*Original Research Article*

EFFECT OF SOWING DENSITY ON THE GROWTH AND YIELD OF TWO HYBRID VARIETIES OF MAIZE (*Zea mays* L.) IN DSCHANG, WEST CAMEROON

ABSTRACT

|  |
| --- |
| Maize (*Zea mays* L.) is vital to Cameroon's agricultural sector, supporting food security and economic stability. Despite production efforts, yields remain low, necessitating agronomic interventions. This study assessed the effect of sowing density on the growth and yield of two hybrid maize varieties, Pannar 12 and Kabamanoj F1, in Dschang, Cameroon.  A completely randomized block design with a split-plot arrangement and three replications was used, with variety as the main plot and sowing density as the subplot. The study was conducted at the Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon, from February to June, 2023. Four sowing densities were tested: 62,500 plants/ha, 83,333 plants/ha, 62,500 plants/ha, and 71,428 plants/ha. Growth parameters, including plant height, collar diameter, and number of leaves per plant, were recorded at different growth stages. Yield components such as ear diameter, ear length, grain weight, and total yield were also assessed. Statistical analyses included ANOVA, LSD tests for mean separation, and Pearson correlation analysis. Sowing density significantly influenced the number of leaves per plant (P < 0.05), with the highest at 62,500 plants/ha (11.60) and the lowest at 83,333 plants/ha (9.58) at 42 days after sowing. Variety significantly affected ear diameter (P < 0.01), with Pannar 12 (51.70 mm) outperforming Kabamanoj F1 (50.34 mm). Grain weight was variety-dependent but unaffected by sowing density. Correlation analysis showed significant positive relationships between yield and growth parameters such as leaf length (r = 0.54\*\*), stalk height (r = 0.55\*\*), and collar diameter (r = 0.56\*\*). Higher sowing densities reduced individual plant growth but optimized total plot yield. The Pannar 12 variety at 62,500 plants/ha is recommended for maximizing maize productivity in Dschang. These findings provide valuable agronomic insights for optimizing maize production in similar agro-ecological zones. |

*Keywords: Maize, Hybrid Varieties, Plant Density, Agronomic Performance, Yield Components, West Cameroon*

1. INTRODUCTION

Similar to most sub-Saharan African countries, Cameroon’s economy is heavily dependent on agriculture for economic growth, contributing around 22.2% to its Gross Domestic Product (GDP) and employing approximately 45% of the workforce (INS, 2016). Agriculture plays a vital role in stimulating growth in other sectors, reducing poverty, and ensuring food security. The sector is primarily driven by small-scale farmers, who control nearly 70% of the total agricultural land (Yengoh & Jonas, 2014). With its five agro-ecological zones offering diverse landscapes and climates, Cameroon presents significant agricultural potential (Abossolo, 2017).

Maize (*Zea mays* L.) is an essential cereal crop worldwide and a critical staple in Cameroon. It ranks among the three most important grains globally, alongside wheat and rice, playing a strategic role in food security (Ngoucheme et al., 2020). The global production of maize stands at approximately 1,210.2 million tonnes, with an average yield of 5.8 tonnes per hectare (FAO, 2021). Maize is cultivated for its starch-rich grains, utilized in human and animal nutrition, as well as in various industrial applications, including the textile, pharmaceutical, and biofuel industries (Kaho et al., 2011; Useni et al., 2014). In Africa, maize consumption is rapidly increasing, primarily due to population growth and evolving dietary preferences (Seck et al., 2013).

In Cameroon, maize and other staple crops, such as rice, sorghum, millet, wheat, cassava, plantain, and macabo, dominate food production. Among cereals, maize ranks first in production area, surpassing wheat and rice. National maize production is estimated at 2 million tonnes, with an average yield of 1.7 tonnes per hectare (FAO, 2021), yet demand exceeds 3 million tonnes, creating a significant production gap (MINADER, 2021). Despite its importance, maize productivity remains low due to several constraints.

Several factors contribute to the low maize yields in Cameroon. Soil fertility depletion, limited access to improved seed varieties, and the high cost of synthetic fertilizers are major obstacles (Nyembo et al., 2010; Useni et al., 2012). Additionally, climatic challenges such as erratic rainfall patterns and pest infestations, exacerbated by climate change, further hinder production (Kalonji et al., 2004; Issa et al., 2011). Other constraints include poor agricultural practices, inadequate extension services, and farming systems that are not adapted to local conditions.

Over the years, maize cultivation areas in Cameroon have expanded, increasing from 846,130 hectares in 2012 to 1,186,193 hectares in 2021. However, yields have declined from 1.97 tonnes per hectare to 1.7 tonnes per hectare over the same period (FAO, 2021). This decline is largely attributed to farmers' reliance on traditional varieties with low yield potential (Kaho et al., 2011). The western region of Cameroon alone accounts for approximately 60% of national maize production (INS, 2010). Increasing demographic pressures have further led to higher food demand, reduced fallow periods, and declining soil fertility, all of which negatively impact maize yields (Konan et al., 2018).

Genetic improvement has played a crucial role in increasing maize productivity globally. In the United States, maize yields increased from 1 tonne per hectare in the 1930s to 7 tonnes per hectare in the 1990s, with 60% of this increase attributed to genetic advancements. Similarly, in France, 58% of maize yield improvements are linked to breeding innovations (Konan et al., 2018). Consequently, the adoption of improved maize varieties with high agronomic potential is a viable strategy to enhance maize yields in Cameroon. These improved varieties often exhibit greater resistance to pests, diseases, and climatic stresses, making them suitable for large-scale production (Nyembo, 2010).

One of the key agronomic practices influencing maize yield is sowing density. Planting density affects competition for water, nutrients, and sunlight, which directly impacts plant growth and yield (Argenta, 2001; Caliskan, 2007). Research indicates that different maize varieties exhibit varying levels of tolerance to high planting densities (Kouassi et al., 2017). Some hybrids perform well under dense planting conditions, while others require wider spacing for optimal growth. Therefore, determining the appropriate sowing density for specific maize varieties is crucial for optimizing yield potential.

The relationship between plant density and maize productivity has been widely studied. Higher sowing densities typically result in increased competition among plants, leading to reduced individual plant growth. However, at the plot level, increased densities can maximize overall yield by optimizing land use (Sai & Umesha, 2022). Research conducted on baby corn (*Zea mays* L.) has shown that spacing significantly influences key growth attributes such as plant height, number of leaves per plant, and dry biomass accumulation. For instance, plant height was highest (172.38 cm) at a spacing of 60 cm × 15 cm, whereas the highest number of leaves per plant (12.75) was recorded at the same spacing (Sai & Umesha, 2022).

Moreover, sowing density also affects maize ear characteristics, including cob length, cob weight, and yield per hectare. Studies have shown that a balance must be struck between maximizing plant populations and ensuring adequate resource allocation per plant to achieve high yields (Pandey et al., 2002). In Cameroon, research on optimal sowing densities for different maize varieties remains limited, highlighting the need for further investigations to identify density recommendations for different agro-ecological conditions.

Given the challenges facing maize production in Cameroon, there is an urgent need to identify optimal planting densities for improved hybrid maize varieties. This study aims to evaluate the impact of sowing density on the growth and yield of two hybrid maize varieties in Dschang, West Cameroon. The findings will contribute to enhanced agronomic practices by providing farmers with science-based recommendations on suitable planting densities for improved maize yields.

Additionally, this research will generate valuable technical knowledge for farmers, informing them about the benefits of optimized sowing densities and guiding their choice of maize varieties. The study will also support the promotion of high-yielding maize varieties adapted to the local environment. Overall, these insights will aid in closing the maize production gap, improving food security, and enhancing the livelihoods of maize growers in Cameroon and similar agro-ecological regions.

2. material and methods

**2.1 Description of the study site**

This study was carried out at the Faculty of Agronomy and Agricultural Sciences (FASA) Research and Application Farm at the University of Dschang (UDs), 5°20' latitude North and 10°03' longitude East altitude of 1407 m, in the Menoua Division of the West Region of Cameroon; from the11th of February to the 2nd of June 2023. The site (FAR) is located in zone III of Cameroon's five agro-ecological zones, known as the Western Highlands zone. The western region of Cameroon experiences substantial annual precipitation averaging around 3,459 mm and stable temperatures ranging between 23°C and 26°C (Nomad Season, 2025). The climate in Dschang is tropical and humid, with a rainy season from mid-March to mid-November (8 months) and a dry season from mid-November to mid-March (4 months). In Dschang, a key agricultural area in the region, the mean annual temperature is approximately 19.7°C, with an annual precipitation of 4,473 mm (Climate-Data, 2025). Sun exposure is highest during the dry season, when it accounts for 8.5 hours per day, whereas in the rainy season it falls to 2.2 hours per day. Total annual sunshine is 1,864 hours (Metambou, 2016). The dominant vegetation on the site is made up of the following species: *Tithonia diversifolia*, *Mimosa pudica*, *Ageratum conyzoides*, *Cyperus esculentus* and *Pennisetum purpureum* (Metambou, 2016). The type of soil encountered in the study area belongs to the group of brown or red soils on basic rocks, otherwise known as Oxisol (according to the US Soil classification) or red ferralitic soil according to the French classification (Orstom, 1965).

**2.1.2 Plant materials**

The plant material studied consisted of two hybrid maize varieties, Kabamanoj F1 and Pannar 12 from Arysta Lifesciences Cameroun, the characteristics of which are presented in Table 1 below.

**Table 1: Characteristics of the different varieties**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Varieties** | **Cycle (days)** | **Potential yield/ha** | **Special features** | **Grain characteristics** |
| **Pannar 12** | 115-120 | 8 tons | Very high drought tolerance;  Resistant to leaf diseases. | Hard dark yellow grain, tolerant to insect attack |
| **Kabamanoj F1** | 85-90 | 10 tons | Plant resistance to lodging;  Better tolerance to drought stress;  disease resistance. | Yellow-orange grain, horny and toothed;  Protein-rich maize ideal for feed and poultry farming. |

**2.3 Phytosanitary materials used**

Throughout the trial, several phytosanitary products were used to treat the plot, alternating products for each treatment. Table 2 shows these products with some information marked on their labels.

**Table 2: Phytosanitary materials**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Insecticides** | **Commercial names** | **Active ingredient** | **Nature** | **Target pest** |
| K-OPTIMAL | Lambda-cyhalothrine 15 g/l + Acetamipride 20 g/l | Systemic | defoliator caterpillars, noctuid moths, leaf miners, the borers and the aphids |
| CAÏMAN B | Emamectine benzoate 50 g/kg | Contact and systemic | Army worm |
| PYRIFORCE | Chloropyriphos-ethyl 600 g/l | Contact and systemic | Defoliating caterpillars, aphids, whitefly |

Organic fertiliser was not used in this study because soil analyses showed that the organic matter on site was high. Only mineral fertilisers were used, in particular NPK14-23-14 at a rate of 300 kg/ha and urea at a rate of 100 kg/ha, taking into account the quantities already present in the soil.

**2.4 Land preparation**

Land preparation consisted firstly of clearing the plot using machetes, then delimiting the trial area. A flat ploughing was also carried out, followed by the preparation of the different experimental units on which the seeds were to be sown. The experiment followed a completely randomized block design with a split-plot arrangement and three replicates. Variety served as the main plot factor, randomly distributed within each block, while density was the subplot factor. This classic Fischer block design ensured randomization and replication for robust statistical analysis. Each sub-block was randomly divided based on the density factor, with each block representing a replicate where all treatments appeared once. The design included three (3) blocks, each containing eight (8) experimental units, resulting in a total of twenty-four (24) experimental units. Each experimental unit covered an area of 2.5 m × 2.5 m (6.25 m²). The experimental layout included 50 cm spacing between units, 1 m spacing between blocks and sub-blocks, and a 1 m outer margin for passage. The total area of the experimental plot was 299 m² (Figure 1). The trial required 387 g of seed for each variety.

The treatment descriptions were as follows:

V1D1: Variety Pannar 12 + Density 80cm x 40cm

V1D2: Variety Pannar 12 + Density 80cm x 20cm

V1D3: Variety Pannar 12 + Density 60cm x 20cm

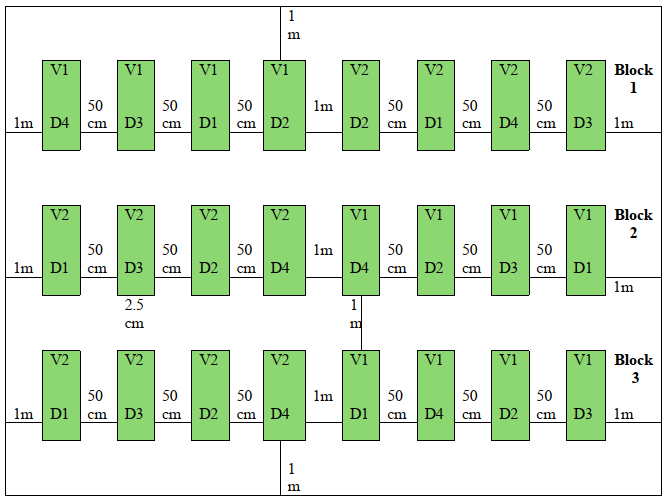
V1D4: Variety Pannar 12 + Density 70cm x 20cm

V2D1: Variety Kabamanoj F1 + Density 80cm x 40cm

V2D2: Variety Kabamanoj F1 + Density 80cm x 20cm

V2D3: Variety Kabamanoj F1 + Density 60cm x 20cm

V2D4: Variety Kabamanoj F1 + Density 70cm x 20cm



**Figure 1: Field layout**

**2.5 Sowing**

The seeds were sown manually, with the number of seeds per pocket determined by the spacing. For 80 cm × 40 cm spacings, two seeds were sown per pocket, while for 80 cm × 20 cm, 60 cm × 20 cm, and 70 cm × 20 cm spacings, one seed was sown per pocket.

This resulted in plant densities per experimental unit as follows:

* 80 cm × 40 cm: 24 plants per unit (62,500 plants/ha),
* 60 cm × 20 cm: 50 plants per unit (83,333 plants/ha),
* 80 cm × 20 cm: 40 plants per unit (62,500 plants/ha),
* 70 cm × 20 cm: 40 plants per unit (71,428 plants/ha).

**2.6 Fertilisation**

The first fertilization was conducted 14 days after sowing, using a formulated mineral fertilizer (NPK 14-23-14). The fertilizer was applied 5 cm from the sowing line at a depth of 2–3 cm, with a dose of 300 kg/ha, corresponding to 70.95 g per experimental unit. The second fertilization, using urea, was applied 52 days after sowing, immediately following the second weeding. This application was also placed 5 cm from the seed line at a depth of 2–3 cm, with a dose of 100 kg/ha, equivalent to 62.5 g per experimental unit.

**2.7 Phytosanitary treatment**

The insecticide CAÏMAN B WG, as detailed in Table 2, was applied to control armyworms upon their appearance on the maize crop. Additionally, K-OPTIMAL and PYRIFORCE insecticides were used to manage infestations of aphids and borers when they appeared.

**2.8 Harvesting**

Harvesting was performed manually in a single operation, 15 weeks and 6 days after sowing.

**2.9 Data collection**

Data were collected from 8, 12, and 15 plants located at the center of each experimental unit, depending on the plant density. Sampling was conducted at four intervals, spaced two weeks (14 days) apart, beginning two weeks after seedling emergence. Plants for data collection were randomly selected from the center of the plot to minimize border effects.

**2.9.1 Growth variables**

Data was collected on the following growth parameters.

1. Plant Height
2. Crown Diameter
3. Number of Leaves per Plant
4. Leaf Length and Width

The leaf area (LA) was calculated using the formula from Ruget et al. (1996):

LA= L × W × 0.75……………………………………………………………………………………(1)

Where LA = leaf area, L = length and W = width

**2.9.2 Yield variables**

Data was collected on the following yield parameters.

1. *Ear diameter*
2. *Ear length*
3. *Seed weight of ears and 1000 seeds*
4. *Dry grain yield at 15% moisture*

To determine the dry grain yield at 15% moisture, the ears of the sampled plants were harvested from each experimental unit, then destemmed and oven-dried at a temperature of 25°C. Once removed from the oven, the ears were dehulled and the total weight of the seeds was weighed using an electronic balance. The yield was calculated using the following formulae:

……………………………….(2)

Where: E.A = Spacing × Number of sampled plants

………………………………………………………………(3)

*RT* = Total Yield of maize grains (t/ha); *PT* = Total Weight of maize grains at 15% moisture; *S.U* = Effective Area ; *PT at Y* = The total weight of maize grains at moisture content Y%; *Y* = The actual moisture content of the maize grains during measurement; *15* = The desired standard moisture content (15%).

**2.10 Data analysis**

The data collected was entered into a Microsoft Excel version 2013 spreadsheet. The data was then imported into the R software, which was used to perform the statistical analyses. The following tests were carried out: the Shapiro-Wilk normality test to check whether the data conformed to the normal distribution, a two-way ANOVA test was used to check for significant differences between treatment combinations and the LSD (Least Significant Difference) test was used to separate the means. A Pearson’s correlation analysis was also performed between growth and yield parameters.

3. results and discussion

**3.1 Results**

**3.1.1 Effect of variety and plant density on growth variables**

*3.1.1.1 Number of leaves per plant*

The main effect of variety was significant (*P* < .01) on the number of leaves per plant at 14 days after sowing while the main effect of plant density was not significant (*P* > .05) on the number of leaves per plant throughout the experiment. The variety x plant density (V x D) interaction significantly affected the number of leaves per plant at 42 days after sowing (Table 3).

**Table 3:** **Main and interaction effect of variety and plant density on the number of leaves per plant**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | **Degree of freedom** | **P-value** | | | |
|  |  | **14 DAS** | **28 DAS** | **42 DAS** | **56 DAS** |
| Variety (V) | 1 | .009\*\* | .24 | .41 | .37 |
| Density (D) | 3 | .28 | .64 | .28 | .65 |
| V x D | 3 | .65 | .47 | .02\* | .81 |

*Significance levels, \*P<.05; \*\*P<.001. DAS: Days after sowing.*

At 42 days after planting, the highest number of leaves per plant was recorded by Pannar 12 at the D1 (80 cm x 40 cm) plant density while the lowest number of leaves per plant was recorded by Kabamanoj F1 at the D3 (60 cm x 20 cm) plant density (Table 4).

**Table 4:** **Variation in the mean number of leaves per plant for the variety x density interaction**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Variety** | **Density** | **Mean number of leaves per plant** | | | | |
| **14 DAS** | **28 DAS** | **42 DAS** | | **56 DAS** |
| Pannar 12 | D1 | 4.00 ± 0.00a | 7.95 ± 1.04a | 11.60 ± 1.22a | | 14.20 ± 0.31a |
| D2 | 3.91 ± 0.14a | 7.80 ± 0.42a | 10.88 ± 0.59ab | | 14.16 ± 1.49a |
| D3 | 3.93 ± 0.11a | 7.66 ± 0.35a | 9.93 ± 0.52c | | 14.08 ± 0.49a |
| D4 | 4.00 ± 0.00a | 8.28 ± 0.25a | 11.23 ± 1.56a | | 13.57 ± 0.35a |
| Kabamanoj F1 | D1 | 3.25 ± 0.43a | 7.08 ± 0.68a | 10.17 ± 1.30c | | 13.59 ± 0.36a |
| D2 | 3.05 ± 0.09a | 7.22 ± 0.96a | 9.97 ± 0.67c | | 13.91 ± 1.12a |
| D3 | 3.02 ± 0.03a | 6.68 ± 0.67a | 9.58 ± 0.80c | | 13.61 ± 1.14a |
| D4 | 3.05 ± 0.09a | 7.05 ± 0.75a | 9.94 ± 0.93c | | 13.64 ± 1.25a |
| P-value |  | .13 | .06 | | .04\* | .15 |

***NB:*** *Values that share the same superscript letter along the same column are not significantly different from each other.* ***Significance levels:*** *\*P <.05;* ***DAS:*** *Days after sowing.* *Mean ± SD = Mean values ± Standard deviation of means*

At 14 days after sowing, Pannar 12 significantly (*P* < .01) outperformed Kabamanoj F1 in terms of number of leaves per plant, with Pannar 12 recording an average of 3.96 as oppose to 3.09 leaves per plant for Kabamanoj F1(Table 5).

**Table 5:** **Variation in the mean number of leaves per plant across varieties**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variety** | **Mean number of leaves per plant** | | | |
| **14 DAS** | **28 DAS** | **42 DAS** | **56 DAS** |
| Pannar 12 | 3.96 ± 0.08a | 7.92 ± 0.57a | 10.91 ± 1.11a | 14.00 ± 0.74a |
| Kabamanoj F1 | 3.09 ± 0.21b | 7.01 ± 0.69a | 9.91 ± 0.84a | 13.69 ± 0.89a |
| Significance | .001\*\* | .77 | .26 | .81 |

***NB:*** *Values that share the same superscript letter along the same column are not significantly different from each other.* ***Significance levels:*** *\*\*P<.01;* ***DAS:*** *Days after sowing.* *Mean ± SD = Mean values ± Standard deviation of means*

*3.1.1.2 Plant height*

The main effect of variety was significant (*P* = .05) on plant height at 28 days after sowing and 56 days after sowing. The main effect of plant density and the interaction effect of variety x plant density (V x D) were not significant on plant height throughout the experiment (Table 6).

**Table 6: Main and interaction effect of variety and plant density on the mean plant height**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | **Degrees of freedom** | **P-value** | | | |
|  |  | **14 DAS** | **28 DAS** | **42 DAS** | **56 DAS** |
| Variety (V) | 1 | .06 | .002\*\* | .17 | .03\* |
| Density (D) | 3 | .51 | .59 | .50 | .79 |
| V x D | 3 | .65 | .99 | .52 | .60 |

*Significance levels: \*P<.05; \*\*P<.01; DAS: Days after sowing.*

At 28 days after sowing, Pannar 12 significantly (*P* = .05) outperformed Kabamanoj F1 in terms of plant height, with Pannar 12 recording an average plant height of 59.48cm as oppose to 51.57cm for Kabamanoj F1. A similar result was recoded at 56 days after sowing, in which Pannar 12 significantly outperformed Kabamanoj F1, with Pannar 12 recording an average height of 174.82cm as oppose to Kabamanoj F1which recorded an average plant height of 152.49cm (Table 7).

**Table 7: Variation in the mean plant height across varieties**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variety** | **Mean plant height (cm)** | | | |
| **14 DAS** | **28 DAS** | **42 DAS** | **56 DAS** |
| Pannar 12 | 17.88 ± 2.65a | 59.48 ± 4.11a | 113.37 ± 23.61a | 174.82 ± 11.98a |
| Kabamanoj F1 | 14.57 ± 0.84a | 51.57 ± 4.87b | 91.96 ± 10.93a | 152.49 ± 5.99b |
| P-value | .08 | .004\*\* | .06 | .03\* |

***NB:*** *Values that share the same superscript letter along the same column are not significantly different from each other. Significance levels: \*P<.05; \*\*P<.01; DAS: Days after sowing. Mean ± SD = Mean values ± Standard deviation of means*

*3.1.1.3 Collar diameter*

The main effect of variety was significant (*P* = .05) on collar diameter at 14, 28 and 56 days after sowing while the main effect of plant density was significant collar diameter at 42 and 56 days after sowing. The interaction effect of variety and plant density (V and D) was not significant (P > 0.05) on the collar diameter (Table 8).

**Table 8: Main and interaction effect of variety and plant density on the collar diameter**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | **Degrees of freedom** | **P-value** | | | |
|  |  | **14 DAS** | **28 DAS** | **42 DAS** | **56 DAS** |
| Variety (V) | 1 | .02\* | .049\* | .53 | .02\* |
| Density (D) | 3 | .24 | .66 | .046\* | .03\* |
| V x D | 3 | .81 | .81 | .08 | .83 |

*Significance levels: \*P<.05; DAS: Days after sowing.*

At 14 days after sowing, Pannar 12 significantly (*P* = .05) outperformed Kabamanoj F1 in terms of collar diameter, with Pannar 12 recording an average collar diameter of 5.45mm as oppose to 3.63mm for Kabamanoj F1. A similar observation was made at 28 days after sowing, in which Pannar 12 significantly outperformed Kabamanoj F1, with Pannar 12 recording an average collar diameter of 11.23mm as oppose to Kabamanoj F1which recorded an average plant height of 8.50mm (Table 11). A similar trend was equally recorded at 56 days after sowing, in which Pannar 12 significantly outperformed Kabamanoj F1, with Pannar 12 recording an average collar diameter of 23.63mm as oppose to Kabamanoj F1 which recorded an average collar diameter of 8.50mm (Table 9).

**Table 9: Variation in collar diameter across varieties**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variety** | **Collar diameter (mm)** | | | |
| **14 DAS** | **28 DAS** | **42 DAS** | **56 DAS** |
| Pannar 12 | 5.45 ± 0.67a | 11.23 ± 1.29a | 21.37 ± 5.09a | 23.63 ± 1.23a |
| Kabamanoj F1 | 3.63 ± 0.25b | 8.50 ± 0.57b | 18.69 ± 2.04a | 21.19 ± 1.11b |
| P-value | .03\* | .04\* | .65 | .02\* |

***NB:*** *Values that share the same superscript letter along the same column are not significantly different from each other. Significance levels: \*P<.05; DAS: Days after sowing. Mean ± SD = Mean values ± Standard deviation of means*

At 42 days after sowing, the highest (22.37mm) collar diameter was recorded for the D1 (80 cm x 40 cm) plant density while the lowest (19.04mm) was recorded for the D3 (60 cm x 20 cm) plant density. On the other hand, at 56 days after sowing, the highest (23.18mm) collar diameter was recorded for the D1 (80 cm x 40 cm) plant density while the lowest (19.04mm) was recorded for the D3 (60 cm x 20 cm) plant density (Table 10).

**Table 10: Variation in collar diameter across plant densities**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Density** | **Collar diameter (mm)** | | | |
| **14 DAS** | **28 DAS** | **42 DAS** | **56 DAS** |
| D1 | 4.89 ± 1.15a | 10.03 ± 1.73a | 22.37 ± 6.33a | 23.18 ± 1.28a |
| D2 | 4.27 ± 1.05a | 9.98 ± 2.01a | 19.32±2.8b | 22.92 ± 1.70ab |
| D3 | 4.56 ± 1.26a | 9.92 ± 1.99a | 19.04 ± 3.19b | 21.51 ± 1.93c |
| D4 | 4.45 ± 0.91a | 9.54 ± 1.44a | 19.38 ± 2.80b | 22.02 ± 1.66bc |
| P-value | .74 | .67 | .02\* | .04\* |

***NB:*** *Values that share the same superscript letter along the same column are not significantly different from each other. Significance levels: \*P<.05; DAS: Days after sowing. Mean ± SD = Mean values ± Standard deviation of means*

*3.1.1.4 Leaf area*

The main effect of variety on the leaf area was significant (*P* = .05) at 14, 28 and 56 days after sowing while the main effect of plant density and the interaction effect of variety and plant density (V and D) on the leaf area was not significant (*P* = .05) throughout the experimental period (Table 11).

**Table 11: Main and interaction effect of variety and plant density on the leaf area**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | **Degrees of freedom** | **P-value** | | | |
| **14 DAS** | **28 DAS** | **42 DAS** | **56 DAS** |
| Variety (V) | 1 | .045\* | .02\* | .46 | .02\* |
| Density (D) | 3 | .31 | .47 | .27 | .31 |
| V x D | 3 | .19 | .97 | .20 | .87 |

*Significance levels: \*P<.05; DAS: Days after sowing.*

At 14 days after sowing, Pannar 12 significantly (*P* = .05) outperformed Kabamanoj F1 in terms of leaf area, with Pannar 12 recording an average leaf area of 17.02cm2 as oppose to 13.43cm2 for Kabamanoj F1. Similarly, at 28 days after sowing, Pannar 12 significantly (*P* = .05) outperformed Kabamanoj F1 in leaf area, with Pannar 12 recording an average leaf area of 176.79cm2 as oppose to Kabamanoj F1which recorded an average leaf area of 123.47cm2 (Table 11). Furthermore, a similar trend was recorded at 56 days after sowing, in which Pannar 12 significantly (*P* = .05) outperformed Kabamanoj F1, with Pannar 12 recording an average leaf area of 720.17cm2 as oppose to Kabamanoj F1which recorded an average leaf area of 616.62cm2 (Table 12).

**Table 12: Variation in leaf area across varieties**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variety** | **Leaf area (cm2)** | | | |
| **14DAS** | **28DAS** | **42DAS** | **56DAS** |
| Pannar 12 | 17.02 ± 1.59a | 176.79 ± 21.94a | 402.58 ± 85.74a | 720.17 ± 50.04a |
| Kabamanoj F1 | 13.43 ± 1.45b | 123.47 ± 22.67b | 325.59 ± 61.09a | 616.62 ± 48.81b |
| P\_value | .02\* | .01\* | .08 | .04\* |

***NB:*** *Values that share the same superscript letter along the same column are not significantly different from each other. Significance levels: \*P<.05; DAS: Days after sowing. Mean ± SD = Mean values ± Standard deviation of means*

**3.1.2 Effect of variety and sowing density on yield variables**

*3.1.2.1 Ear diameter*

The main effect of variety was significant (*P* < .01) on the ear diameter while the main effect of plant density and the interaction effect of variety and plant density were not significant (*P* = .05) on the ear diameter (Table 13)

**Table 13: Main and interaction effect of variety and plant density on the ear diameter**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | **Degrees of freedom** | **Sum of squares** | **Medium squares** | **F** | **P-value** |
| Variety (V) | 1 | 11.09 | 11.09 | 184.14 | .005\*\* |
| Density (D) | 3 | 3.98 | 1.33 | 2.46 | .11 |
| V x D | 3 | 1.55 | 0.52 | 0.96 | .45 |

***Significance levels:*** *\*\*P<.01.*

The ear diameter varied significantly (*P* < .01) across varieties, with Pannar 12 outperforming Kabamanoj F1 as indicated by an ear diameter of 51.70mm as oppose to 50.34mm respectively (Table 14).

**Table 14: Variation in ear diameter across varieties**

|  |  |
| --- | --- |
| **Varieties** | **Ear diameter (mm)** |
| Pannar 12 | 51.70 ± 0.95a |
| Kabamanoj F1 | 50.34 ± 0.65b |
| P-value | .002\*\* |

***NB:*** *Values that share the same superscript letter along the same column are not significantly different from each other. Significance levels: \*\*P<.01. Mean ± SD = Mean values ± Standard deviation of means*

*3.1.2.2 Ear length*

The main effects and the interaction effect of variety and plant density on ear length were not significant (*P* = .05) (Table 15).

**Table 15: Main and interaction effect of variety and plant density on the ear length**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | **Degrees of freedom** | **Sums of squares** | **Medium squares** | **F** | **P-value** |
| Variety (V) | 1 | 0.140 | 0.140 | 0.061 | .82 |
| Density (D) | 3 | 3.414 | 1.138 | 0.433 | .73 |
| V x D | 3 | 5.819 | 1.940 | 0.738 | .55 |

*3.1.2.3 Number of rows per cob*

The main effect of plant density and the interaction effect of variety and plant density on the number of rows per cob was significant (*P* = .05) while the main effect of variety on the number of rows per cob was not significant (*P* = .05) (Table 16).

**Table 16: Main and interaction effect of variety and plant density on the number of rows per cob**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | **Degrees of freedom** | **Sums of squares** | **Medium squares** | **F** | **P-value** |
| Variety (V) | 1 | 0.073 | 0.073 | 0.346 | .62 |
| Density (D) | 3 | 2.354 | 0.785 | 17.396 | <.001\*\*\* |
| V x D | 3 | 0.542 | 0.181 | 4.006 | .04\* |

*Significance levels: \*P<.05; \*\*\*P<.001*

Kabamanoj F1 significantly (*P* = .05) outperformed Pannar 12 at plant density D2 (80 cm x 20 cm) in terms of the number of rows per cob, with Kabamanoj F1recording an average of 14.44 rows per cob as oppose to an average of 13.41 rows per cob for Pannar 12 (Table 17).

**Table 17: Variation in the number of rows per cob for the variety x density interaction**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Varieties** | **Number of rows per cob** | | | |
| **D1** | **D2** | **D3** | **D4** |
| Pannar 12 | 13.50 ± 0.25bc | 13.83 ± 0.52 b | 13.50 ± 0.25bc | 13.33 ± 0.14c |
| Kabamanoj F1 | 13.33 ± 0.14c | 14.44 ± 0.16 a | 13.41 ± 0.14c | 13.41 ± 0.14c |
| P-value | .89 | .04\* | .90 | .97 |

***NB:*** *Values that share the same superscript letter along the same column are not significantly different from each other. Significance levels: \*P<.05. Mean ± SD = Mean values ± Standard deviation of means*

The number of rows per cob varied significantly (*P* < .001) across plant densities with the highest number of rows per cob recorded for D2 (80 cm x 20 cm) (14.13 rows per cob) and the lowest was recorded for D4 (80 cm x 40 cm) (13.37 rows per cob) (Table 18).

**Table 18: Variation in the number of rows per cob across plant densities**

|  |  |
| --- | --- |
| **Density** | **Number of rows per cob** |
| D1 | 13.41 ± 0.20b |
| D2 | 14.13 ± 0.47a |
| D3 | 13.45 ± 0.18b |
| D4 | 13.37 ± 0.13b |
| P-value | <.001\*\*\* |

***NB:*** *Values that share the same superscript letter along the same column are not significantly different from each other. Significance levels: \*\*\*P<.001. Mean ± SD = Mean values ± Standard deviation of means*

*3.1.2.4 1000-grain weight*

The main and interaction effects of variety and plant density were not significant (*P* = .05) on 1000-grain weight (Table 19).

**Table 19: Main and interaction effect of variety and plant density on 1000-grain weight**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | **Degrees of freedom** | **Sums of squares** | **Medium squares** | **F** | **P-value** |
| Variety (V) | 1 | 1683.0 | 1683.0 | 1.7418 | .32 |
| Density (D) | 3 | 2389.1 | 796.4 | 0.5089 | .68 |
| V x D | 3 | 9679.9 | 3226.6 | 2.0618 | .16 |

*3.1.2.5 Grain yield*

The main and interaction effects of variety and plant density were not significant (*P* = .05) on 1000-grain weight (Table 20).

**Table 20: Main and interaction effect of variety and plant density on grain yield**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | **Degrees of freedom** | **Sums of squares** | **Medium squares** | **F** | **P-value** |
| Variety (V) | 1 | 5.196 | 5.196 | 13.918 | .07 |
| Density (D) | 3 | 0.555 | 0.185 | 0.202 | .89 |
| V x D | 3 | 1.515 | 0.505 | 0.553 | .67 |

**3.1.3 Correlation between growth variables and yield**

Pearson’s correlation analysis results (Table 21) showed that yield had a significant (*P* < .01) moderate positive correlation with leaf length (r = 0.54), collar diameter (r = 0.56) and plant height (r = 0.55).

**Table 21: Pearson’s correlation coefficient for the correlation between growth parameters and yield**

|  |  |
| --- | --- |
| **Growth parameter** | **Correlation coefficient (r)** |
| Leaf width | 0.4 |
| Leaf length | 0.54\*\* |
| Collar diameter | 0.56\*\* |
| Plant height | 0.55\*\* |
| Number of leaves | 0.36 |

*Significance levels: \*\*P<.01*

**3.2 Discussion**

This study examined the effect of sowing density on the growth and yield of two hybrid maize varieties, Pannar 12 and Kabamanoj F1, in Dschang, West Cameroon. The findings revealed that plant density significantly influenced several growth and yield parameters, while variety played a more dominant role in determining yield components.

The results showed that sowing density significantly affected the number of leaves per plant at 42 days after sowing (P < 0.05). The highest number of leaves per plant was recorded at the 80 cm × 40 cm spacing for Pannar 12, whereas the lowest was observed at the 60 cm × 20 cm density for Kabamanoj F1. This suggests that lower densities provide more space and resources per plant, promoting better vegetative growth, a trend similarly observed by Kouassi et al. (2017) and Mahmudul et al. (2019).

Plant height, collar diameter, and leaf area were found to be significantly affected by variety but not by sowing density. Pannar 12 consistently outperformed Kabamanoj F1 in plant height and collar diameter across all growth stages. These findings are consistent with previous studies (Taffouo et al., 2008; Mauad et al., 2010), which suggest that genetic factors primarily determine maize growth, while sowing density plays a secondary role.

Yield components such as ear diameter, ear length, number of rows per cob, number of grains per row, grain weight per cob, and total grain yield per hectare were significantly influenced by variety, with Pannar 12 recording the highest values. The ear diameter of Pannar 12 was significantly larger (51.70 mm) than that of Kabamanoj F1 (50.34 mm). However, sowing density had a notable effect on the number of grains per row and grain weight per cob, with the highest values recorded at lower sowing densities. The total grain yield per hectare was highest at a sowing density of 62,500 plants/ha (80 cm × 40 cm), confirming that optimized plant spacing can enhance maize productivity. These results are in line with findings by Sai and Umesha (2022) and Essy et al. (2022), indicating that maize varieties exhibit differential responses to plant density based on their genetic makeup and resource allocation.

Correlation analysis revealed that leaf length, collar diameter, plant height, ear length, and number of grains per row were positively correlated with yield, with coefficients of r = 0.54\*\*, r = 0.56\*\*, r = 0.55\*\*, r = 0.57\*\*, and r = 0.59\*\*, respectively. These findings suggest that robust vegetative growth and enhanced reproductive structures contribute to higher grain yield and can serve as early indicators of yield potential. Similar correlations have been reported by Essy et al. (2022), reinforcing the importance of monitoring these parameters for yield prediction.

These findings emphasize the need for optimized agronomic practices in maize production. Farmers in Dschang should consider adopting the Pannar 12 variety due to its superior performance. The recommended sowing density for optimal growth and yield in this region is 80 cm × 40 cm (62,500 plants/ha). Further research should investigate how sowing density interacts with soil fertility and irrigation management to refine these recommendations (Konan et al., 2018).

4. Conclusion

This study assessed the influence of sowing density on the growth and yield of two hybrid maize varieties in Dschang, West Cameroon. The key findings are as follows: Sowing density significantly affected the number of leaves per plant, with lower densities favoring higher leaf numbers. Variety played a more significant role in determining plant height, collar diameter, ear diameter, ear length, and total grain yield, with Pannar 12 outperforming Kabamanoj F1 in these parameters. Sowing density influenced the number of grains per row, grain weight per cob, and total grain yield per hectare, with optimal yield recorded at 62,500 plants/ha (80 cm × 40 cm). Growth parameters such as leaf length, collar diameter, plant height, ear length, and number of grains per row were positively correlated with total yield, suggesting their potential use as early predictors of maize productivity. Based on these findings, Pannar 12 at a planting density of 80 cm × 40 cm (62,500 plants/ha) is recommended for maximizing maize yield in Dschang.

Disclaimer (Artificial intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Definitions, Acronyms, Abbreviations