedlings that germinated. Treatments of 30 ppm and 70 ppm improved the plant growth upon emergence. It is recommended that further study be carried out to determine the physiological effects of Hg treatment.

Keywords: *Carica papaya***,** mercury, germination, treatments, soils

INTRODUCTION

Papaya (*Carica papaya* L.) is a tropical fruit tree with physiological reactions that are closely connected to environmental circumstances (Campostrini and Glenn, 2007). During field development, the papaya is considered a full-sun plant that is fairly resistant to salinity and water restriction. The plants are sensitive to salinity and intense irradiance during their early stages of development (Cavalcante *et al*., 2010; Mengarda *et al*., 2014). Extreme temperatures, drought, winds, injuries, and viral infections are all stressors that papaya is susceptible to, especially during the reproductive phase (Raza *et al*., 2019). Reduced humidity and light conditions affect the photosynthetic processes in papaya (Carr, 2014). Variations in temperature, water restriction, and CO_2 diffusion limits are all linked to high luminosity (Liana *et al*., 2016). The photosynthetic mechanisms of papaya are influenced by several environmental variables (Campostrini and Glenn, 2007). The emergence of seedlings is affected by high irradiance, whereas the development of seedlings is affected by low irradiance (Mengarda *et al*., 2014).There is genetic diversity in papaya response to light conditions, including adjustments to leaf chlorophyll concentration that prevent photosynthetic photoinhibition (Campostrini and Glenn, 2007).

Papaya accumulates abscisic acid, jasmonic acid, proline, sodium, potassium, and chloride in response to water stress, implying osmotic adjustment (de Ollas *et al*., 2015). There is a decrease in photosynthetic rate, transpiration, stomatal conductance, and leaf growth when there is a lack of water (Mahouachi *et al*., 2012).When cultivated under moderate or severe water stress, certain papaya types showed a reduction of chlorophyll content, stomatal conductance, and photochemical efficiency (Campostrini and Glenn, 2007). The study of papaya responses to environmental stressors aims to reduce the negative impacts of these stresses on physiological processes, allowing for novel management techniques in seedling production, plant breeding, and encouraging greater productivity (Campostrini and Glenn, 2007).

Mercury (Hg) is a heavy metal that is a major environmental contaminant. When plants collect Hg in contaminated areas, it transforms into a non-degradable hazardous heavy metal contaminant. The information on its absorption mechanism and growth inhibition is scarce. Mercury is released into the atmosphere through a variety of sources. Anthropogenic sources account for around half of the vapor-phase mercury budget in the atmosphere, while natural sources account for the other half (Gaffney and Marley, 2014; Obrist *et al*., 2018). Mercury is easily transported through the atmosphere and has a one-year atmospheric half-life (Ling *et al*., 2010). The aim of this study is to assess the effects of Mercury-treated soils on pawpaw (*Carica papaya* L.).

MATERIALS AND METHODS

Sample collection

Homogenized soil sample was collected from Wellspring University farm, Benin City. The test plant was obtained from the market. Mercury sulphate was introduced into the soil at different concentration level. The soil was watered daily with 20ml of tap water (pH 6.5-7.3).

Seed materials

The seeds of *Carica papaya* were purchased from Ogba market, in Oredo Local Government area of Edo State. Seeds with uniform size, colour and weight were chosen for the experimental purpose.

Seed Germination

Twenty healthy seeds were surface sterilized with 0.1% mercuric chloride solution, and were spread uniformly in pots. The pots were treated with an equal volume of the different concentrations of 0, 30, 50, 70 and 100 ppm.

Pot culture experiment

The culture experiment was conducted at Wellspring University farm, Benin City. The seeds were grown in pots containing untreated soil (Control) and soil mixed with various levels of mercury sulphate (viz., 0, 30, 50, 70 and 100 ppm). Fifteen seeds were sown in each pot. All pots were watered to field capacity every four days (to avoid logging). Plants were thinned to a maximum of nine per pots, after a week of germination. Each treatment including the control was replicated four times.

Growth Measurements

The plant samples were collected after sowing, that is, three plants from each replicates of pot were analyzed for the various growth parameters. The number of leaves, plant height, and stem girth were used to monitor plant growth and morphological responses, as reported by Ikhajiagbe (2016) and Ikhajiagbe et al. (2021)..

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Number of leaves: The number of leaves per plant was the total number of leaves standing per plant at a specific given time and they were physically counted.

Plant height: This was determined periodically on weekly basis. It was taken as the length of plant from the soil level to the meristematic tip using a measuring tape.

Stem girth: Stem girth was determined by using a Vernier caliper

Germination percentage (%): This was calculated as the percent (%) of germinating seeds starting from the first germination to no further germination.

$$Germinationpercentage\ (\%) = \frac{numberofgerminatedseedling}{totalnumberofseedssown} \times \frac{100}{1}$$

Soil physiochemical parameter

pH, Electric conductivity, Total organic carbon, Total Nitrogen, Exchangeable acidity, Clay, Silt, Sand and Hg were determined in the laboratory according to the methods of APHA (2008).

Statistical Analysis

Statistical analysis was performed using SPSS-20. The data represented mean calculated and standard deviation from 4 replicates. Thereafter, data were subjected to ANOVA and LSD.

RESULTS

Table 1: The physicochemical properties of farm soil used for the experiment

Parameters	Values
pH	5. 87
Electrical conductivity (µs cm^{-1})	294.12
Total organic carbon (%)	0.53
Total Nitrogen (%)	0.22
Exchangeable acidity	0.26
Na (meq/100 g soil)	9.74
K (meq/100 g soil)	1.42
Ca (meq/100 g soil)	12.23
Mg (meq/100 g soil)	10.20
NO_2- (mg kg^{-1})	14.34
NO_3- (mg kg^{-1})	28.10
Clay (%)	5.31
Silt (%)	6.60
Sand (%)	78.18
Fe (mg kg^{-1})	897.45
Hg (mg kg^{-1})	0.14

Table 2: Percentage (%) germination of *Carica papaya* seeds grown in Mercury-treated soils

Concentration of Hg solution applied	Days after planting (%)				
	7	14	21	28	35
0 ppm	-	-	13.33	33.33	53.33
30 ppm	-	-	13.33	26.67	40
50 ppm	-	-	13.33	26.67	40
70 ppm	-	-	13.33	26.67	40
100 ppm	-	-	0.00	13.33	26.67

Values = average of four replicates; ppm = parts per million

Table 2 shows that after planting at varied concentrations, no growth was observed on days 7 and 14. However, growth was observed on days 21, 28, and 35 respectively. The highest growth was observed in 0 ppm concentration on day 35 (53.33 %), whereas the lowest growth was observe on days 21 (0 – 70 ppm) and 28 days (100 ppm). Although there was no growth in the 100 ppm concentration at day 21, consistent growth was observed at day 35 (30, 50 and 70ppm).

Table 3: Plant height (cm) of *Carica papaya* grown in Mercury-treated soils

Treatment (ppm)	10 WAP	11 WAP	12 WAP	13 WAP	14 WAP	15 WAP
0	10.97±3.83a*	13.80±5.23a*	14.05±5.22a*	14.38±5.13a*	5.00±10.00a	5.00±10.00a
30	9.68±1.99a*	10.55±2.17a*	10.88±2.26a*	11.13±2.10a*	11.98±2.35a*	12.08±2.45a*
50	8.40±2.49a*	8.85±2.53a*	9.15±2.59a*	9.58±2.60a*	5.33±6.21a	5.43±6.35a
70	11.58±4.52a*	12.68±4.96a*	12.98±4.94a*	13.35±4.79a*	13.68±10.13a*	13.78±10.21a*
100	9.88±1.12a*	11.18±0.80a*	11.65±0.76a*	12.08±0.62a*	7.53±7.28a	10.45±7.13a*
Mean	**10.10±2.94**	**11.41±3.63**	**11.74±3.62**	**12.10±3.55**	**8.70±7.77**	**9.35±7.80**
LSD(0.05)	**1.94**	**2.27**	**2.28**	**2.22**	**4.92**	**4.93**
Pvalue	**> 0.01**	**> 0.01**	**> 0.01**	**> 0.01**	**6.58**	**6.60**

Value: Mean±S.D on the same column with asterisks are significantly different from the control (0ppm) ($p<0.05$); WAP = weeks after planting; ppm = parts per million

Table 3 shows the plant heights of *Carica papaya* plants grown in Mercury sulphate treated soil; the highest growth was observed in 0ppm (13WAP) with 14.38±5.13 cm while the lowest growth was recorded in 0 ppm (14WAP) with 5.00±10.00cm. Generally, there were significant differences in the plant heights across the treatments. It was observed that there were steady growth across 10WAP – 15WAP in 30 ppm (9.68±1.99 cm to 12.08±2.45 cm) and 70 ppm (11.58±4.52 cm to 13.78±10.21 cm) respectively. But a decrease were recorded in 0 ppm (5.00±10.00 cm) and 50 ppm (5.33±6.21 cm). .

Table 4: Stem girth (cm) of *Carica papaya* grown in Mercury-treated soils

Treatment (ppm)	10 WAP	11 WAP	12 WAP	13 WAP	14 WAP	15 WAP
0	0.30±0.08a	0.50±0.16a*	0.78±0.19b*	0.78±0.13a	0.28±0.55a	0.28±0.55a
30	0.30±0.14a	0.38±0.10a	0.53±0.10b*	0.63±0.10a	0.73±0.10a*	0.75±0.13a*
50	0.23±0.15a	0.43±0.15a*	0.60±0.14ab*	0.73±0.10a	0.38±0.43a	0.38±0.43a

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70	0.30±0.08a	0.43±0.10a*	0.63±0.10ab*	0.75±0.06a	0.63±0.42a*	0.65±0.44a*
100	0.28±0.05a	0.38±0.13a	0.50±0.08a*	0.70±0.08a	0.60±0.41a*	0.65±0.44a*
Mean	**0.28±0.10**	**0.42±0.13**	**0.61±0.15**	**0.72±0.10**	**0.52±0.40**	**0.54±0.42**
LSD(0.05)	**0.22**	**0.26**	**0.25**	**0.19**	**0.26**	**0.27**
Pvalue	**< 0.01**	**0.35**	**> 0.01**	**> 0.01**	**0.35**	**0.36**

Value: Mean±S.D on the same column with asterisks are significantly different from the control (0ppm) (p<0.05). WAP = weeks after planting; ppm = parts per million

The results for stem girth of *Carica papaya* plants growing in Mercury sulphate treated soil are shown in Table 4. The highest stem girth was observed in 0 ppm (12WAP) with 0.78±0.19 cm while the lowest was recorded in 50 ppm (10WAP) with 0.23±0.15 cm. There was a steady increase in the stem girth in 30 ppm ranging from 0.30±0.14 cm – 0.75±0.13cm.

Table 5: Number of leaves per plant for *Carica papaya* grown in Mercury-treated soils

Treatment (ppm)	10 WAP	11 WAP	12 WAP	13 WAP	14 WAP	15 WAP
0	4.75±1.71a*	4.75±1.71a*	4.00±2.83a*	1.25±1.89a	0.75±1.50a	0.50±1.00a
30	6.25±1.50a*	6.75±0.50a*	6.75±0.96b*	4.25±0.96b*	3.50±1.00a*	2.75±0.96a*
50	5.50±1.00a*	6.25±1.26a*	6.00±0.82ab*	4.50±2.52b*	3.00±3.83a*	2.75±3.40a*
70	3.75±1.26a*	5.00±1.41a*	5.25±0.96ab*	3.50±1.00ab*	2.50±1.73a	2.00±1.41a
100	5.00±2.00a*	5.00±1.41a*	4.25±0.50b*	4.00±0.82b*	2.75±1.89a	3.25±2.22a*
Mean	**5.05±1.61**	**5.55±1.43**	**5.25±1.68**	**3.50±1.85**	**2.50±2.19**	**2.25±2.05**
LSD(0.05)	**0.97**	**0.84**	**0.93**	**1.01**	**1.41**	**1.28**
Pvalue	**> 0.01**	**> 0.01**	**> 0.01**	**1.35**	**1.88**	**1.72**

Value: Mean±S.D on the same column with asterisks are significantly different from the control (0ppm) (p<0.05). WAP = weeks after planting; ppm = parts per million

The number of leaves obtained for *Carica papaya* plants growing in Mercury sulphate-treated soil is shown in Table 5. Concentration was a factor in the results obtained weeks after planting. The highest number of leaves were observed in 30 ppm with 6.75±0.50 cm (11WAP) and 6.75±0.96 cm (12WAP) respectively, whereas the lowest number of leaves was recorded in 0 ppm (15WAP) with 0.50±1.00 cm. It was generally observed that, the higher the concentration, the lower the number of leaves. The number of leaves decreased significantly across from 11WAP to 15WAP (4.75±1.71 cm – 0.50±1.00 cm) at 0 ppm.

DISCUSSION

This study revealed that the impact of mercury sulphate in soil is implicated in the growth of papaya (*Carica papaya* L.).

It is evident that Carica papaya germination in soil treated with Hg was delayed for 14 days with 0% germination and fewer seeds germinated at 21 days (13.33%) after planting owing to the inability of the seeds to break dormancy in the presence of metal. The proportion of seedlings grown in soil treated with Hg revealed a lower percentage from the lowest concentration (0 ppm) to the highest concentration (70 ppm). At 21 days after planting, a further delay in germination was recorded at 100 ppm, with no germination observed. Generally, the higher the treatment concentration, the lower the percentage of germination. This finding is in agreement with the study of Sethy and Ghosh (2013), who reported that metals cause a decrease in the germination of seeds. Furthermore, in a different study conducted by Li *et al*. (2005) on Arabidopsis thaliana, they reported that Hg toxicity influenced the seed germination, leading to a decreased germination rate. As a result, the increased concentration of Hg in the germination of papaya seeds in the soil resulted in a reduction in accessible water in the embryo axis, which might explain the poor germination rate.

The response of *Carica papaya* to Hg-treated soil exhibited some stimulating variances. The effects of Hg solution on the height of *Carica papaya* indicated that as Hg content increases, the plant height decreases, except at 70 ppm, when a significant increase was observed. The plant heights reported in this study were significant in some ways. The height of the plants varied significantly through the week after planting (WAP). Hg solutions boosted plant height, and stable growth was observed at 30 ppm. The explanation for this might be deduced from the fact that treatments were applied weekly. The plants had enough time to absorb the available Hg ions in the soil for positive development due to the distance between treatment applications. The findings were comparable to those of Vwioko and Digwe (2018), who employed copper to accelerate the development of *Cyperus esculentus* L. in the field. However, Hans *et al*. (2004) found that chromium inhibits plant development as measured by plant height. Bernado *et al*. (2006) observed a significant decrease in plant height in a cowpea cultivar as Hg stress increased.

The effects of Hg on the stem girth of *Carica papaya* The measurement data did not follow a specific pattern of impact, indicating that the treatment had little or no influence on this parameter. Similar discoveries were found in other treatments, though. Sandalio *et al*. (2001) found that heavy metals in soil reduce stem girth in pea plants, while John *et al*. (2009) found that heavy metals in soil reduce stem girth in *Brassica junicea* L.

The number of leaves formed by *Carica papaya* plants growing in Hg-treated soil rose when the treatment level was increased, with the exception of 70 ppm, where the number of leaves was reduced. Despite this, the treatments had minimal influence on the measured metrics. According to the findings of this study, the presence of Hg influenced the growth of the *Carica papaya* plant.

CONCLUSION

The results of this study revealed that seed germination and growth of *Carica papaya* were influenced by mercury (Hg) treatments. Although, the presence of Hg reduced the duration of seedling emergence in contaminated soil, lowering the proportion of seedlings that germinated. The most damaging concentration of Hg to germination and growth was at 100 ppm, whereas 30ppm and 70 ppm treatment improved the plant growth upon emergence. It is therefore recommended that further study be carried out to determine the physiological effects of Hg treatment.

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