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International Journal of Agricultural Science and Food Technology

LIFE SCIENCES GROUP

ISSN: 2455-815X DOI: https://dx.doi.org/10.17352/ijasft

Research Article

# Influence of intra-row spacing on improved maize variety at Dambi Dollo University Research Site, Western Ethiopia

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**Received:** 11 April, 2022
**Accepted:** 06 August, 2022
**Published:** 08 August, 2022

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**Keywords:** Hybrid maize; Intra-line spacing; Product and Product-related traits



## Abstract

Maize (Zea mays L.) is one of the greatest significant grain crops in Ethiopia which ranked second only next tef in local production. However, its production is limited due to incorrect line spaces between crops. Therefore, field research was conducted at Dambi Dollo University during the 2020/2021 growing season under irrigated conditions for the production and yield of hybrid maize (BH546) with the help of optimizing spaces between rows. The test is performed using a three-dimensional Random Block Design with three replication in a single-factor test having three different line spaces (20 cm, 30 cm and 40 cm). The highest values of total ears in each crop, length of the ears, total seed rows in each cob, seed in each cob, the weight of a thousand grains, seed yield, and the harvest index are recorded in wide spaces (40 cm). The performance of hybrid maize (BH546) and part of the crop, a wide range of 40 cm rows between crops can be recommended in the study area.

## Introduction

Maize (*Zea mays* L.) belongs to the Poaceae family (Gramineae) which is native to Mexico and Central America and has 20 chromosomes [1]. Maize is one of the most important cereal crops in the world ranked third in the total area coverage after wheat and rice [2]. In Africa, Ethiopia is the fourth major maize manufacturer and the first in the East African region in terms of production [3]. Due to its great request for cereals and great yields in each region [3]. Maize has grown rapidly and transformed production systems in Africa as a popular and widely grown food crop since it was introduced to the continent around 1500 A.D. and arrived in Ethiopia later, in the late 17th century [4]. In the country, maize is the largest grain crop in terms of product value and yield and secondly in terms of an acre near tef. In Ethiopia, the national average is 4.179 t ha-1 [5]. The major maize-producing regions in Ethiopia are Oromia, Amhara, and the Southern Nations Nationalities and Peoples 'Regional State (SNNPRS) [5].

A post-harvest crop production study for the 2019/20 season March revealed that at a national level, 17.68 hectares (approximately 2,274,305.93 hectares), were covered with maize and grain production was approximately 28.75 or 96, 357, 34.5 tons with an average yield of 4,237 tha-1 [6]. Even though the production potential of Ethiopia is favorable, the average national yield (4.179 t $ha^{-1}$) overall and regional yield (4.292 t $ha^{-1}$) are low [5] compared with the average yield of developed countries at about 6.2 t $ha^{-1}$ [7]. Poor maize production is caused by a number of factors such as poor agricultural practices such as poor seed quality, poor crop rotation, poor soil fertility, drought, pests, diseases, and weeds, farmers' inability to get fertilizer, low seed availability, Improved maize varieties [8].

Crop density is one of the factors that affect yields by influencing the yield components such as the number of ears, the number of grains in each ear, and the weight of the grain [9]. The use of incorrect line spaces by farmers results in lower yields compared to the research field of the country. This may be due to the use of narrow internal space leading



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to high competition leading to a decrease in nutrients and soil moisture prior to crop ripening and ultimately reducing yields. And the use of wide space between the maize crops may result in a greater number of ears per plant, more kernels per ear, cobs, and more grain per hectare but in most cases reduces the yield per hectare due to the small number of crops in each location.

Higher crop yields for higher grain yields in each region may differ from hybrid maize to other hybrids due to the important interaction between hybrids and congestion [10]. However, in Ethiopia, 44,444 (75 cm × 30 cm) maize plant population $ha^{-1}$ have been widely used over a long period of time without considering the many morphological differences between maize varieties and the presence of soil and climate change [11]. In addition, there is a lack of information on the number of plants and the separation of spaces between rows according to different conditions such as height and time of ripening variety, soil fertility status, etc. Most farmers in the study area use not recommended space between plants. This variation of spaces needs to be compared with the recommended 75 cm × 30 cm space with that of farmers.

Therefore, it is essential to identify the ideal space in the hybrid maize crop based on ecological conditions and agricultural management processes for increasing maize production in the study area. Thus, the experiment was done for the following purposes.

- To investigate the influence of variable spacing among plants on improved maize at Dambi Dollo University.
- Determining the optimum space between maize plants in the Dambi Dollo area.

# Materials and methods

## Description of the test area

A field trial was done at the Dambi Dollo research field at Efa Galano in Sayo District, Kellem Wollega Zone of the Oromia region, Ethiopia; between October-February under the growing conditions of 2020/21 under irrigation. The area is situated in the Kellem Wollega zone of the west part of Oromia, Ethiopia located at 652 km from Addis Ababa at altitudes of 1500 - 1740 meters above sea level. The area receives an annual rainfall of 850 to 1200 mm. The minimum and maximum temperatures of the area are 15 to 28 $^{o}c$ respectively. The soil of the study area was characterized as a sandy loam (Degefa, et al. 2021).

## Description of the experimental materials

BH-546 hybrid maize was used for the test. BH-546 is a medium-sized mature variety released by the Bako Agricultural Research Centre in 2013. This hybrid has the shape of small and set leaves that make it different from other hybrids. Urea (46% N) and NPS (19% N, 38% P2O5, and 7 % S,) were used as the source for N, P and S, respectively.

## Treatment and trial design

The field trial included three treatment combinations with 75 cm between rows, and three spacing lines between plants 40 cm, 30 cm, and 20 cm. The experiment is laid out in a randomized complete block design (RCBD) as a single factor test. The total rows in each plot were 6 and the data was taken from four plants in the middle of the net. The total area of plot size was 4.5 m × 2.4 m (10.8 $m^2$) and length of the line was 2.4 m and the width was 4.5 m. The area from which data were taken is 3 m × 1.6 m (4.8 $m^2$). Treatment was randomly assigned to a test unit independently for the three blocks (repetition). The total area of the test site was 15.5 × 8.2 = 127.1 $m^2$. The blocks and plots are spaced 1m and 0.5 m wide respectively. The number of plants per plot in 20 cm, 30 cm, and 40 cm between the rows of spaces was 12, 10 and 8 respectively.

## Trial procedures

The field was tilled three times by oxen in early September 2020. Planting is done by the end of September 2020. The total NPS (100 kg $ha^{-1}$) at a national rate recommended were drilled equally to total plots during sowing. 50kg $ha^{-1}$ of urea was applied during planting and the left dose of N fertilizer (50 kg $ha^{-1}$) was drilled after 35 days of planting. All agronomic practices were applied. Finally, crops in the middle region were collected at harvest time for analysis.

## Data collected

Data were collected at the site's total location. In this case, the test records were taken from ten randomly selected sample plants at the remaining site, and then an average of ten plants per site was taken.

## Yield and yield-related traits

**Total plant ears:** Were counted from ten plants randomly identified at harvest time and an average of ten plants was taken as a representative of total plant ears.

**Ear lengths:** Measured by cm from the base to the tip of the ear from the ears taken randomly from the net during harvesting. Ear lengths are measured after removing the husk cover and average values are calculated per plot.

**Total seed row per cob:** Row numbers are counted in ten randomly selected ears and average values are calculated per plot.

**Total seed in each row:** It was recorded by counting the number of seeds in each row of ten ears taken randomly during crop harvesting and averaging.

**One hundred grains weight:** Determined from 100 randomly drawn (by hand) calculations per piece and measured using a digital balance.

**Grain yield:** The total number of plants collected. After that, the grain was removed from the ears of each crop. Thereafter, the yield weight of the grain and moisture was quickly measured using an electronic balance and a moisture detector, respectively in each section.

**Yield index:** It is the ratio between average seed yield to biological yield expressed as a percentage.



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Harvest index (HI) = (Economic yield) / (Biological yield) * 100.

### Data analysis

All data taken were analyzed by analysis of variance (ANOVA) using the SAS software system [12]. Significant differences between treatments mean were compared with the LSD test at a 5% significance level [13].

## Results and discussion

### Yield and yield-related traits

**Total plant ears:** Variance analysis showed that the spacing between plants ($p < 0.01$) had an influence on total plant ears. The maximum ears in each plant (1.50) were obtained from (40 cm) spacing between plants and the minimum ears in each plant (1.08) were documented in the narrow row (20 cm) (Table 1). Increased plant space has resulted in a significant rise in total plant ears. Reducing ears in each plant due to crop diversity can lead to more arguments for available resources such as minerals, rainwater, sunlight, and air. Consistent with this result, Karasu [14] and Golla, et al. [15], reported that maximum ears in each plant's ears per crop were noted from the widest and lowest total crop ears were registered from closer space of the inner row.

### Ear length

Variation analysis showed that the significant effect of the spaces between the rows indicated a significant difference ($P < 0.05$) for the length of ears of the corn crop. The maximum length of the ear (20.59 cm) was recorded in the widest 30 cm lines, and the minimum ear lengths (15.67 cm) were achieved in the closer lines (20 cm) (Table 1). The reduction in ear length in a thin crop space may be a result of intense competition between crops and between diverse parts of the crops due to available resources (moisture, minerals, $O_2$, and sunlight). Inconsistent with the present outcome, Azam, et al. [16] and Golla, et al. [15], reported that the minimum length of the ear was achieved from a 20 cm line between crops.

### Total seed lines per ear

Total seed lines per ear were significantly influenced by the space between the inner lines. The maximum number of rows of the single ear (16.38) was recorded at a distance of 40 cm between plants, but statistically, it was 15.13 found with fewer than 30 cm between spaces between rows. The lowest number of kernel lines in each ear (15.80) was recorded from the space within the narrow row (20 cm) (Table 1). This can be due to the high demand among crops for available resources within a small space. Similar to these findings, Azam, et al. [16] and Golla, et al. [15] revealed that total seed lines per ear decrease as plant population density increases.

### Number of seeds in each ear

The results of the variance analysis indicated that the total seed in each ear was significantly influenced by the space between the lines. The highest number of seeds in each ear (593.2) was registered at 40 cm followed by 30 cm (583.8). The minimum kernel number in each ear (563.5) was harvested in the smallest space of the middle row (20 cm) (Table 1). The decline in the number of seeds in each ear in a small area between rows may be due to the competition of plants in dense vegetation houses leading to less nutrient uptake and grain growth. The result was consistent with the results of Azam, et al. [16], who stated that the seed yield of the maize crop declined by its nearness to its neighbors.

### 100 Seed weight

Hundred seed weight was highly influenced by the distance between crops. The highest one thousand grains weight (346.1g) was harvested when maize seeds were sown in a 40 cm seedbed, but statistically, the amount was 333.30 g found 30 cm between rows. The lowest grain weight (305.7 g) is produced in a very small plant area (20 cm) (Table 1). The decrease in grain weight by thousands of internal gaps may be due to strong demand for minerals while the separation of spaces between rows provides better crop use and integration of available resources with less competition; because of the production of a thousand grains of grain under a very wide vegetation space. This outcome is similar to the results of Khan, et al. [17].

### Grain yield

Variation analysis showed that the greater effect of the gaps between the rows had an influence on the seed yield of the hybrid maize variety. The main aim of crop cultivation is to increase the yield of the economy. The maximum seed yield (10224 kg ha$^{-1}$) was achieved from the (40 cm) distance between crops and a small yield of grain (8213 kg ha$^{-1}$) was obtained at a distance of 20 cm between rows. The decline in maize yields under limited space may be due to greater competition between maize crops through the use of available resources (nutrients and light) leading to reduced yields.

### Harvest index

The spacing between plants had a significant difference in yield index. The yield indexes were improved by increasing the spacing between the plants and the higher yield index (38.63%) was recorded at the widest spacing between the plants (40 cm) which was statistically similar to the space between the 30 cm lines with HI (36.88%). The lowest HI (33.51%) was obtained at a distance of 20 cm lines (Table 1). This reduction in the yield index is due to the small space between the crop densities that

**Table 1:** Influence of different plant spacing among crops on yield and yield components of maize during 2020/2021 growing season.

| Treatment SBP (cm) | TPE | LoE (cm) | SRPE | SPC | HSW (g) | GY(kg ha$^{-1}$) | HI (%) |
|---|---|---|---|---|---|---|---|
| 20 | 1.08$^{b}$ | 15.67$^{b}$ | 15.80$^{c}$ | 563.5$^{c}$ | 305.7$^{c}$ | 8213$^{c}$ | 33.51$^{b}$ |
| 30 | 1.37$^{a}$ | 20.59$^{a}$ | 16.12$^{b}$ | 583.8$^{b}$ | 333.3$^{b}$ | 9545$^{b}$ | 36.88$^{a}$ |
| 40 | 1.50$^{a}$ | 17.44$^{b}$ | 16.38$^{a}$ | 593.2$^{a}$ | 346.1$^{a}$ | 10224$^{a}$ | 38.63$^{a}$ |
| LSD (0.05) | 0.14 | 0.26 | 0.20 | 4.73 | 7.74 | 33.2 | 2.4 |
| CV (%) | 4.7 | 2.26 | 6.1 | 2.4 | 1.5 | 5.27 | 2.9 |

Where, SBP: Space Between Plants; TPE: Total Plant Ears; LOF: length of the Ear; SRPE: Seed Rows Per Ear; SPC: Seed Per Cob; HSW: Hundred Seed Weight; SY: Seed Yield; HI: Harvest Index; SBP: Spacing Between Plants



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enhance the demand for sunlight so that the crop can grow faster in length and partition the stored food for stem parts of the crop which has led to a decrease in grain rate completely stored food. This outcome agrees with *Arif*, et al. [18].

## Conclusion and recommendation

From the current investigation, it is possible to conclude that the distance among plants influenced yields and the parameters associated with the hybrid maize yield. Total ear in each crop, length of ear, cob lines, cob seed, the weight of 100 grains, seed yield, and yield index of hybrid maize yields were significantly affected by the spacing between plants. Among the three different spaced spaces between hybrid maize, the wide intra-spacing (40 cm) recorded the maximum number of ears per crop, the length of the ear, cob lines, cob seed the number of the grain per ear, thousand weight of the grain, the grain yield. and yield index. A small ear per crop, ear lengths, cob seed, grain row per cob, 1,000 grains mass, seed yield, and crop index were found in small spacing (20 cm). Depending on the outcomes gained from this test, hybrid maize BH-546 provides high productivity when the hybrid was planted with 40 cm between rows. Therefore spacing between plants (40 cm) is recommended for the maximum yield of BH-546 hybrid maize in the study area.

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