Impact Of Simulated Acid Rain of Different ph on the Growth and Yield of NR 930025 Cultivar of Manihot *Esculenta* (Crantz)

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ABSTRACT

The impact of simulated acid rain on the survival, growth and yield of NR 930025 cultivar of cassava *Manihot esculenta* (Crantz) is studied. A field experiment was conducted from October 2012 to March 2013 at the Federal University of Technology, Akure, Ondo state, Nigeria. Simulated acid rain was prepared with a mixed concentrated sulphuric acid (H_2SO_4) and concentrated nitric acid (HNO_3) in a ratio 2:1 to get the desired pH using a Deluxe pH meter. Plants was exposed to simulated acid rain of pH 2.0, 3.0, 4.0, 5.0, 6.0 and 7.0 which was the control, respectively. Simulated acid rain induced morphological changes including chlorosis, early leaf senescence, necrosis, leaf abscission, leaf folding and death. Plant height, leaf area, fresh weight, dry weight, relative growth rate , the chlorophyll content of the leaf and the harvest index was highest at 7.0 (control) and significantly ($p<0.05$) decreased with increasing acidity.

Keywords: Chlorophyll content, harvest index, *Manihot esculenta*, simulated acid rain.

INTRODUCTION

Acid rain is a major polluting agent harmful to terrestrial and aquatic ecosystems (Brimblecombe *et al*., 2007). It is the wet deposition that has been acidified when pollutants such as oxides of sulphur and nitrogen contained in power plant emission, factory smoke and car exhaust, react with the moisture in the atmosphere (Kita *et al*., 2004). In natural conditions atmospheric precipitation is slightly acidic due to the dissolution of atmospheric carbon dioxide. Rain that presents a concentration of H^+ ions greater than $2.5\mu eq^{-1}$ and pH values lower than 5.6 is considered acid. Acid deposition may cause decline in health and growth plants (Wyrwicha and Sklodowska, 2006). Several experiments have been carried out in the field and in greenhouses to investigate the effect of acid rain in plants (Silva *et al*., 2005). Acid rain exposure of plants resulted in characteristic of foliar injury symptoms, modified leaf anatomy (Stoynora and Velikova, 1998), structural changes in the photosynthetic pigment apparatus and a decrease in the chlorophyll concentrations (Sant' Anna-Santos *et al*., 2006). Also, reduction in plant growth and yield of field corn (Banwart, *et al*.,1988), green pepper (Shripal *et al*., 2000), tomato (Dursun *et al*., 2002) were reported. Acid rain has negative effect on seed germination of rice, wheat and grapes and also inhibit reproduction of these plants (Huang et al., 2005). Acid rain also has a detrimental effect on the developmental stages of ovules and seed protein in bean plants *Phaseolus vulgaris*. (Chehregani, 2007). An important component of the effect of acid rain on our ecosystem is

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its impact on the yield of agricultural crops.

Cassava is a woody shrub that belongs to the family Euphorbiaceae (Nweke *et al*., 2002). Since the introduction into Nigeria it has become very popular throughout the country. It is grown in 70% of the Nigerian states, available from the swamp forest area to the Guinea savannah area of Nigeria. So, keeping in view the importance of this plant in human diet and the adverse effect of simulated acid rain, the present study was carried out to assess the impact of simulated acid rain on this plant cultivar.

MATERIALS AND METHODS

Planting procedure

A field experiment was conducted in the school farm of the Federal University of Technology, Akure, Ondo state, Nigeria. Stem cuttings of 30cm long each of NR 930025 cultivar of *M. esculenta* were planted horizontally with a spacing of 100cm and four stem cuttings were planted on each row. Each pH treatment had four replicates and was arranged in a Completely Randomized Design (CRD). The plants were watered every other day and grown for a week before the application of the simulated acid rain treatment. The experimental field was hoe weeded as necessary. Simulated acid rain was sprayed to the planted cassava cultivars according to their pH values of 2.0, 3.0, 4.0, 5.0, 6.0 and the control (7.0). The solutions were applied using a medium size pressurized sprayer on the plants. The plants grew for twenty five weeks before the termination of the experiment.

Preparation of simulated acid rain

The simulated acid rain was formed from mixture of concentrated sulphuric acid (H_2SO_4) and concentrated nitric acid (HNO_3) in a ratio 2:1. The acidic solution was then calibrated using distilled water with a Deluxe pH meter to get the desired pH (2.0, 3.0. 4.0, 5.0 and 6.0) and cross checked with pH pen. The control pH (7.0) had distilled water.

Several parameters were used in assessing the growth and productivity of the plant. The height of shoots was measured using a tape rule in (cm) from the soil level to the terminal bud. The measurements were taken in an interval of 2 weeks from the day the acid rain treatment commenced to the day of harvest. Leaf area was determined by the proportional method of weighing a cut-out of traced area of the leaves on graph paper with standard paper of known weight to area ratio. The fresh and dry weights were determined after twenty four weeks of treatment following the method of Hunt (1990). Relative growth rate (RGR) was calculated following the methods of Hunt (1990) and the fresh weight of the whole plant was used to determine the relative growth rate.

$RGR = (\log_e W_2 - \log_e W_1)/ (T_2-T_1)$

Where: W_2 = final weight

W_1 =initial weight

T_2 =final time

T_1 = initial time.

The chlorophyll content of the leaves was determined and the harvest index was determined by the method of Ekanayake (1994).

$$\text{Harvest Index (HI)} = \frac{\text{Tuber dry weight}}{\text{Total plant dry weight}}$$

Statistical analysis

Data obtained were subjected to analysis using the Statistical Package for Social Sciences, Version 15.0 (SPSS, 2003). Treatment means were separated using the Duncan Multiple Range Test (Zar, 1984).

RESULTS AND DISCUSSION

Morphological changes were observed in NR 930025 through the 24 weeks after simulated acid rain treatment. The effects of simulated acid rain on the morphology

shows that the leaves turned brownish, withered with 70% leaf abscission. The dropping and eventual collapse of leaves stretched over a period of 16-20 weeks at pH 4.0 to pH 2.0. Leaf abscission started with the leaves at the base of the shoot droppings with long petiole at pH 4.0 treatment. Leaves were chlorotic and necrotic. At 2.0 pH treatment, plants died from the base of the shoot. Leaves had 60% leaf abscission.

Table 1. Effect of simulated acid rain (SAR) on the plant height (cm), leaf area (cm), fresh weight (g), dry weight (g) of NR 930025 cultivar of *Manihot esculenta*, 24 weeks after treatment.

pH of SAR	Plant height (cm)	Leaf area (cm)	Fresh weight (g)	Dry weight (g)
7.0 (Control)	190.20 ± 5.36 a	308.64 ± 4.27 a	892.11 ± 0.17 a	442.36 ± 0.24 a
6.0	99.12 ± 5.02 b	269.08 ± 4.17 b	730.32 ± 0.14 b	396.14 ± 0.20 b
5.0	89.16 ± 4.20 b	273.54 ± 3.08 b	512.16 ± 0.12 c	326.28 ± 0.17 b
4.0	80.33 ± 3.60 b	235.24 ± 3.10b	384.23 ± 0.10 d	258.52 ± 0.14 c
3.0	62.34 ± 3.31 c	204.26 ± 1.28c	304 .10 ± 0.07e	174.20 ± 0.10 d
2.0	50.01 ± 3.10 d	176.32 ± 1.24c	126.28 ± 0.03 f	92.43 ± 0.05 e

Each value is a mean of ± standard error of four replicates. Means within the same column followed by the same letter are not significantly different at (P>0.05) from each other using New Duncan Multiple Range Test.

The plant had the highest plant height, leaf area, fresh weight and dry weight significantly higher ($p< 0.05$) at the control (pH 7.0) compared to the other acidity treatments.

Table 2. Effect of simulated acid rain (SAR) on the relative growth rate ($gg^{-1}d^{-1}$), chlorophyll content (mg/g) and harvest index of NR 930025 cultivar of *Manihot esculenta*, 24 weeks after treatment.

pH of SAR	Relative growth rate	Chlorophyll content	Harvest index
7.0 (Control)	3.0 ± 0.22 a	3.7 ± 0.20 a	0.5
6.0	2.6 ± 0.21 a	3.0 ± 0.18 a	0.4
5.0	2.1 ± 0.20 b	2.4 ± 0.14 b	0.3
4.0	1.7 ± 0.16 b	1.8 ± 0.10 b	0.2
3.0	1.2 ± 0.12 b	0.7 ± 0.07 c	0.1
2.0	0.8 ± 0.06 c	0.2 ± 0.03 c	0.1

Each value is a mean of ± standard error of four replicates. Means within the same column followed by the same letter are not significantly different at (P>0.05) from each other using New Duncan Multiple Range Test.

The effect of simulated acid rain on the relative growth rate (RGR), the chlorophyll content and the harvest index of NR 930025. The cultivar had the relative growth rate, the chlorophyll content and the harvest index significantly higher ($p< 0.05$) at pH 7.0 compared to the other acidity treatments. There was a

significant reduction in the relative growth rate, the chlorophyll content and the harvest index with decreasing pH level.

Simulated acid rain treatment deposited on leaves affect mainly the epidermal cells causing erosion of the cuticle and altering the leaf permeability (Evans, 1984). Symptoms of plants polluted with simulated acid rain include chlorosis, necrosis, stunted growth, lesion, suppression of leaf production, leaf curling, withering of leaves, leaf abscission and even death of plants. Silva *et al*, 2006 found that plants exposed to low pH rain (pH 3.0) are generally retarded with leaf chlorosis, necrotic spot coupled with dehydration of the plants. Simulated acid rain exposure caused chlorosis, necrotic lesions and leaf tip injuries at the different pH levels of NR 930025 cultivar. Necrosis progressed from nodal region to the adjacent inter-nodal region leading to large scale leaf abscission at pH 2.0 and 3.0 of NR 930025. Marked chlorotic and marginal necrotic symptoms were observed at pH 4.0 and 5.0. However, this was less pronounced in comparison to pH 3.0 and pH 2.0. Similar symptoms were also observed by Johnston and Shriner (1985) on wheat at pH 4.3 and 2.3.

NR 930025 showed marked decrease in growth parameters compared to the control. Simulated acid rain at pH 2.0 caused characteristic burned irregular lesions on the plant leaves of NR 930025. It is well reported by many workers that plants sensitive to acid rain can present changes in their morphology, anatomy, physiology and biochemistry (Neufeld *et al*., 1985). All the plant growth parameters studied the plant height, leaf area, fresh weight and dry weight of NR 930025 were decreased significantly at all acidity levels with respect to the control set and highest reduction were observed at pH 2.0 level (Table 1). The adverse effects of simulated acid rain on plant growth parameters on several crops were also observed by Evans *et al*. (1997), Banwart *et al.* (1990), Chevone *et al*. (1984).

Photosynthetic pigments were also inhibited with respect to acidity levels. Chlorophyll content was significantly reduced by simulated acid rain treatment relative to the control at pH 2.0 and pH 3.0 (Table 2). The greater foliar injury noticed in plants exposed to pH 2.0 is associated with the decreased chlorophyll content and the damage to the photosynthetic apparatus. This is similar to the earlier results of Sheridan and Rosenstreter (1973), Evans (1984). Reduction was due to the removal of Mg^{+} from the tetrapyrol ring of the chlorophyll molecules by H^{+} (Foster, 1990) or due to increase of transpiration by acid rain (Evans *et al*.,1997). Recently similar results were also observed on many crops like mustard, radish, potato (Agrawal *et al*., 2005; Kausar *et al*., 2005; Khan and Devpura 2005; Varshney *et al*., 2005).

Relative growth rate and harvest index was lowest at pH 2.0 and pH 3.0 of NR 930025 compared to the control plants (Table 2) and this have been reported by a number of authors (Seinfield *et al*., 1998; Ekanayake 1994; Cock *et al*., 1977; Kawano 1978). According to Iglesias *et al*., (1994), harvest index of 0.5- 0.6 is the optimum level for crops because at higher values of harvest index, root production decreases due to reduced leaf area, light interception and photosynthesis. This research shows that simulated acid rain with pH 2.0 and 3.0 has negative effect on the growth and yield of NR 930025 cultivar of *Manihot esculenta* due to reduction of photosynthesis as a result of chlorosis, necrosis and leaf abscission.

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أثر الأمطار الحامضية الاصطناعية ذات أرقام حامضية مختلفة على نمو وإنتاج الكسافا (صنف930025 NR) Manihote sculenta (Crantz)

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ملخــص

لقد تمت دراسة الأرقام الحامضية المختلفة للأمطار الصناعية على الإنتاج والنمو والحياة لصنف نبات الكسافا ManihotEsculenta (Crantz). حيث أجريت الدراسة في شهر تشرين أول 2012 وحتى آذار 2013 في جامعة التكنولوجيا الفيدرالية في أكورا، ولاية اوندو في نيجيريا. تم تحقيق الحموضية بخلط حامض الكبريتيك (H_2SO_4) المركز، وحامض النيتريك (HNO_3) المركز، بنسبة 1:2. تمت إضافة المياه إلى النباتات بحامض ذات درجة حموضة (pH) تساوي (2، 3، 4، 5، 6، و 7). وكانت المعاملة 7 هي الشاهد، أثرت الحموضة بشكل ملحوظ حيث تغيرت أشكال النباتات وحصل منها أيضا الاصفرار (Chlorosis)، هرم مبكر للأوراق (Early Leaf Senescence)، تبقع أو نخر الأوراق (Necrosis)، سقوط الأوراق (Leaf Abscission)، انطواء أو التفاف الأوراق (Leaf Folding)، موت الأوراق (Death). حصل أعلى طول للنبات، كبر مساحة للأوراق، زيادة في كمية الكلوروفيل في الأوراق وفي معامل الحصاد (Harvest Index) وبعامل معنوي ($p<0.05$) منخفض مع زيادة الحموضة.

الكلمات الدالة: محتوى الكلوروفيل، معامل حصاد، ManihotEsculenta، مطر اصطناعي حامضي.

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