ASSESSING MAIZE (*Zea mays*) ACCESSIONS FROM EDO STATE UNDER WATER LOGGING CONDITIONS AT 5 LEAF STAGE

BY

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FACULTY OF AGRICULTURE
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BENIN CITY.

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF CROP SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF AGRICULTURE DEGREE B. AGRIC (CROP SCIENCE)

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CERTIFICATION

This is to certify that this research was carried out by GIFT AIMEDE IKHIDE (Miss) of the Department of Crop Science, Faculty of Agriculture, University of Benin, Edo State. Nigeria.

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_________________________ _______________

Prof. S.U. Ewansiha Date
Head of Department.

DEDICATION

This project is dedicated to God Almighty, whose wisdom and grace have brightened my journey throughout my time at the University of Benin.

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Truly every Journey begins with a Step with Joy in my heart, I would like to express my profound gratitude to God, the creator of life and everything in it. And everyone who has supported me through this journey.

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TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

This study evaluated the tolerance of maize accessions Edo Statefrom South-South Nigeria to waterlogging stress, a major constraint to maize productivity. This study was conducted in a screen house at the Faculty of Agriculture, University of Benin, the experiment was in a Completely Randomized Design (CRD) with six Accessions from South -South replicated three times. The Accessions were obtained from Aduwawa, Agbede, Auchi, New Benin, and Useh were pre-treated, and waterlogging was induced at the five-leaf stage (5LS) for four weeks. Neem leaves were used as an organic insecticide, and fertilizer was applied to support growth. Data on plant height, leaf dimensions, number of leaves, tasseling, silking, pollen shedding, ear height, adventitious roots, and plant mortality were collected as from 2 weeks after planting . The results showed significant plant death due to hypoxia, with few surviving genotypes like Useh,Aduwawa and New Benin but failed to produce grain, likely due to high screen house temperatures that could have disrupted pollination.The results also showed that accession from Useh showed the highest growth characteristics on leaf breadth and leaf area, despite the waterlogging effect. Some Accessions also showed high value for healthy leaves under waterlogging, indicating that amongst all accessions used in the study, Accession Useh has the potential ability to grow and thrive on waterlogged soil. The study highlights the challenges of waterlogging stress and the need for further research to identify tolerant genotypes, providing insights into maize's physiological responses and the importance of

environmental control in stress tolerance experiments and be potentials genotypes for breeding work for tolerance to waterlogging.

CHAPTER ONE

INTRODUCTION

In Nigeria, there is an era where the effect of climatic change is becoming more apparent leading to unusual and unpredictable weather patterns. The south-south region of Nigeria with its costal and riverine landscape, has been particularly impacted, increased temperature, prolonged period of intense rainfall and erratic weather events such as unseasonal floods and storms are now common. These unusual weather characteristics are disrupting agricultural cycle especially for crops like maize, cassava and rice, which are central to the region's economy.

Agriculture around the world is constantly challenged by the rising incidence of adverse weather events as a consequence of global warming. Extreme events that alter water availability, like droughts and floods, constitute big threats to food security (Food and Agriculture Organization of the United Nations [FAO], 2017). Flooding of agricultural fields is generally caused by intensive and/or extensive rainfall over a period of time, but it may also result from overflowing of a body of water over land. Floods have a negative impact on economic and social aspects. Floods cause loss of livestock and seed stocks, destruction of infrastructure, machinery and tools, food shortage, diseases, and loss of agricultural productivity. This makes affected farmers and the general population vulnerable, causing poverty and migrations (Saldaña-Zorrilla, 2008).

According to statistics excessive rainfall can lead to waterlogging which affects 12% of the worlds crop hectare and can result in up to 20% crop losses (Ren et al., 2016, Shabala., 2011), There are so many arable crops which are being cultivated in Nigeria some of them includes maize, millet, rice, cereals and many others. Maize has become one of the most widely grown crops across Nigeria due to its adaptability to various ecological zones and farming methods. It is used in industries for a variety of purposes including maize starch, dextrose, maize syrup and maize flask (Gul *et al*., 2021). It also grows well in a wide range of soil and climatic conditions. It extracts more nutrient than other crops such as tiny grains ,cereals and grain legumes. Maize is farmed for a variety of purpose including animal feed (silage and grains) and pig feed (grains) as well as human consumption in the form of grains, sweet maize and grain maize. Yellow maize and white maize are the most prevalent colour of maize globally though there may be a slight differences in their nutritional value but generally grown and accepted cause of its availability. Maize is grown almost in all geographical zones in Nigeria but majority of the country's maize are produced in Bornu, Niger, Katsina, Oyo, Bauchi, Taraba, Gombe, Kogi and Plateau State.

Waterlogging mainly decreased the dry matter accumulation and transportation from other organs to the grain, resulting in significant decreases in grain weight and yield. Grain filling is crucial for grain yield in summer maize, and the grain filling rate is affected by both the genotype and environmental conditions. Waterlogging significantly reduces maize yield by decreasing ear length and width and increasing the bald tip length (Tian *et al*., 2019).

When the amount of water in the soil exceeds field capacity, this results in waterlogging or excessive soil moisture. Excessive moisture in the root zone in the form of free water (not bound to soil particles) fills the air spaces in the soil, results in poor soil aeration and eventually affects plant growth and development. Waterlogging causes major changes in soil physical and chemical properties, major changes in soil physical and chemical properties, which results in multiple crop stresses, including oxygen stress caused by low/no oxygen in the root zone, nutrient imbalance and biotic stress due anaerobic conditions. The identification waterlogging-responsive genotypes of maize is important for creating new waterlogging -tolerant maize varieties. When the crop is waterlogged for 6 days, the yield loss can reach 44.9% when the waterlogging lasts for 10 days, the leaf area, ear, length, number of grains per ear and grain weight are significantly reduced, and the yield is greatly reduced with the highest loss being 95.2% (Huang *et al*., 2022). Thus acquired knowledge would be instrumental to guide targeted breeding of waterlogging tolerant crops with more resilient root system and help in understanding plant response to waterlogging stress.

1.1 Objectives of study

1. The main objective of this study was to asses maize Accessions from Edo state under waterlogging at 5 leaf stage so as to identify and select tolerant genotypes for further breeding work on waterlogging resistance in maize.

The specific objective were to :

1.Access maize genotypes from Edo state ,South-South Nigeria under waterlogging at 5 leaf stage.

2. Screen for genetic resources for the developing of waterlogging resistant maize genotypes from local Accesions from Edo State.

CHAPTER TWO

LITERATURE REVIEW

2.0 MAIZE

Maize is an essential component of agricultural food, livestock, feed and many essential industrial products (Gazel *et al*., 2017). In Nigeria maize is a widely cultivated cereal crop in all the ecological zones thus the demand for maize is very high and continuously increases through the years for human and livestock production. It is also one of the most highly demanded crop in Nigeria and can be used for varieties of purpose.

The Northern part of Nigeria particularly the north-central and north western zones has the largest production of maize in the country. States under these regions benefit from combination of favorable amount of climatic conditions, particularly the extended growing season in the north where both rain-fed and irrigated maize farming is practiced in Kano, Kaduna and Niger are especially noted for their large scale maize cultivation due to their fertile soil and more organized agricultural system. White and yellow maize are mostly cultivated very often in Nigeria because of its adaptability.

Maize, scientifically known as *Zea mays*, is the third most significant staple food globally, following wheat and rice. It holds tremendous socioeconomic significance in Sub-Saharan Africa. It is widely acknowledged as one of the longest-standing farmed food crops (Biswas *et al*., 2022; Elham *et al*., 2023) and a substantial provider of protein, minerals, carbohydrates, and vitamin B (Adeola *et al*., 2023). Maize farming is widespread in Nigeria and many places (Okorie *et al*., 2020). In Nigeria, maize holds significant importance as a grain in terms of the number of farmers involved in its production and its economic value (Okoroh and Ejike, 2019; Olasehinde *et al*., 2023). The cereal plant produces grains that can be prepared in numerous ways, such as cooking, roasting, frying, grinding, pounding, or crushing. These grains make food items, including pap, 'tuwo,' 'gwate', 'dokunnu,' and many more (Ta'awu et al., ; 2023).

One of the major abiotic stress in agricultural productivity is water logging which affects 10% of the worlds land area (Shabala *et al* 2011). The causes of waterlogging can be due to substantial and frequent rainfall, improper soil drainage, soil texture and high water table level, grain yield of maize is significantly reduced by limited crop growth and development during water logging conditions(Ren *et al*., 2014).

In Nigeria, particularly in the south-south region about 2.5 million acres of maize cultivation is affected by waterlogging, which directly influence in the reduction of annual maize production by 25 to 30% on average. Generally maize crop largely consumes nutrient and has a good response to frequent irrigation, but is susceptible to waterlogging .The susceptibility of maize plant to waterlogging was due to absence of air holes in their roots, unlike rice plants. Therefore, maize crops when exposed to prolonged, excess soil moisture condition, plant roots undergo a condition known as hypoxia (low oxygen) followed by anoxia (no oxygen).

Maize is more susceptible to water logging stress, especially at seedling stage thus resulting in poor stand establishment (Ren *et al*., 2016). Anaerobic conditions due to waterlogging, inhibit the growth of plant roots, causing decline in root/shoot ratio and root dry weight thus indirectly affect the aboveground growth (Grzesiak *et al*., 2014; McDaniel *et al*., 2016; Yu *et al*., 2017). In response to waterlogging stress, maize root cells cleave to form aeration tissue for maintaining oxygen diffusion and high absorption efficiency (Zaidi *et al*., 2003).

2.1 INFLUENCE OF TEMPERATURE CHANGE ON MAIZE VARIETIES

In as much as maize is a temperature loving plant, it is also very sensitive to temperature fluctuations climate variability is considered one of the greatest impediments to the attainment of the sustainable development goals, particularly those focused on the no poverty and zero hunger, respectively (Bruckner *et al*., 2014; Nilson *et al*., 2016). Increased temperature increases crop development rate, which shortens the growing period of about 8 to 10% in all regions.

Low temperature negatively affects gaseous exchange, water use efficiency, morphology and physiology (Hussain *et al*., 2019). Farmers sow maize early to escape heat stage at the reproductive stage but plants are exposed to low soil temperature (below 10^0c) during early seedling development. During this stage soil temperature strongly affects leaf development as the shoot apex is positioned very near to the soil surface, therefore to cope with extreme temperature in maize, a comprehensive set of adjustments in cultural as well as in molecular techniques (such as breeding climate resilient genotypes) and an improved understanding of the genetic physiological perturbations resulting in stunted maize growth and reduced grain yield (Rafique *et al*., 2019).

Temperature influences growth and development of plants, the higher the temperature the faster plant grows and mature, higher temperature increases mineralization of organic matter content of the soil. Higher temperature will induce post-harvest spoilage in crops and putrefaction of animal product such as meat and milk (Bancy 2018). Higher temperature will also increase nutrient leaching and bring about high rate of fertilizer application.

The global temperature has been rising in recent decades and climate warming has been accelerating. Continuously warming climate conditions have also triggered more extreme weather events that affect agricultural production, which is highly sensitive to natural resources (Crost *et al*., 2018). Research suggests that climate change is placing great pressure on agricultural production (Wilson *et al*., 2022). Under the stress of climate change, food production has been facing prominent negative shocks (e.g., the increase in disaster areas and food production reductions), which may lead to hunger and malnutrition. Thus, these issues have been catapulted into the forefront of international discussions across numerous countries. Indeed, researchers propose that various countries urgently need to look for effective strategies to address the adverse effects of climate change, such as promoting the training for farmers on climate change adaptation behaviors (Moore and Lobell, 2014), enhancing the irrigation facilities (Aragón *et al*., 2021), and further developing a "climate-smart food system" (Wheeler and von Braun, 2013).

2.2 IMPACT OF WATER SUPPLY /WATER REQUIREMENT IN MAIZE PRODUCTION

Maize is an effective user of water in terms of total dry matter production and among cereal. It is potentially the highest yielding grain crop. For maximum production a medium maturity grain crop requires between 500-800 mm of water. Depending on climate to this, water losses during conveyance and application must be added .During key period maize is highly sensitive to a water deficit. The key management period that impacts yield is period from 20-30 days before flowering (8-10 leaf stage) to 10-15 days after, and even during the grain fill stage .As the plants develop larger leaf surface the demand for water rises as well, approaching maximum water use when the canopy has fully grown (50-60 days after planting)which means that severe water deficit at that stage will negatively affect the fertilization ,grain number per cob as a result the final yield of maize. Based on experimental results, the application of irrigation with sprinklers during the night may increase 10% the final yield of the plant (Caverns, 2018).

2.3 IMPACT OF WATER LOGGING ON MAIZE DEVELOPMENT

Water-logging inhibits plant growth, resulting in reduced plant height, ear height, dry weight, leaf area index and grain characteristics. It also decreases the chlorophyll content in maize ,water logging can remain a significant constraint to maize production across the globe. In Nigeria waterlogging decreases the vegetative development which has become a major impediment to maize production (Li *et al*., 2020).

For maize 4 days in early growing stage limited the seedlings growth (Azahar *et al*., 2020) reduced plant height, internode length, stem diameter and decreased leaf area index [LAI] of maize leaves to varying degrees (Ren *et al*., 2020, Ren *et al*., 2016).

Water replaces the air in the soil pores, creating anaerobic conditions detrimental to plant roots and soil organism. This oxygen deficiency hampers root respiration and nutrient uptake. The adverse effect has been observed not only under the prolonged period of waterlogging (weeks) but also under the short-term waterlogging (hours or days) (Malik *et al*., 2016). Waterlogging decreases the number of spikelet's per spike and kernels per spike of barley which ultimately leads to a decrease in yield (Maison *et al*., 2016). Waterlogging significantly reduces maize grain yield by decreasing ear length and width and increasing the bald tip length (Tian *et al*., 2019).

2.4 ADAPTATION OF MAIZE TO DROUUGHT IN MAIZE PRODUCTION

Drought stress is an abiotic factor that affects maize growth and yield. Climate change such as drought causes losses annually between 10-20% (Pauw *et al*., 2010) or even more, of the Gross Domestic Product (GDP) among sub-Saharan African countries (De pinto *et* *a*l., 2019 IPCC, 2018; Mairura et al., 2021) The threat are even higher in countries with a large Agricultural GDP(Ag GDP), like Tanzania (Ochieng *et al*., 2021). Drought risk are systemic and increasing (UNDRR, 2021). In 2019 scientist from African countries urged the world to "end the drought in drought research "and asked for more support to identify and prepare for drought disaster (Padma, 2019). Early maturing drought tolerance (DT) maize varieties are needed for intercropping by providing less competition for moisture light and nutrient than late maturing ones.

Drought stress can trigger early leaf senescence during the duration of photosynthetic activities and impacting overall plant productivity, reduces wheat and maize yield by 20.6% and 39.3% respectively.

2.5 IMPACT OF CLIMATIC CHANGE IN MAIZE PRODUCTION

The changes which occurs in the climate pattern which is caused by global warming has affected so many sectors in the world of which agriculture is inclusive. Agricultural sector is very important to the Nigerian economy and the world; consequently the change occurring in the climate pattern is a threat to the development of agriculture (Chikezie *et al*., 2015). Agricultural production in Nigeria is highly vulnerable to climate change, it is one of the most important sectors that are extremely relevant to Nigeria economy, This is because it is important in sustaining livelihood, job creation and poverty reduction. It also helps secures food, fuel and contributes to economic development.

In Nigeria, climate change is evident from temperature increase, rainfall variability (increase in costal areas and decline in continental areas). It is also reflected in drought, desertification, rising sea level, erosion, floods, thunderstorms, bushfire, landslide, land degradation, more frequent extreme weather conditions and loss of bio-diversity.

In maize production, increased temperature and drought have negative effect on maize seed germination, gamete formation, pollination, fertilization, seed formation and filling.

Maize is very sensitive to frost mostly in the seedling stage but it can tolerate hot and dry atmospheric condition as long as there is sufficient water available to the plant and temperature is below 45 degrees. Temperature requirement expressed as sum of mean daily temperature, for medium varieties are 2500-3000 degree days, while early varieties requires about 1800 and late varieties 3700 or more degree days. It flourishes on moist soils but does less on very sandy soils or less dense soils. Soils should be wet, aerated and well drained as the crop is susceptible to water-logging.

CHAPTER THREE

MATERIALS ANND METHODS

3.1 EXPERIMENTAL SITE

The experiment was conducted at the screen house 2 in the Department Of Crop Science, Faculty of Agriculture. University of Benin, Benin City. The location lied between latitude 6^{0}14North and Longitude 5^{0}41 and 6^{0}43. The experiment site falls within the humid tropical climate. It is within the rainforest agro ecological zone of Nigeria and has an annual rainfall of 1762-2300mm per annum with high relative humidity. The daily temperature ranged from 28-41°c as the minimum and maximum respectively.

3.2 MAIZE GENOTYPES

The genotypes used were accessions from Aduwawa, Agbede, Auchi, Ighara, New Benin, Useh/Uselu in Edo State.

3.3 SOURCE OF EXPERIMENTAL MATERIIAL

Top soil was collected from the Training and Research Farm, Department of Crop Science, University of Benin. The buckets were purchased locally.

The wire mesh, Masking Tapes, measuring tape were purchased locally as well.

3.4 EXPERIMENTAL DESIGN AND TREATMENT

The experiment was laid out using a Completely Randomized Design (CRD) with 3 replications. The distance between each plot (buckets) was with 30 cm and 50 cm between rows. Each replication had 6 buckets and total of 24 buckets including control were used for the experiment.

3.5 CULTURAL PRACTICES

The screen house was cleared with cutlass and hoe. A total of 4 seeds were planted per bucket and thinned to 2 plants per bucket after emergence. Seeds were planted in a ringed arrangement. Weeding was done as at when appropriate. NPK 15:15:15 fertilizer was applied. The plants were mulched with neem (*Azadiracta indica*) leaves. The neem leaves were used as mulch to also control Army worm infestation (Ewansiah *et al*., 2023). Waterlogging treatment was carried out at five Leaf stage.

3.6 COLLECTION OF DATA

3.6.0 PLANT HEIGHT

The height was measured from the soil level to the point where the last leave terminate using a measuring tape. The height of the plants in all 18 buckets per treatments were measured and the units expressed in centimeters (cm).

3.6.1 LEAF LENGTH

The length was measured from where the leaf blade attach to the leaf sheat to the tip of the leaf blade. The length of the leaves of the plant in the 18 buckets per treatment was measured and the unit expressed in centimeter at 6 weeks after planting.

3.6.2 LEAF WIDTH

The width of leave was measured from the widest part of the leaf (across). The measurement was taken and expressed in centimeters.

3.6.3 CHLOROTIC LEAVES

The leaves having chlorosis were observed and visually counted.

3.6.4 DEAD PLANTS

The number of dead plants were counted and recorded

3.6.5 ADVENTITIOUS ROOTS

Visual observation was done for adventitious roots

CHAPTER FOUR

RESULTS

4.1 Variation due to waterlogging Duration on a 5 leave stage maize Accessions from South south Nigeria

The mean square value due to the effect of Accessions and waterlogging on growth of maize seedlings are presented in Table 1. There was significant ($p<0.05$) difference due to Accession on leaf width and plant height. Accesion did not significantly differ on leave number and leaf area.

Variation due to waterlogging was not significant for leaf number and leaf width but there was significance($p<0.05$) due to waterlogging on leaf area and plant height .The effect due to Accession×Waterlogging was not significant on all the growth characters.

4.2 Growth characters of maize as influenced by Accessions and water logging treatment

The mean value of growth characters as influenced by Accessions and waterlogging are presented in Table 2. There was no significant difference of the Accession on plant height.The waterlogging treatment significantly influenced plant height which was highest at 6WAP. There was a gradual and sequential decrease in plant height as waterlogging duration increased. There was significant difference due to Accession on leaf width with the Accession Useh having the highest mean value of 4.072. The water logging duration did not significantly affect the leave width.

Leave area due to Accession was significant with the Accession Useh having the highest mean value of 161.0 and the lowest mean value from Ighara genotype.Waterlogging treatment did not significantly influenced the duration of waterlogging. Variation due to Accession did not significantly affect the number of leaves but there was a significant difference due to the duration of the Number of leaves which was highest at 5WAP.

4.3 Growth characteristics on Maize seedlings influenced by Ear height, No of days shedding, Silking and Tasseling.

From table 3 : Accession has no significant difference on chlorotic leaves but there was a significant difference on healthy leaves and dead laves . Variation due to waterlogging was not significant on healthy leaves but there was significant difference in dead leaves and chlorotic leaves.Effects due to Accession ×waterlogging was not significant on all growth characteristics.

4.4 Variation due to waterlogging Duration on a 5 leave stage maize Accessions from South south Nigeria

Table 4 showed that .For healthy leaves, there was a significant difference with Useh Accession having the highest mean value of 7.00 and the lowest form Aduwawa Accession having the lowest of 3.167 but there was no significant difference on healthy leaves due to waterlogging duration. There was a significant difference on dead laves due to Accession with Useh and New Benin Accessions having the highest mean value of (2.00) respectively and lowest mean value from Aduwawa Accession(1.208). Variation due to waterlogging duration has significant difference on dead leaves with an increasing number of recorded dead leaves from 9WAP all through the duration of waterlogging.

There was significant difference due to Accession in chlorotic leaves with Useh Accession having the highest mean value and Aduwawa having the lowest . Variation due to waterlogging duration was highly significant with a tremendous increase from 9WAP to 11 WAP.

Table 5 :Mean Square value due to the effect of waterlogging on a 5 leaf stage maize Accession from South -South in Edo state Nigeria Table 5 as seen shows that Tasseling, silking, Ear height were not significantly different but shedding has a significant difference in the Accession.

Table 6: There was no significant difference from all Accessions on Tasseling,Ear height, silking, shedding.

Table 1a.Mean square Value due to the effect of waterlogging on a 5 leaf stage maize Accessions from South south Nigeria

Source of variation	d.f	Leaf Number	Leaf area	Leaf Width	Plant height
Accessions (A)	5	21.38^{ns}	31606^{ns}	23.873 *	2002*
Waterlogging (WAP)	9	22.91^{ns}	41270 *	12.474 ^{ns}	7338**
Accessions (A) × Waterlogging (WAP)	45	3.52^{ns}	7670 ^{ns}	6.820 ^{ns}	774^{ns}
Residual	180	12.71	14687	8.81	1695

Ns-Non significant **Highly significant *Significant

Table 1b mean value of growth characteristics on maize seedlings at 5 leaves stage as influenced by water logging on accession at 11 weeks duration after planting

Accessions	Plant height	Leaf breath	Leaf area	Number of leaves
Aduwawa	53.98^{a}	1.965^{b}	91.4^{ab}	4.325^{a}
Agbede	61.34^{a}	2.505^{b}	102.0^{a}	5.713^{a}
Auchi	67.41^{a}	2.478^{b}	92.2^{ab}	5.692^{a}
Ighara	51.15^{a}	1.991^{b}	87.3^{ab}	5.138^{a}
New Benin	57.98^{a}	2.455^{ab}	92.9^{b}	6.145^{a}
Useh	68.66^{a}	4.072^{a}	161.0^{ab}	6.325^{a}
Significance	ns	*	*	ns
Sed	9.21	0.604	53.47	0.797
Water logging (WAP)				
2WAP	41.57^{bcde}	1.792^{a}	47.2^{a}	4.142^{b}
3WAP	44.44^{bcde}	1.615^{a}	49.9^{a}	4.583^{ab}
4WAP	72.19^{ab}	2.131^{a}	77.9^{a}	5.960^{ab}
5WAP	82.88^{a}	2.879^{a}	135.9^{a}	7.500^{a}
6WAP	84.00^{a}	3.036^{a}	152. 0 ^{a}	6.312^{ab}
7WAP	65.40^{ab}	3.677^{a}	151.6^{a}	5.958^{ab}
8WAP	65.92^{abc}	2.429^{a}	102.1^{a}	5.615^{ab}
9WAP	58.75^{abcde}	2.319^{a}	92.9^{a}	4.917^{ab}
10WAP	30.86^{ce}	3.677 ^{a}	151.1^{a}	5.742^{ab}
11WAP	53.88^{abcde}	2.223^{a}	89.1^{a}	4.833^{ab}

2a Mean square Value due to the effect of waterlogging on a 5 leaf stage maize Accessions from South-South Nigeria.

Source of variation	d.f	Healthy leaves	Dead leaves	Chlorotic leaves
Accessions (A)	5	44.41*	7.107 *	9.394 ^{ns}
Waterlogging (WAP)	5	7.25^{ns}	20. 090**	19.944**
Accessions (A) × Waterlogging (WAP)	25	4.76 ^{ns}	1.224^{ns}	1.608^{ns}
Residual	108	12.96	3.062	4.299

Ns-Not significant **Highly Significant *Significant

2b Mean value of growth characteristics on maize seedlings at 5 leaves stage as influenced by water logging on accession at 11 weeks duration after planting

Accessions	Health leaves	Dead leaves	Chlorotic leaves
Aduwawa	3. 167^{b}	1.208^{b}	1.250^{b}
Agbede	4.125^{ab}	1.458^{ab}	2.62^{ab}
Auchi	5.667^{ab}	2.792^{a}	1.875^{ab}
Ighara	4.325^{ab}	1.792^{ab}	
New Benin	5.542^{ab}	2.000^{ab}	2.333^{ab}
Useh	7.000^{a}	2.000^{ab}	2.583^{ab}
Significance	*	*	*
Sed	1.237	2.517	1.237
Waterlogging (WAP)			
6WAP	5.708^{a}	0.500^{c}	2.042^{ab}
7WAP	5.167^{a}	1.292^{b}	1.292^{b}
8WAP	4.833^{a}	1.417^{bc}	1.167^{b}
9WAP	5.417^{a}	2.375^{bc}	2.833^{a}
10WAP	4.375^{a}	2.583^{ab}	3.208^{a}
11WAP	4.375^{a}	2.87^{b}a	3.125^{a}
Significance	ns	**	**

Table 3a: Mean square Valerie due to the effect of waterlogging on a 5 leaf stage maize Accessions from South south Nigeria

Source of variation	d.f.	Tasseling	Shedding	Silking	Ear height
Accessions (A)	5	1687.7^{ns}	2254*	1199^{ns}	248^{ns}
Residual	18	8652	1059	2624	1348

Ns-Not significant **Highly Significant *Significant

Table 3b: Mean value of growth characteristics on maize seedlings at 5 leaves stage as influenced by water logging on accession at 11 weeks duration after planting

Accessions	Ear height	shedding	Silking	Tasseling
Aduwawa	23.00^{a}	18.25^{a}	24.50^{a}	15.50^{a}
Agbede	23.50^{a}	64.00^{a}	48.25^{a}	55.75^{a}
Auchi	27.50^{a}	59.50^{a}	46.25^{a}	55.50^{a}
Ighara	20.75^{a}	57.50^{a}	$4\ 7.00^{a}$	51.50^{a}
New Benin	31.00^{a}	85.00^{a}	70.25^{a}	70.75^{a}
Useh	42.25a	80.75^{a}	80.75^{a}	69.60^{a}
Significance	ns	ns	ns	ns
Cv	131.1	53.5	102.2	55.4

Ns-Not significant **Highly Significant *Significant

CHAPTER FIVE

5.1 DISCUSSION

This study indicated that maize Accessions from the South - South zone of Nigeria are susceptible to waterlogging. There were no significant difference. However Accessions from were able to withstand the waterlogging stress.

Waterlogging treatments reduced the maize growth parameters; the maximum decrease was found when waterlogging occurred at five-leaf stage.

Studies have reported that waterlogging at the Five-leaf stage in summer maize resulted in maximum grain yield loss (Purvis, 2016),followed by the six-leaf and tasseling stages (Mcfarlane et al, 2014).Consistent with these observations in maize, the present study also demonstrated that waterlogging at 5 leaves stage (5 LS) caused severe damage to maize growth parameters than those without waterlogging treatment.The maize growth parameters seemed to be at highest at no waterlogging treatment. Data from the present experiment confirmed that waterlogging at three and five-leaf stages resulted in a signifcant decrease in maize growth parameters in the varous accession.There was no significant effect on the interaction between accessions and waterlogging at various weeks after planting. The results of the study showed that accession useh had the highest growth characteristics on leaf width and leaf area despite the waterlogging effect. Accession useh also showed the highest value for healthy leaves under waterlogging, showing that amongst all accessions used in the study, accession useh has the ability to grow and thrive on waterlogged soil. Studies also showed that accession auchi had the highest values for dead and chlorotic leaves indicating it's inability to survive on waterlogged soil.

There was no significant effect on ear height, silking, shedding and tasseling across all accessions, showing their inability to produce grain under waterlogging conditions.

5.2 CONCLUSION

Six plants from replicate namely Aduwawa, Agbede, Auchi, Ighara, New Benin, Useh survived waterlogging stress for 4 weeks from 5 leave stage corresponding to 2 weeks after planting.

Based on this experiment it is recommended that resistant varieties be isolated, further observed and preserved in optimal temperature to produce grain which will become breeding materials for waterlogging genotypes

Further trials and programs for screening for maize tolerance to waterlogging from existing maize germplasm is encouraged and recommended.

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