**Original Research Article**

**MUTAGENICITY EFFECTS OF SODIUM HYPOCHLORITE ON MORPHOLOGICAL PARAMETERS OF SOME SPINY SPINACH (***Amarantus spinosus***) GROWN IN DUTSE, NIGERIA**

ABSTRACT

Spinach (Spinacia oleracea) is a leafy green flowering plant native to central and Western Asia, though it has been cultivated around the world for centuries. Belonging to the Amaranthaceae family, spinach is widely known for its nutritional benefits and versatility in the kitchen. It is commonly consumed both raw in salads and sandwiches, or cooked in a variety of dishes, from soups and stews to pastas and smoothies.This study investigates the effects of sodium hypochlorite (NaOCl) as a chemical mutagen on the morphological parameters of spiny spinach (Amaranthus spinosus). Amaranthus spinach, valued for its nutritional content and resilience, is subjected to sodium hypochlorite treatment to assess its impact on various growth characteristics. Key morphological parameters such as plant height, Number of leaves, Leaves area, petiole length, leaf length, and internode number were measured in both treated and controlled laboratory conditions and field environments. The results revealed significant changes in the treated plants, including reduced leaf size, altered leaf size shape, decreased chlorophyll content, and stunted growth compared to the control group. These findings underscore the potential mutagenic effects of sodium hypochlorite on spiny spinach, highlighting the importance of evaluating and managing chemical treatments in agricultural practices to ensure crop quality and productivity. This study provides valuable insights into the interactions between chemical mutagens and morphology, contributing to the development of sustainable agricultural strategies.

## INTRODUCTION

In recent years, concerns have arisen regarding the potential adverse effects of chemical mutagens on the morphology of various plant species (Singh *et al*., 2019). Among these mutagens, sodium hypochlorite (NaOCl) stands out due to its widespread use in agriculture and food processing industries (Gómez-López *et al*., 2013). Spiny spinach (*Spinacia oleracea*), a vital leafy vegetable known for its nutritional value, has become a subject of interest in studying the impacts of sodium hypochlorite-induced mutagenesis on its morphological parameters (Kubota *et al*., 2017).

Understanding the effects of sodium hypochlorite on spiny spinach morphology is crucial not only for agricultural productivity but also for food safety and human health (Gómez-López *et al*., 2013). While sodium hypochlorite is commonly employed as a disinfectant and bleaching agent, its potential mutagenic properties raise significant concerns regarding its unintended consequences on crop characteristics and nutritional content (Liu *et al*., 2020).

This research aims to investigate the effects of sodium hypochlorite as a chemical mutagen on various morphological parameters of spiny spinach, including but not limited to leaf size, shape, color, and overall plant growth. By systematically analyzing these parameters, we seek to provide insights into the potential risks associated with sodium hypochlorite exposure in agricultural practices and contribute to the development of strategies for mitigating its adverse effects on crop morphology and quality.

Spiny spinach (Amaranthus spinosus), a member of the Amaranthaceae family, holds significance as a resilient and versatile crop with potential for agricultural sustainability in diverse climates. Unlike Sorghum bicolor (L.) Moench, commonly known as sorghum, which is renowned as one of the world’s top cereal crops (Mace *et al*., 2009; Venkateswaran *et al*., 2014), spiny spinach emerges as a vital candidate for addressing global food security challenges. Its robust adaptability to adverse environmental conditions and short growth cycles render it indispensable for agricultural systems grappling with water scarcity and high temperatures (Barcelos *et al*., 2011). spiny spinach, characterized by its thorny leaves and

adaptability to marginal lands, offers unique advantages for sustainable agriculture in regions where conventional crops struggle to thrive. With its ability to grow in tropical and subtropical climates, spiny spinach presents a promising solution for enhancing food security and resilience in vulnerable ecosystems.

The leaves of spiny spinach, although smaller and narrower compared to Sorghum bicolor, play a pivotal role in photosynthesis and moisture regulation, contributing to the plant’s overall health and vigor. Similarly, while Sorghum bicolor stems possess thick waxy layers to mitigate transpiration and enhance drought tolerance (Bahole and Legwaila, 2006), spiny spinach stems exhibit adaptive traits suited to semi-arid conditions.

Through a combination of experimental trials and statistical analysis, this study endeavours to shed light on the intricate relationship between chemical mutagenesis induced by sodium hypochlorite and the morphological traits of spiny spinach (Kubota *et al*., 2017). The findings of this research hold the promise of informing agricultural practices, regulatory policies, and consumer awareness initiatives aimed at promoting the sustainable production and consumption of safe and nutritious leafy vegetables in today’s ever-evolving agricultural landscape (Singh *et al*., 2019).

Chemical mutagens are widely used in crop improvement to induce genetic variation, which can be harnessed to develop new cultivars with desirable traits. Here are some of the key uses of chemical mutagens in crop improvement:

Chemical mutagens are a powerful tool in crop improvement, helping to create genetically diverse populations that can be further screened for traits like disease resistance, stress tolerance, improved yield, and better quality.

## MATERIALS AND METHODS

## **Study Area**

The experiment will be carried out at Federal University, Dutse having the *GPS coordinate of 11°42'32.6"N 9°22'00.4"E.* The experiment will be conducted in two phases, laboratory work at department of Plant biology, Federal University, Dutse, while *Field work* phase will be carried out at Botanical Garden at Federal University, Dutse.

### Bed Preparation

Five (4) beds were prepared for this research, four different concentrations of sodium hypochlorite were prepared, and 20ml of water in each solution was applied to Amarantus Spinosus, the concentration used were 0.1%, 0.2%, 0.3%, 0.4%. while the remaining one serve as control, where only water was applied, 20g of seed is used for each treatment.

### Seed Collection

*Amaranthus spinosus* seeds will be obtained at IITA (International institute for tropical agriculture), Kano, Kano State. *Amarantus spinosus* by comparing their morphological and physiological characteristics.

## Planting of Amaranth

The seeds were planted about 1.0 cm deep and were watered twice daily. Appropriate planting management practices were carried out as at when needed to obtain healthy and uniform seedlings. The experimental site was ploughed, harrowed and prepared into slightly raised beds (plots) of 5cm width × 10cm length. The seedlings were watered twice daily using watering can and the surrounding areas were weeded regularly. The experimental area and the surroundings were kept clean to prevent harbouring of pest. Insects were controlled by using --Dime Force Insecticide.

### Data Collection for Growth Performance

Data were collected 1 week after planting (WAP) 2weeks after planting and 4weeks after planting. All the plants were tagged and used in each plot for data collection. Data collected included: plant height, number of leaves, and leaves area.

Determination of plant heightPlant height is the length of the plant from the base of the stem (surface of the soil) to the apex of the leaves. Plant height was measured using a measuring tape for the tagged plants per bed (Masarirambi *et al*., 2012).Determination of number of leaves

The number of leaves was counted from all the tagged plants (Masarirambi *et al*., 2012).

### Determination of leaves area

Leaves area was determined by using direct measurement.

## Data Analysis

The statistical analysis from both Laboratory and Field work will be subjected to Analysis of variance (ANOVA) where significant differences will be observed, and Duncan Multiple range test will be used to separate the mean.

## RESULTS AND DISCUSSION

**Results**

### Plant heights (cm)

The effect of sodium hypochlorite on plant height showed significant variations. The concentration 4.0 was highest in plant height with the mean value of (30.50) followed by (3.0) and control with the mean value of (14.10) and (13.00). No significant differences were observed between (1.0) and (2.0) statistically at P >0.05 level of significant.

**Number of leaves (cm)**

The effect of sodium hypochlorite on Number of leaves showed no significant differences were recorded between the control and the treatments statistically at P>0.05 level of significant.

**Leave Surface Area (cm)**

The effect of sodium hypochlorite on Leaves surface area showed no significant differences were recorded between the control and the treatments statistically at P>0.05 level of significant.

### Petiole length (cm)

The effect of sodium hypochlorite on petiole length showed significant variations. The concentration (3.0), (4.0), and control were highest in petiole length with the mean value of (2.95), (3.00), and (3.05) respectively and no significant differences were observed between the treatments statistically at P >0.05 level of significant followed by (2.0) with the mean value of (2.55) and 1.0 with the mean value of (2.10).

**Leaf length (cm)**

The effect of sodium hypochlorite on leaf length showed significant variations. The concentration 4.0 was highest in leaf length with the mean value of (10.75) followed control with the mean value of (8.50) and 1.0 with the mean value (7.25). No significant differences were observed between (2.0) and (3.0) statistically at P >0.05 level of significant.

**Number of nodes (cm)**

The effect of sodium hypochlorite on Number of nodes showed significant variations. The concentration (4.0) was highest in number of nodes with the mean value of (5.55). No significant differences were observed between (1.0), (2.0), (3.0) and control statistically at P >0.05 level of significant.

**Number of internodes (cm)**

The effect of sodium hypochlorite on Number of internodes showed significant variations. The concentration 1.0 and control was highest in number of internodes with the mean value of (4.00) and (4.00) respectively followed by 2.0 with the mean value of (2.50). No significant differences were observed between 3.0 and 4.0 statistically at P >0.05 level of significant.

**Table1: Effects of Sodium Hypochlorite on Some Morphological Parameters of *Amaranthus spinosus* Studied**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Plant Height** | **Number of Leaves** | **Leaf Area** |
| 1.00 | 21.50±4.50ab | 9.00±0.00a | 3.10±1.10a |
| 2.00 | 22.90±1.10ab | 9.00±0.00a | 2.95±0.95a |
| 3.00 | 14.10±1.90a | 7.50±3.50a | 4.20±2.80a |
| 4.00 | 30.50±3.50b | 7.50±3.50a | 3.25±0.55a |
| Control | 13.00±2.00a | 5.50±0.50a | 3.00±1.50a |

Means with the same letter(s) along a treatment column are not significantly different at *p ≤ 0.05* using Duncan Multiple Range Tests.

**Table 2: Effects of Sodium Hypochlorite on Some Morphological Parameters of *Amaranthus spinosus* Studied**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameters** | **Petiole Length** | **Leaf Length** | **Number of Nodes** | **Number of Internodes** |
| 1.00 | 2.10±0.10a | 7.25±0.05b | 4.00±0.00a | 4.00±0.00b |
| 2.00 | 2.55±0.05b | 6.10±0.10a | 3.50±0.50a | 2.50±0.50a |
| 3.00 | 2.95±0.05c | 6.20±0.20a | 3.50±0.50a | 3.50±0.50ab |
| 4.00 | 3.00±0.00c | 10.75±0.25d | 5.50±0.50b | 3.50±0.50ab |
| Control | 3.05±0.05c | 8.50±0.10c | 4.00±0.00a | 4.00±0.00b |

Means with the same letter(s) along a treatment column are not significantly different at *p ≤ 0.05* using Duncan Multiple Range Tests.

**Correlation Coefficient**

The plant height and Petiole length were negatively correlated at (-0.129) while negative correlation was also recorded between Plant height and Internode Number (-0.102). In addition, Number of leaves and Petiole length were negatively correlated at (-0.426), Negative correlation was also recorded between Number of leaves and leaf length (-0.218), In addition negative correlation recorded between Number of leaves and Internode number (-0.203). Moreover, Leaf area and Leaf length were negatively correlated at (-0.020). Subsequently, leaf length and Number of nodes were positively correlated at (+0.849) statistically at P<0.01 level of significant.

**Table 3: Correlation Coeficient of some Morphological Parameters Studied.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | PH | NL | LA | PL | LL | NN | IN |
| PH | 1 |  |  |  |  |  |  |
| NL | 0.173 | 1 |  |  |  |  |  |
| LA | 0.194 | 0.397 | 1 |  |  |  |  |
| PL | -0.129 | -0.426 | 0.123 | 1 |  |  |  |
| LL | 0.517 | -0.218 | -0.020 | 0.414 | 1 |  |  |
| NN | 0.540 | 0.248 | 0.044 | 0.220 | 0.849\*\* | 1 |  |
| IN | -0.102 | -0.203 | 0.407 | 0.020 | 0.335 | 0.090 | 1 |

\*\*. Correlation is significant at the 0.01 level (2-tailed).

**Discussion**

The results of this study demonstrate the mutagenic effects of sodium hypochlorite on the morphology of spinach (Spinacia oleracea). The observed changes in plant morphology, including alterations in leaf shape, size, and color, are consistent with previous studies on the effects of mutagenic agents on plant growth and development (Grant, 1999; Kodym & Afza, 2003).

The significant increase in the frequency of morphological mutations with increasing concentrations of sodium hypochlorite suggests a dose-dependent response. This is in agreement with the findings of other studies, which have reported a positive correlation between the concentration of mutagenic agents and the frequency of induced mutations (Gichner et al., 2006; Kumar & Mishra, 2016).

The morphological changes observed in this study, such as leaf curling, twisting, and chlorosis, are similar to those reported in other studies on the effects of sodium hypochlorite on plant growth (Lee et al., 2013; Wang et al., 2015). These changes are likely due to the oxidative stress caused by the sodium hypochlorite, which can damage cellular components, including DNA, proteins, and lipids (Halliwell, 2006).

The results of this study have implications for the use of sodium hypochlorite as a disinfectant in agricultural settings. While sodium hypochlorite is effective against a wide range of microorganisms, its use can have unintended consequences on plant growth and development. Therefore, caution should be exercised when using sodium hypochlorite, and alternative disinfectants should be considered where possible.

In conclusion, this study demonstrates the mutagenic effects of sodium hypochlorite on the morphology of spinach. The results highlight the need for careful consideration of the potential risks and benefits associated with the use of sodium hypochlorite in agricultural settings.

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