ASESSEMENT OF THE EFFICACY OF SEED HARDENING CHEMICALS AND WETTING CYCLES ON THE PERFORMANCE OF MAIZE (*Zea mays* L.) DURING EARLY SEASON DROUGHT

BY

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A DISSERTATION SUBMITTED TO DEPARTMENT OF AGRONOMY, FACULTY OF AGRICULTURE, BAYERO UNIVERSITY, KANO IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OFTHE DEGREE OF MASTER OF SCIENCE (M.Sc) IN AGRONOMY

OCTOBER, 2019

DECLARATION

I hereby declared that this project is written by me and is the record of my own research, undertaken under the supervision of Dr. S.U Yahaya and has not been presented before in any previous application for the award of a degree.References made to published literature have been dully acknowledged.

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CERTIFICATION

This is to certify that this project titled "Asessement of the efficacy of seed hardening chemicals and wetting cycles on the performance of maize (*Zea mays L.*) during early season drought" by Zubaida Garba Dabo meets the regulations governing the award of the Master of Agronomy of Bayero University, Kano and is approved for its contribution to knowledge and literary presentation.

…………………………………..   …………………………

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(Supervisor)

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Date

Dr S. U. Yahaya

(Head of department)

DEDICATION

This work is dedicated to my late brother Yaya Gaddafi. May Allah forgive him and grant him Jannatul Firdaus. Amin

ACKNOWLEDMENTS

All praise be to Allah (SWT) whom without nothing is possible and special regards to our noble Prophet Muhammad (SAW). My special thanks to my supervisor in Person of Dr. S.U. Yahaya for his guidance and support at every stage of this work, may Allah reward him abundantly. I remain indebted to all academic and non-academic staff of Agronomy department and faculty of Agriculture at large for their help, support and encouragement, may Allah bless them all.

My sincere thanksgo to my parent Alh Garba Halliru and Haj Zainab Lawal Aliyu for their unconditional love,support, prayer and guidance all my life. May Allah grant them Jannatul firdaus.My warmest wish goes to my loving sisters,brother,nephews and nieces. May Allah continue to bless them.

Finally,my deepest appreciationgoes to my dearhusband M. N Hussein for everything and to all my friends,colleagues and everyone who has in one way or the other contributed to the success of this work. Thank you and May Allah reward you all.

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ABSTRACT

Several management strategies are practiced to enhance the potential of the crop under rain fed condition. Pre-sowing hardening is one of the approach used to overcome the ailing effects of abiotic stresses in agricultural production because of its low cost and risk. This also improves seed emergence, good stand establishment, growth and yield of crops. In-view of this, experiment was conducted at the Teaching and Research Farm of Bayero University, Kano and Doka, Tofa local government area of Kano state, to assess the efficacy of seed hardening and wetting cycles on the productivity of maize during early season drought. Treatments consisted of two maize varieties (EVDT 99 and IWD), three wetting cycles (once, twice and thrice) and four seed hardening chemicals (KCl, $NaCl_2$, H_2O and $CaCl_2$). These were laid in split split plot design and replicated three times. Wetting cycle was assigned to the main plot while seed hardening chemical and variety were assigned to the sub and sub-sub plots respectively. The results of the study indicated that seedling survival rate, number of leaves and plant height were significantly ($p<0.05$) affected by the seed hardening chemicals. Stover weight was also significantly ($p<0.05$) affected by wetting cycle. KCl and H_2O were found to be the best hardening chemicals on maize with IWD variety performs better than EVDT 99 at both locations. Therefore, these chemicals can be used to hardened seed prior to planting so as to have better start at early stage and uniform stand establishment for improved maize productivity.

CHAPTER ONE

1.0 INTRODUCTION

Exploring ways to improve stand establishment and crop productivity under abiotic stresses like drought is important. Several management strategies are followed to enhance the potential of the crop under rain fed condition. Pre-sowing hardening technique have been used as alternate approaches to overcome the ailing effects of abiotic stresses in agricultural production because of its low cost and risk. This improves seed emergence and growth of crop (Pill and Necker, 2001). Pre-sowing hardening technique is a repeated soaking and control seed hydration in solution containing organic or inorganic solutes followed by re-drying of seeds. Seed hardening is a practice adopted to make crop plants tolerant or resistant to soil moisture stress.

Chemicals like $CaCl_2$, Na_2SO_4, KCl, $MgSO_4$, KH_2PO_4, K_2SO_4, NaCl, NaH_2PO_4, Nitric acid, Succinic acid, Auxins, Cow urine and Cow dung extract are used for seed hardening (Solaimalai and Subburamu, 2004). Henckel (1964) developed these wetting and drying treatments of seeds for imparting resistance to drought and adverse conditions. Seeds are allowed to take up a certain amount of water and are kept at 10℃ -25℃ for several hours before drying in a stream of air. The best results are claimed for seeds subjected to two or three cycles of wetting and drying although for some species one cycle is sufficient (Solaimalai and Subburamu, 2004).

Drought tolerance is the ability of crop to withstand water deficit as measured by degree and duration of low plant water potential. Drought is one of the most important factors inhibiting photosynthesis and decreasing growth and productivity of plants. It is one of the major causes of crop loss worldwide reducing average yields for most major crop plants by more than 50% (Bray, Bailey and Weretilnyk, 2000; Wang, Ma, Li, and Zou,2006). One of the possible ways to ensure future food needs of an increasing world population involves better techniques that will safeguard seeds during initial stage of germination to become more tolerant to drought. Therefore, the improvement of drought tolerance in seed is a major objective particularly in arid and semi-arid areas of the world (Moustafa, Boersma, and Kronstad, 1996).

Maize is one of the most important cereal crops in the world (FAO, 2006). It is high yielding, easy to process readily digested and cheaper than most other cereals. Like many other cereals, it is an important source of carbohydrate, protein, iron, vitamin B and minerals (Aldrich, 2001). According to FAO (2007) data, the area planted for maize in west and central Africa alone increased from 3.2million hectares in 1961 to 10.2million hectare in 2015.

1.1 PROBLEM STATEMENT

The most common problem faced by every farmer is the inadequate and poor distribution of rainfall, which in its extreme lead to droughts. In some regions, erratic rainfall lead to drought during the vegetative phase thereby upsetting the water balance of a plant and consequently, the physiological functions contributing to growth and yield of the plant. Global water shortage is very likely to become a serious problem by the year 2025 especially in areas with high population density (Cosgrove and Rijsberman, 2000). Safe guarding seeds during initial stage will give a special care for the seed to overcome moisture stress condition and develop into a plant. Sorghum, maize and millet are among the major cereal crop in Africa that needs to be given much attention in terms of increasing productivity through moisture stress management. This creates a need to evaluate various ways to protect their seeds from the adverse effect of drought, particularly the early season.

1.2 JUSTIFICATION OF THE STUDY

One of the primary causes of food insecurity in Nigeria is the risk of agricultural production failure due to drought, resulting in reduced harvest and farm incomes (Dercon, Hoddinott and Woldehanna, 2008; Doss, Peak and Barett, 2008). The incorporation of greater drought resistance into the world major field crops is urgently needed to increase food supplies while using less energy intensive technology. A major drought can reduce crop yields and crop hectarage because less water and soil moisture are available for crop growth. Water deficit resulting from drought reduces crop yield because of its negative impacts on plant growth (Karl, Melillo and Peterson, 2009). Changes in the magnitude and frequency of droughts due to climate change will have severe impacts on agriculture, especially crop production, cropping systems and livestock (Karl *et al.,*2009; Olesen*et al.,*2011).Even though, much has been done in research for drought tolerance; however, the outcome of these efforts has not met the demand for crop production (Bunu, 2016).

1.3 OBJECTIVES OF THE STUDY

The objectives of the study were to:

1. Assess the effect of seed hardening chemicals on drought tolerance traits of some selected varieties of maize.
2. Identify the best seed hardening chemical among others on drought tolerance in the selected maize varieties.
3. Identify the best wetting cycle for seed hardening on maize.

CHAPTER TWO

2.0LITERATURE REVIEW

2.1 INFLUENCE OF DROUGHT ON CEREALS

Drought resistance is the result of numerous morphological, anatomical and physiological characters, both constitutive as well as inducible, which interact, with maintenance of growth and development process under edaphic and climatic conditions (Zheng, Jin, Zhi, Ruan and Song, 2002). Moisture stress results in loss of turgor, leading to decrease in stomatal conductivity, photosynthesis and grain yield (Tao and Liu, 2000).

Drought occurs in virtually all climatic regions and it reduce crop yield. Yield loss is considered the greatest losses in agriculture (Daryanto, Wang, and Jacinthe, 2016). Our food source heavily depends on cereals, yet their agricultural production is greatly affected by drought (Kadan, Fang and Liu, 2014). Despite ongoing breeding efforts to develop drought resistant cultivars (Bennett *et al.,* 2013), prolonged drought in the food insecure regions may cause famine, epidemics and deaths, generate water crises due to drying up of perennial streams, impact agriculture based livelihood systems, food security and overall economic development (Karim *et al.,* 2014).

Drought occurring during late phenological phase generates greater yield reduction than any other climatic factor (Bennett *et al.,* 2013). Soil drought inhibits plant growth and development. Water stress inhibits accumulation in fresh plant mass in greater extent than dry biomass (Ramos *et al.,* 1999).

2.2 ROLES OF SEED HARDENING CHEMICALS IN ENHANCING DROUGHT TOLERANCE IN CEREALS

Seed hardening, a promising technique has been successfully employed to overcome the problem associated with poor germination and subsequent erratic crop stand under normal and stressful conditions (Farooq *et al.,* 2009; Rehman *et al*., 2011; Jafar *et al.,* 2012). Stimulation of early vigor and seedling growth either through crop improvement for tolerant genotypes (Leipner and Stamp, 2009) or exogenous application of compatible solutes (Farooq, Aziz, Wahid, Lee and Saddique, 2009). Pre sowing seed hardening brings about physiological organization that results in an increase in the hydrophilic property of the protoplasmic colloids namely the viscosity and elasticity increase in the osmotic pressure, changes in the quality of protein and overall increase in the water holding capacity of the seed. Metabolic changes due to seed hardening are increased respiration, high level of synthetic reactions even during drought; leaves of hardened plants have more starch, increase phosphorylation activity of their mitochondria, higher rate of photosynthesis because of increase in the bound water and higher organic phosphorous and nucleo-protein.

Hardened seeds produce plants with xeromorphic morphology more extensive and denser network of veins and midribs, epidermis and stomatal cells are smaller, number of stomata per unit leaf area is more, foliage area is increased, faster recovery from atmospheric drought, greater total and absorbing surface into root systems, as well as more number of primary roots and leaves of these plants will have more starch (Vanangamudi, Srimathi, Natarajan and Bhaskaran,2003).

Studies have shown that pre-sowing seed treatment in various concentration of indole acetic acid (Gulnaz, Javed and Azam, 1999), gibberellic acid (Shah and Deshpande, 2007) and indole butyric acid (Strader, Wheeler, Christensen, Berens and

Bartel, 2011) may promote or inhibit seedling growth. Therefore, presoaking seeds with optimal concentration of phyto-hormones and chemicals enhance their germination, growth and yield under stress condition by increasing nutrient reserves mobilization through increase physiological activities and root proliferation (Ozturk, Gemici, Yilmazer, and Ozdemir, 1993).

Seed hardening improved the activity of alpha amylase activity which led to increase in reducing sugar concentration thus speeding up the metabolic activity and increased yield (Basra, Farooq, Tabassun, and Ahmad, 2005). According to Shivamurthy and Patil (2009), seed hardening with chemicals recorded significantly higher returns over seed hardening with water and dry seed treatments. Farooq, Basra, Hafeez, and Ahmad (2005) reported that seed hardened with chemicals such as $CaCl_2$ and salicylic acid improve seedling growth. Highest seedling vigor in term of root and shoot lengths was also observed.

In recent years, a lot of work has been done on seed hardening to improve germination rate and uniformity of crop growth in many field crops including maize. Germination and early growth stages of maize are sensitive to low temperature and detrimental to subsequent crop establishment and productivity (Farooq *et al.,* 2009). It is believed that hardened seeds perform better with vigor levels under stress environment (Ruan, Xue, and Tylkowska, 2002a) and results in rapid germination with higher emergence index. Seed hardening modifies the physiological and biochemical nature of seeds to get the characters that are favorable for drought tolerance (Manjunath and Dhanoji, 2011). Drought tolerance for 0.5% KH_2PO_4 was observed in dry land crops (Solamalai and Sabburamu, 2004).Upland rice raised from the pre-hardened seeds with different salt solutions gave better root development, higher growth and yield (Singh and Chatterjee, 1985). Soaking the seed of maize in

0.1% salicylic acid enhance germination (Asthana *et al.,* 1978). Improved yield had been observed in direct seeded rice hardened with KCl and $CaCl_2$ under flooded conditions (Zheng *et al.,* 2002) and also Farooq, Aziz, Wahid, Khaliq and Cheema (2006) reported that in rice, mere soaking reduced days for emergence while hardening with KCl or $CaCl_2$ was found to reduce it even further.

According to Bunu (2016) LCICMV-2 pearl millet had been observed to give the highest yield when hardened with KCl. To achieve uniformity and synchrony of growth of plant under drought or salt stress condition, seed hardening can be adopted as a regular practice to boost the yield of grain/cereals. (Solaimalai and Subburamu, 2004). Seed hardening modify the physiological and biochemical nature of seeds to get the characters that are favorable for drought tolerance. It is quite possible that yields due to seed hardening treatment would be apparent when the drought is not too severe and be obliterated by extreme moisture stress (Henkel and Kolotova, 1934). Grain yield is the ultimate economic of the crop, which is determined mainly by grain weight and number of grains per unit land area. Punithavathi and Palinisany, (2001) reported that the seeds treatment of ragi cultivars viz, Co -13, PR 202 and Indaf 9 with combination of 1% KCl and $CaCl_2$ had resulted in maximum yield. Similarly, pre sowing seed hardening of wheat with $CaCl_2$ produced significantly higher grain yield over control. The higher fodder productivity was observed in seed hardening with K_2HPO_4.

In another report Ramesh (2004) noticed during 1998 and 1999 that the foliar spray of 22ppm benzaldenine along with 2% DAP and 2% KCl enhanced leaf chlorophyll contents. Punithavathi and Palaniswanny (2001) also reported that ragi seeds soaked in 1% concentration of KCl, $CaCl_2$ for 12hrs recorded higher germination percent as well as root length, shoot length, vigor index and dry matter production. In another work Zheng *et al.,* (2002) reported that ascorbic acid treatment among showed increase in the number of pea nodules and dry weight of the plants as compared to the control.

According to Vanangamudi, Srimath and Bhaskaran (2003), the success of the seed treatment would depend largely upon the right kind of chemical and its concentration most suited for the kind of seed. For seed hardening, mostly polyethylene glycol or salt solution is used to regulate water uptake and to check radical protrusion (Liu *et al.,* 2011). These salts provide nutrient like nitrogen to the germinating seed, which is required for the protein synthesis during the germination process. However, these salts rarely cause nutrient toxicity to the germinating young seedling (He *et al.,*2009).

Seed soaking in water is known to enhance germination, seed length, seed vigour index, growth characters like plant height, leaf area and yield characters namely number of tillers, number of grains and grain yield of crops (May, 1962). Pre sowing hardening of seeds involves a number of physio-chemical changes, which influence the emergence of specific protective adoptive reaction against moisture stress due to stimulatory effects on root growth and changes in the properties of protoplasm leading to an overall increase in grain yield (Henckel, 1964).

Avijit (1983) also reported that seed hardening with $CaCl_2$, KCl and H_2O recorded marked increase in plant height, tiller number, leaf area and dry weight of shoot and grain yield of wheat under rainfed condition. Rathinavel and Dharmalingam (2000) observed that seed hardening of cotton with KCl and $CaCl_2$ recorded more germination compared to control but root length, shoot length and vigour index reduced significantly over control but seed treatment with KCl recorded higher value.

Hardening of maize seed enhanced the speed of emergence and improve the field stand and plant growth both at vegetative and maturity stage. It also reduced period to anthesis and silking by about one day each (Nagar, Dadhalani and Sharama, 1998). Seed soaking over night with tap water resulted in early emergence, deeper roots, early flowering and maturity and higher yield (Haris, Joshi, Khan, Gothkar, 1999).

Haris *et al.* (2001) conducted laboratory and field experiments and reported that germination of maize without hardening ranged from less than 40hrs to more than 70hrs in the laboratory. Hardened seeds of maize for 12hrs reduced the time for germination. The maize seed responded positively to hardening, the treatment reduced the range of germination times to between 20hrs and 40hrs. Similarly, Ren and Tao (2003) noticed that hardening enhanced seed germination and seedling vigour. Kulkalni and Jalshakthi (2002) reported that seed treatment of maize seeds with 1% $CaCl_2$ increased germination speed of germination, field emergence, vigour index and seedling vigour significantly over untreated seed.

2.3RESPONSE OF CEREALS TO DIFFERENT WETTING CYCLES WITH SEED HARDENING CHEMICALS

Henckel (1964) developed wetting and drying treatments of seeds for imparting resistance to drought and adverse conditions. The responses of plants following wetting and drying cycles at the seed stage are variable. Repeated cycle of soaking the seeds in water of dilute solutions such as 0.25% $CaCl_2$ and drying induced drought hardness in plants. According to Hidetoshi and Tohru (2002) seed hardening, wetting and re-drying of seed before sowing, promotes germination under low soil moisture conditions in wheat varieties bred and grown in semiarid areas.

Seeds are likely to remain viable after dehydration during the first two cycles (phases) (Taylor, Prusinski, Hill and Dickson, 1992). Some species have been detected to have more seed germination after a wetting and drying than after constant moisture. For other species, germination percentage increases with increasing number of wetting cycle (Ren and Tao, 2003). Seeds of some species seems to have " hydration memory" or a capacity to retain some of the physiological changes, like the differential expression of proteins (Lopez- Urratia *et al.,*2014) induced by imbibition even after temporary drying, having these seeds the same moisture content as the seeds that have never been hydrated (Dubrousky, 1996).

Water uptake by the seed is influenced by permeability of the testa, environmental factors, seed shape and moisture content (Vertucci, 1989;Taylor *et al*., 1992). Imbibition times are likely to be longer in natural conditions depending on substrate and moisture availability (Tao, 2000). Dubrousky (1996) also found that repeated cycles of hydration/dehydration caused cumulative effect.

Short rainfall may have accumulative physiological effect on seeds and this can be stimulated using hydration/ dehydration cycles to promote seed germination (Dubrousky, 1996; Lopez Urrotia *et al*., 2014; Rito *et al*., 2009; Santini and Martorell, 2013; Sanchez-Soto *et al* 2005). Seed germination in arid lands is likely to be fast due to the short periods that the soil retains moisture (Jurado and Westoby 1992; Gutterman, 1993).

Hydration–dehydration–rehydration cycles are likely to be important in natural seed populations of some species by reducing the time lag between the occurrence of favourable germination conditions and actual germination (Dubrovsky, 1996). Incremental repair of damaged DNA during hydration phases, and the stability of repaired DNA during rehydration phases may effectively shorten the minimal time for germination when seeds eventually receive sufficient moisture to complete germination (Adams, 1999).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 EXPERIMENTAL SITES

The experiment was conducted during 2017 wet season at the Teaching and Research farm of Bayero University Kano (latitude $11^{o}58'$N and longitude $8^{o}25'$E) and at Doka, village in Tofa Local Government Area of Kano State ($11^{0}99'$N and 8^{0} $30'$E).

3.2 TREATMENTS AND EXPERIMENTAL DESIGN

The experiment comprised of two maize varieties (EVDT 99 and IWD) three wetting cycle (once, twice and thrice) and four seed hardening chemicals (Water, $CaCl_2$, NaCl and KCl). These were laid out in split-split plot design and replicated three times. Wetting cycle was assigned to the main plot, chemicals to the sub plot and maize variety to the sub-sub plot. The gross plot size was 2.5m x 4.5m (11.25m) consisting of 4 rows of 2.5m long while the net plot size is 3.75m.

3.3 SOIL ANALYSIS

Soil samples were collected randomly from 5 spots in each plot, using augar at 0-30cm depths at both sites before the start of the experiment. These were bulked, grounded, dried and sieved before taken to the soil science laboratory for determination of physical and chemical properties using standard procedure (Black, 1965).

3.4 METEROLOGICAL DATA

Records of some climatic variables were collected from Faculty of Agriculture, Bayero University Kano weather station.

3.5 CULTURAL PRACTICES

3.5.1 Land Preparation

The land was cleared, harrowed and ridges were made prior to layout and sowing

3.5.2 Seed Selection

Seeds were sourced from International Institute of Tropical Agriculture (IITA) Kano station. EVDT 99 and IWD were used. EVDT 99, which is early variety drought tolerant that matures in 90-95 days, and IWD which is an intermediate white dent that matures in about 120days.

3.5.3 Seed Treatment

The seeds were divided into four equal parts each were treated with different chemical as follows;

Water: The first part was further sub divided into three parts and each was labeled once, twice and thrice. The first part labeled as once was soaked in water for 6hours and dry back to its original moisture or weight (Solaimai and Sabburamu, 2004). The second part was soaked for the same 6hours and dried back then re-soaked again for another six hours and dried back. The third part was also treated using the same procedure but was re- soaked and dried three times to obtain the cycle (thrice). This was done for all the seeds.

KCl: The second part was treated using the same wetting cycle but different chemical, in this about 2% KCl was used to dissolve 20gm salt in 1000ml of water. 1kg of the seed was soaked in 650ml of the solution for 10hrs and dried back to its original moisture (TNAU, 2016).

$CaCl_2$ and NaCl: In the third part also, the seeds were treated using the same wetting cycle but different chemical. 1% $CaCl_2$ solution was used to soak the seeds for 6hours followed by 5hours shade drying (Kulkarni and Jalshakthi, 2002). This was repeated three times to obtain all the cycles as appropriate.

3.5.4 Sowing

Seeds were sown on ridges at 75cm by 25cm spacing inter and intra row respectively using 3 to 4 seeds per hole at about 3cm depths. These were later be thinned to one plant per stand at 2weeks after sowing (WAS).

3.5.5 Weed Control

Atrazine + Metolachlor as pre emergence herbicide at 2.0kg ai/ha was also used followed by manual hoe weeding as at when due.

3.5.6 Fertilizer Application

Fertilizer was applied at the rate of 120kg N, 60kg P_2O_5 and 60 kg K_2O per hectare using split application at 2 WAS and at 6weeks after first application was employed.

3.5.8 Harvesting

Harvesting was carried out manually when the grains were fully matured and dry. Maize cob was handpicked when there is a black layer at the point of attachment of the grain to the cob.

3.6 DATA COLLECTION

Five plants per net plots were selected at random and tagged. Data were collected from these tagged plants on the following parameters.

3.6.1 Plant Height(cm)

This was measured at 3, 6, 9 and 12WAS with the use of a meter rule; the mean was collected and recorded as mean height per plant.

3.6.2 Number of Leaves Per Plant

This was taken at 3, 6, 9 and 12 WAS and the mean was calculated and recorded.

3.6.3 Leaf Chlorophyll Content

This was taken at 3, 6. 9 and 12 WAS using chlorophyll meter (Minolta SPAD 502).

3.6.4Cob Length(cm)

This was also taken from the base to the tip of the panicle at harvest using meter rule.

3.6.5 Cob Weight

The cob was weighed from the five randomly selected plants the mean recorded.

3.6.6 Stover Weight

At harvest, the overall stover of the two middle ridges on each plot was cut and weighed, and the mean recorded.

3.6.7 Seed Dry Weight

Grain obtain from the five randomly selected plants were threshed and weighed.

3.6.8 100 Grain Weight

100 grain were counted from the five randomly selected plants maize cobs and weighed.

3.6.9 Leaf Temperature

This was measured using infrared thermometer at 3, 6, 9 and 12 WAS.

3.6.10Harvest Index

This was measured using final grain weight per net plot divided by total dry matter per net plot measured at harvest.

$$\text{H.I} = \frac{\text{Grain weight/net plot at harvest}}{\text{Total dry matter/net plot at harvest}}$$

3.6.11 Grain Yield Per Hectare(kg)

This was determined by weighing all threshed grains from each net plot and converted to kg per hectare using the formula:

$$\text{Grain yield (kg/hectare)} = \frac{\text{Grain yeild/net plot (kg) x 10000 } (m^2)}{\text{Net plot area } (m^2)}$$

3.7 DATA ANALYSIS

Data collected were subjected to analysis of variance (ANOVA) using Genstat 17^{th}edition. Means were compared using Duncan Multiple Range Test. Simple correlation analysis was carried out to determine the relationship between the grain yield and characters measured.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1Physical and Chemical Properties of Soils of the Experimental Sites

The results of the soil analysis of the experimental sites are shown in Table 1.This indicated that the soils textural class of BUK was sandy loam with pH of 6.3. The soil had 1.08% organic carbon (OC) and 0.76% total nitrogen (N). The exchangeable cations (Ca, Mg) were 4.74C/mol/kg and 0.762Cmol/kg, Potassium (K) was 0.24Cmol/kg, Sodium (Na) was 0.09Cmol/kg. The CEC from this location was 6.01Cmol/kg.

Similarly, the results of the soil analysis for Doka showed that the soil textural class was loamy sand with pH of 5.75. The soil had 0.48% OC and 0.59% total N. The exchangeable cations (Ca, Mg) were 2.81C/mol/kg and 0.47Cmol/kg. K was 0.23Cmol/kg. Both soils were moderately fertile with BUK soils being relatively more fertile than that of Doka.

4.1.2 Seedling Survival and Seedling Emergence

The effects of wetting cycle, chemical and variety on the seedling emergence and seedling survival in maize are presented in Table 2. Results of the study indicated that seedling emergence and survival were not significantly affected by wetting cycle, chemical and variety, in both locations. Significant ($p = 0.033$) effect of chemical hardening was however recorded on seedling survival of maize at Doka only. Water treated plants had the highest seedling survival, than the other treatments that were statistically at par. It was further observed that the emergence and seedling survival were not significant among the maize varieties.

Table1. Physical and chemical properties of soils of the experimental sites prior to sowing.

Soil Properties	BUK	Doka
Physical composition (%)		
Sand	73.60	85.60
Silt	20.56	12.56
Clay	5.84	1.84
Textural class	Sandy loam	Loamy sand
Chemical composition		
pH ($CaCl_2$)	4.55	3.88
EC (ds/m)	0.16	0.17
Organic carbon (g/kg)	1.08	0.48
Total nitrogen (g/kg)	0.67	0.60
EA (cmol/kg)	0.17	0.33
Exchangeable cations (cmol/kg)		
Ca	4.74	2.81
Mg	0.76	0.47
K	0.25	0.23
Na	0.09	0.24
CEC	6.01	4.07

Analysed at the Department of Soil Science Laboratory of Bayero University Kano.

Table 2. Seedling emergence (%) and seedling survival (%) as affected by wetting cyclechemical and variety ofmaize during 2017 rainy season at BUK and Doka.

	Seedling Emergence		Seedling Survival	
Treatment	BUK	Doka	BUK	Doka
Wetting cycle(WC)				
Once	24.42	82.34	45.30	35.52
Twice	24.54	84.79	49.10	35.21
Thrice	22.75	84.90	35.20	36.67
SE ±	0.605	0.997	6.450	0.959
Chemical(CM)				
$CaCl_2$	26.11	84.17	46.20	35.28b
KCl	23.67	84.72	43.80	34.44b
NaCl	23.28	83.47	44.60	35.42b
H20	22.56	83.68	38.20	38.06a
SE±	1.375	1.464	3.47	0.823
Variety(V)				
EVDT 99	23.86	83.79	41.90	35.49
IWD	23.94	84.24	44.40	36.11
SE±	0.823	0.644	1.860	0.508
Interaction				
W x CM	NS	NS	NS	*
W x V	NS	NS	NS	NS
CM x V	*	NS	NS	NS
Wx CM x V	NS	NS	NS	*

Means followed by the same letter(s) within treatment columns are not significantly different using DMRT at 5% level of probability. * = significant at 5% level of probability, NS = not significant.

Interactions of wetting cycle and chemical as well as chemical and variety were significant ($p=0.018$ and $p=0.023$) on SS at Doka. There was also a significant ($p=0.026$) interaction of wetting cycle, chemical and variety on SE (Tables 3, 4 and 5). This indicated that IWD soaked in $CaCl_2$ at BUK had the highest SE (Table 3) that was at par with the other chemicals. Similarly, the highest seedling survival was observed from those that were wetted thrice. This was also at par with water treated seeds that were wetted once and twice in H_2O and $CaCl_2$ (Table 3). It was further observed that IWD hardened with $CaCl_2$ and H_2O twice had the highest SS from Doka (Table 5) that was statistically similar with other chemicals at once, twice and thrice wetting cycle.

4.1.3 Leaf chlorophyll content

The leaf chlorophyll content in maize did not significantly ($p>0.05$) responded to wetting cycle, hardening chemical and variety in all the sampling periods as well as in both locations (Table 6). There were however significant interactions of wetting cycle ($p = 0.030$) and hardening chemical ($p =0.023$) on leaf chlorophyll content of maize during 9 WAS (Table 7), wetting cycle and variety and chemical and variety at 12 WAS, respectively in Doka (Tables 8 and 9). Leaf chlorophyll content in maize was higher in water treated seedlings that were wetted twice. This was also at par with other chemicals treated seed that were wetted once, twice and thrice. The results further showed that IWD wetted twice and thrice had the highest chlorophyll content (Table 8). This was also at par with EVDT that was wetted once, twice and thrice. The results also indicated EVDT had the highest leaf chlorophyll content irrespective of the seed hardening chemical used (Table 9). This was also at par IWD hardened with KCl, NaCl and H_2O.

Table 3. Interaction of chemical and variety on seedling emergence rate of maize at 1WASduring 2017 rainy season at BUK.

	Variety	
Chemical	EVDT 99	IWD
$CaCl_2$	24.33abc	27.89a
KCl	21.44bc	25.89ab
NaCl	25.00abc	21.56bc
H_20	24.67abc	20.44
SE±	1.801	

Table 4. Interaction of wetting cycle and chemical on seedling survival rate of maize at 2WAS during 2018 rainy season at BUK.

	Chemical			
Wetting cycle	$CaCl_2$	KCl	NaCl	H_20
Once	32.08f	37.50a-d	33.75c-f	38.75ab
Twice	37.50a-e	32.92df	34.58b-f	35.83a-f
Thrice	36.25a-f	32.92def	37.92abc	39.58a
SE±	1.563			

Means followed by the same letter(s) within treatment columns are not significantly different using DMRT at 5% level of probability.

Table 5. Interaction of wetting cycle, chemical and variety on seedling survival rate of maize at 2 WAS during 2017 rainy season at Doka.

		Variety	
Wetting cycle	Chemical	EVDT 99	IWD
Once	$CaCl_2$	30.83f	33.33def
	KCl	38.33a-d	36.67b-e
	NaCl	33.33def	34.17c-f
	H_20	39.17abc	38.33a-d
Twice	$CaCl_2$	32.50ef	42.50a
	KCl	33.33def	32.50ef
	NaCl	34.17c-f	35.00b-f
	H_20	35.00b-f	36.67abc
Thrice	$CaCl_2$	39.17abc	33.33def
	KCl	31.67ef	34.17c-f
	NaCl	39.17abc	36.67bcde
	H_20	39.17abc	40.00ab
SE±		1.998	

Means followed by the same letter(s) with treatment columns are not significantly different using DMRT at 5% level of probability.

Table 6. Leaf Chlorophyll content of maize as affected by wetting cycle, chemical and variety on maize during 2017 rainy season at BUK and Doka.

	BUK (WAS)				Doka (WAS)			
Treatment	3	6	9	12	3	6	9	12
<u>Wetting cycle(WC)</u>								
Once	24.05	42.80	20.64	19.40	25.02	47.46	47.52	40.30
	25.34	44.14	22.36	21.19	26.60	42.42	46.84	43.40
Thrice	24.49	44.12	24.15	22.64	25.29	46.30	45.70	43.80
SE ±	0.917	2.053	1.177	1.338	0.968	1.969	2.062	1.730
<u>Chemical(CM)</u>								
$CaCl_2$	24.35	43.62	23.03	21.46	25.38	47.37	46.69	40.30
KCl	24.78	41.83	22.86	21.35	25.52	44.57	44.13	44.80
NaCl	25.39	44.59	23.60	21.69	26.31	46.76	47.12	40.30
H_2O	23.99	44.70	20.59	19.84	25.34	48.20	48.81	44.50
SE±	0.950	1.929	2.702	2.381	1.117	1.701	1.745	3.370
<u>Variety (V)</u>								
EVDT 99	23.82	44.64	22.25	20.86	24.68	47.97	47.97	42.10
IWD	25.43	42.74	22.79	21.31	26.60	45.41	45.41	42.90
SE±	0.633	1.190	1.283	1.212	0.662	1.174	1.174	1.540
<u>Interactions</u>								
W x CM	NS	NS	NS	NS	NS	NS	*	NS
W x V	NS	NS	NS	NS	NS	NS	NS	*
CM x V	NS	NS	NS	NS	NS	NS	NS	*
W x CM x V	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within treatment columns are not significantly different using DMRT at 5% level of probability. * = significant at 5% level of probability, NS = not significant.

Table 7. Interaction of wetting cycle and chemical on leaf chlorophyll content of maize at 9 WAS during 2017 rainy season at Doka.

	Chemical			
Wetting cycle	$CaCl_2$	KCl	NaCl	H_20
Once	48.34a-d	45.63a-d	51.26ab	44.84a-d
Twice	42.28bcd	41.20cd	51.24ab	52.66a
Thrice	49.44abc	45.56a-d	38.86d	48.94abc
SE±		3.33		

Table 8. Interaction of wetting cycle and variety on chlorophyll content of maize at 12WAS during 2017 rainy season at BUK.

	Variety	
Wettin cycle	EVDT 99	IWD
Once	44.32a	36.27b
Twice	40.87ab	45.96a
Thrice	41.22ab	46.38a
SE±	5.01	

Table 9. Interaction of Chemical and variety on leaf chlorophyll content of maize at 12WAS during 2017 rainy season at Doka.

	Variety	
Chemical	EVDT 99	IWD
$CaCl_2$	46.06a	34.62b
KCl	43.0ab	46.53a
NaCl	36.1ab	44.50ab
H_2O	43.21ab	45.82ab
SE±	0.204	

Means followed by the same letter(s) among treatments are not significantly different using DMRT at 5% level of probability.

Table 10. Leaf temperature in maize as affected by wetting cycle, chemical and variety on maize during 2017 rainy season at BUK and Doka.

	BUK (WAS)				Doka (WAS)			
Treatment	3	6	9	12	3	6	9	12
<u>Wetting cycle(WC)</u>								
Once	23.52	26.54	24.23	22.09	25.71	23.03	28.29	28.10
Twice	23.75	27.09	24.22	22.20	25.40	23.42	31.12	29.20
Thrice	223.87	27.50	24.29	22.45	25.62	24.34	27.34	32.50
SE ±	0.585	0.882	0.256	0.10	0.552	1.076	1.824	2.00
<u>Chemical(CM)</u>								
$CaCl_2$	23.93	27.04	24.46	22.38	25.98	23.66	28.20	28.40
KCl	23.35	26.75	23.70	22.17	25.15	23.76	29.51	28.80
NaCl	25.79	26.01	24.57	22.36	25.38	24.00	29.54	28.60
H_2O	23.78	28.25	24.26	22.06	25.79	22.96	28.42	33.60
SE±	0.392	0.809	0.298	0.161	0.458	0.608	0.583	2.310
<u>Variety (V)</u>								
EVDT 99	23.88	27.19	24.09	22.11	25.86	23.73	29.05	31.20
IWD	23.55	26.89	24.40	22.38	25.30	23.47	28.78	28.70
SE±	0.207	0.245	0.175	0.088	0.195	0.404	0.256	1.740
<u>Interactions</u>								
W x CM	NS	NS	NS	NS	NS	NS	NS	NS
W x V	NS	NS	NS	NS	NS	NS	NS	NS
CM x V	NS	NS	NS	NS	NS	NS	NS	*
W x CM Xv	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) among treatments are not significantly different using DMRT at 5% level of probability.* = significant at 5% level of probability, NS = not significant.

Table 11. Interaction of Chemical and variety on leaf temperature of maize at 12WAS during 2017 rainy season at Doka.

	Variety	
Chemical	EVDT 99	IWD
$CaCl_2$	22.33ab	22.43ab
KCl	22.14b	22.21b
NaCl	21.85b	22.87a
H_2O	22.13 b	21.99b
SE±	0.204	

Means followed by the same letter(s) among treatments are not significantly different using DMRT at 5% level of probability.

4.1.4 Leaf Temperature

Table 10 shows the effect of wetting cycle, chemical and variety on leaf temperature in maize during 3-12 WAS at BUK and Doka. Results indicated non-significant response of leaf to wetting cycle, chemical and variety ($p > 0.05$) response of leaf to wetting cycle, chemical and variety at both locations and in all the sampling periods of the study however there was significant ($p = 0.049$) interactions between chemical and variety at 12WAS in Doka. Table 11 showed that IWD treated with NaCl gave the highest leaf temperature that was at par with $CaCl_2$ on EVDT and IWD. KCl and H_2O used in treating both EVDT99 and IWD gave the lowest leaf temperature.

4.1.5 Plant height

The effects of wetting cycle, chemical and variety on plant height in maize is presented in (Table 12).Wetting cycle and variety had no significant effects on plant height in all the sampling periods of the study at both locations. Significant ($p = 0.028$) effect of chemical hardening on plant height was observed at BUK during 9 WAS. The results indicated that plants that were hardened with $CaCl_2$, KCl and NaCl gave the tallest plants than those hardened with H_2O that were statistically similar. Interactions of chemical and variety and between wetting cycle, chemical and variety were also significant ($p = 0.031$, $p = 0.022$, respectively) at 3WAS in BUK (Tables 13 and 14). The results showed that KCl had significantly ($p = 0.031$) taller plants from both varieties that were statistically similar (Table 13). The results of the interactions further revealed that tallest plants were recorded from EVDT that was wetted with KCl once only. This was also at Par with EVDT wetted thrice with NaCl, IWD that was wetted twice with $CaCl_2$ but different from all other treatment combinations.

4.1.6.Number of leaves per plant

Table 15 shows the effects of wetting cycle, chemical and variety on number of leaves per plant of maize during 2017 rainy season at BUK and Doka. This showed that both wetting cycle and variety had no significant effect on number of leaves per plant in all the sampling periods and also from both locations. However, there was significant ($p = 0.046$) effect of chemical on number of leaves per plant. From the results, it shows that plants that were hardened with KCl produced the highest number of leaves per plant that was at par with NaCl during 6WAS. Interactions of chemical and variety on number of leaves of maize was significant at $p = 0.027$during 9WAS of the study at BUK (Table 16). The result shows a significant effect of all the hardening chemicals on both varieties at BUK except for EVDT 99 hardened with H_2O that give the least number of leaves per plant.

Table 17 also shows the interactions of wetting cycle, chemical and variety on number of leave per plant of maize at 3WAS. The results showed that IWD hardened with KCl once and H_2O thrice gave the highest number of leaves per plant. However, EVDT 99 hardened with NaCl thrice, IWD with $CaCl_2$ twice and thrice, IWD with H_2O once, were statistically at par. Similarly, IWD variety hardened with H_2O twice gave the least number of leaves per plant.

Table 12. Plant height as affected by wetting cycle, chemical and variety on maize during2017 rainy season at BUK and Doka.

	BUK (WAS)				Doka (WAS)			
Treatment	3	6	9	12	3	6	9	12
Wetting cycle(WC)								
Once	30.41	75.20	159.5	162.1	31.02	73.50	167.9	173.7
Twice	26.88	84.80	154.8	158.4	26.22	78.60	160.7	172.1
Thrice	28.10	91.10	160.1	164.8	27.25	88.70	169.3	176.5
SE ±	0.76	15.26	3.72	1.82	1.32	16.44	3.28	1.21
Chemical(CM)								
$CaCl_2$	27.22	84.00	163.7a	167.6	28.48	80.50	172.5	179.5
KCl	28.70	80.20	150.4b	157.5	27.44	77.80	158.5	170.6
NaCl	29.52	83.10	163.6a	163.2	28.08	79.30	168.0	173.4
H_2O	28.34	87.60	154.7ab	158.6	28.66	83.50	164.9	172.7
SE±	0.95	6.70	3.39	2.91	1.03	5.27	3.78	2.99
Variety (V)								
EVDT 99	28.66	81.80	153.2	159.1	27.87	76.60	161.1	171.4
IWD	28.23	85.60	163.0	164.4	28.46	84.00	170.9	176.7
SE±	0.58	3.29	2.74	2.59	0.54	2.19	2.88	2.30
Interactions								
W x CM	NS	NS	NS	NS	NS	NS	NS	NS
W x V	NS	NS	NS	NS	NS	NS	NS	NS
CM x V	*	NS	NS	NS	NS	NS	NS	NS
W x CM x V	*	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) with treatment columns are not significantly different using DMRT at 5% level of probability.* = significant at 5% level of probability, NS = not significant.

Table 13. Interaction of Chemical and variety on plant height of maize at 3 WAS during 2017 rainy season at BUK.

	Variety	
Chemical	EVDT 99	IWD
$CaCl_2$	26.06c	28.38abc
KCl	31.01a	26.39bc
NaCl	29.91ab	29.14abc
H_20z	27.67abc	29.02abc
SE±	1.256	

Table 14. Interaction of wetting cycle, chemical and variety on plant height of maize at 3 WAS during 2017 rainy season at BUK.

		Variety	
Wetting cycle	Chemical	EVDT 99	IWD
Once	$CaCl_2$	29.06a-g	27.00b-f
	KCl	35.12a	32.46ab
	NaCl	26.49b-h	27.09b-g
	H_20	29.38a-f	32.48ab
Twice	$CaCl_2$	24.63e-h	33.50ab
	KCl	22.18h	20.86h
	NaCl	25.09d-h	30.97a-d
	H_20	30.62a-f	25.03d-h
Thrice	$CaCl_2$	24.49fgh	28.17b-g
	KCl	31.87abc	25.84d-h
	NaCl	32.56ab	29.36a-f
	H_20	23.00gh	29.56a-f
SE±		2.423	

Means followed by the same letter(s) with treatment columns are not significantly different using DMRT at 5% level of probability.

Table 15. Number of leaves per plant in maize as affected by wetting cycle, chemical and variety on maize during 2017 rainy season at BUK and Doka.

	BUK (WAS)				Doka (WAS)			
Treatment	3	6	9	12	3	6	9	12
Wetting cycle(WC)								
Once	5.94	8.54	11.44	10.18	5.76	9.94	10.57	10.92
Twice	5.60	8.01	10.87	9.54	5.26	9.56	10.61	10.42
Thrice	5.72	7.50	10.67	9.64	5.76	9.24	10.60	10.56
SE ±	0.09	0.15	0.20	0.38	0.12	0.31	0.24	0.31
Chemical(CM)								
$CaCl_2$	5.82	7.76b	11.19	10.15	5.50	9.81	10.80	11.00
KCl	5.54	8.70a	11.13	9.54	5.33	9.41	10.57	10.50
NaCl	5.82	8.20ab	11.00	9.83	5.56	9.39	10.61	10.59
H_20	5.85	7.41b	10.67	9.63	5.59	9.70	10.39	10.43
SE±	0.15	0.31	0.26	0.28	0.14	0.25	0.20	0.23
Variety(V)								
EVDT 99	5.65	8.05	10.92	9.73	5.37	9.50	10.45	10.60
IWD	5.86	7.99	11.07	9.84	5.62	9.66	10.73	10.66
SE±	0.09	0.20	0.15	0.17	0.09	0.17	0.20	0.15
Interactions								
W x CM	NS	NS	NS	NS	NS	NS	NS	NS
W x V	NS	NS	NS	NS	NS	NS	NS	NS
CM x V	NS	NS	*	NS	NS	NS	NS	NS
W x CM x V	NS	NS	NS	NS	*	NS	NS	NS

Means followed by the same letter(s) with treatment columns are not significantly different using DMRT at 5% level of probability.* = significant at 5% level of probability, NS = not significant.

Table 16. Interaction of chemical and variety on number of leaf of maize at 9WAS during 2017 rainy season at BUK.

	Variety	
Chemical	EVDT 99	IWD
$CaCl_2$	11.26a	11.11a
KCl	11.30a	10.96a
NaCl	11.11a	10.89ab
H_20	10.00 b	11.33a
SE±	0.328	

Means followed by the same letter(s) are not significantly different using DMRT.

4.1.7 Cob weight and Cob length

Cob weight and Cob length of maize were not significantly (P>0.050 affected by wetting cycle, chemical and variety in all the sampling periods at both locations (Table 18). There was however significant interactions of wetting cycle and chemical on cob weight at BUK only (Table 19). This showed that cob weight was higher in seeds that were hardened with $CaCl_2$ and wetted twice which was at par with seeds hardened with KCl and wetted once.

4.1.8 Stover weight, 100 Seed weight and Grain moisture

Table 20 shows the effects of wetting cycle, chemical and variety on Stover weight, 100 seed weight and grain moisture of maize during 2017 rainy season at BUK and Doka. There were no significant effects of all the factors on 100 seed weight and grain moisture at both locations. Stover weight was however significant with p = 0.043 for wetting cycle at Doka. This showed that seeds that were wetted thrice had the highest stover weight. While the least stover weight was observed from seeds that were wetted once and twice. There was however significant interaction of wetting cycle and variety at 100 seed weight only (Table 21). This shows that EVDT hardened once produced the highest 100seed weight which was statistically similar with other wetting cycle. All other treatment combinations were statistically at par with EVDT hardened once except for IWD seeds hardened once having the lowest 100seed weight.

Table 17. Interaction of wetting cycle, chemical and variety on number of leaves per plant of maize a 3 WAS during 2017 rainy season at Doka.

		Variety	
Wetting cycle	Chemical	EVDT 99	IWD
Once	$CaCl_2$	5.11b-e	5.67a-e
	KCl	5.56a-e	6.33a
	NaCl	6.22a	5.56a-e
	H_20	5.78abc	5.89ab
Twice	$CaCl_2$	5.22b-e	6.00ab
	KCl	4.78de	4.78de
	NaCl	4.89cde	5.67b-e
	H_20	5.67b-e	4.78e
Thrice	$CaCl_2$	5.11b-e	5.8ab
	KCl	5.11b-e	5.11b-e
	NaCl	5.8ab	5.11b-e
	H_20	5.11b-e	6.33a
SE±		0.597	

Means followed by the same letter(s) are not significantly different using DMRT at 5% level of probability.

Table 18: Cob weight and Cob length as affected by wetting cycle, chemical and variety in maize during 2017 rainy season at BUK and Doka.

	BUK		Doka	
Treatment	Cob weight	Cob length	Cob weight	Cob length
Wetting cycle(WC)				
Once	0.433	11.39	40.44	14.07
Twice	0.429	11.66	40.00	14.17
Thrice	0.388	11.30	42.06	14.07
SE ±	0.095	0.148	1.316	0.231
Chemical(CM)	0.58	11.32	38.78	14.21
KCl	0.40	11.74	37.79	14.22
NaCl	0.40	11.16	41.48	14.21
H_20	0.28	11.57	45.28	14.43
SE±	0.068	0.255	2.048	0.307
Variety				
EVDT 99	0.386	0.386	40.97	14.41
IWD	0.448	0.448	40.70	14.12
SE±	0.038	0.120	1.142	0.269
Interactions				
W x CM	*	NS	NS	NS
W x V	NS	NS	NS	NS
CM x V	NS	NS	NS	NS
W x CM x V	NS	NS	NS	NS

* = significant at 5% level of probability, NS = not significant.

Table 19. Interaction of wetting cycle and chemical on cob weight of maize at 3 weeks during 2018 rainy season at BUK.

	Chemical			
Wetting cycle	$CaCl_2$	KCl	NaCl	H_20
Once	0.504a-f	0.553ab	0.517a-e	0.157cdf
Twice	0.793a	0.220b-f	0.156b-f	0.546a-d
Thrice	0.433a-f	0.433a-f	0.540a-d	0.147b-f
SE±		0.139		

Means followed by the same letter(s) with treatment columns are not significantly different using DMRT at 5% level of probability.

Table 20 Stover weight, 100 seed weight and grain moisture as affected by wetting cycle, chemical and variety on maize during 2017 rainy season at BUK and Doka.

	BUK				Doka			
Treatment	Stover weight(kg)	Stover weight (kg)	100seed weight (g)	Grain moisture (%)	Stover weight (kg)	Stover weight(kg)	100seed weight (g)	Grain moisture (%)
Wetting cycle(WC)								
Once	1.010	2693	14.43	6.66	1.89	5051b	70.23	21.21
Twice	0.968	2580	12.68	3.78	1.80	4796b	71.46	22.17
Thrice	0.715	1907	12.46	2.78	2.25	6004a	73.85	20.75
SE ±	0.200	543.2	1.35	1.88	0.09	230.5	153.9	0.752
Chemical(CM)								
$CaCl_2$	1.01	2693	13.02	3.41	2.09	5573	71.11	22.42
KCl	0.94	2516	13.01	3.75	2.04	5440	71.39	20.52
NaCl	0.96	2572	13.85	4.49	1.64	4364	72.78	20.82
H_20	0.67	1793	12.89	5.18	2.16	5757	72.11	21.74
SE±	0.137	364	0.81	1.02	0.19	4982	1.40	0.90
Variety (V)								
EVDT 99	0.83	2212	13.60	5.36	2.10	5596	71.54	21.55
IWD	0.97	2575	12.78	3.06	1.86	4972	72.15	21.20
SE±	0.086	229.7	0.57	1.01	0.11	284.2	0.68	0.53
Interactions								
W x CM	NS	NS	NS	NS	NS	NS	NS	NS
W x V	NS	NS	*	NS	NS	NS	NS	NS
CM x V	NS	NS	NS	NS	NS	NS	NS	NS
W x CM x V	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) with treatment columns are not significantly different using DMRT at 5% level of probability. * = significant at 5% level of probability, NS = not significant.

Table 21. Interaction of wetting cycle and variety on 100 seed weigh of maize at 2017 rainy season at BUK.

	Variety	
Wetting cycle	EVDT 99	IWD
Once	16.62a	12.25b
Twice	12.35ab	13.02ab
Thrice	11.83ab	13.09ab
SE±	1.14	

Means followed by the same letter(s)are not significantly different using DMRT at 5% level of probability.

4.1.9 Grain yield and Harvest index

Table 22 shows the effects of wetting cycle, chemical and variety on grain yield and harvest index of maize at BUK and Doka. Results of the study shows that wetting cycle, chemical and variety had no significant effects on grain yield and harvest index in all the locations. The treatments interactions at both locations were not significant.

4.1.10 Correlation Analysis

Tables 23 and 24 shows the correlation matrix at both locations. From the results obtained there is a significant correlation between cob weight, plant height, number of leaves with yield/ha at BUK. Highly significant effects were obtained in seedling survival correlated with yield/ha and correlated with yield. Maize yield was significantly correlated with harvest index and cob weight and highly significant with seedling survival at Doka.

Table 22. Grain yield and harvest index as affected by wetting cycle, chemical and variety in maize during 2017 rainy season at BUK and Doka.

Treatment	BUK		Doka	
	Grain yield(kg/ha)	Havest index	Grain yield(kg/ha)	Havest index
Wetting cycle(WC)				
Once	686	27.60	3008	62.00
Twice	365	15.80	2455	56.30
Thrice	227	17.70	2964	54.60
SE ±	155.7	3.59	208.3	2.67
Chemical(CM)				
$CaCl_2$	524	20.50	2572	50.80
KCl	490	26.80	2728	57.40
NaCl	430	16.50	2681	66.10
H_20	261	17.80	3256	56.00
SE±	78.2	4.53	199.4	4.670
Variety (V)				
EVDT 99	503	22.50	2823	53.20
IWD	349	18.30	2795	62.10
N	61.80	2.73	128.9	3.39
SE±				
Interactions				
WC x CM	NS	NS	NS	NS
W x V	NS	NS	NS	NS
CM x V	NS	NS	NS	NS
W x CM x V	NS	NS	NS	NS

Table 23. Matrix of correlation coefficients(r) between some selected growth and yield of maize at BUK during 2017 rainy season.

Parameters	Yield (kg/ha)	Harvest Index	Cob length (cm)	Cob weight (g)	Chlorophyll content	Leaf temperature (^{0}C)	Number of leaves	Plant height (cm)	Seedling emergence (%)
Yield (kg/ha)	1.00								
Harvest Index	0.535**	1.00							
Cob length (cm)	-0.123	0.106	1.00						
Cob weight (g)	0.339*	-0.028	-0.337*	1.00					
Chlorophyll content	0.025	-0.133	0.025	-0.039	1.00				
Leaf temperature (^{o}C)	-0.207	-0.042	-0.029	-0.041	-0.118	1.00			
Number of leaves	-0.205	-0.248*	0.010	0.088	-0.127	0.008	1.00		
Plant height (cm)	-0.343*	-0.079	-0.024	-0.079	-0.178	0.167	0.339*	1.00	
Seedling emergence (%)	0.152	-0.017	-0.187	0.246*	0.001	-0.049	0.154	-0.089	1.00
Seedling survival (%)	0.519**	0.043	-0.218	0.600**	0.277*	-0.200	0.045	-0.396*	0.404**

* and ** Significant at 5% and 1% levels of probability.

Table 24. Matrix of correlation coefficients(r) between some selected growth and yield of maize at Doka during 2017 rainy season.

Parameters	Yield (kg/ha)	Harvest Index	Cob length (cm)	Cob weight (g)	Chlorophyll content	Leaf temperature (^{0}C)	Number of leaves	Plant height (cm)	Seedling emergence (%)
Yield (kg/ha)	1.00								
Harvest Index	0.299*	1.00							
Cob length (cm)	0.009	-0.092	1.00						
Cob weight (g)	0.303*	0.032	0.334*	1.00					
Chlorophyll content	0.244*	-0.004	0.011	0.045	1.00				
Leaf temperature (^{o}C)	0.095	0.011	0.063	0.008	0.059	1.00			
Number of leaves	0.139	-0.118	0.093	0.009	-0.115	-0.138	1.00		
Plant height (cm)	0.152	-0.222	0.015	0.115	0.282*	0.008	0.321*	1.00	
Seedling emergence (%)	0.034	0.093	0.046	-0.146	0.109	0.289*	0.148	-0.015	1.00
Seedling survival (%)	0.530**	0.178	0.072	0.599**	-0.011	0.061	-0.040	0.106	-0.031

* and ** Significant at 5% and 1% levels of probability.

4.2 DISCUSSION

4.2.1 Effect of wetting cycle on growth and yield parameters of maize

The lack of response in seedling emergence and seedling survival (SE and SS) in this study might be attributed to the moisture stress which resulted in poor germination and subsequent erratic crop stand under stressful condition (Farooq *et.al.,*2009; Rehman *et al.,* 2011; Jaafar *et al.,* 2012), which may be due to the short time span of suitable conditions for germination in arid zones. The result also revealed a non-significant effect of wetting cycle on leaf chlorophyll content and leaf temperature, which resulted in shorter plants and number of leaves per plant. The non-significant effect of cob length, cob weight, stover weight, 100 seed weight, grain moisture, grain yield and harvest index might be attributed to the non- significant effect of wetting cycle on seedling emergence and survival rate. As such, the seeds were unable to take the most of available moisture and germinate at high speed (Gutterman,1993) or as a result of lower water deficit and increased metabolic activity (Mitraa*et al*.,1999).

From the results, wetting cycle also had a great influence on cob weight, length and stover weight. This could be as a result of rapid embryo enlargement, improving seedling vigor and affecting the productivity of crops (Cheema *et al.,*1975).

4.2.2 Effect of seed hardening chemicals on growth and yield parameters

From the analysis, it is evident that seed hardening chemical had significant influence on seedling survival and emergence. The significant response of SE and SS to soaking with water observed in this study corroborates with the findings of (Ruan *et al.,* 2002) who reported that hardened seeds perform better with vigor levels under stress environment and results in rapid germination with higher emergence index.

Farooq *et al.,* (2006) also reported that mere soaking with water reduces days to emergence. The result also revealed that chemical had no significant effect on leaf chlorophyll and leaf temperature. However, a significant effect was observed on plant height at 9WAS.Plant treated with $CaCl_2$ and NaCl produced the tallest plant. These might be attributed to the action and interactions of particular essentials elements within the cell system, and that has been added with the action of particular growth regulator, specifically required for the accumulation of source property, for enhancing the performance of sink in particular part of organ of the plant/crop (Liu *et al.,* 2011). This supported the observation reported by Avijit (1983) that seed hardening with $CaCl_2$ recorded marked increase in plant height, tiller number, leaf area and dry weight of shoot and grain yield of wheat.

4.2.3 Varietal response

The varieties had no significant effect on growth and yield characters indicates that the varieties used in this are genetically similar. This might also be attributed to their characteristics as both are drought tolerant maize or it could be because of low fertility of the soil as it contains low organic carbon, nitrogen, magnesium, potassium and sodium. The soil was also slightly acidic even though the optimum pH of plants is between 5.5 and 7.5. As such the toxicity as well as nutrient deficiency may have resulted in varieties of stresses to the plant (Brady and Weil, 2002).

4.2.4 Interactions of wetting cycle, chemical and variety on growth and yield parameters of maize.

The significant interactions of wetting cycle and chemical gave a significant effect on seedling survival and seedling emergence observed in the study corroborates with the findings of Solaimalai and Sabburamu (2004) that best results are claimed on seeds subjected to two or three cycles of wetting and drying even though for some species one cycle is sufficient. The significant Interaction of IWD variety with $CaCl_2$ to have produced the highest seedling emergence. These are in support of the findings of Farooq *et al.,* (2006) in rice, that mere soaking reduced day for emergence while hardening with KCl or $CaCl_2$ was found to reduce it even further.

The significant effect of wetting twice with water on leaf chlorophyll content observed at Doka during the study could be attributed to the maintenance of cell turgidity, denser cytoplasm and inhibition of chlorophyll break down. In addition, the tendencies of EVDT and IWD plants wetted twice and thrice at 12WAS to produce higher chlorophyll content supported the work of Bunu (2014) that the interaction of chemicals such as KCl with variety of millet LCICMV-2, LCICMV-3, LCICMV-4 on chlorophyll content was significant at Kano. In addition, Ramesh (2004) noticed during 1998 and 1999 that foliar spray of 22pm benzaldenine along with 2% KCl enhanced leaf chlorophyll content. Similar results have also been found in Cheema *et a.,* (1975), in barley and wheat. Shasidhar *et al.*(1981) in groundnut and Ramesh (2004) in Sorghum, who reported an increase in relative water content, chlorophyll and proline in seed hardening plants. Similarly, the ability of EVDT varieties treated with KCl to produce the tallest plant height compared to all other chemicals may be due to the availability of high-energy compounds and vital bio molecules to the growing seedling as reported by Renugadevi and Vijayageetha (2006).The tendency of EVDT wetted with KCl once to bear the tallest plants compared to all other treatments is supported by the findings of Punithavathi and Palaniswamy (2001) which indicated that ragi seeds soaked in 1% concentration of KCl, $CaCl_2$ for 12hrs recorded higher germination percent as well as root length, shoot length, vigor index and dry matter production. In addition, Paul *et al*., (1993) reported that KCl and $CaCl_2$ produced higher shoot length. Bunu (2016) also reported that $CaCl_2$ gave the tallest plant height when used on pearl millet and it may be because of improved and faster seedling emergence.

The significant interaction of EVDT with $CaCl_2$, NaCl and KCl and IWD with KCl, $CaCl_2$ and H_2O to produce a greater number of leaves per plant as well IWD plants wetted once and thrice with KCl and H_2O respectively to bear the highest number of leaves per plant .This supported with the findings of Nagar *et a1*.(1998) that hardening of maize seed enhanced the speed of emergence and improve the field stand and plant growth both at vegetative and maturity stage. Also, Rathinavel and Dharmalingam (2000) observed that seed hardening of cotton with KCl and CaCl recorded more germination compared to control but root length, shoot length and vigour index reduced significantly over control but seed treatment with KCl recorded higher value.

The heaviest cob recorded from maize wetted twice with $CaCl_2$ corroborated with the findings of Punithavathi and Palinisany (2001) who reported that treatment of maize seeds with 1% $CaCl_2$ increased germination speed germination, field emergence, vigour index and seedling vigour significantly over untreated seed. Also, the interaction of EVDT 99 wetted once with water to bear the highest 100 seed weight. This is in support with the findings of Avijit (1985) that seeds hardened with water and different salts solutions increased the number of panicles and grain yield.

4.2.5 Correlation

Correlation analysis measures the relationship between various plant characters and determine the component characters on which selection could be used for improvement in yield. From the results obtained cob weight was significantly correlated with cob length, chlorophyll with yield/ha and plant height with number of leaves at BUK. Highly significant effects were obtained in harvest index correlated with yield/ha and cob length and seedling survival correlated with seedling emergence. Maize yield was significantly correlated with harvest index and cob weight and highly significant with seedling survival at Doka. This is in supported the findings of Hidetoshi and Tohru (2003) that maize seed responded positively to hardening, the treatment reduced the range of germination times to between 20hrs and 40hrs and similarly, noticed that hardening enhanced seed germination and seedling vigor.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

A study was conducted at Teaching and Research Farm of Faculty of Agriculture, Bayero University, Kano and Doka Tofa Local Government Area of Kano State during 2017 rainy season. The research was aimed at assessing the effects of seed hardening chemicals using different wetting cycles on drought tolerance of maize. The experiment consists of 24 treatments as comprised of wetting cycle, four seed hardening chemicals (H_2O, NaCl, $CaCl_2$ and KCl) and two maize varieties. These were laid out in split-split plot design and replicated three times. Data were collected in growth, yield component and grain yield. The data were subjected to analysis of variance using GENSTAT 17thedition and significant means were separated using analysis of variance.

From the results generally, it was observed that interactions of hardening chemical, wetting cycle and variety have great influence on both growth and yield on maize. The interactions of IWD and $CaCl_2$ improved seedling emergence of seeds that were hardened with H_2O thrice gave the highest survival rate. All chemicals had significant influence on plant height but EVDT 99 that was wetted once with KCl gave the tallest plant height and Cob weight.

KCl and NaCl at 6 weeks produced the highest number of leaves per plant compared to H_2O and $CaCl_{2.}$ In addition, IWD seeds were more promising when hardened with H_2O (once) and KCl (thrice) and produced a significant number of seeds. Seeds hardened with H_2O (twice) gave the highest chlorophyll content.

Wetting cycle had significant effect on EVDT 99, which undergoes hydration-dehydration and produced higher stover yield. However, grain yield and harvest index were not influenced by these interactions. It is quite possible that yield advantages due to seed hardening treatment would be apparent when the drought was not too severe and be obliterated by extreme moisture stress.

5.2 CONCLUSION

Seeds hardening with chemicals were found to increase seedling emergence and survival rate. It is possible that early radical emergence and seedling treatment on planting in the field following seed hardening treatments simply give the plant a better start than non- hardened plants. Further, the germination will be more synchronized which might ultimately result in a uniform crop population (Kurkarni and Jalshakthi, 2002).

In conclusion, $CaCl_2$and H_2O were found to be the best seed-hardening chemicals in both Kano and Doka followed by NaCl and KCl. The best wetting cycle was found in seed hardened twice and thrice followed by seeds that are hardened once. Between the two varieties of maize, IWD is found to be more promising when assessing drought tolerance in maize plant.

5.3 RECOMMENDATION

Further studies need to be carried out on maize plants at different locations, using local varieties and at different seasons.

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