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`EFFECT OF SOWING DEPTH AND SOWING WINDOW ON THE GROWTH AND YIELD PERFORMANCE OF MAIZE (*Zea mays* L.) IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Field trials were conducted during the 2023 raining season at the Teaching and Research Farm of the faculty of Agriculture, Bayero University, Kano and Agricultural Education Department Research Farm at Federal College of Education (Tech) Bichi, Kano State. The study was aimed to determine the effect of sowing depth and sowing window on the performance of maize. The experiment consisted of four planting depth (2cm, 4cm,6cm and 8cm) and three sowing windows (Early July, Mid-July and Late July) which were factorially combined and laid out in a Randomised Complete Block Design (RCBD) and replicated three times. The result generated from the experiment was subjected to analysis of variance (ANOVA) using Genstat 17th Edition. Treatment means were separated using Student-Newman Keuls Test (SNK). The result of the study showed significant ($P<0.05$) effect of sowing depth and sowing window on plant height, LAI, days to 50% silking, biomass weight and grain yield at both locations. Sowing depth showed a non-significant effect on days to 95% emergence at both locations. Sowing window showed a significant effect on days to 95% emergence at both locations, while a non-significant effect on days to 50% emergence was recorded at Bichi only. There was a significant interaction between sowing depth and sowing window on plant height, 50% silking, biomass weight and grain yield. 6cm sowing depth showed the highest grain yield (2477 $kgha^{-1}$ and 2260 $kgha^{-1}$) at BUK and Bichi respectively. Early July showed the highest grain yield (2840 $kgha^{-1}$ and 2599 $kgha^{-1}$). Sowing at 6cm depth at early July produced the tallest plant, highest biomass weight and highest grain yield per hectare (3218 $kgha^{-1}$ and 2912 $kgha^{-1}$) at both BUK and Bichi. The deepest sowing depth of 8cm showed poor performance in the parameters considered. Sowing too deep at 8cm and too shallow at 2cm depth are unfavourable for the growth performance of maize seedlings. Furthermore, sowing at late July or when the temperature is very low is unfavourable for the growth and yield performance of maize seedlings. It is recommended among others, that sowing at 6cm depth at early sowing window (early July) gives the best optimum plant growth and yield.

Keywords: Sowing depth, Sowing window, Growth and Yield Performance, Maize

INTRODUCTION

Maize (*Zea-mays* L.) also known as corn is believed to be the third most important grain crop in the world after rice and wheat (Ding *et al*., 2016) unlike many cereal grains such as Barely, wheat and Rice that evolved and were selected as food crop in the old world. Maize stands as one of the most extensively cultivated and consumed cereal crops globally, currently, more than 170 countries collectively produce a staggering 1.6 billion tons from an agricultural expanse spanning 193.7 million hectares, achieving an average yield of 5.75 tons per hectare (FAO 2022). Africa produces 6.5% (92.8 million tons) and Nigeria being the second largest producer in Africa with about 12 million tons. Africa imports 28% of the required maize from countries outside the continent (PricewaterhouseCoopers Nigeria, 2021). Nigeria, one of the sub-Saharan African (SSA) countries is characterized by low-input agriculture. Many studies have proved that SSA is a region with very low yield and crop water productivity (Liu, 2009), being at the same time very high at risk to climate change impacts on agricultural production (Fader *et al*., 2010). Sowing depth among other factors remains the most important one even if there is no as such consideration about the sowing of maize due to having larger seed size when compared to other cereal crop which has not gotten such attention as other factors. Sowing the seeds too deeply can have an adverse effect on crop growth, which in turn can cause a decrease in yield (Aikins *et al*., 2006). A large number of farmers sow their maize seed at a random depth which are non-responsive to improved agronomic management practices (Ajeigbe *et al.,* 2018). In line with this, by evaluating the performance of sowing depth, farmers would be able to choose and adopt the use of the recommended sowing depth.

Climate variability and change causes irregularity of rainfall, affecting the availability of groundwater, and decreases crop production. Sowing window plays a key role in the management aspects (cultivar selection, plant density, amount and timing of fertilizers etc.) of growing a maize crop and is probably subject to variation due to differences in weather at planting time between seasons and within the range of climates. The sowing window for crop are usually adjusted in response to the effects of global warming. The timing of sowing plays a significant role in the growth and development of crops, influencing several agronomic traits such as yield and quality characteristics (Islam and Garcia, 2012). The objective of this study is to determine the best sowing depth and sowing window for the growth and yield of maize.

MATERIALS AND METHODS

Experimental Sites

The field experiment was carried out during 2023 wet season at two locations. The first location at Faculty of Agriculture Teaching and Research Farm, Bayero University, Kano

(11º58'50"N 8º28'46" E). The second location located at Department of Agricultural Education Teaching and Research Farm at Federal College of Education (Tech) Bichi (12º14'03"N 8º14'28" E).

Treatments And Experimental Design

The experiment consisted of four sowing depths (2cm, 4cm, 6cm and 8cm), and three sowing windows (Early July, mid-July and late July). The treatments were laid out in a Randomised Complete Block Design (RCBD) and was replicated three times.

DATA COLLECTION

Data on non-destructive parameters were collected from five randomly tagged plants in two middle rows (net plot). The following growth and yield data were collected from the five tagged plants.

Days to 50% emergence

This was done by counting number of days from planting to when 50% of the plants have emerged.

Leaf area Index (LAI)

This was recorded by placing the LP-80 LAI Ceptometer above five sampled plant and average was recorded automatically.

Plant height (cm)

Plant height was measured at 3, 6 and 9 weeks after sowing (WAS) using meter rule from ground level to top level of the highest growing point of five sampled plants and the average was recorded in centimetre for all the plots.

Days to 50% silking

This was done by counting number of days from planting to when 50% of the plants have silked.

Days to physiological maturity

This was done by counting number of days from planting to when plants have matured physiologically.

Weight of biomass (kg)

The fresh stalk of the already sampled plants were dried and later weighed using a sensitive scale.

$$\text{Biomass weight} = \frac{Stalk\ weight\ of\ net\ plot\ (kg)}{Harvested\ area\ per\ net\ plot\ (sq.m)} \times 10000/ha$$

Grain yield hectare^{-1} (kgha^{-1})

This was determined by extrapolating the grain yield per net plot to kilogram per hectare using formula

Yield (kg/ha^{-1}) = Yield net-plot^{-1} (kg)/ Net plot area (m^2) x 10,000m^2/1

DATA ANALYSIS

Data obtained were subjected to analysis of variance (ANOVA) using Genstat Statistical package (17th Edition), and treatment means were separated using Student-Newman Keuls Test (SNK).

RESULTS

Days to 50% Emergence

Table 1 also presents the effect of sowing depth and sowing window on days to 50% emergence at both BUK and Bichi. Sowing depth had a highly significant effect on days to 50% emergence at both locations, where 8cm depth recorded the plant with the highest number of days to 50% emergence at BUK (10.56) and Bichi (11.56), while 2cm depth recorded plant with lowest days to 50% emergence (3.67) and (4.22) at BUK and Bichi respectively. Sowing window recorded a highly significant effect on days to 50% emergence at BUK. Sowing at early July recorded plant with the lowest number of days to 50% emergence (6.08), while late July recorded plant with the highest number of days to 50% emergence (7.16). Sowing window had no significant effect at Bichi. Furthermore, there was no interaction between sowing depth and sowing window on days to 50% emergence at BUK and Bichi.

Table 1: Effects of Sowing Depth and Sowing Window on Days to 50% emergence and Leave Area Index (cm^2) of Maize During 2023 Rainy Season at BUK and Bichi.

Treatment	Days to 50% emergence		Leaf Area Index 9WAS	
	BUK	Bichi	BUK	Bichi
Sowing Depth (SD)				
2cm	3.67a	4.22a	3.41b	2.99ab
4cm	5.22b	5.67b	3.46b	3.02ab
6cm	7.22c	7.22c	3.67a	3.13a
8cm	10.56d	11.56d	3.28c	2.73b
Probability Level	0.0001	0.0001	0.001	0.031
SE±	0.17	0.20	0.045	0.126
Sowing Window (SW)				
Early July	6.08a	7.0	3.90a	3.30a
Mid July	6.75b	7.0	3.57b	3.02b
Late July	7.16c	7.5	2.90c	2.58c
Probability Level	0.0002	0.0828	0.001	0.001
SE±	0.152	0.173	0.039	0.109
Interaction (SD x SW)	0.51	0.32	0.023	0.261

Means followed with the same letter within a treatment group are not significantly different at 5% probability level using Student Newman-Keuls (SNK).

Leaf Area Index

Table 1 shows the effect of sowing depth and sowing window on leaf area index of maize plant at BUK and Bichi during 2023 raining season. Sowing depth was observed to have a highly significant effect on leaf area index at BUK, while a significant effect was observed at Bichi. At BUK, 6cm depth recorded plant with highest LAI (3.67), although statistically at par with 4cm (3.46) and 2cm (3.41), while 8cm recorded plant with the lowest LAI (3.28). At Bichi, 6cm depth recorded plant with highest LAI (3.13), although statistically at par with 4cm (3.02) and 2cm (2.99), while 8cm recorded plant with the lowest LAI (2.78). Sowing window was observed to have a high significant effect on leaf area index at both BUK and Bichi. Sowing at Early July recorded plant with the highest LAI at BUK (3.90) and Bichi (3.30), and late July recorded plant with the lowest LAI (2.89) and (2.58) at both BUK and Bichi respectively. Furthermore, the interaction between sowing depth and sowing window on leaf area index was significant at BUK, while at Bichi, a non-significant interaction was recorded. Table 2 indicates the interaction of sowing depth across sowing window on leaf area index at 9WAS at BUK. The 6cm depth across Early July recorded plant with the highest LAI (4.15), followed by 4cm depth across Early July (3.94). The least performance was observed from 8cm across late July which recorded plant with the lowest LAI (2.61).

Table 2: Interaction between Sowing Depth and Sowing Window on Leaf Area Index of Maize During 2023 Rainy Season at BUK.

Treatment	Sowing Window		
	Early July	Mid July	Late July
Sowing Depth			
2cm	3.76b	3.49c	2.97d
4cm	3.94b	3.50c	2.94d
6cm	4.15a	3.80b	3.06d
8cm	3.75b	3.47c	2.61e
SE±		0.078	

Means within and across columns followed by the same letter are not significantly different using SNK at 5% level of probability.

Plant Height (cm)

Results in table 3 presents the effect of sowing depth on plant height at 9WAS which was highly significant at BUK and Bichi. Sowing depth of 6cm recorded the tallest plant at BUK (157.8) and Bichi (152.6), while 2cm recorded the shortest plant (125.4) and (129.9) at BUK and Bichi respectively. Sowing at Early July recorded the tallest plant at BUK (166.9) and Bichi (161.5), while sowing at late July recorded the shortest plant (121.1) and (115.8) at BUK and Bichi respectively. A high significant interaction was observed between sowing depth and sowing window on plant height at BUK and Bichi. Table 4 indicates the interaction of sowing depth and sowing window on plant height at BUK. Sowing at 6cm depth across Early July recorded the tallest plant (185.9), while the shortest plant (119.2) was recorded from 8cm depth across late July at BUK. Table 4 indicates the interaction of sowing depth across sowing window on plant height at 9WAS at Bichi. Sowing at 6cm depth across Early July recorded the tallest plant (180.4), while the shortest plant was recorded from 2cm and 8cm depth across late July.

Days to 50% silking

Table 3 presents the effect sowing depth and sowing window on days to 50% silking of maize plant at BUK and Bichi, It was observed that sowing depth had a high significant effect on days to 50% silking, where 6cm sowing depth recorded the lowest days to 50% silking at BUK (54.5) and Bichi (58.00), 2cm and 8cm were statistically similar which recorded the highest days to 50% silking (58.0) and (60.30) at BUK and Bichi respectively. Sowing window had a high significant effect on days to 50% silking at BUK and Bichi. Sowing at Early July recorded the lowest days to 50% silking at BUK (51.0) and Bichi (54.33), while late July recorded the highest days to 50% silking (61.73) and (65.10) at BUK and Bichi respectively. Furthermore, a highly significant interaction was observed between sowing depth and sowing window on days to 50% silking at BUK and Bichi. Table 5 indicate the interaction of sowing depth across sowing window on days to 50% silking at BUK. Sowing at 6cm depth across Early July recorded plant with the lowest days to 50% silking (49.67), while the least performance was observed from 2cm and 8cm depth across late July which recorded plant with the highest days to 50% silking (63.00). Table 5 indicate the interaction of sowing depth across sowing window on days to 50% silking at Bichi. Sowing at 6cm depth across Early July recorded plant with the lowest days to 50% silking (50.65), while the least performance was observed from 2cm and 8cm depth across late July which recorded plant with the highest days to 50% silking (64.10).

Table 3: Effects of Sowing Depth and Sowing Window on days to 50% tasselling, days to 50% silking and days to 50% maturity

Treatment	Plant Height (cm)		Days to 50% silking		Days to 95% maturity	
	BUK	Bichi	BUK	Bichi	BUK	Bichi
Sowing Depth (SD)						
2cm	135.4d	129.9d	58.00a	60.30a	79.00a	79.20a
4cm	150.4b	144.9b	55.70b	59.20b	80.33a	82.00a
6cm	157.8a	152.6a	54.50c	58.00c	82.33a	83.70a
8cm	135.8c	133.6c	58.08a	60.30a	78.67a	80.70a
Probability Level	0.001	0.001	0.001	0.001	0.212	0.241
SE±	0.97	0.94	0.169	0.192	4.236	5.501
Sowing Window (SW)						
Early July	166.9a	161.5a	51.03c	54.33c	89.00a	90.0a
Mid July	148.9b	143.3b	57.05b	59.30b	78.80b	80.0b
Late July	121.1c	115.8c	61.73a	65.10a	73..25c	69.4c
Probability Level	0.001	0.001	0.001	0.001	0.001	0.001
SE±	0.844	0.814	0.146	0.160	3.425	4.76
Interaction (SD x SW)	0.001	0.001	0.001	0.001	0.346	0.411

of Maize During 2023 Rainy Season at BUK and Bichi.

Means within and across columns followed by the same letter are not significantly different using SNK at 5% level of probability

Table 4: Interaction between Sowing Depth and Sowing Window on Plant Height (cm) of Maize During 2023 Rainy Season at BUK and Bichi.

Treatment	Sowing Window		
	Early July	Mid July	Late July
Sowing Depth		BUK	
2cm	148.9f	137.4g	119.9h
4cm	172.1b	156.1e	123.1h
6cm	185.9a	165.5c	122.2h
8cm	160.7d	136.7g	119.2h
SE±		1.68	
		Bichi	
2cm	143.5f	131.8g	114.4h
4cm	166.7b	150.3e	171.7h
6cm	180.4a	160.5c	116.9h
8cm	155.4d	131.0g	114.4h
SE±		1.62	

Means within and across columns followed by the same letter are not significantly different using SNK at 5% level of probability.

Table 5: Interaction between Sowing Depth and Sowing Window on days to 50% silking of Maize During 2023 Rainy Season at BUK and Bichi.

Treatment	Sowing Window		
	Early July	Mid July	Late July
Sowing Depth		BUK	
2cm	52.00g	59.00d	63.00a
4cm	50.33h	56.00e	61.00b
6cm	49.67i	54.00f	60.00c
8cm	52.00g	59.00d	63.00a
SE±		0.29	
		Bichi	
2cm	54.33g	61.00d	64.00a
4cm	52.00h	58.82e	62.50b
6cm	50.65i	56.10f	61.00c
8cm	54.50g	61.10d	64.10a
SE±		0.31	

Means within and across columns followed by the same letter are not significantly different using SNK at 5% level of probability.

Days to 50% maturity

Table 3 presents the effect of sowing depth and sowing window on days to 50% maturity at BUK and Bichi. Sowing depth has no significant difference on days to 50% maturity at both locations. Sowing window had no significant effect at BUK, but had a high significant effect at Bichi. Early July recorded plant with the highest days to maturity (90.0) and late July recorded plant with the lowest days to maturity (69.4). However, it was observed that sowing depth and sowing window had a non-significant interaction on days to 50% maturity at both locations.

Biomass (kgha^{-1})

The effect of sowing depth on dry biomass on maize plant at BUK and Bichi during the 2023 raining season was presented in table 6. The result showed that sowing depth had a high significant effect on dry biomass. Sowing at 6cm depth recorded plant with the highest biomass at BUK (2176.6) and Bichi (2022.2), whereas sowing at 8cm depth recorded the lowest biomass (1084.4) and (1049.9) at BUK and Bichi respectively. It was observed that sowing window had a high significant effect on dry biomass at both locations. Early July

recorded plant with the highest biomass at BUK (3027.7) and Bichi (2058.8), while late July recorded plant with the lowest dry biomass (1119.9) and (1010.1) at BUK and Bichi respectively. However, a highly significant interaction was observed between sowing depth and sowing window on dry biomass at BUK and Bichi. Table 7 indicate the interaction of sowing depth across sowing window on biomass at BUK. Sowing at 6cm depth across Early July recorded plant with the highest biomass (2325.0), while the least performance was observed from 8cm depth across late July which recorded plant with the lowest biomass (1007.0). Table 7 indicate the interaction of sowing depth across sowing window on dry biomass at Bichi. Sowing at 6cm depth across Early July recorded plant with the highest biomass (2405.7), while the least performance was observed from 8cm depth across late July which recorded plant with the lowest biomass (900.7).

Table 6: Effects of Sowing Depth and Sowing Window on Biomass and Grain yield ($kgha^{-1}$) of Maize During 2023 Rainy Season at BUK and Bichi.

Treatment	Biomass ($kgha^{-1}$)		Grain Yield ($kgha^{-1}$)	
	BUK	Bichi	BUK	Bichi
Sowing Depth (SD)				
2cm	191.1c	152.2c	1762c	1580c
4cm	233.3b	185.5b	2123b	1890b
6cm	276.6a	222.2a	2477a	2260a
8cm	184.4d	149.9d	1717c	1516d
Probability Level	0.001	0.001	0.001	0.001
SE±	0.00089	0.00084	25.6	13.6
Sowing Window (SW)				
Early July	327.7a	258.8a	2840.a	2599a
Mid July	217.7b	172.2b	2155.b	1959b
Late July	119.9c	100.1c	1339.c	1201c
Probability Level	0.001	0.001	0.001	0.001
SE±	0.00077	0.00073	22.2	11.8
Interaction				
(SD x SW)	0.001	0.001	0.036	0.001

Means followed by unlike letter(s) within a treatment group are significantly different at 5% probability level using Student Newman-Keuls (SNK)

Table 7: Interaction between Sowing Depth and Sowing Window on biomass ($kgha^{-1}$) of Maize During 2023 Rainy Season at BUK and Bichi.

Treatment	Sowing Window		
	Early July	Mid July	Late July
Sowing Depth		BUK	
2cm	1775.7c	1085.3f	1014.0j
4cm	2192.4b	2135.0e	1121.3i
6cm	2325.0a	2171.3d	1134.3h
8cm	1708.3d	1078.3g	1007.0k
SE±		0.0015	
		Bichi	
2cm	1639.7c	1053.3f	904.7i
4cm	2172.7b	1880.3e	1102.3h
6cm	2405.7a	2006.3c	1115.3g
8cm	1606.3d	1051.3f	900.7j
SE±		0.0014	

Means within and across columns followed by the same letter are not significantly different using SNK at 5% level of probability.

Grain Yield (kgha^{-1})

The effect of sowing depth on grain yield (kgha^{-1}) of maize at BUK and Bichi during 2023 raining season is presented in Table 6. The results showed that sowing depth had a high significant effect on grain yield at both locations. The highest grain yield (2477 kgha^{-1}) was observed at 6cm sowing depth at BUK, whereas, the lowest grain yield (1717 kgha^{-1}) was recorded from plant at 8cm sowing depth which was statistically similar with 2cm (1762 kgha^{-1}). Similarly, At Bichi, highest grain yield (2260 kgha^{-1}) was recorded from 6cm sowing depth, whereas the lowest grain yield (1516 kgha^{-1}) was recorded from 8cm sowing depth. However, a high significant effect of sowing window on grain yield was observed at both locations. Early July recorded plant with the highest grain yield at BUK (2840 kgha^{-1}) and Bichi (2599 kgha^{-1}), the lowest grain yield (1339 kgha^{-1}) and (1201 kgha^{-1}) was recorded from late July at BUK and Bichi, respectively. Furthermore, there was a high significant interaction between sowing depth and sowing window on grain yield at both locations. Table 8 indicate the interaction of sowing depth across sowing window on grain yield (kgha^{-1}) at BUK. Sowing at 6cm depth across Early July recorded plant with the highest grain yield (3218), followed by 4cm depth across Early July (2945). The least performance was observed from 8cm depth across late July which recorded plant with the lowest grain yield (1029). Table 8 indicate the interaction of sowing depth across sowing window on grain yield per (kgha^{-1}) at Bichi. Sowing at 6cm depth across Early July recorded plant with the highest grain yield (2912), followed by 4cm depth across Early July (2708). The least performance was observed from 8cm depth across late July which recorded plant with the lowest grain yield (1052).

Table 8: Interaction between Sowing Depth and Sowing Window on Grain yield (kgha^{-1}) of Maize During 2023 Rainy Season at BUK and Bichi.

Treatment	Sowing Window		
	Early July	Mid July	Late July
Sowing Depth		BUK	
2cm	2549c	1747f	1091j
4cm	2945b	2050e	1526i
6cm	3218a	2444d	1659h
8cm	2596c	1626g	1029j
SE±		44.4	
		Bichi	
2cm	2432c	1822g	1087k
4cm	2708b	2065f	1496j
6cm	2912a	2201e	1556i
8cm	2344d	1751h	1052k
SE±		16.7	

Means within and across columns followed by the same letter are not significantly different using SNK at 5% level of probability.

DISCUSSION

The highest significant response exhibited by plant sown at 8cm depth could be due to the fact that during emergence, the time of seedling increases with increase in depth of sowing. This finding is in line with the result of Molatud *et al* (2009) who observed that, the shoot apex of newly germinated seeds may not able to push up the soil to come out into the surface when sown at higher depth and the water applied may not acquire wet the soil that can also cause variation in emergence. Sowing at 6cm across early July exhibited significantly taller plants at both locations across the sampling period could be attributed suitable soil moisture, temperature and less competition from weeds and other associated plants. Similar observation was reported by Danaie (2007) and Beiragi *et al*. (2011) who reported that longer growing period with favourable weather conditions and better access to soil moisture resulted in increasing plant height in maize. Sowing depth and sowing window showed highly significance difference at 50% silking at both location, this could be due to nutrient and water availability at the stages. This is in line with the study of Shrestha (2013) who reported that nitrogen is considered as one of the most important factors affecting flowering (days to tasselling and silking), maturity and grain yield performance of maize.

Furthermore, the increase in biomass weight and grain yield observed at 6cm depth and early sowing window could be attributed to the increase in nutrient rate, adequate moisture and other weather conditions. This statement is in line with the findings of Kumar *et al*. (2011) and Tsimba *et al*., (2013) stating that the growing season of maize with different sowing window exposed to varied climatic factors such as

temperature, precipitation, and radiation, ultimately affect the formation of maize yield.

CONCLUSION

Maize seedlings performances are greatly affected by different sowing depth as well as sowing window. Sowing too deep at 8cm above and too shallow at 2cm depth are unfavourable for the growth performance of maize seedlings. On the other hand, sowing too late at late July or when the temperature is very low is unfavourable for the growth and yield performance of maize seedlings. Sowing depth at 6cm at Early July showed increase in leaf area, number of leaves, plant height that can significantly increase cob length, cob weight and grain yield $kgha^{-1}$.

RECOMMENDATION

Based on the findings of this study, sowing at 6cm depth and early sowing window (Early July) can be used to increase growth and yield. Further research should be carried out over subsequent years and location to validate the treatment results and identify the most productive sowing window for achieving high maize growth and yield due to climate variability or change.

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