Agrogenesis Journal of Sustainable Agriculture and Innovation. 2025. 1(1); 64-76

AGROGENESIS
Journal of Sustainable Agriculture and Innovation
www.agrogenesis.umi.ac.id

Growth and Yield of Various Maize Varieties Grown at Different Planting Distances

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ARTICLE INFO

Keywords:
Growth
Maize
Planting Distance
Variety
Yield

Article History:
Received: February 03, 2025
Accepted: June 26, 2024

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ABSTRACT

This study aimed to evaluate the interaction effect between maize varieties and planting distances on the growth and yield of maize plants. Three maize varieties used were NK 7328, Bisi-18, and Pioneer 27, with two planting distance treatments: 70x20 cm and 75x25 cm. The study employed a Split-Plot Design and was conducted in Takalar Regency, South Sulawesi. The analysis results showed that variety had a significant effect on most growth and yield parameters, including plant height, number of leaves, male and female flowering time, cob length, cob diameter, and yield. The Pioneer 27 variety produced the highest yield (6.67 tons/ha), followed by NK 7328 and Bisi-18. Meanwhile, the planting distance of 70x20 cm resulted in higher yields compared to 75x25 cm. There was no significant interaction between variety and planting distance on yield, although certain varieties responded better to specific planting distances. The study concluded that a combination of superior varieties and optimal planting distances can significantly increase maize productivity. These results can serve as a reference for agronomic decision-making to improve maize production in tropical areas.

INTRODUCTION

Maize (*Zea mays* L.) is one of the primary food crops that plays a crucial role in food security and economic stability in Indonesia. Despite its vital importance, maize productivity in various regions remains below its maximum potential, largely due to suboptimal cultivation practices, including variety selection and planting distance. This research aims to evaluate the interaction between different maize varieties and their respective planting distances to optimize growth parameters and yield performance.

The selection of maize varieties is a critical factor determining the success of plant growth and yield. Various studies have shown that maize varieties respond differently to agronomic factors such as planting distance and nutrient availability. Research findings indicate that intercropping maize with legumes can increase maize yield by optimizing nutrient uptake and reducing light competition through effective planting distance management (Wangiyana et al., 2025). In addition, aligning specific maize hybrids with optimal plant populations is essential to maximize yield, indicating that variety selection and planting density are closely related to crop performance (Aleri et al., 2021). This highlights the variability in growth characteristics, which can significantly influence yield across different spacing configurations.

Planting distance is also an important agronomic factor affecting maize productivity. Research suggests that optimal spacing can reduce competition among plants for resources, thereby improving growth parameters such as plant height and ear length. Findings show that maize yield can be increased through strategic intercropping arrangements that consider spacing and interspecies interactions, ultimately enhancing nitrogen accumulation and overall plant productivity (Dong et al., 2022). Moreover, higher planting density has been shown to significantly increase maize yield by optimizing resource utilization, although it must be carefully managed to avoid yield reduction due to issues such as stem lodging (Shah et al., 2021).

Integrated studies exploring the combined effects of planting distance and variety remain limited. This research takes a comprehensive approach by evaluating several maize varieties under different spacing arrangements. Optimal nutrient management has been shown to contribute to yield improvements when aligned with appropriate cultivation practices (Du et al., 2021a). Furthermore, significant growth improvements

ISSN: 3090-2657
DOI: https://doi.org/10.33096/agrogenesis.v1i1.679

can also be achieved through the integration of rhizobacteria within various planting configurations, highlighting the benefits of tailored agronomic interventions (Ikhwan et al., 2023).

This study aims to identify and define the optimal planting distances for different maize varieties. It is expected that the results of this research will provide practical insights applicable to diverse agroecological contexts, ultimately contributing to increased maize productivity.

MATERIALS AND METHODS

This research was conducted from February to May 2024 in Bulukunyi Village, Polongbangkeng Selatan Subdistrict, Takalar Regency, South Sulawesi, Indonesia. The materials used in this study included hybrid maize seeds of the NK 7328 Sumo, Bisi 18, and Pioneer 27 varieties, as well as urea and NPK fertilizers. The tools used in this research were planting dibble, weighing scale, measuring tape, marker pens, plot markers, string, scissors, caliper, documentation equipment, and writing tools.

The study employed a Split-Plot Design consisting of main plots and subplots. The main plots were the maize varieties, which comprised three levels of treatment: V1 (NK 7328 Sumo variety), V2 (Bisi-18 variety), and V3 (Pioneer 27 variety). The subplots were planting distances, which consisted of two levels of treatment: J1 (70 x 20 cm spacing) and J2 (75 x 25 cm spacing). These two factors resulted in 6 treatment combinations, each replicated three times, yielding a total of 18 experimental units. The collected data were analyzed using analysis of variance (ANOVA) and further tested using the Least Significant Difference (LSD) test at the 0.05 significance level.

RESULTS AND DISCUSSION

1. Plant Height

The analysis of variance showed that the variety had a highly significant effect, while planting distance and the interaction between variety and planting distance had no significant effect on maize plant height.

Table 1. Average plant height of maize (cm) at 8 weeks after planting (WAP) under different varieties and planting distances

Variety	Average	LSD 0.05
V1 (NK 7328)	173,73^{b}	5,13
V2 (Bisi-18)	192,68^{a}	
V3 (Pioneer 27)	190,70^{a}	

Note: Numbers followed by different letters (a, b) indicate significant differences based on the LSD test at the 0.05 level.

Based on Table 1, the observation of significant differences in the average plant height of maize among varieties at 8 Weeks After Planting (WAP), particularly the finding that the Bisi-18 variety (V2) achieved the highest average height of 192.68 cm compared to NK 7328 (V1), which only reached 173.73 cm, highlights the importance of genetic variation in the growth performance of maize. This finding reinforces the importance of optimizing cultivation conditions. Wider spacing in maize cultivation allows plants to maximize sunlight absorption, thereby enhancing photosynthetic activity and contributing to greater overall growth, including increased plant height and leaf area (Adebayo et al., 2024).

In addition, the influence of various growth conditions and management practices is also emphasized, showing that environmental factors such as shading effects from surrounding plants can significantly affect maize growth, including plant height and yield, especially during critical developmental stages (Sution et al., 2021). Therefore, the observed height differences between Bisi-18 and NK 7328 may also be influenced by each variety’s response to these environmental variables.

The genetic background of maize varieties also plays a fundamental role in plant growth. Substantial morphological variations among maize varieties, due to genetic differences, can significantly affect important traits such as plant height, which is essential for optimizing yield (Olawuyi et al., 2021). The marked differences in growth performance between Bisi-18 and NK 7328 at 8 WAP are most likely due to differences in their genetic composition.

Moreover, research indicates that optimal plant population density is crucial for maximizing maize yield. Matching hybrids with appropriate plant populations can enhance light capture and utilization more efficiently, potentially supporting greater height growth for varieties such as Bisi-18 compared to NK 7328 (Aleri et al., 2021). The results of statistical tests also support this observation, indicating that specific combinations of variety and planting density can significantly improve plant height and overall growth.

These differences in maize plant height highlight the importance of genetic diversity among varieties as well as agronomic practices such as planting density and spatial arrangement. The superior performance of the Bisi-18 variety in terms of plant height underscores the need for more targeted research and the implementation of effective cultivation strategies to improve maize productivity.

2. Number of Leaves

The analysis of variance showed that the variety treatment had a significant effect, while planting distance and the interaction between variety and planting distance had no significant effect on the number of leaves in maize plants.

Table 2. Average number of maize leaves (leaves) at 8 weeks after planting (WAP) under different varieties and planting distances

Variety	Average	LSD 0.05
V1 (NK 7328)	12,89[a]	0,31
V2 (Bisi-18)	12,33[b]	
V3 (Pioneer 27)	12,50[b]	

Note: Numbers followed by different letters (a, b) indicate significant differences based on the LSD test at the 0.05 level.

Based on Table 2, the analysis of the average number of leaves of corn plants at 8 weeks after planting (WAP) for three different varieties NK 7328 (V1), Bisi-18 (V2), and Pioneer 27 (V3) shows a noticeable variation in leaf number. Variety V1 exhibited the highest average number of leaves, which was 12.89, statistically higher than V2, which had an average of 12.33, indicating potential agronomic benefits through variety selection to enhance crop productivity. Interestingly, the average leaf number in V3 was 12.50, falling between the two other varieties; however, the difference between V3 and V2 was not statistically significant. This pattern suggests that V1 may possess favorable growth characteristics and is worthy of further investigation.

Various factors can influence leaf development in corn plants, including genetic traits, environmental conditions, and cultivation practices. Plant density and nutrient application significantly affect corn's agronomic traits, indicating that environmental stress can impact leaf production under different farming methods (Zhao et al., 2023). Their study suggests that each variety may respond differently to environmental stress, making it important to select corn varieties that suit the expected agronomic conditions.

Further support for the observed differences in leaf number emphasizes that uniform plant growth with optimal leaf expansion is crucial to maximizing corn yield, especially under diverse environmental conditions (Qandeel et al., 2021). Their research showed that temperature is a significant environmental factor affecting the growth and productivity of corn plants. Therefore, the superiority in leaf number of V1 compared to V2 may be linked to the better physiological resilience and adaptive strategies of the NK 7328 variety.

The relationship between planting density and light energy utilization also suggests that optimized planting density can improve photosynthesis efficiency and overall yield (Meng et al., 2022). This strengthens the potential of V1 to utilize resources more efficiently, ultimately producing a higher number of leaves compared to V2 and V3. The average leaf number can serve as an important indicator of future productivity, highlighting the need for in-depth genetic and environmental analysis to maximize the potential of corn plants.

Although V1 excels in leaf number metrics, maintaining plant health and achieving significant yields likely involve a complex interaction of genetic traits, environmental factors, and agronomic decisions. This holistic approach can guide best practices in future corn breeding and cultivation to achieve optimal yields.

3. 50% Male Flowering Age (days)

The analysis of variance showed that the variety treatment had a significant effect, whereas the planting spacing and the interaction between variety and planting spacing had no significant effect on the days to 50% male flowering in maize plants.

Table 3. Mean Days to 50% Male Flowering of Maize Plants (days) at Different Varieties and Planting Spacings

Veriety	Average	LSD 0.05
V1 (NK 7328)	52,67[b]	1,13
V2 (Bisi-18)	50,67[a]	
V3 (Pioneer 27)	51,17[a]	

Note: Numbers followed by different letters (a, b) indicate significant differences based on the LSD test at the 0.05 level.

Based on Table 3 on maize flowering time, the noticeable differences among varieties highlight the importance of genetic selection and adaptability to environmental conditions. The Bisi-18 and Pioneer 27 varieties were found to flower at 50.67 and 51.17 days, respectively, significantly earlier than the NK 7328 variety, which required approximately 52.67 days to reach 50% male flowering. This consistent flowering pattern confirms the genetic basis of flowering time, which has been shown to be influenced by various molecular factors and gene interactions (Shi et al., 2022; Wu et al., 2023). Specifically, certain alleles associated with early flowering in maize, as identified in studies on quantitative trait loci (QTL) and genome-wide association studies (GWAS), play a vital role in regulating flowering time and adapting to local environments (Salvi et al., 2021). The ability to select stable varieties based on these genetic markers can enhance crop yields under diverse climatic conditions.

Although there were differences in flowering time among maize varieties, this study found that planting spacing and the interaction between variety and spacing did not significantly affect flowering time. Previous research indicates that while wider spacing may improve overall plant growth and photosynthesis due to increased light interception, these factors do not necessarily alter the flowering time in specific maize varieties (Adebayo et al., 2024; Luo et al., 2023). In fact, the inherent genetic characteristics of maize varieties appear to play a more dominant role than cultivation practices such as planting configuration, which might otherwise influence growth and yield potential (Akyeaw et al., 2023). These findings align with previous discussions showing that maize varieties, even when grown under identical environmental conditions, display different responses largely due to their genetic makeup, as demonstrated in heritability studies (Syahruddin & Suwardi, 2023).

Furthermore, understanding the dynamics of flowering time in maize is crucial not only for improving yields but also for breeding strategies aimed at optimizing crop management under various climatic conditions. The alignment or misalignment of the flowering period with environmental factors such as temperature and rainfall can affect pollination success and ultimately impact yields (Fan et al., 2022). Therefore, recommendations for farmers often include selecting varieties that perform well under specific conditions and are resilient to environmental stress, which is especially important in regions prone to climate variability (Diabate et al., 2023). Genetic factors have a major influence on flowering time in maize, whereas agronomic practices such as planting density may not have the expected impact, highlighting the complexity of interactions within crop production systems.

4. 50% Female Flowering Age (days)

The analysis of variance showed that the variety had a significant effect, whereas planting spacing and the interaction between variety and planting spacing had no significant effect on the time to 50% silking female flowering in maize plants.

Table 4. Average time to 50% silking (female flowering) of maize plants across different varieties and planting spacings

Veriety	Average	LSD 0.05
V1 (NK 7328)	54,67[a]	1,13
V2 (Bisi-18)	52,67[b]	
V3 (Pioneer 27)	53,17[b]	

Note: Numbers followed by different letters (a, b) indicate significant differences based on the LSD test at the 0.05 level

Based on Table 4, silking time in maize is a crucial phenological trait that significantly influences overall yield potential. The observed differences in silking time among varieties Bisi-18 (52.67 days) and Pioneer 27 (53.17 days) highlight considerable genetic diversity in flowering responses, while NK 7328 (54.67 days) exhibits a later silking time. This variation indicates that the genetic factors underlying flowering time affect subsequent developmental stages, such as silking, as these stages are closely interrelated within the maize plant's growth cycle (L. Wang et al., 2021).

Earlier silking is generally advantageous for maize production, particularly in regions prone to environmental stresses such as drought or temperature fluctuations, as it allows the plant to complete its life cycle and grain development during favorable weather conditions (Sari et al., 2023). Varieties that silk earlier often achieve higher rates of successful pollination and kernel formation, which can lead to improved yield outcomes (Mutyambai et al., 2022). The performance of older maize varieties like NK 7328 may reflect historical breeding patterns that prioritized resilience over early developmental traits, potentially making them less adaptable to current climatic challenges compared to more recently developed varieties (Caballero-Salinas et al., 2024).

Moreover, the relationship between pest resistance and silking time supports previous findings regarding flowering time interactions with pest infestation levels. Earlier-silking varieties may escape peak pest pressure by completing their life cycles more rapidly, indicating that breeding programs focusing on modifying flowering and silking traits can significantly impact both yield performance and pest management strategies (Abdelghany et al., 2023). This highlights the importance of selecting newer varieties that not only exhibit earlier flowering and silking times but also enhanced resistance to biotic stress.

5. Ear Length

The analysis of variance showed a significant effect on the variety. However, planting distance and the interaction between variety and planting distance had no significant effect on ear length observation.

Table 5. Average ear length (cm) of maize plants across different varieties and planting distances

Variety	Average	LSD 0.05
V1 (NK 7328)	17,45[a]	0,57
V2 (Bisi-18)	16,57[b]	
V3 (Pioneer 27)	16,77[b]	

Note: Numbers followed by different letters (a, b) indicate significant differences based on the LSD test at the 0.05 level

Based on Table 5, the significant differences in ear length among the maize varieties observed in this study with NK 7328 having an average ear length of 17.45 cm compared to Bisi-18 at 16.57 cm and Pioneer 27 at 16.77 cm highlight the importance of selecting specific genotypes to improve maize productivity. The positive correlation between ear length and grain production potential has been well documented in agronomic research, showing that longer ears generally accommodate more kernels per row, thereby directly affecting overall yield (Bi et al., 2024; Guimarães et al., 2023). The longer ear size of NK 7328 compared to Bisi-18 and Pioneer 27 indicates that this variety possesses favorable traits for enhancing productivity, likely due to underlying genetic factors associated with increased grain yield in maize breeding programs (Ahmad et al., 2024; Luo et al., 2023).

Furthermore, the absence of significant differences in ear length between Bisi-18 and Pioneer 27 suggests that these two varieties may share similar genetic backgrounds or be constrained by similar developmental factors affecting their ear size. Such genetic similarity could limit the effectiveness of breeding programs aimed at increasing yield solely through ear length improvement, unless other traits are also considered (Khatun et al., 2022). Therefore, although NK 7328 shows superior ear length, further investigation into the genetic contributions of Bisi-18 and Pioneer 27 is necessary to understand their roles in overall maize performance and yield improvement potential.

Practically, greater ear length not only influences yield potential but also reflects an adaptation to resource utilization (Ahmad et al., 2024). Varieties like NK 7328 can utilize nutrients and light more efficiently, which is critical for optimizing maize production, especially under variable environmental conditions. Hence, as breeding programs continue to prioritize traits such as ear length, considerations of agronomic adaptation, pest resistance, and resource use efficiency must also be integrated to develop comprehensive strategies for successful maize cultivation (Costa et al., 2021).

6. Ear Diameter

The analysis of variance shows that the variety has a significant effect, whereas planting spacing and the interaction between variety and planting spacing do not have a significant effect on the observed ear diameter of maize plants.

Table 6. Average Ear Diameter of Maize Plants (mm) at Different Varieties and Planting Spacings.

Variety	Average	LSD 0.05
V1 (NK 7328)	45,28[b]	1,98
V2 (Bisi-18)	44,62[b]	
V3 (Pioneer 27)	48,06[a]	

Note: Numbers followed by different letters (a, b) indicate significant differences based on the LSD test at the 0.05 level

Based on Table 6, there are significant differences in ear diameter among the three maize varieties, with Pioneer 27 showing the largest average ear diameter of 48.06 mm. This contrasts with NK 7328 and Bisi-18, which have average ear diameters of 45.28 mm and 44.62 mm, respectively. The significant variation between Pioneer 27 and the other two varieties emphasizes the importance of genetic factors in determining ear characteristics, which play a crucial role in the overall yield potential of maize (Fikri et al., 2023; Hisham et al., 2021). The larger ear diameter of Pioneer 27 indicates its superior ability to accommodate more kernels, potentially increasing yield when grown under optimal conditions (Muhajir et al., 2023).

Furthermore, the fact that NK 7328 and Bisi-18 do not show significant differences in ear size suggests that these two varieties may share similar genetic traits or adaptations to their growing environments (Sukma & Iswahyudi, 2021). The lack of significant difference between these two varieties indicates a limitation in their potential to maximize yield compared to Pioneer 27. Understanding these genetic similarities is crucial in breeding and selection programs aimed at improving ear size and, more broadly, overall maize productivity (Ren et al., 2022).

With differences of 2.78 mm (Pioneer 27 vs. NK 7328) and 3.44 mm (Pioneer 27 vs. Bisi-18) exceeding the LSD threshold, it confirms that the larger ear diameter of Pioneer 27 is statistically significant. Conversely, the difference of 0.66 mm between NK 7328 and Bisi-18 falls below the LSD threshold, reinforcing the conclusion that these two varieties have comparable ear diameter characteristics (Ruswandi et al., 2023).

These results are consistent with previous studies highlighting the importance of ear diameter as a key trait influencing maize yield. Larger ears not only hold more kernels but also tend to be more resistant to lodging and other mechanical stresses during growth (Amzeri et al., 2024). Considering current challenges in maize cultivation, such as climate variability and pest pressures, selecting varieties that exhibit advantageous traits like larger ear diameters can be a critical strategy in breeding programs focused on yield improvement and sustainability of maize production systems (Yanuarsa & Soegianto, 2022).

7. Kernel Weight per Ear

The analysis of variance showed that variety, planting spacing, and the interaction between variety and planting spacing had no significant effect on the ear weight of maize plants.

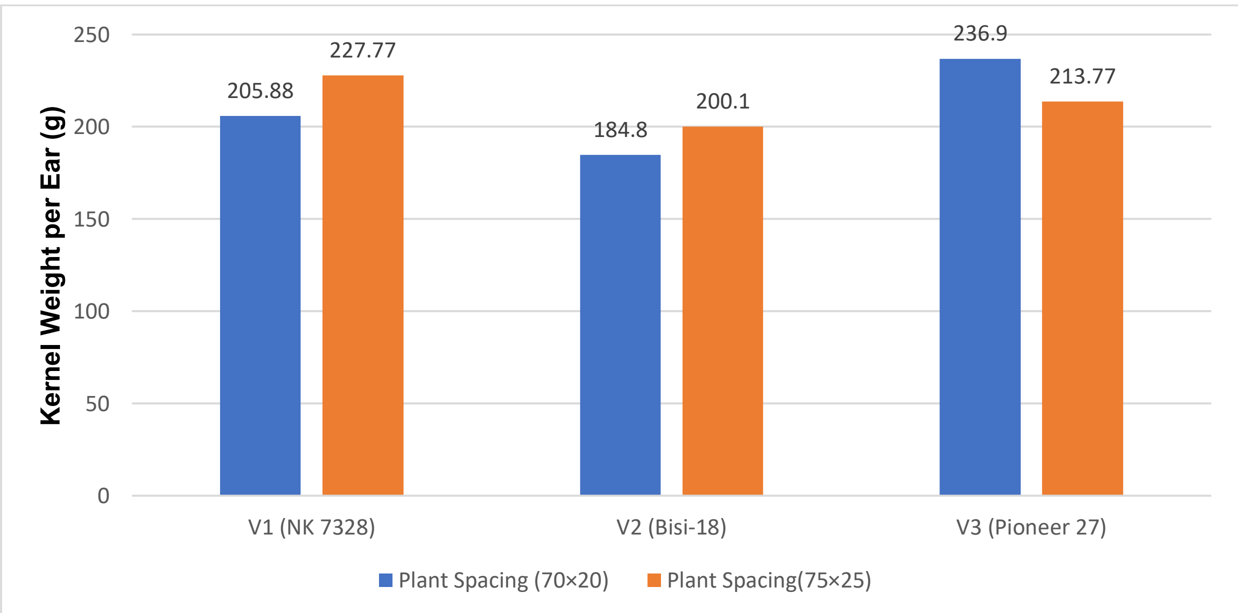

Figure 1. Average Kernel Weight per Ear

Based on Figure 1, the analysis of kernel weight per ear across various maize varieties and planting densities reveals important insights into the agronomic performance of each cultivar. In this study, it was found that variety V1 (NK 7328) showed a significant increase in average kernel weight from 205.88 g at a planting density of 70 cm × 20 cm to 227.77 g at a wider spacing of 75 cm × 25 cm. Similarly, V2 (Bisi-18) also demonstrated an increase in kernel weight from 184.8 g to 200.1 g under the same conditions. The positive relationship between wider spacing and kernel weight suggests that optimal planting density enhances the availability of nutrients and water, supports overall plant development, and results in higher grain yield (Peng et al., 2024). A similar mechanism was emphasized by Kenea et al., who stated that increased planting density, accompanied by adequate nutrient input, can significantly boost maize productivity (Kenea et al., 2024).

In contrast, V3 (Pioneer 27) exhibited an unusual pattern, with kernel weight peaking at 236.9 g under denser planting conditions, then decreasing to 213.77 g at wider spacing. This behavior suggests that Pioneer 27 may possess unique morphological or physiological traits that are more advantageous under crowded conditions, as noted in studies on the effects of population structure on nitrogen use efficiency in maize (He et al., 2022). Hybrid vigor often allows certain maize varieties to perform better under high planting densities, highlighting the importance of genetic factors in determining yield responses (Du et al., 2021b).

The differing responses among varieties indicate a complex interaction between genetic factors and environmental conditions, including adjustments in planting density. For instance, studies have shown that maize ability to optimize light capture and resource use efficiency is critical to increasing yield potential under varying planting conditions (Yang et al., 2021). Furthermore, increased planting density is often associated with improved water-use efficiency, which ultimately affects yield outcomes across different varieties in diverse ecological environments (Qin et al., 2022).

Although wider spacing generally benefits NK 7328 and Bisi-18, the preference of Pioneer 27 for denser spacing highlights the importance of understanding varietal responses to planting arrangement. The implementation of agronomic practices that take density management into account can optimize the genetic potential of maize varieties, thereby increasing kernel weight and overall yield in maize production systems (Winans et al., 2021).

8. Cob Weight per Plot

The analysis of variance showed that planting distance had a highly significant effect, whereas the variety and the interaction between variety and planting distance had no significant effect on the observed cob weight per plot.

Table 7. Average Cob Weight per Plot (kg/plot) of Maize at Different Varieties and Planting Distances.

Plant Distance	Average	LSD 0.05
J1 (70X20)	2,62^{a}	0,35
J2 (75X25)	2,11^{b}	

Note: Numbers followed by different letters (a, b) indicate significant differences based on the LSD test at the 0.05 level

Based on Table 7, the data presented on average cob weight per plot demonstrates the effect of planting distance on maize productivity, where J1 (70×20 cm) yielded an average cob weight of 2.62 kg/plot, while J2 (75×25 cm) produced a lower average of 2.11 kg/plot. These results highlight a significant relationship between planting density and crop yield, as supported by various studies emphasizing the importance of proper spacing for optimal growth and maximum yield potential.

The increased cob weight observed at the J1 spacing can be explained by agronomic theories related to plant population and resource allocation. Closer spacing (such as in J1) can enhance light interception and photosynthetic efficiency, as plants benefit from reduced shading effects. This increased light availability correlates with improved photosynthetic activity, which is crucial during the grain-filling period and contributes to biomass accumulation in maize cobs (Ngairangbam et al., 2024; Piao et al., 2022). It has been shown that proper plant spacing can improve yield parameters such as higher cob weight due to better individual plant performance arising from enhanced photosynthetic capacity (Mathur et al., 2023).

On the other hand, the reduced cob weight observed at J2 spacing may indicate competitive stress resulting from wider spatial arrangements. While wider spacing allows for greater canopy expansion, it can also reduce the total number of cobs produced per unit area, particularly if nutrients and water are not evenly distributed. It has been reported that although wider spacing allows for larger individual plant growth, it does not guarantee higher overall yields when plant competition for essential resources becomes suboptimal (Adebayo et al., 2024). Furthermore, increased row spacing without adequate nutrient management has been found to result in yield reductions, indicating a complex interaction between planting density and agronomic practices (Jin et al., 2023).

Under varying environmental conditions, factors influencing maize growth, such as root development and water availability, greatly affect cob weight, Plant physiological responses to spacing-induced stress particularly in semi-arid climates can complicate yield outcomes due to limited water during critical growth phases. It has been explained that water stress during key developmental stages can negatively impact cob weight, further reinforcing the effect of planting geometry on maize yield (Suriadi et al., 2024).

Overall, the differences in cob weight across various planting distances emphasize the importance of selecting appropriate spacing, considering both the genetic characteristics of maize varieties and relevant environmental and nutrient management practices. A comprehensive understanding of these interactions is crucial for optimizing maize yields and enhancing agricultural productivity in modern farming systems.

9. Weight of 100 Grains

The analysis of variance showed that variety (V), planting distance (J), and the interaction between variety and planting distance (VJ) had no significant effect on the observation of 100-grain weight of maize.

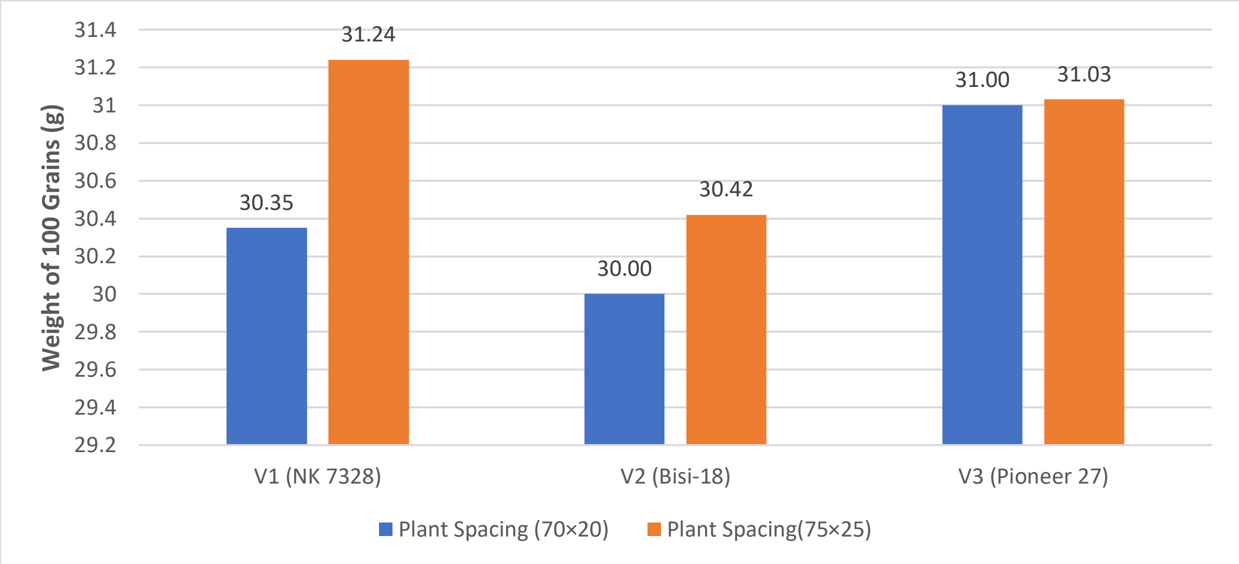

Figure 2. Average 100-Grain Weight

Based on Figure 2, the average 100-grain weight of maize for the NK 7328, Bisi-18, and Pioneer 27 varieties at planting distances of 70x20 cm and 75x25 cm reveals important findings related to planting practices in maize cultivation. It is evident that wider planting distances tend to increase grain weight across all observed varieties. The NK 7328 variety showed the most significant increase in grain weight, rising from 30.35 g at the narrower spacing to 31.24 g at the wider spacing. This pattern can be attributed to improved resource allocation and the plant's physiological response to wider spacing, as supported by research indicating that wider spacing enhances light interception and reduces inter-plant competition (F. Wang et al., 2023).

However, it is important to emphasize that although there were increases in the 100-grain weight for Bisi-18 and Pioneer 27, the changes were not as substantial as those observed for NK 7328. The increase from 30.00 g to 30.42 g for Bisi-18, and the very slight rise for Pioneer 27 (from 31.00 g to 31.03 g), indicate variability in each variety's response to planting distance. Although numerical differences were observed in the interaction between planting distance and variety, the analysis of variance showed that these differences were not statistically significant. This suggests that factors such as genetic traits and inherent varietal characteristics influence how maize plants respond to planting density, consistent with findings highlighting the role of genetic variation in yield traits under different environmental conditions (He et al., 2022).

In addition, the increase in 100-grain weight due to wider planting distance can also be understood from the perspective of nutrient dynamics in maize cultivation. Wider spacing allows for improved absorption and utilization of nutrients, particularly nitrogen, which plays a key role in seed development and weight accumulation (Wangiyana et al., 2025). The same principle applies to the dynamics of cellulose content in maize grains, which has been shown to positively correlate with grain weight when plants are treated with growth regulators such as gibberellins (Lv et al., 2021). Therefore, although planting distance and genetic variety influence grain weight, the physiological and biochemical responses of maize to these variables must be taken into account in order to optimize grain yield effectively.

10. Yield

The analysis of variance showed that both variety and planting distance had a significant effect on maize yield (tons/ha), while the interaction between variety and planting distance had no significant effect.

Table 8. Average maize yield per hectare (tons/ha) for different varieties and planting distances.

Variety	Average	LSD 0.05	Palanting Distance	Average	LSD 0.05
V1 (NK 7328)	$6{,}14^{b}$	0,20	J1 (70x20)	$6{,}89^{a}$	0,20
V2 (Bisi-18)	$5{,}96^{b}$				
V3 (Pioneer 27)	$6{,}67^{a}$		J2 (75X25)	$5{,}63^{b}$	

Note: Numbers followed by different letters (a, b) indicate significant differences based on the LSD test at the 0.05 level

Based on Table 8, maize yield per hectare according to variety and planting distance provides important insights into the agronomic performance of maize under various cultivation practices. Among the tested varieties, Pioneer 27 exhibited the highest yield, reaching 6.67 tons/ha, surpassing Bisi-18 which yielded 5.96 tons/ha, and NK 7328 with an average of 6.14 tons/ha. These results are consistent with established principles in plant breeding, where hybrid varieties typically demonstrate higher yield potential due to superior genetic traits related to growth and adaptability to environmental conditions (Mdoda et al., 2025).

The statistically significant advantage of Pioneer 27 can be attributed to its better nutrient utilization capacity and adaptability to a range of environmental conditions, which are crucial factors in maximizing yield per unit area (Dwamena et al., 2022). Furthermore, yield data indicate that factors influencing maize yield such as the number of kernels per ear and overall plant health play vital roles, emphasizing the importance of selecting high-yielding varieties for maize production (Korsa et al., 2024).

In terms of planting distance, the analysis shows that a 70x20 cm spacing produced an average yield of 6.89 tons/ha, which was significantly higher than the wider 75x25 cm spacing, which only yielded 5.63 tons/ha. These results support previous findings showing the impact of planting density on yield. For example, optimized plant spacing reduces competition among plants for light, water, and nutrients, thereby enhancing individual plant growth and ultimately increasing overall yield (Ye et al., 2023).

Moreover, the increased yield associated with closer spacing can be explained by improved canopy structure and better radiation interception, as it allows plants to maximize photosynthetic efficiency, which in turn increases both kernel number and weight (Ren et al., 2022). However, although favorable yields were observed with the 70x20 cm spacing, caution must be taken to avoid excessive plant density, which may lead to increased disease incidence and competition, potentially offsetting the yield benefits.

CONCLUSIONS

Maize variety and planting distance significantly affect yield. The Pioneer 27 variety produced the highest yield, while the planting distance of 70x20 cm resulted in better yield compared to 75x25 cm. The combination of superior varieties and optimal planting distances can increase maize productivity, but care must be taken to avoid excessive plant density.

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