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DROUGHT STRESS TOLERANCE OF GREEN MAIZE (Zea mays L.) VARIETIES AS

INFLUENCED BY SEED PRIMING AGENTS, DURATION AND CONCENTRATION

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## ABSTRACT

Two experiments (screen house and open field) were conducted at the Research and Teaching Farm of the Department of Agronomy, Bayero University, Kano, Nigeria (Lat 11°58'N, Long  $8^{\circ}25$ 'E, and altitude of 475 m asl) during the 2019 dry season. The open field trials were undertaken between March and May 2019, while the screen house trial was carried out between August and November 2019. The treatments consisted of two varieties (SAMMAZ 15 and SAMMAZ 17), five priming materials (cow dung, poultry dropping, CaCl, KCl, and distilled water), five priming durations (2, 4, 6, 8, and 10 hrs), and two concentration levels (2 and 4%), all fractionally combined to give 100 treatments. The design used was a fractional factorial design in 60 incomplete blocks. The treatments were assigned to the blocks using the design of the experiment platform of JMP version 14 software (SAS Institute Inc..) according to the D-optimality criterion for an ANOVA model that has the main effects of priming agents, priming duration, and priming concentration, including all their 2<sup>nd</sup> order interactions and a random effect of three replications. The findings from the study show that seed priming, regardless of the priming agent, duration, or concentration used, did not generally have a significant impact on most measured parameters in either open field or screen house environments. However, the positive impact of 2% KCl priming on cob yield in the open field suggests it might be a beneficial strategy for mitigating the adverse effects of drought. In general, on-farm seed priming of maize seeds with KCL can enhance the growth and vield characteristics of the plant while assisting the seedling to withstand drought at the lowest feasible cost.

Keywords: Agents, Chlorophyll, Concentration, Green and Temperature

## **INTRODUCTION**

Maize (*Zea mays* L.), a popular cereal in Africa and an important crop next to rice and wheat in the world, is highly dependent on climatic conditions and is highly versatile (Benjamin *et al.*, 2024; Revilla *et al.*, 2022). With the highest number of growers and largest acreage under cultivation, it is high-yielding, easy to process, readily digested, and cheaper than other cereals (Revilla *et al.*, 2022). Nigeria contributed 1.0% to global maize production in 2015, but dropped to 13th in the world and 1st in Africa in 2016 (FAOSTAT, 2016).

Maize, traditionally grown in Nigeria's forest ecology, has shifted to the savanna zone, particularly Northern Guinea Savanna, due to higher yield potential and better environmental conditions. Maize has evolved from a subsistence crop to a commercial crop for agro-based industries (Galani *et al.*, 2022). Green maize, also known as table maize, roasted or boiled maize, is ready for harvest when the grain hardens or the silky flowering turns blackish brown. It is more nutritious than processed maize products and some farmers prefer to wait for it to dry for more income (Esilaba *et al.*, 2021). Nigeria's roasted or boiled maize business is a significant source of employment, particularly for young women and girls, as green maize is widely consumed in Africa (Wossen *et al.*, 2023).

Drought stress, caused by limited water supply or high evapo-transpiration rates, is a significant threat to crop production worldwide, particularly in areas where irrigation is essential.



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It hinders metabolic activities, water and nutrient relations, and productivity of arable crops, affecting the sustainability of agricultural production systems (Bheemanahall *et al.*, 2022; Dodig *et al.*, 2021). Drought causes up to 24 million tons of maize yield loss annually, with the highest impact in Sub-Saharan Africa. Climate change has already led to a 3.8% decline in maize yields since the 1980s, with a further 5-10% decline expected by 2050. Maize responds to climate change in three ways: decrease, increase, and rapid decline. By 2055, yields are expected to decrease dramatically in nearly three-quarters of African countries. Drought impacts every stage of maize development, particularly during flowering and pollination, causing potential 100% yield loss (Kim and Lee, 2023; Simanjuntak *et al.*, 2023). It is therefore a promising option for diversifying agriculture due to its resilience to changing climates (Benjamin *et al.*, 2024).

Seed priming is a short-term method to combat drought and environmental stresses on seedling emergence and stand establishment. It enhances early emergence and allows crops to capture more soil moisture, nutrients, and solar radiation, increasing dry matter production. Methods include osmo-priming, hydro-priming, hormonal-priming, bio-priming, and matric priming (Chen *et al.*, 2022; Ben Youssef *et al.*, 2024). Priming is a simple and safe technique that allows seeds to absorb water, allowing them to pass early germination stages without growing roots, thereby increasing seedling establishment and crop production under stressful conditions, resulting in faster root and stem appearance, stronger plant tolerance, and early flowering and harvesting. For crops to be produced successfully, especially maize, which cannot adjust to subpar tillering, seed priming is essential. The consequences of drought can be mitigated by using a variety of inexpensive, locally sourced materials. Optimal priming duration and concentrations of organic and inorganic priming agents must be determined before adoption. Hence, the study was conceived with the aim of evaluating the effects of both organic and inorganic seed priming treatments on drought stress in maize and to identify the ideal priming agent concentrations and duration.

## MATERIALS AND METHODS

## The Study Area

Two experiments (screen house and open field) were conducted during the 2019 dry season at the Research and Teaching Farm of the Department of Agronomy, Bayero University, Kano, Nigeria (Lat 11°58'N, Long 8°25'E, and altitude of 475 m asl). The open field trials were undertaken between March and May 2019, while the screen house trial was undertaken between August and November 2019. The treatments consisted of two varieties (SAMMAZ 15 and SAMMAZ 17), five priming materials (cow dung, poultry dropping, CaCl, KCl, and distilled water), five priming durations (2, 4, 6, 8, and 10 hrs), and two concentration levels (2 and 4%), all fractionally combined to give 100 treatments. The design used was a fractional factorial design in 60 incomplete blocks. The treatments were assigned to the blocks using the design of the experiment platform of JMP version 14 software (SAS Institute Inc..) according to the Doptimality criterion for an ANOVA model that has the main effects of priming agents, priming duration, and priming concentration, including all their 2<sup>nd</sup> order interactions and a random effect of three replications. Main plot size was 5 m  $\times$  4.5 m (22.5 m<sup>2</sup>) consisting of six rows spaced 0.75 m apart and row length of 5 m. Then net plot size was 5 m x 1.5 m  $(7.5 \text{ m}^2)$ . Distance between plots was 0.5 m and distance between replications was 1 m. Main plot size was 5 m  $\times$  4.5 m (22.5  $m^2$ ) consisting of six rows spaced 0.75 m apart and row length of 5 m. Then net plot size was 5 m x 1.5 m (7.5 m<sup>2</sup>). Distance between plots was 0.5 m and distance between replications was 1 m.



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## **Priming Procedure**

1 ltr of 2% of the priming agent was achieved by dissolving 20.0 g (priming agent) in 1 ltr of water. 4% was achieved by dissolving 40.0 g of priming agent in 1 liter of water. One liter of priming media was prepared for each priming application, and 250 g of seeds of both varieties were soaked according to treatments. Later, seeds were removed from the priming solution and then rinsed in distilled water for 60 seconds to reduce testa damage. The seeds were then dried under shade for 24 hours and then sun-dried for three hours to bring back their original moisture content, which was used for sowing.

## **Drought Imposition**

Drought was imposed by withholding irrigation at V3 (the three-collar leaf stage). Normal irrigation was given to the plants from sowing to the critical stage, where irrigation was stopped until visible signs of wilting began to appear (e.g., rolling and drying of leaf tips), then normal irrigation was continued. The control treatment (no stress) was achieved by irrigating the plot completely, i.e., there was no moisture stress at all, where three moisture management treatments were imposed on the two maize varieties at both locations.

## **Cultural Practices**

## Land Preparation and Sowing

The experimental field was cleared, ploughed, and ridged at the beginning of the dry season. The ridges were made 0.75 m apart, and then the plots were laid out as per the treatment combinations. Two to three seeds were planted per hole at a 25-cm spacing and later thinned to one plant per stand after two weeks. At the screen house, two to three seeds were planted about 2.5 cm deep into the soil per pot containing soil weighing 8 kg and then later thinned to two plants per pot after two weeks. The containers were spaced 10–12 cm away from each other.

## **Fertilizer Application**

Fertilizer was applied at a rate of 120:60:60 of elemental N, P, and K in the forms of N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O fertilizers. A compound fertilizer (NPK 15:15:15) was used to supply 60 kg each of N, P, and K ha<sup>-1</sup> as a basal application, and urea (46% N) was used to supply the remaining dose (60 kg N ha<sup>-1</sup>) of nitrogen at 4 weeks after the first application. At the screen house, fertilizer was applied two weeks after sowing using the recommended rates, which are equivalent to 1.6 g of compound fertilizer (NPK 15:15:15), and then 0.52 g of urea in each pot was applied four weeks after the first application.

### Irrigation

The water management was as follows: Field capacity throughout the period of experimentation. Drought stress was imposed at V3 by withholding water during the periods until visible signs of wilting were observed on the leaves (rolling of leaves, drying of leaf tips, and darkening colors) before irrigation was resumed in both locations.

### Weed Control

The experimental field was kept relatively weed-free by employing manual weed control management, i.e., hoe weeding, to check weeds as soon as they appeared. At the screen house, weeds were also removed manually by hand pulling.

## Harvesting

The crop was harvested when the silky flowering at the top of the maize cob turns blackish brown (60–70 days after planting) by handpicking, which was carried out by harvesting the net plot.



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### **Data Collection and Data Analysis**

Soil samples from the two locations were collected at 0–30 cm using a soil auger. It was analyzed for physical and chemical properties using standard procedures as described by Black (1965). In addition, the priming agents of cow dung and poultry manure were analyzed for chemical properties prior to the commencement of the experiment. Data were collected on agronomic parameters such as plant height, leaf area index, and chlorophyll content. Similarly, drought parameters such as relative water content, canopy temperature, and leaf temperature were also measured using standard procedures as described by Yu *et al.* (2000). The data collected was subjected to analysis of variance (ANOVA) using the fit model platform of JMP Pro version 14 (SAS, 2018), as described by Snedecor and Cochran (1967). Means were separated using the SNK (Student Newman-Keul Test) at a 5% probability level.

## **RESULTS AND DISCUSSION**

### Physical and Chemical Properties of Soils at the Experimental Sites

Table 1 showed the results of the physical and chemical properties of the soil of the experimental sites. The physical properties of soil samples collected from 0 - 30 cm showed that the open field has a higher percentage of sand (850 g/kg) compared to the screen house (73 g/kg). Conversely, the screen house has a higher percentage of silt (10 g/kg) and clay (16 g/kg) compared to the open field (100 g/kg and 170 g/kg), respectively. The Chemical Properties revealed that the pH of the open field is slightly higher than the screen house for both H<sub>2</sub>O (7.39 vs 6.56) and CaCl<sub>2</sub> (6.93 vs 6.25) measurements. The electrical conductivity (EC) is higher in the screen house (0.10 dS/m) compared to the open field (0.04 dS/m). EC indicates the amount of salts dissolved in the soil. Organic Carbon (O.C) is significantly higher in the screen house (6.52 g/kg) compared to the open field (2.10 g/kg). This suggests a greater concentration of organic matter in the screen house soil. Total Nitrogen (Total N) follows a similar pattern to O.C, being higher in the screen house (2.10 g/kg) than the open field (0.665 g/kg). Nitrogen is a crucial nutrient for plant growth. Available Phosphorus (P) is also higher in the screen house (2.740 mg/kg) compared to the open field (5.663 mg/kg). The Exchange Acidity (E.A) was higher in the screen house (0.45 cmol/kg) compared to the open field (0.25 cmol/kg). Calcium (Ca) - higher in the screen house (4.46 cmol/kg) compared to the open field (3.35 cmol/kg). Magnesium (Mg) - higher in the screen house (2.28 cmol/kg) compared to the open field (1.08 cmol/kg). Potassium (K) - higher in the screen house (0.57 cmol/kg) compared to the open field (0.27 cmol/kg). Sodium (Na) - higher in the screen house (0.12 cmol/kg) compared to the open field (0.01 cmol/kg). The Cation Exchange Capacity (ECEC) is higher in the screen house (8.41 cmol/kg) compared to the open field (4.94 cmol/kg). ECEC is a measure of the soil's ability to hold exchangeable cations. The textural class is determined by the proportions of sand, silt, and clay. The open field is classified as loamy sand, while the screen house is classified as sandy loam. This aligns with the findings of Tuo et al. (2018) and 2023, who highlighted that open-field environments typically have coarser textures due to factors like wind and water erosion. This in turn causes variation in the physicochemical properties of the soils. The higher values of the chemical properties and the exchangeable bases of the soil obtained in the net house compared to the open field could be attributed to the higher organic matter content in the screen house soil, as earlier reported by Ghimire et al. (2020). This also aligns with research by Ghimire et al. (2020), who found that screen houses often have practices promoting organic matter accumulation, leading to improved nutrient availability. This therefore



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suggests better water holding capacity, nutrient retention, and overall soil fertility compared to the open field.

## Table 1: Physical and Chemical Properties of Soils (0-30cm) of the Experimental sites during the 2019 dry Season

Soil Properties	Open field	Screen house
Physical Composition (g kg <sup>-1</sup> )		
Sand	850	73
Silt	100	10
Clay	170	16
Textural Class	loamy sand	Sandy loam
Chemical properties		
pH (H <sub>2</sub> O)	7.39	6.56
pH (CaCl <sub>2</sub> )	6.93	6.25
EC (dS/m)	0.04	0.10
O.C (g/kg)	2.10	6.52
Total N (g/kg)	6.65	2.10
Available P (mg/kg)	5.663	2.740
Exchangeable bases [Cmol/kg]		
E.A	0.25	0.45
Ca	3.35	4.46
Mg	1.08	2.28
K	0.27	0.57
Na	0.01	0.12
ECEC (Cmol/kg)	4.94	8.41

Analysed at the Soil Science Laboratory, BUK.

### The Chemical Properties of Cow dung and Poultry droppings as priming agent

The Chemical Properties of Cow dung and Poultry droppings as priming agent was presented in Table 2. Result indicated that Poultry droppings have a significantly higher nitrogen content (6.00%) compared to cow dung (2.00%). Poultry droppings also boast a higher phosphorus content (328.38 mg/kg) compared to cow dung (182.6 mg/kg). Phosphorus is essential for root development, energy transfer, and seed production in plants. Interestingly, the potassium content is very similar between the two priming agents: poultry droppings (4102.19 mg/kg) and cow dung (3700.73 mg/kg). The higher nitrogen and phosphorus obtained in poultry droppings than cow dung indicates the role of N as a crucial element for plant growth, promoting healthy leaf development and overall biomass. Phosphorus is essential for root development, energy transfer, and seed production in plants. This aligns with research by Jiang *et al.* (2024) and Kitchen *et al.* (2022), who found poultry manure to be a rich source of readily available N and P. However, the K levels did not differ between PM and CD as priming agents, suggesting that potassium plays a vital role in plant functions like water regulation, photosynthesis, and disease resistance.

Sample properties	Priming Agents			
	Poultry droppings	Cow dung		
N (%)	6.00	2.00		
P (mg/kg)	328.38	182.6		
K (mg/kg)	4102.19	3700.73		

**Table 2: Chemical properties of the Priming Agent** 

Analysed at the Soil Science Laboratory, BUK



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Effects of Priming Agents, Variety, Duration and Concentration on Plant height, Leaf area index and Chlorophyll content Maize

The effects of seed priming, priming duration and priming concentration on plant height, leaf area index and chlorophyll content of maize varieties during the 2019 dry season at BUK are shown in Table 3. The results indicated that there was no significant difference (P > 0.05) among the different priming agents, varieties, priming duration and concentration on parameters in both the open field and the screen house condition.

Treatments		Open fie	ld	Screen house		
	Plant height (cm)	Leaf area index	Chlorophyll content (SPAD)	Plant Height (cm)	Leaf area index	Chlorophyll content (SPAD)
Priming Agent (PA)			· ·			<u> </u>
Poultry Droppings	173.57	1.61	25.76	108.52	1.19	31.21
Cow Dung	177.65	1.67	26.9	101.97	1.34	31.72
KCl	191.97	1.75	24.85	127.65	1.49	31.71
CaCl	186.45	2.01	26.21	114.45	1.44	31.62
Water	179.46	1.37	23.99	107.29	1.23	33.05
P of F	0.67	0.07	0.71	0.18	0.203	0.927
SE±	9.628	0.145	1.570	7.337	0.101	1.511
Variety (V)						
SAMMAZ 15	179.84	1.64	25.08	110.03	1.30	31.45
SAMMAZ 17	183.79	1.73	26.01	113.92	1.37	32.03
P of F	0.66	0.51	0.52	0.57	0.42	0.55
SE±	6.125	0.092	0.999	4.668	0.641	0.961
Priming duration (PD) (hrs)						
2	163.22	1.68	26.44	99.19	1.22	30.96
4	190.34	1.81	26.84	117.36	1.46	35.24
6	185.46	1.57	24.61	117.77	1.25	29.38
8	183.46	1.62	25.36	118.55	1.42	33.07
10	186.56	1.72	24.47	107.01	1.32	30.74
P of F	0.32	0.81	0.77	0.29	0.44	0.13
SE±	9.634	0.145	1.571	7.341	0.102	1.511
Concentration (C) (%)						
2	184.53	1.74	25.36	111.33	2.01	32.59
4	179.10	1.62	25.73	112.63	1.95	31.17
P of F	0.54	0.40	0.71	0.85	0.51	0.32
SE±	6.132	0.092	1.000	4.637	0.055	0.962
Interaction						
$PA \times V$	0.639	0.838	0.954	0.74	0.356	0.66
$PA \times PD$	0.398	0.247	0.741	0.412	0.339	0.421
V  imes PD	0.171	0.408	0.575	0.411	0.031	0.083
$PA \times C$	0.568	0.545	0.965	0.351	0.198	0.656
$\mathbf{V} \times \mathbf{C}$	0.237	0.018	0.141	0.551	0.015	0.922
$PD \times C$	0.519	0.331	0.653	0.61	0.296	0.716

# Table 3: Effect of seed priming on priming duration and concentration on Plant height, Leaf area index and chlorophyll content of maize varieties during the 2019 dry season at the open field and Screen house condition of BUK

Means followed by similar/no letters are not significantly different following Student Neuman Keuls' Test. ns = not significant at 5% LS, \* significant at 5% LS.

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However, there was a significant interaction between variety and priming duration and variety and priming concentration on LAI in the net house (Table 4 and 5). The priming of SAMMAZ 15 for 4 hrs significantly (P > 0.05) produced larger leaf index although statistically comparable with the rest of the interaction effects (Table 4), which may be due to the varietal response of the seeds to both priming and drought.

 Table 4: Interaction of variety and priming duration on leaf area index at 3 collar leaf stage

		Priming duration (hrs)				
Priming agent	2	4	6	8	10	
SAMMAZ 15	0.92c	1.72a	1.26abc	1.27abc	1.32abc	
SAMMAZ 17	1.55ab	1.21bc	1.24bc	1.24ab	1.32abc	
SE±			0.151			

Means followed by similar letters across row and column are not significantly different following Student Neuman Keul's test

On the other hand, the combination of SAMMAZ 17 with 2% concentration significantly (P > 0.05) produced larger leaf index which was at par with other interaction effects (Table 5), which may be due to varietal responses to drought and priming materials. SAMMAZ 17 seems to be more drought-tolerant as it showed similar characteristics under drought conditions, i.e., low canopy temperatures, high stomatal resistance, high chlorophyll contents, and a high percentage of leaf relative water content at both locations. Similar reports were presented by Yu *et al.* (2015). **Table 5: Interaction of variety and concentration on leaf area index at 3 collar leaf stage** 

**Concentration** (%)

Variety	2	4	
SAMMAZ 15	1.29b	1.47ab	
SAMMAZ 17	1.63a	1.11b	
SE±		0.111	

Means followed by similar letters across row and column are not significantly different following Student Neuman Keul's test.

## Effects of Priming Agents, Variety, Duration and Concentration on Relative water content, Canopy temperature and Leaf temperature of Maize

Table 6 presents the effects of seed priming, variety, priming duration and concentration on relative water content, canopy temperature and leaf temperature of maize during the 2019 dry season at open field and screen house condition of BUK. Results shows that relative water content, canopy temperature and leaf temperature were not significantly (P>0.05) influenced by priming agents, priming duration, concentration and varieties. Although not significant, mong the seed priming techniques, KCl seed priming increased plant water content, aiding young seedlings in absorbing more water and nutrients under drought stress, resulting in taller plants and enhanced water and nutrient uptake. This aligns with Soliman *et al.* (2023), who stated that plants from primed seeds had enhanced water and nutrient uptake, and as a result, they were taller. Similarly, the leaf temperature is linked to crop water stress, as plants with drought tolerance tend to transpire more, maintaining a cooler canopy temperature even under water stress. Seeds primed with CaCl have lower temperatures at both stages and locations. This is consistent with the findings of Urban *et al.* (2017) and Gräf *et al.* (2021) who reported decrease in leaf canopy temperature due reduced transpiration arising from stomatal closure. The RWC in both sites dropped when the priming



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period was extended to four hours. It was also noted that the RWC in both sites was significantly lower when concentration was raised from 2% to 4%. The antagonistic action of higher concentrations could be the cause of this. Decreasing leaf relative water content is an indication of a decrease turgor pressure in plant cells and causes growth to decrease. When increasing the priming agent's concentration from 2% to 4%, growth performances decreased in both maize varieties and both locations. Significant interaction between priming duration and concentration for cob yield, with 6 hours of priming duration at 2% concentration producing a higher yield, could be attributed to the changes in hormonal balance caused by seed priming, which improves seedling growth. These findings corroborate those of Ren *et al.* (2023) and Nie *et al.* (2022) in rice.

Treatment	- <b>I</b>	Open field		S	creen hous	e
—	RWC	СТ	LT	RWC	СТ	LT
Priming Agent (PA)						
Poultry Droppings	68.43	37.23	29.68	44.79	39.17	35.32
Cow Dung	65.43	37.08	30.82	40.17	40.58	36.24
KCl	73.83	34.62	27.63	58.56	37.81	35.84
CaCl	73.80	32.03	27.11	50.97	36.09	33.76
Water	71.56	38.61	29.07	40.59	37.29	34.46
P of F	0.88	0.31	0.529	0.39	1.630	0.71
SE±	6.668	2.329	1.641	7.514	2.151	1.365
Variety (V)						
SAMMAZ 15	70.36	36.09	28.93	44.70	37.89	34.80
SAMMAZ 17	70.86	35.73	28.82	49.33	38.53	35.45
P of F	0.94	0.87	0.943	0.51	0.67	0.61
SE±	4.242	1.482	1.044	4.780	1.037	0.868
Priming duration (PD) (hrs)						
2	60.83	41.06	31.95	33.85	41.03	36.91
4	76.29	35.15	30.27	55.38	36.35	33.23
6	72.11	31.81	26.24	49.72	36.87	34.11
8	74.83	37.63	28.21	50.45	37.60	35.57
10	69.01	33.91	27.72	45.53	39.20	35.72
P of F	0.52	0.01	0.16	0.350	0.28	0.391
SE±	6.67	2.330	1.642	7.581	1.632	1.366
Concentration (C) (%)						
2	74.44	34.01	27.86	51.48	37.06	34.11
4	66.79	37.82	29.81	42.56	39.35	36.15
P of F	0.221	0.090	0.193	0.211	0.14	0.121
SE±	4.247	1.483	1.045	4.781	1.038	0.869
Interaction						
$PA \times V$	0.876	0.551	0.648	0.661	0.039	0.052
$PA \times PD$	0.292	0.217	0.434	0.574	0.754	0.835
$V \times PD$	0.091	0.067	0.762	0.488	0.094	0.184
$PA \times C$	0.746	0.119	0.672	0.471	0.140	0.425
$V \times C$	0.713	0.651	0.918	0.455	0.836	0.763
$PD \times C$	0.368	0.292	0.371	0.915	0.371	0.413

Table 6: Effect of seed priming on priming duration and concentration on Relative watercontent, Canopy temperature and Leaf temperature of maize varieties during the2019 dry season at the Open field and screen house condition of BUK

Means followed by similar letter are not significantly different following Student Neuman Keuls' Test at 5%. RWC=Relative water content; CT=Canopy temperature; LT=Leaf temperature.

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<u>ISSN (Print): 2651-6144; ISSN (Online): 2651-6365</u><u>Website:http://www.jasd.daee.atbu.edu.ng</u> Effects of Priming Agents, Variety, Duration and Concentration on number of kernels per cob, cob length, cob weight and cob yield of green maize

The effects of seed priming, variety, priming duration and concentration on number of kernels per cob, cob length, cob weight and cob yield of maize during the 2019 dry season at open field and screen house condition of BUK is shown in Table 7. Results indicated that variety, priming duration and concentration did not significantly (P<0.05) influenced the above yield characters in both open field and screen house condition. However, cob length, cob weight and cob yield were significantly (P < 0.05) influenced by priming agent in the open field condition while it was not significant in the screen house. Priming using KCl significantly resulted in higher cob length, cob weight and cob yield although at par with the rest of the priming agent. Unfortunately, the cob yield of the screen house was stolen by hood looms that broke into the net house at the point of weighing. Significant interaction was observed between priming agent and priming duration on cob yield (Table 8) results shows that application of CaCl for 6 hours significantly (P < 0.05) resulted in higher cob yield although at par with the rest of the interaction effects. The significant interaction observed between priming agents and priming duration on cob weight and cob where priming with CaCl for the duration of 6 hours out yielded other interaction combinations could be due to improvement in root length and seedling fresh weight by Osmo priming with CaCl compared with unprimed seeds. This is in agreement with the findings of Yadav et al. (2023). On the other hand, the significant interaction observed between varieties and priming duration on cob weight and yield, where soaking SAMMAZ 17 for 2 hours resulted in higher cob weight and yield, may be attributed to varietal differences in drought stress (Table 9). Similar findings were reported by Kakar et al. (2023) and Debta et al. (2023), where they separately documented a range of seed priming, and the duration of priming may extend from almost 8 h to 14 days based on plant species, osmotic solution, osmotic potential, and temperature. On the other hand, the interaction between priming agent and concentration was significant (Table 10). The application of CaCl<sub>2</sub> for 2 hours significantly (P < 0.05) increase cob yield although statistically similar to other interactions. Table 11 presents the interaction between priming duration and concentration on cob yield of maize where combination of 6 hours priming with 2% concentration resulted in higher cob yield although at par with the rest of the interaction effects. This could be linked to the ability of young seedlings to absorb more water and nutrients from the soil and ultimately lead to the production of quality and healthy cobs under drought stress. Similarly, the combination of CaCl as a priming agent and a concentration of 2% significantly resulted in a higher cob yield. This also validates the earlier findings on the role of CaCl as a growth enhancer at lower rates.

Priming agents like KCl significantly impact cob length, weight, and yield due to K supplements' regulatory functions in plant growth, osmotic adjustment, and drought withstand ability. K increases cell membrane stability and decreases leaf water potential in maize, as earlier reported by Ali *et al.* (2021) and Zrig *et al.* (2023). Similarly, Lechowska *et al.* (2019) found that osmo priming, hardening, and matric priming improved Brassica napus performance by increasing germination, seed pod number, and seed weight, leading to improved yield and dry matter. The variation in yield attributes between screen house and field could be attributed to the differences in weather, soil types, and the amount of water in the root zones, which ensured higher transpiration, leading to the absorption of more nutrients from the soil, and the translocation of photosynthates within the plant systems, which significantly resulted in higher yield. Although the maize water requirement is highest in the reproductive stage, water shortage during the vegetative growth can also significantly reduce grain yield (Mi *et al.*, 2018). Stress during the maize vegetative growth period leads to a significant reduction in plant height and leaf area (determinants of radiation interception and biomass accumulation), which

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<u>ISSN (Print): 2651-6144; ISSN (Online): 2651-6365</u> <u>Website:http://www.jasd.daee.atbu.edu.ng</u> indirectly affect the growth rate at flowering and the seed number (Dodig *et al.*, 2021). However all priming techniques mitigated the effects of drought and improved the surface

However, all priming techniques mitigated the effects of drought and improved the surface crop performance under stressful and well-watered conditions, compared with control seed. In general, priming with inorganic materials proved more effective than organic materials and the control, but it depends on variety, duration, and also the concentration of the priming agent. Moreover, plants emerging from primed seeds exhibit faster activation of cellular defence systems, which trigger tolerance against subsequent exposure to environmental stresses in the field.

Onen field				Screen house			
Treatment _	Number	Coh	Coh	Cob vield	Number of	Cob	Coh
11 catiliciti	of kernels	length	weight	$(k\sigma ha^{-1})$	kernels cob	length	weight
	cob <sup>-1</sup>	(cm)	(g)	(Kg na )	1	(cm)	(g)
Priming Agent	(PA)	(em)	(8)			(011)	(8/
	220.25	17.00.1	112 10	1004.52	157.04	14.22	16 29
Poultry	338.35	17.98ab	112.19c	1994.52c	157.94	14.33	46.38
Droppings Com Dung	261 51	17.00ab	117 79ha	2002 84ha	156.06	12.00	46.01
Cow Dung	301.34	17.9980	117.78DC	2095.84DC	150.00	15.09	40.21
KCI G. Cl	382.37	19.63a	147.79a	2617.17a	197.44	15.25	48.69
CaCl	385.30	16.546	141.22ab	2510.15ab	206.92	14.57	51.29
Water	357.46	17.77b	125.79abc	2230.04abc	168.84	12.91	44.45
P of F	0.73	0.036	0.03	4.91	0.59	0.01	0.63
SE±	27.237	0.589	8.305	147.63	27.759	0.666	3.320
Variety (V)							
SAMMAZ 15	366.96	17.87	125.26	2226.88	163.53	14.13	47.40
SAMMAZ 17	363.05	18.09	132.37	2353.39	191.35	13.93	47.44
P of F	0.88	0.69	0.358	0.36	0.29	0.29	0.99
SE±	17.327	0.374	5.281	93.924	17.659	0.424	2.112
Priming duration	on (PD) (hrs	<u>s)</u>					
2	347.34	18.24	123.86	2202.01	172.76	13.22	45.67
4	378.04	18.87	129.86	2353.39	165.36	14.07	49.41
6	371.02	17.18	141.97	2523.86	204.81	14.35	49.01
8	364.67	17.42	117.39	2086.89	154.97	14.41	45.67
10	363.95	18.15	131.14	2331.36	189.29	14.10	47.35
PofF	0.95	0.3	0.358	0.36	0.75	0.72	0.88
SE±	27.253	0.589	8.301	147.727	27.775	0.667	3.321
Concentration	_ / / /						
(C)(%)							
2	375.47	17.98	133.04	2365.07	190.18	13.99	48.59
4	354.5	17.98	124.61	2215.20	170.75	14.08	46.26
P of F	0.41	0.99	0.28	0.28	0.32	0.88	0.45
SE±	17.348	0.375	5.281	94.035	17.68	0.424	2.115
Interaction							
$\mathbf{PA} \times \mathbf{V}$	0.639	0.216	0.066	0.066	0.626	0.819	0.947
$PA \times PD$	0.225	0.117	0.037	0.038	0.917	0.419	0.745
$PA \times C$	0.383	0.073	0.029	0.029	0.253	0.601	0.397
$V \times PD$	0.743	0.478	0.024	0.024	0.304	0.631	0.614
$V \times C$	0.386	0.663	0.287	0.287	0.492	0.869	0.291
PD x C	0.466	0.605	0.043	0.043	0.778	0.441	0.696

### Table 7: Effect of seed priming on priming duration and concentration on kernel number per cob, Cob length, Cob weight and Cob yield of Green maize varieties during the 2019 dry season at the Open field and Screen house condition of BUK

Means followed by similar letter(s) are not significantly different following Student Neuman Keuls' Test at 5%.

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<u>ISSN (Print): 2651-6144; ISSN (Online): 2651-6365</u><u>Website:http://www.jasd.daee.atbu.edu.ng</u> Table 8: Interaction of Priming agent and Priming duration on cob yield of green maize during 2019 Dry season at the open field condition of BUK

uui iiig 201	213 season	ut the open i	iera comarcion			
		Priming duration (hour)				
Priming agent	2	4	6	8	10	
Poultry droppings	2293.45cde	2001.67cde	2339.37b-е	1799.87de	1538.21e	
Cow dung	1475.66e	2768.18a-d	2595.73bcd	1915.08de	1724.56de	
KCl	2918.22abc	2310.11cde	2225.00cde	2315.24cde	3317.29ab	
CaCl	2000.77cde	2290.04cde	3629.07a	1996.33cde	2634.55a-d	
Water	2331.93cde	2162.81cde	1830.11de	2407.89b-e	2442.19b-e	
SE±			339.636			

Means followed by similar letters are not significantly different following Student Neuman Keul's test.

## Table 9: Interaction of Varieties and Priming duration on Cob yield of green maizeduring the 2019 Dry season at the open field condition of BUK

		P	riming duration	(hr.)	
<u>Variety</u>	2	4	6	8	10
SAMMAZ 15	1657.87c	2522.37ab	2597.01ab	1956.65bc	2400.49ab
SAMMAZ 17	2746.14a	2090.79abc	2450.71ab	2217.11abc	2262.23abc
SE±			220.078		

Means followed by similar letters are not significantly different following Student Neuman Keul's test

## Table 10: Interaction of Priming agent and Priming concentration on cob yield of greenmaize during the 2019 Dry season at the open field condition of BUK

	<b>Concentration (%)</b>			
Priming agent	2	4		
Poultry droppings	1761.80d	227.23bcd		
Cow dung	2325.21cd	1862.39cd		
KCl	2453.58a-d	2780.76ab		
CaCl	3061.33a	1958.98cd		
Water	2223.34bcd	2246.66bcd		
SE±	220.788			

Means followed by similar letters across rows and column are not significantly different following Student Neuman Keul's test

## Table 11: Interaction of Priming duration and Priming concentration on Cob yield of maize varieties during the 2019 Dry season at the open field condition of BUK

	Concentration (%)				
Priming duration (Hrs)	2 4				
2	1971.23bc	2432.78ab			
4	2164.21bc	2448.94ab			
6	2872.65a	2175.07abc			
8	2512.54ab	1661.23c			
10	2304.72abc	2358ab			
SE±	220.259				

Means followed by similar letters across rows and column re not significantly different following Student Neuman Keul's test

## CONCLUSION AND RECOMMENDATIONS

Green maize productivity is known to be substantially hampered by drought. The key finding from this study is that seed priming, regardless of the priming agent, duration, or concentration used, did not generally have a significant impact on most measured parameters in either open field or screen house environments. However, the positive impact of 2% KCl priming on cob yield in the open field suggests it might be a beneficial strategy for mitigating the adverse effects of drought. In general, on-farm seed priming of maize seeds with KCL can

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<u>ISSN (Print): 2651-6144; ISSN (Online): 2651-6365</u> <u>Website:http://www.jasd.daee.atbu.edu.ng</u> enhance the growth and yield characteristics of the plant while assisting the seedling to withstand drought at the lowest feasible cost.

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