Assessment of Impact of Simulated Acid Rain on the Growth of *Amaranthus hybridus* L. and *Abelmoschus esculentus*L.

Okon, Okon Godwin*[1]and Akpan, Gabriel Ukpong[2]

[1]*Department of Botany and Ecological Studies, University of Uyo, Nigeria.*
[2]*Department of Crop Science, University of Uyo, Nigeria.*
**Corresponding author: okjunior4zeeb@gmail.com*

Abstract

Assessment of the impact of simulated acid rain of different concentrations (pH 7.0, 6.0, 4.0 and 2.0) the growth and development of Amaranthus hybridus and Abelmoschus esculentus was carried out in the fieldusing earthen pots filled with 300 g sandy-loam soil. Seeds of A. hybridus and A. esculentus were planted in the different pots, after germination the plants were allowed to grow under normal conditions for one (1) week before applying the different grades of the simulated laboratory prepared acid rain every day for six (6) weeks. From this study, steady decrease in growth parameters of Amaranthus hybridus and Abelmoschus esculentus was observed with increasing acidity. Shoot length of A. esculentus recorded 109.20 ± 1.21 (control), 69.42 ± 1.01 (pH 6.0), 42.91 ± 0.34 (pH 4.0) and 24.86 ± 1.21 (pH 2.0) respectively. Similar observation was recorded for A. hybridus as its shoot length recording 69.21 ± 0.92 (control), 64.93 ± 0.41(pH 6.0), 54.21 ± 0.91 (pH 4.0) and 44.43 ± 0.28 (pH 2.0). Similar decrease was also recorded in the number of leaves, petiole length and leaf area. From this research, it is evident that acid rain can severely impede the growth and development of A. hybridus and A. esculentus. This could cause large scale loss to farmers and great economic loss to agricultural based economies. The occurrence of acid rain is likely to increase with steady and uncontrolled industrialization in the urban centres and spreading into the rural areas where these farmers grow these crops.

Key Terms *–Abelmoschus esculentus,*Acid rain, *Amaranthus hybridus*,Nitrogen dioxide and Sulfur dioxide

1. Introduction

Acid rain any form of precipitation or rain that is unusually acidic, meaning that it possesses elevated levels of hydrogen ions (low pH). It can have detrimental effects on plants, aquatic animals and infrastructure. Acid rain is caused by emissions of sulfur dioxide and nitrogen oxide, which react with the water molecules in the atmosphere to produce acids.The sources of atmospheric deposition can be categorized as either natural or anthropogenic (Bruno *et al.*, 2006).Unlike the case of fluoride that is emitted by afewer industries such as the aluminum ones, thereare many anthropogenic sources that acidify rainwater. The acids come from cars and fossil fuel- burning electrical power plants. Sulfur dioxide (SO_2) and nitrogen dioxide (NO_2)are the two main pollutants in the exhaust smoke that causethe acid rain problem. They react with other substances in theatmosphere to make the acids found in acid rain. NO_2 reactsto make nitric acid, and SO_2 reacts to make sulfuric acid.Together, these acids dissolve in thewater droplets that make up rainclouds where they change thechemical properties of the clouditself, and eventually the rain that follows (Morris, 2004).Acidity as well as harmful action of toxic elements damages vegetation whilesusceptible microbial species are eliminated from thesoil affecting processes such as decay anddecomposition of organic debris and the capacity of abalanced regulation of nutrients (Verma *et al.*, 2010).Acid rain results into acidification of soil, which increases the exchange between hydrogen ion and nutrientcations like potassium (K), magnesium (Mg) and calcium (Ca) in thesoil (Singh and Madhoolika, 2008). These cations are liberated into soil and can be rapidly leachedout in soil solution along with sulphate from acid input (Van Breeman*et al.*, 1984).Soils in general have a greater buffering capacity than aquatic system.However excessive amount of acids introduced byacid rains may disturb the entire soil chemistry(Bunyard, 1985; Verma *et al.*, 2010). Effects of acid rain on crops haveimportant economic and agricultural implications (Verma *et al.*, 2010).

In this study the plants used are *Amaranthus hybridus* L. belongs to the family Amaranthaceae and *Abelmoschus esculentus* L. belongs to the family Malvaceae.These plants are being produced in large scale for domestic and commercial purposes production around local farms, towns and large cities, areas where theproblem of acid rain is enormous. This researchis aimed at assessing the impact of simulated acid rainof different concentration (pH) on the production ofthese major crops used in this study.

2. Materials and Method

Experimental Setup and Procedure

The field experiment was carried out using earthen pots filled with 300 g sandy-loam soil. Seeds of *Amaranthus hybridus*and *Abelmoschus esculentus* were planted in the different pots, after germination the plants were allowed to grow under normal conditions for one (1) week before applying the different grades of the simulated laboratory prepared acid rain every day for six (6) weeks. The acid rain grades were filled in a mechanical hand sprayer and acted like rain shower according to the method described by Amar (2009).Simulated acid rain was sprayed to the *Amaranthus hybridus*and *Abelmoschus esculentus* cultivars according to different pH grades of 2.0, 4.0, 6.0 and 7.0 (Control).

Simulated Acid Rain Preparation

The simulated acid was prepared by acids acidic mixture of concentrated sulphuric acid (H_2SO_4) and concentrated nitric acid (HNO_3) using the ratio 2:1. The acidic solution was then calibrated using distilled water with a Deluxe pH meter to get the desiredpH (2.0, 4.0, and 6.0) and cross checked with pH pen according to the method described by Odiyi and Bamidele (2014). pH (7.0) was used as control which had distilled water.

Determination of Growth Parameters

The growth parameters such as plant height (shoot length) and petiole length were measured using meter rule (in centimeters); number of leaves was also determined by counting. Leaf Area (LA) was determined by multiplying leaf length by leaf width with the correction co-efficient (r) which is 0.72 (Hoyt and Bradfield, 1962) (Udo and Oputa, 1984).

LA = L x W x r

Where L = leaf Length,W = Leaf width, r = correlation coefficient (0.72).

Statistical Analysis

Results are expressed as mean ± Standard Error of Mean (SEM) of three replicates. Statistical significance between the different groups was determined by two-way Analysis of Variance (ANOVA) $P<0.05$ was considered as statistically significant (Ubom, 2004).

3. Results and Discussion

From this study, steady decrease in growth parameters of *Amaranthus hybridus*and *Abelmoschus esculentus*was observed with increased acidity. Shoot length of *A. esculentus* recorded 109.20 ± 1.21 (control), 69.42 ± 1.01 (pH 6.0), 42.91 ± 0.34 (pH 4.0) and 24.86 ± 1.21 (pH 2.0) respectively (Figure 1). Similar observation was recorded for *A. hybridus*as its shoot length recorded69.21 ± 0.92 (control), 64.93 ± 0.41(pH 6.0),54.21 ± 0.91 (pH 4.0) and 44.43 ± 0.28 (pH 2.0) (Figure 1). Similar decrease was also recorded in the number of leaves, petiole length and leaf area as shown on Table 1 and Figure 1, 2, 3 and 4. Chlorosis was observed at pH 2.0 and pH 4.0 in both *Amaranthus hybridus*and *Abelmoschus esculentus.*

Table 1: The effect of simulated acid rain on the growth of *Amaranthus hybridus*and *Abelmoschus esculentus*after six (6) weeks of planting.

	Abelmoschus esculentus				***Amaranthus Hybridus***			
Parameters	**Control**	**pH 6.0**	**pH 4.0**	**pH 2.0**	**Control**	**pH 6.0**	**pH 4.0**	**pH 2.0**
Shoot length (cm)	109.20 ± 1.21	69.42 ± 1.01	42.91 ± 0.34	24.86 ± 1.21	69.21 ± 0.92	64.93 ± 0.41	54.21 ± 0.91	44.43 ± 0.28
No. of leaves	79.00 ± 0.00	70.00 ± 0.00	63.00 ± 0.00	58.00 ± 0.00	41.00 ± 0.00	32.00 ± 0.00	26.00 ± 0.00	17.00 ± 0.00
Petiole length (cm)	19.36 ± 0.41	12.41 ± 0.91	9.25 ± 1.03	3.41 ± 0.71	12.41 ± 1.21	7.97 ± 1.01	6.01 ± 0.49	4.21 ± 0.10
Leaf area (cm^2)	89.21 ± 2.21	29.72 ± 0.41	26.10 ± 0.73	23.41 ± 0.14	67.49 ± 2.01	33.62 ± 1.00	18.01 ± 1.09	9.82 ± 0.92

The findings of this study agrees with the work Odiyi and Bamidele (2014) who reported thatcultivar of *Manihot esculenta* showed marked decrease in growth parameters compared to thecontrol. They also reported that simulated acid rain at pH 2.0 caused characteristic burn and irregular lesions on the plant leaves; similar observation was made in this study. Verma *et al.* (2010) also reported that plant growth of *L.esculentum*, *C.annuum* and *S.melongea*was hampered and the biomass reduced by increasing acidity of the simulated acid rain.This is similar to the earlier results of Halman *et al*.(2008); Evans *et al.* (1997) and Banwart *et al*. (1990). This could be as a result of reduction of photosynthetic activities as a result of chlorosis, necrosis and leaf abscission.

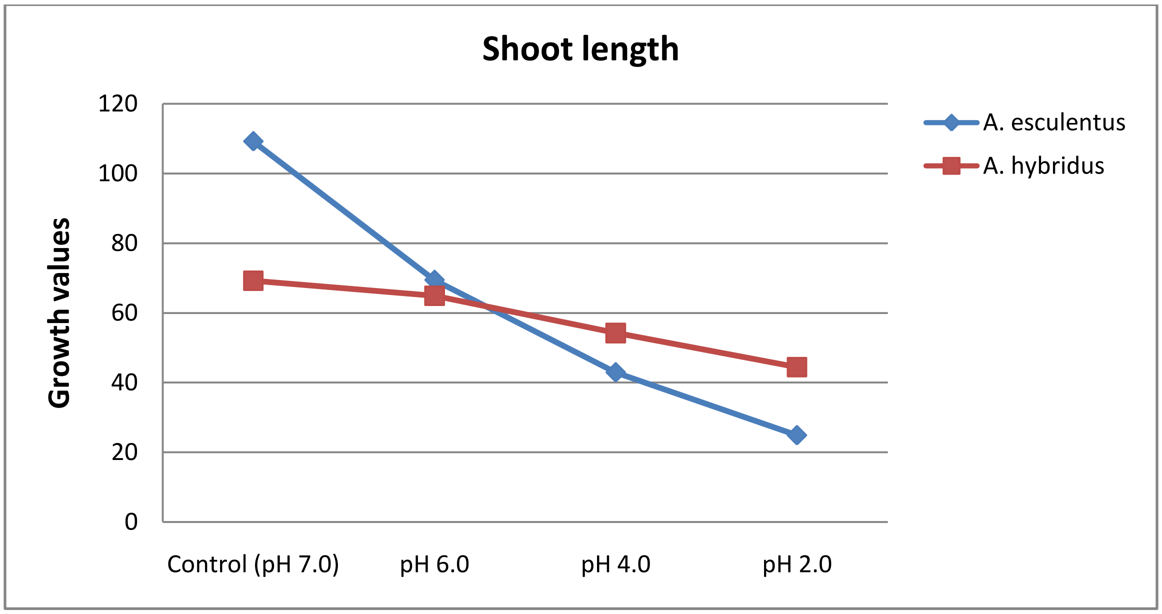

Figure 1: Impact of simulated acid rain on the shoot length of *A. esculentus* and *A. hybridus*

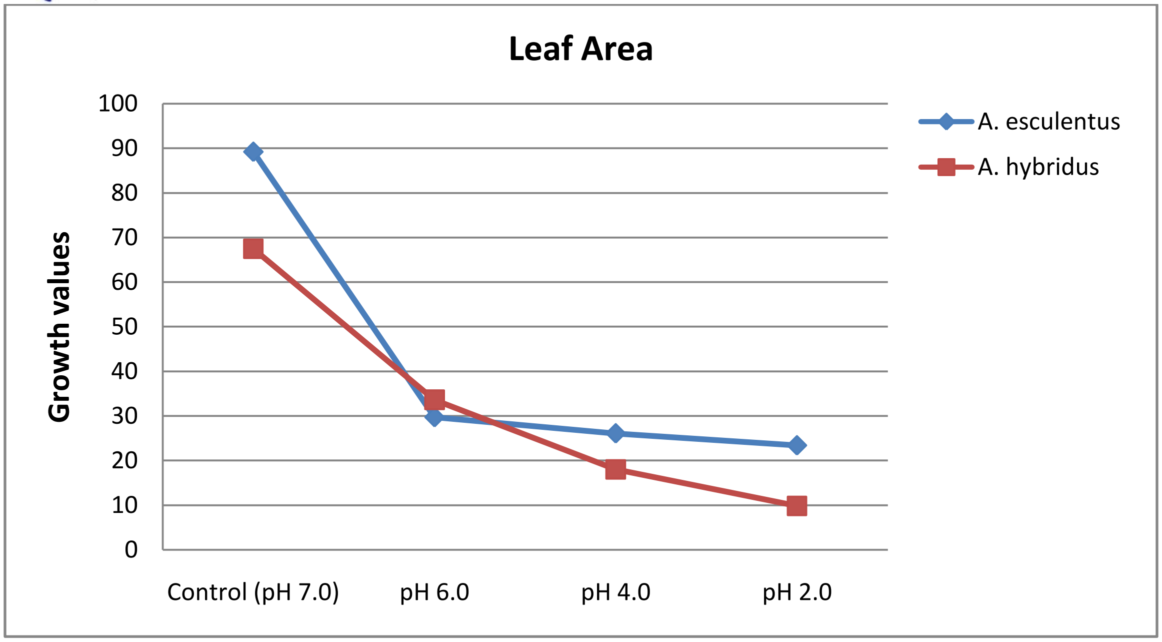

Figure 2: Impact of simulated acid rain on the leaf area of *A. esculentus* and *A. hybridus*

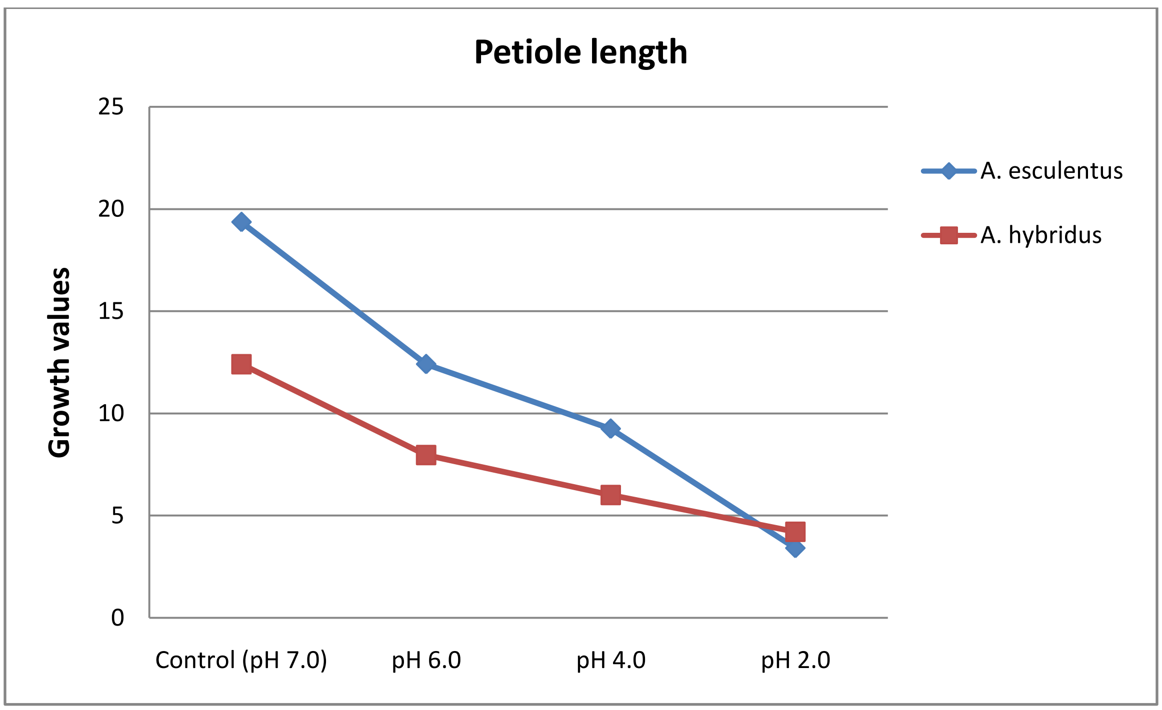

Figure 3: Impact of simulated acid rain on the petiole length of *A. esculentus* and *A. hybridus*

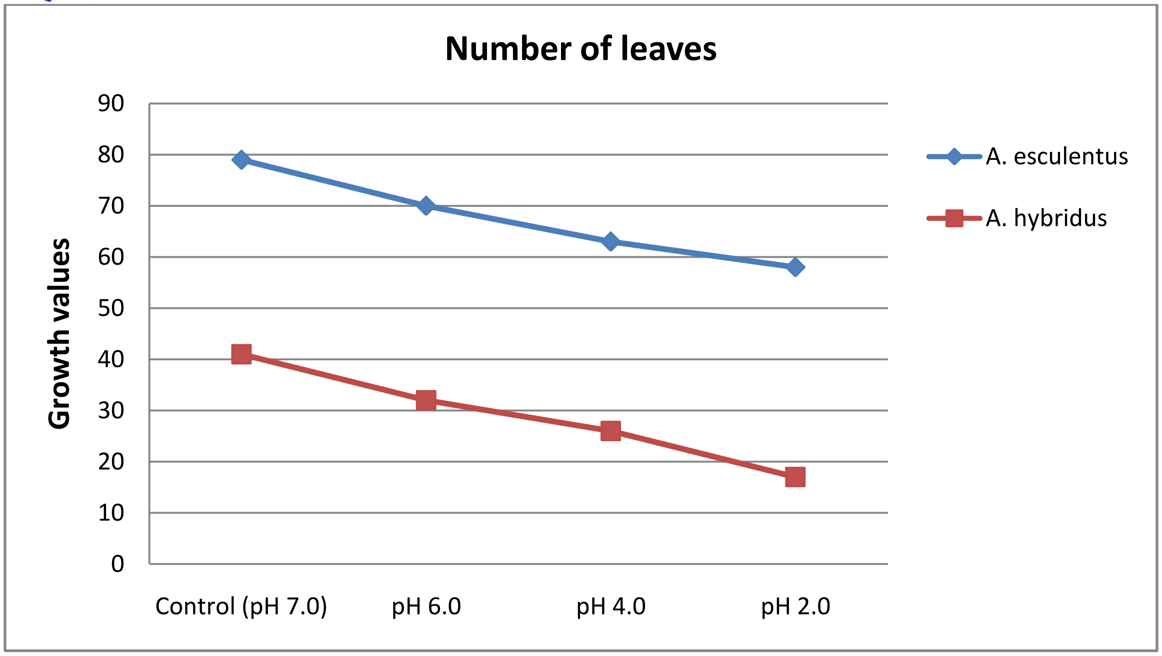

Figure 4: Impact of simulated acid rain on the number of leaves of *A. esculentus* and *A. hybridus*

Conclusion

From this research, it is evident that acid rain canseverely impede the growth and developmentof *Amaranthus hybridus*and *Abelmoschus esculentus.* This could cause large scale loss to farmers and great economic loss to agricultural based economies. The occurrence of acid rain is likely to increase with steady and uncontrolled industrialization in the urban centres and spreading into the rural areas where most of this farmers grow these crops. Thus, more research should be carried out to test the resistance of different varieties of *Amaranthus hybridus* and *Abelmoschus esculentus* to acid rain.

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