PRODUCTIVITY OF MAIZE (*ZEA MAYS* L.) VARIETIES AS INFLUENCED BY FERTILIZATION AND IRRIGATION METHODS IN KADAWA, SUDAN SAVANNA, NIGERIA

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ABSTRACT

Field trials were conducted during 2023 and 2024 dry seasons at the experimental farm of Institute for Agricultural Research, Ahmadu Bello University, located at Kadawa 11°38'44" N and Longitude 8°26'52" E in Sudan savanna of Nigeria, Kano State. The treatments evaluated consisted of three maize varieties [SAMMAZ 51, SAMMAZ 52 and SAMMAZ 65]; three fertilization rates [120-60-60 NPK ha^{-1}; 5 tons Poultry Manure (PM) and 60-30-30 NPK + 2.5ton ha^{-1} PM] and three irrigation methods [Furrow, Basin and Border]. The treatments were laid out in a split-split plot design with fertilization and irrigation methods allocated to the main plot, while maize varieties assigned to sub-sub plot and replicated three times. Data were measured on plant height, ear height, number of days to 50% tasseling and grain yield (kg ha^{-1}). All the required agronomic practices were duly observed. The data collected were statistically analyzed and the means were separated using Duncan's Multiple Range Test (DMRT) at 5% probability. The results showed that SAMMAZ 51 significantly ($p< 0.05$) recorded taller plants and ear heights as well as grain yield in all the years than the other two varieties. Combine application of NPK 60-30-30 + 2.5 tons PM recorded higher growth parameters and maize grain yield except days to 50% tasseling in which 5 tons PM significantly ($p< 0.05$) took longer days to attain 50% tasseling. Effect of irrigation method showed that, furrow method recorded taller plants and ear heights as well as grain yield than the other two irrigation methods. Basin irrigation method recorded significantly ($p< 0.05$) higher days to 50% tasseling than furrow and border methods. It could therefore be concluded that for an improved yield of maize in the study area, farmers are encouraged to plant SAMMAZ 51, combine application of NPK 63-30-30 + 2.5 tons PM using furrow irrigation method.

Keywords: Maize (*Zea mays* L.) varieties, fertilization, irrigation methods, Kadawa and Sudan savanna

Introduction

Maize (*Zea mays* L.), is one of the three most important cereal crops in the world after rice and wheat. It is the most popular because of its high yield, ease of processing, easy digestion, and had lower production cost than other grain crops (Law-Ogbomo and Law-Ogbomo, 2009). A staple crop in sub-Saharan Africa and Nigeria in particular, because of its high yield potential, growing role in human diet, use in animal feed, and agro-allied industries. Globally, maize output in the year 2018-2019 was estimated by FAOSTAT (2020) at grain yield of 1124 million metric tons produced on an area of about 190 m ha. United States is the leading producer and exporter of Maize in the world.

The crop is incorporated into several maize-based cropping systems in Nigeria. According to Cancellier *et al*. (2011), maize is one of the crops of agronomic relevance that exhibits nutrition dependence, particularly on nitrogen. Traditional habitats for millet and sorghum in drier regions, maize has almost taken over because of the inherent qualities of the crop (Muhammad *et al*., 2024). Researchers were able to accomplish this by creating early and extra-early varieties that can give substantial yields even in marginal areas such as Sahel savanna areas. Improved agronomic methods, such as using improved varieties, applying fertilizer at optimal rates and plant densities, controlling weeds, and insect pests and diseases, have been found to positively affect crop growth and yield (Ahmad *et al*., 2024). Organic matter plays a significant role in crop production and promotion of good soil health. This is done through improvement in soil physical structure, chemical and biological functions in the soil. Soil organic matter has been found to provide essential soil nutrients, improves soil structures, enhance soli water holding capacity as well as promoting good microbial activities. These practices combine with inorganic fertilizers provides conducive environment for growth and development of crops leading to higher yield envisage by any farmer wishing to succeed in crop production. According to Berge *et al*. (2019), maize is a nutrient-hungry crop that requires a lot of nutrients, particularly nitrogen, for growth and yield development. The ideal fertilizer recommendations for open pollinated maize types are 120 kg N, 60 kg P_2O_5, and 60 kg K_2O hectare^{-1}, whereas hybrids in the northern Guinea savanna require 150 kg N, 60 kg P_2O_5, and 60 kg K_2O hectare^{-1} (Chude *et al*., 2011). The use of mineral fertilizer is the fastest and most dependable technique of enhancing crop output nevertheless, their intrinsic costs and other constraints limit farmers from adopting application of recommended levels (Adesoji *et al*., 2018).

Crops production potential depends on the crop, its genetic composition, and its surroundings, according to Asghar *et al*. (2010). Low grain yield, *striga* parasitism, drought, and low soil fertility particularly N are some of the factors that may limit maize production in Africa (Badu-Apraku *et al*., 2013). A favorable climate combined with a variety's strong genetic makeup could results in a higher crop yield advantage. Inorganic fertilizers, organic manures, and poultry manures are highly advised for the highest crop output (Mani *et al*., 2024; Muhammad *et al*., 2024; Muhammad *et al*., 2019). Chronic drought and low N levels significantly limit maize production in the savanna of West and Central Africa (WCA) resulting in a 15% loss, according to Badu-Apraku *et al*. (2013) and Badu-Apraku *et al*. (2009).

Irrigation methods are artificial ways of providing water to plants especially in areas where rainfall is insufficient or unreliable. These can be achieved through surface (flooding, furrow, basin and border), Sub-surface, drip and sprinkler irrigation methods. Furrow irrigation involves application of water in channels or furrows between rows of crops. Border on the other hand entails application of water in strips of land with levees and basin involves damming water within the basin to irrigate crops. In contrast to border irrigation, which can be used on a sloping land up to 2% on sandy soils and 5% on clay soils, furrow irrigation is practical for flat land and slightly sloping terrain. Scientists have been developing and releasing new maize varieties on a continued basis. These varieties are improved with tolerant to pests and diseases, striga, drought and other stresses that may reduce crop productivity. Evaluating these varieties for adoption to different soil and climatic conditions becomes relevant in developing and releasing new maize varieties. In this study, it is crucial to evaluate the most suitable irrigation method and fertilization practices for raising maize productivity and production in Nigeria's savanna agro-ecologies.

Materials and Methods

During the 2023 and 2024 rainy seasons, field trials were carried out at Institute for Agricultural Research, Ahmadu Bello University's experimental farm, which is situated in Kadawa, Sudan savanna in Kano State, Latitude 11°38'44" N and Longitude 8°26'52" E. Rainfall in the region is monomodal and averages between 550 and 1000 mm annually. For crops that are rain fed, the growing season lasts 90 to 165 days, with the majority of rain falling between July and September. The wet season has high air humidity, while the dry season has very low air humidity. The months of November through February have the lowest temperatures, while March and April have the highest. The dry season has a high daily temperature variation, while the wet season has a low one (Garba *et al.*, 2022). Three intermediate maize varieties (SAMMAZ 51, SAMMAZ 52, and SAMMAZ 65) were evaluated together with three irrigation methods (Furrow, Basin, and Border) and three fertilization rates (120-60-60 NPK ha^{-1}, 5 tons Poultry Manure (PM), and 60-30-30 NPK + 2.5 tons ha^{-1} PM) in a split-split plot design. Treatments were set up using irrigation method and fertilization techniques in the main plot and maize varieties assigned to the sub plot, which were then replicated three times. The parameters assessed were plant height, ear height, days to 50% tasselling, and grain yield kg $ha^{-1.}$ All the required agronomic practices were observed. Statistical analysis of variance (ANOVA), as outlined by Gomez and Gomez (1984), was performed on the data gathered from the observations using SAS program version 9.0 (SAS Institute, 2002).

Results and Discussion

The effects of fertilization, irrigation methods and varieties on plant, ear heights and days to 50% tasseling are presented on Tables and 1and 2. Results obtained showed that SAMMAZ 51 significantly produced taller plants, ear heights and grain yield than SAMMAZ 52 and SAMMAZ 65, respectively that were statistically similar. Similar trend was observed with days to 50% tasseling.

There were notable differences in the effects of plant height, ear height, days to 50% tasseling, fertilization, and irrigation technique on the types of maize shown in Table 1. The grain yield of the SAMMAZ 51 variety was noticeably higher than that of the SAMMAZ 52 and SAMMAZ 65 varieties. With a potential yield of 8.5 t ha^{-1}, SAMMAZ 51 is particularly notable for its high grain yield, drought tolerance, and resistance to *Striga hermonthica*, a parasitic weed that can significantly ($p < 0.05$) reduce maize yields. SAMMAZ 51 is suitable for both Southern and Northern Guinea Savanna agroecological zones. Variations in growth indicators, such as plant height and ear height, where SAMMAZ 51 appeared superior over SAMMAZ 52 and 65, may be partially due to genetic variability and likely further enhanced by environmental factors like temperature and sunshine, which were optimal throughout the crop's growing periods (Ndagana *et al*., 2021). The research outcome is also consistent with research by Mani *et al*. (2017) and Garba *et al*. (2013), which found that the primary factor influencing plant heights was genetic makeup, with Faro 57 growing taller than Faro 44 and Faro 45, respectively. Their genetic composition may be the cause of this discrepancy. In a related study, Garba *et al*. (2013) observed that NERICA-1 rice was found to be taller than Ex-China due to an innate genetic variation. Ladan and Hassan, (2020), attributed considerable increase in plant height with more leaves for more dry matter has been reported to be governed by duration of growing season which is an integral aspect of the expression of many genes and the interaction between them (genes and environment). Significant differences in plaint height, leaf count, and total dry matter output were noted by Ladan and Hassan (2020) among different genotypes of maize varieties with respect to the length of the growing season.

Application of half dose of both poultry manure and NPK fertilizer resulted in significantly ($p < 0.05$) taller plants, ear height and grain yield but days to 50% tasseling were reduced significantly. According to Setiyono *et al*. (2010), the concentration of nitrogen, phosphorus, and potassium in the whole plant and grain is closely related to the grain yield of maize, and the higher levels of combined application of nutrient sources greatly increased the growth parameters, yield attributes, and ultimately the grain yield of maize in the current study. Optimizing maize productivity requires balanced nutrition. When NPK (60-30-30) + 2.5 tons of manure were applied together, the highest plant height, ear height, and grain yield production per hectare were achieved. This could be explained by the fact that NPK is one of the vital nutrients that support plants' meristematic development and other physiological processes. As a result, carbon dioxide is used, solar radiation is intercepted, and water and nutrients are absorbed efficiently. Higher photosynthetic activities are encouraged by these occurrences in order to produce enough photo-assimilates, which are then transferred to different sinks to build more dry matter ultimately (Jaliya *et al*., 2008; Mani *et al*., 2024). Among all animal manures, poultry manure is the most valuable source of nitrogen when treated appropriately (Adekiya and Oyejini, 2016). The use of poultry manure is more profitable than its non-usage and increases yield levels per unit of land. Research comparing soils of organically and chemically managed farming systems has found that increased soil organic matter and total N with the use of organic agriculture (Adekiya and Oyejini, 2016). Poultry manure and other organic materials are recognized as appropriate organic fertilizers. According to Mohamed *et al*. (2010), poultry manure is a significant source of soil nutrients since it has a higher percentage of nitrogen, phosphorous, potassium, and other nutrients that are easily absorbed by plants than other organic soil additions. According to Adesoji (2015), the incorporation of organic amendments, like poultry manure, improves the physical properties and conditions of the soil, as well as the uptake of nutrients and crop productivity. Despite poultry manure's vitality and relevance to crop production, some farmers limit their usage due to higher cost, odor, transportation, wetness, and possibly inaccessibility and bulkiness (Adesoji *et al*., 2018). Additionally, organic matter improves soil structure, which results in increased water holding capacity of the soil, it also enhances root growth into the more permeable soil. This will result in better plant health and allows more movement of mobile nutrients such as nitrates into the soil. Mani *et al*., 2024, they further reported that organic matter improve soil structure by decaying to humus molecules which help to cement particles of sand, silt and clay Invariably improving soil drainage, water holding capacity, soil moisture, provides nutrients and cation exchange capacity.

Furrow irrigation method outperformed the border and basin irrigation methods in terms of plant and ear heights as well as days to 50% tasseling and grain yield. With furrow method, irrigation of vast land is possible while providing time and labor saving. It is low investment required in buying equipment. The methods are cost effective as it minimizes water loss of gravity irrigation. The ability of the furrow method to more efficiently regulate water distribution and supply water directly to the plant roots is probably the cause of this. Furrow design and water management, however, are essential to optimizing these advantages. The most popular surface irrigation technique for supplying water to planted areas is furrow irrigation. In arid and semi-arid regions, this kind of irrigation is frequently utilized to provide water for crops. It requires a lower initial investment and requires no ongoing work to improve its efficiency and administration (Gelu 2018).

Conclusion

Based on the results obtained in this study, it can be concluded that good growth and yield of the maize could be improved by using SAMMAZ 51 variety, application of NPK 60-30-30 + 2.5 tons ha^{-1} poultry manure using furrow irrigation method in the study area.

Table 1: Effect of fertilization and irrigation methods on the performance of maize varieties at Kadawa during 2023 and 2024 cropping seasons

Treatment	Plant height (cm)		Ear Height (cm)		Days to 50% Tasseling	
	2023	2024	2023	2024	2023	2024
Maize Variety						
SAMMAZ 51	130.9a	140.5a	58.7a	60.2a	55.0a	56.0a
SAMMAZ 52	118.0b	119.4b	50.6c	51.5c	50.0c	52.0c
SAMMAZ 65	115.0b	117.4b	52.4b	53.9b	53.0b	54.0b
SE (±)	0.75	0.80	0.35	0.37	0.55	0.56
Fertilization						
NPK 120-60-60	112.0 c	120.3c	49.0c	50.0c	52.0b	53.0b
5ton Poultry Manure (PM)	120.0b	124.0b	53.0b	54.4b	56.0a	56.5a
NPK 60-30-30 + 2.5ton PM	131.0a	135.6a	58.0a	59.4a	50.0c	51.0c
SE (±)	0.72	0.76	0.33	0.34	.66	0.67
Irrigation Method						
Furrow	140.0a	145.6a	61.1a	62.0a	49.0c	50.0c
Basin	101.0c	109.2c	49.6c	51.0c	53.0b	53.5b
Border	121.0b	125.4b	51.0b	52.0b	56.0a	56.6a
SE (±)	0.72	0.76	0.33	0.34	0.66	0.67
Interaction						
V x F	NS	NS	NS	NS	NS	NS

Means followed by unlike letter(s) are significantly different at 5% level of probability using DMRT

Table 2 Effect of fertilization and irrigation methods on the performance of maize varieties at Kadawa during 2023 and 2024 cropping seasons

Treatment	**Grain Yield (kgha^{-1})**	
	2023	**2024**
Maize Variety		
SAMMAZ 51	2437a	2487a
SAMMAZ 52	1907c	1957c
SAMMAZ 65	2197b	2247b
SE (±)	6.12	6.17
Fertilization		
NPK 120-60-60	1684c	1737c
5ton PM	2157b	2207b
NPK 60-30-30 + 2. ton (PM)	2689a	2694a
SE (±)	6.80	6.95
Irrigation Method		
Furrow	2890a	2914a
Basin	1687c	1687c
Border	1968b	2054b
SE (±)	6.80	6.95
Interaction		
V x F	NS	NS

Means followed by unlike letter(s) are significantly different at 5% level of probability using DMRT

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