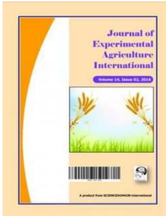

Journal of Experimental Agriculture International

20(1): 1-10, 2018; Article no.JEAI.37096
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Yield Response of Maize *(Zea mays* L.*)* Varieties to Row Spacing Under Irrigation at Geleko, Ofa Woreda, Wolaita Zone, Southern Ethiopia

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Authors' contributions

This work was carried out in collaboration between all authors. Author EE designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author DS edited the manuscript and managed the literature searches. Author DD managed the analyses of the study. Author DD managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2018/37096
Editor(s):
(1) Anita Biesiada, Professor, Department of Horticulture, Wroclaw University of Environmental and Life Sciences, Poland.
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(1) Adalberto Di Benedetto, Buenos Aires University, Argentina.
(2) Raúl Leonel Grijalva Contreras, National Institute of Agricultural and Livestock Forestry Research, México.
Complete Peer review History: http://www.sciencedomain.org/review-history/22788

Short Communication

Received 30th September 2017
Accepted 27th December 2017
Published 19th January 2018

ABSTRACT

A field study was conducted at Ofa district-Geleko irrigation site during the off-season of 2016/17 cropping season with the objective of evaluating different varieties and row spacing on growth, yield and yield components of maize. Four plant row spacing (45 cm, 55 cm, 65 cm and 75 cm) and three maize varieties ('BH-540', Lemu'P3812W'and Jabi 'PHB 3253') were tested in factorial arrangement laid out in RCBD replicated three times. Data on yield and yield components of the crop were recorded. The result indicated that most of the parameters such as number of ears per plant, ear diameter, 1000 kernel weight, number of kernels per ear, number of kernels per rows, grain yield per hectar were significantly influenced by the interaction effect of row spacing and varieties.

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Significantly highest grain yield were produced by maize variety Lemu grown at row spacing of 65 cm, which is statistically similar with variety BH-540 grown at row spacing of 65 and 75 cm and also the same variety grown at row spacing of 75 cm, while lowest was recorded for variety Jabi grown at row spacing of 45 cm. Based on these results, it can be concluded that under irrigated condition Lemu and BH-540 maize varieties at 65-75 cm row spacing resulted higher biomass and grain yield of maize and may be used by farmers of the area. However, since the study was at only one location and for single cropping season repeating the experiment across different locations and years is needed to reach at conclusive recommendations.

Keywords: Interaction; growth parameters; row spacing; varieties; yield and yield components.

1. INTRODUCTION

Maize (*Zea mays* L.) is a member of the grass family, Poaceae. It is believed that maize was originated in Mexico and introduced to West Africa in the early 1500s by the Portuguese traders [1]. Currently maize is widely grown in most parts of the world over a wide range of environmental conditions ranging between 50º latitude north and south of the equator [1]. It was brought to Ethiopia in the 1600s to 1700 s [2].

Maize has a wide range of adaptation, and is an important cereal crop in Ethiopia as a source of both food and cash. The bulk of the production of maize comes from Oromia, Amahara and Southern Nations Nationalities and Peoples' Regional State (SNNPRS) in descending order [3]. In area coverage on a national basis, it stands second to teff (*Eragrostis tef*). In production, it is the foremost important crop in both the country and the region. As a result, the Ethiopian government has been giving due emphasis to the promotion of the crop [4].

As compared to other cereals, maize can attain the highest potential yield per unit area. World average yield for maize is about 4.5 t ha^{-1} and that of developed countries is 6.2 t ha^{-1}. The average yield in developing countries is 2.5t ha^{-1} [5]. The national production of maize in Ethiopia is estimated at 2,069,267.23 ha with a total production of 6673386.82 t and average productivity of 3.2 t ha^{-1} [3].

Low yield of maize in Ethiopia is attributed to several production constraints which include unchecked improved varieties for the agro-ecological zones, poor cultural practices such as lack of improved maize varieties, untimely and inappropriate field operations, inappropriate plant density, weed infestation, low soil fertility, water stress, diseases and insect pests [6].

Wolaita zone is one of the most important maize producing zones in SNNPR State. In this zone, 61,293.533 t of maize was produced on 20363.3 ha of land in 2015 cropping season with average productivity of 3.01 t ha^{-1} and 181873 smallholders were involved in maize production [3], whereas in Ofa district (where this study was conducted) cereals accounted for 52% of the area for food crops and maize accounts for 30.5% of the area allocated for cereals and about 7,368.1 t of maize grain yield was produced on 2,532 ha with productivity of 2.91 t ha^{-1} (Ofa Woreda Office of Agriculture, unpublished data),where as 8 to 10 t ha^{-1} and 5.0-6.5 t ha^{-1} of yield were reported for improved maize varieties at research and farmers field , respectively [7].

The great majority of small holder farmers in Ethiopia are aware of the benefits of adopting input technologies to enhance their maize productivity [4]. However, this awareness is mainly about some improved varieties, Urea and Diammonium phosphate (DAP), while knowledge about recommended varieties for agroecologey and agronomic packages like optimum row spacing are almost not sufficient. Similarly, there is much room for improvement in getting farmers to adopt and implement the recommended package of agronomic management methods including proper land preparation, row planting, time and frequency of weeding and proper time of harvesting [4].

From wide perspective, perhaps no other factor causes greater yield losses in crops than lack of water. Severe water stress results in death of plants while its stress leads to reduced yields [7]. Therefore, irrigation is increasingly important in the semi-arid parts of the world and has become an important topic of discussion with respect to crop production in Ethiopia [8]. Erratic and unreliable rainfall has initiated the rapid increase of irrigation practices as alternate means of crop production [9]. In order to achieve sustainable crop production, matching current irrigation practices with management operations targeted with efficient water use is of paramount importance. Adjusting cultural practices such as row spacing on the basis of crop response in terms of increased plant growth is an opportunity to improve water use efficiency [10]. Optimizing row spacing is crucial in areas where crop growth is constrained by precipitation or a shortage of irrigation water. Thus, low row spacing may deplete most of available water before a crop reaches maturity while high row spacing may leave water unutilized in the soil [11].

The recommended maize row spacing differs from varieties to varieties depending on plant height and maturity. Most farmers in Offa district have been using their own row spacing and agronomic practices rather than the recommended spacing's (80x50 cm, 75x30 cm, 75x25 cm and 75 x 20 cm) most of them use from 40 to 50 cm row spacing even for tall and late maturing varieties(personal observation). This variation in row spacing needs to be compared with the recommended spacing of 75 x 30 cm. Ofa is one of the densely populated districts in Wolaita zone of Southern Ethiopia. The farmers of the district have been practicing intensive agricultural system because they have extremely land shortage problem. To sustain this increased population, it is only wise to increase the productivity of the available farmland. Most of the maize producing farmers in Ofa district did not accept the national recommendation and they have been using narrower row spacing (40 to 50 cm) without research recommendations. Some of the farmers were saying that the national maize spacing is so wide that it did not give higher yield. Moreover, they claim that compromising the land shortage with narrower row spacing may result in more yields (Personal communication with farmers of Ofa District).

Bayu et al. [12] indicated that agronomic practices such as row spacing and varieties are observed to affect crop environment, which influences the yield and yield components of maize. Thus, significantly highest number of seeds per row, kernels per ear and ear length were recorded at row spacing of 90 cm with variety BH-540 while lowest at row spacing of 55 cm with the same variety.

According to Gonzalo et al. [13] in Kombolcha, Eastern Ethiopia the highest mean grain yield per plant (188.5 g) was obtained at 30 cm x 85 cm, but was not statistically different from 25 cm x 85 cm, 30 cm x 75 cm, and 25 cm x 65 cm spacing's. Moreover, the lowest grain yield per plant (112.5 g) was recorded at the narrow spacing combination of 20 cm x 45 cm in maize cultivar. However, information on the performance of modern hybrids maize varieties under different row spacing under irrigation is scanty for maize production in the study area. Further, in spite of the importance of the problem, systematic research has not been done on appropriate row spacing with ideal maize variety in the study area. Therefore, the objective of this study was:-

- To evaluate the effect of different varieties and row spacing on yield and yield components of maize under irrigation in the study area.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Field experiment was conducted during 2016/17 off cropping season with irrigation at Geleko of Ofa woreda Wolaita zone, Southern region. Geographically the experimental site is located at 07º 73' N latitude, 45º 33' E longitudes and at an altitude of 1450 meter above sea level. The average annual rainfall of the area is 1000 mm and the average minimum and maximum temperatures 14 and 28ºC, respectively (Ofa District Agricultural Office 2016 unpublished report). The rainfall has a bimodal distribution patter with two distinct main rainy seasons belg (from March up to August) and Meher (from April to February).

2.2 Experimental Materials, Treatments and Experimental Design

The maize varieties named 'BH-540', Lemu (P3812W) and Jabi (PHB 3253) were used for the study. The varieties were known to perform well in agro-ecology similar to the study area due to their high yield, moderately tolerant to disease and drought. Treatments consisted of three maize varieties ('BH-540', 'PHB3253' and 'P3812W') and four row spacings (45, 55, 65 and 75 cm) were combined in factorial and laid out in randomized complete block design (RCBD) with three replications. The block was separated by a 1.5 m wide space and each plot was separated by 0.5 m space. Each treatment was randomly assigned to the experimental unit within a block. The description of maize varieties used for the trial shown in Table 1.

2.3 Experimental Material Used (Maize Varieties)

Three released maize varieties, namely BH-540, Jabi (PHB 3253) and Lemu (P3812) were used for this study. The varieties were known to perform well in agro-ecology similar to the study area due to their high yield, moderately tolerant to disease and drought. BH-540 (3812) is adapted to low mid altitude ranging from 1000 to 2000 m.a.s.l. The variety has a yield potential of 8.0-10 t ha^{-1} and 5.0-6.5 t ha^{-1} on research and farmers field respectively [7]. P3812W is adapted to grow in agro-ecologies having an altitude range of 1200-2000 m.a.s.l with rainfall range of 1000-1200 mm. It can give 8.0-10.0 ton ha^{-1} on-station, while 6.5-7.5 ton ha^{-1} grain yields on-farm experiments. It is moderately tolerant to disease and lodging with plant height of 235-245 cm [6]. Jabi is well adapted to agro-ecologies with an altitude below 1900 m.a.s.l with rainfall range of 600-1000 mm. It can give 8.0-9.0 ton ha^{-1} and 5.5-6.5 ton ha^{-1} grain yields under on-station and on-farm experiments, respectively. It is moderately tolerant to disease and lodging [6]. The three varieties are medium maturing (145 days).

2.4 Agronomic Practices

The first, second and third ploughings was done in mid September, October and November 2016, respectively, using a pair of oxen and the maize seed was sown on November 2016. Two seeds were planted per hill and later on seedlings were thinned to one plant per hill. Hundred kg/ha of NPS (19N- $38P_20_5$- $7S0_4$) and 100 kg of urea (46 kg N) were applied, which is the national blanket recommendation for Wolaita zone [4]. All the NPS was applied at planting, while urea was applied in two splits (half at planting and the remaining half at knee height). All crop management practices such as cultivation, weeding etc., carried out as desired. Diseases and insect pests were visually monitored during the crop growing season. Irrigation water was obtained from nearby river through motorized pump. The trial was irrigated with furrow method of irrigation at weakly interval at different growth stage. Consequently, irrigations water was applied three times at germination and, vegetative phase, while at flowering and maturity phase irrigation water was applied four and two times, respectively as recommended for maize production in Ethiopian [7].

2.5 Data Collection and Measurements

2.5.1 Soil data sampling and analysis

Soil samples were taken randomly to depth of 0–30 cm from 10 spots of the experimental field before planting. The collected soil sample was composited to one sample, bagged and transported to Wolaita sodo soil testing laboratory. Then the composite soil sample were air dried and analyzed for the determination of soil texture, soil pH, organic matter content, total nitrogen, available phosphorus and cation exchange capacity (CEC).

The soil particle size distribution (soil texture) was determined by using Bouyoucos hydrometer method [14]. The soil pH was measured with standard glass electrode pH meter [15]. The Walkley and Black [16] method was used to determine the organic carbon content. Soil organic matter was obtained by multiplying percent organic carbon by a conversion factor of 1.724. The total nitrogen content of the sample soil was determined following Kjeldahl digestion, distillation and titration procedure as described by Jackson [17]. The cation exchange capacity was determined by Chapman [18] method and the available phosphorus was determined by Olsen et al. [19] method.

2.5.2 Crop data

Number of ears per plant was estimated by dividing the number of ears by number of plants per net plot area at harvest, while ear length was measured as the total length from the base to the tip where kernels were present in the ear from six ears. On the other hand, ear diameter was from six randomly taken ears as the average thickness of the ear at the middle of the ear.

Number of kernels per ear was recorded from ten randomly taken ears from net plot area and the result of each ear will be summed and divided by the number of sampled ears to know the number of the kernels per ear. Similarly, number of rows per ear and number of kernels per row were counted from five randomly selected plants at harvesting. Thousand kernel weights was determined by counting the number of kernels using electronic seed counter from a bulk of shelled seed and weighing it using sensitive balance from a plot at harvest after adjusting to 12.5% moisture content. Grain yield was determined from the net harvestable area and adjusted to 12.5% moisture content level and the result was converted to tons per hectare basis.

2.6 Statistical Data Analysis

All the collected data were subjected to analysis of variance using General Linear Model (GLM) procedure using the SAS package [20]. The differences between treatment means was compared using Least Significant Difference (LSD) test at 5% level of significance when the ANOVA showed the presence of significant difference. Descriptive statics *i,e* percentage was used to analyze farmers response and evaluation.

3. RESULTS AND DISCUSSION

3.1 Physico-Chemical Properties of Experimental Soil

The result of the laboratory analysis for the physical and chemical properties of the soil revealed the soil of the study area has particle size distribution of 70% sand, 22% silt and 8% clay. The soil of the study site was classified as sandy loam according to soil textural triangle. Further, the chemical analysis of the experimental soil showed pH of 6.1, available phosphorus of 0.76 mg/kg, CEC of 18.04 Cmol (+)/kg), organic carbon of 1.95%, and total nitrogen of 0.17%. According to the ratings of Tisdale et al. [21] the soil of the study site is likely acidic. Further, based on the classification made by different researchers the soil of the study site also classified as low in available P [22], total N and organic carbon [23]. The CEC of the soil is also classified as medium [23].

4. EFFECT ON YIELD COMPONENTS OF MAIZE

4.1 Number of Ears Per Plant

There was highly significant (*P<0.01*) difference in number of ears per plant due to interaction between variety and row spacing. The maximum number of ears plant^{-1} (1.57) was produced under 65 cm row spacing by variety Limu, whereas the lowest number (1.0) of ears per plant was produced by variety Jabi grown at row spacing of 45 and 55 cm and by variety BH-540 grown at row spacing of 45 cm (Table 1). On the other hand, the number of ears per plant was statistically the same for maize varieties Lemu and BH-540 grown grown at row spacing of 65 and 75 cm. The lowest number of ears per plant under narrower row spacing could be due to increased intra specific competition, which eventually caused reduction in number of ears per plant. The maximum number of ears per plant recorded under wider row spacing might be ascribed to reduction in competition, higher net assimilation rate and partitioning, which is necessary for healthy plant growth and high seed production. In agreement with this result, Ahamed et al. [24] recorded that the highest number of ears per plant in maize crop sown in 75 cm spaced rows than crops grown at 55 cm and 45 cm. This result was disagreement with that of Raouf et al. [25], who reported that row spacing and maize varieties had no significant variation with respect to number of ears per plant.

4.2 Ear Length and Ear Diameter

Significant (*P<0.01*) difference was observed for ear length and ear diameter due to the interaction effect of varieties and row spacing's. The highest ear length (33.84 cm) was recorded for variety Jabi at row spacing of 75 cm, while the lowest (30.03 cm) ear length was recorded for variety at row spacing of 45 cm. Similarly, the highest ear diameter (33 cm) was recorded for variety Lemu at row spacing of 65 cm, while the lowest (25 cm) ear diameter was recorded for variety Jabi at row spacing of 45 cm (Table 1). Reduction of ear length and diameter with narrower row spacing is attributed to limitation of assimilates as a result of low photosynthetic processes of leaves at narrow row spacing due to less availability of growth influencing factors and genetic variation among the varieties, which resulted in high or low ear length and diameter. This result is in line with the findings of Abuzar et al. [26], where they reported significant differences among the varieties of maize for ear length and ear diameter.

4.3 Number of Kernels Per Ear

The results revealed that number of kernels per ear showed highly significant (*P<0.01*) difference due to interaction between variety and row spacing. Over all, increasing the row spacing increased the number of kernels per ear for the respective varieties of maize. The variety 'Lemu' gave the highest (744.33) number of kernels per ear at row spacing of 75 cm, while variety 'BH-540' produced the lowest (436) number of kernels at row spacing of 45 cm (Table 1). Number of kernels per ear was statistically the same for Jabi and BH-540 maize varieties grown at 65 and 75 cm row spacing. This variation might be due to the fact that widely spaced plants encountered less intra plant competition than closely spaced plants and thus exhibited better growth that contributed to more number of kernels per ear. Similar results were reported by Arif et al. [27], who reported that number of kernels per ear increased with increase in row spacing of maize. This is also in agreement with finding of Ahamed et al. [24], who reported that the number of kernels per ear increased with wider row spacing. In their finding, they reported maximum (391.8) number of kernels per ear at plant density of 8 plants per square meter and minimum (354.2) was recorded at density of 12 plants per square meter.

4.4 Number of Kernel Rows Per Ear

Kernel rows per ear showed statistically highly significant (*P<0.01*) difference as a result of an interaction effect of varieties and row spacing. All the varieties responded differently and significantly to the row spacing. The variety Lemu produced the highest kernel rows per ear (16.34) at 75 cm row spacing, variety Jabi showed significant increase in number of kernel rows per cob as the plant row spacing increased from 45 cm to 75 cm with significant difference between row spacing's. The BH-540 maize variety produced the lowest number of kernel rows per ear (12) at row spacing of of 45 cm (Table 1). Decreasing row spacing led to reduction in number of seeds per row due to increased interplant competition and mutual shading of lower leaves where light could not penetrate throughout and distribute to all leaves for efficient photosynthesis.

Similar result was reported by Abdulatif [28], who observed significant variation at row spacing and maize varieties on number of kernel rows per ear. In this experiment the highest number of kernel rows per ear is of a choice, the association of variety Lemu with row spacing of 75 and 65 cm appeared to be promising under irrigation conditions.

4.5 Number of Kernels per Row

The interaction of plant row spacing and varieties revealed highly significant (*P<0.01*) effect on number of kernels per row. The interaction effect showed consistent increment of kernels per row with increasing row spacing for all maize varieties. The interaction result indicated that the highest mean number of kernels per row (51.67) was observed from the row spacing of 75 cm Lemu maize Varity, which was statistically at per with Lemu maize variety at 65 cm and 65 cm and 75 cm of BH-540, while lowest mean number (36.34) at 45 cm by BH-540 maize Varity, which was statistically similar to other varieties at 45 and 55 cm row spacings (Table 1). Decreasing row spacing led to reduction in number of seeds per row due to increased interplant competition and mutual shading of lower leaves where light could not penetrate throughout and distribute to all leaves for efficient photosynthesis. Sabri et al. [29] also reported that the kernels number per row increased by about 4% when row spacing increased from 55 cm to 85 cm and 6% as nitrogen increased from 0 to 250 kg N ha^{-1} in maize cultivar.

4.6 Thousand Kernels Weight

The result indicated that thousand kernel weight was affected to a large extent by the interaction effect of row spacing and varieties. The interaction effect on thousand kernels weight was consistence for all maize varieties with increasing row spacing. The highest weight of 1000 kernels (456.33 g) was obtained from variety 'Lemu', with row spacing of 75 cm while the lowest (297.1.3 g) was obtained from the variety 'Lemu with row spacing of 45 cm (Table 1). This result shows that the variety 'Lemu' had more efficiency to convert the solar radiation and other resources to economic yield than other varieties at higher row spacing's (65 cm and 75 cm).

In addition, wider spaced plants, that improved the supply of assimilates to be stored in the kernel hence, the weight of thousand kernel increased. The present result was in line with that of Mahmood et al. [30], who reported that row spacing of 75 cm produced significantly higher 1000 kernels weight than 55 cm row spacing in maize. This result is also in conformity with the findings of Gozubenli et al. [31], who reported varietal differences among different maize cultivars and row spacing in 1000 grain weight.

The kernel weight was declined from 456.33 g to 297.1 g as plant row spacing decreased from (75 cm) to (45 cm) (Table 1). The increase in kernel weight at wider row spacing might be due to availability of more resources for comparatively less number of plants, which they

Table 1. Interaction effect of varieties and plant row spacing's on yield components of maize at Geleko in 2016/17 cropping season

Maize variety	RS (cm)	NEP	Ear length	ED	NKE	NKRE	NKR	TKW	GY (ton ha^{-1})
BH-540	45	1^{f}	31.06^{cde}	22.5^{f}	436^{e}	12f	36.34^{c}	306.67^{cd}	4.46^{e}
	55	1.05^{def}	31.07^{cde}	23.84^{def}	514.3^{c}	13.34de	38.68^{c}	309.67^{cd}	6.43^{c}
	65	1.28^{b}	32.01^{abcd}	25.5^{b}	640^{b}	14.67^{b}	46.67^{ab}	418.67^{b}	8.68^{a}
	75	1.27^{b}	32.04^{abcd}	25.0^{bc}	621.67^{b}	14.34^{bc}	48^{a}	428^{ab}	8.64^{a}
Lemu (P3812W)	45	1.02^{ef}	30.44^{de}	22.67^{ef}	455.3^{de}	12.34^{f}	37^{c}	297.1^{d}	5.58^{d}
	55	1.08^{cde}	30.85^{dc}	24.67^{bcd}	509^{c}	13.67^{cd}	37.34^{c}	328.7^{cd}	6.97^{b}
	65	1.57^{a}	33.39^{ab}	28.0^{a}	722.33^{a}	15.67^{a}	51^{ab}	452.13^{ab}	8.96^{a}
	75	1.5^{a}	33.22^{ab}	27.34^{a}	744.33^{a}	16.34^{a}	51.67^{a}	456.33^{a}	8.93^{a}
Jabi (PHB3253)	45	1^{f}	30.03^{e}	20.0^{g}	466cd^{e}	12.34^{f}	37^{c}	337.3^{c}	4.79^{e}
	55	1^{f}	31.74^{bcde}	21.0^{g}	489.67^{cd}	12.67^{ef}	46^{b}	340.33^{c}	4.94^{e}
	65	1.14^{c}	32.75^{abc}	23.34^{def}	659^{b}	14.34^{bc}	46^{b}	425^{ab}	7.16^{b}
	75	1.12$_{dc}$	33.84^{a}	24.0^{cde}	688.67^{b}	14.34^{bc}	46.67^{ab}	426.33^{ab}	7.17^{b}
LSD (5%)		0.081	1.87	1.39	50.29	0.93	5.42	34.21	526.46
CV (%)		4.16	3.48	2.84	2.48	3.99	7.5	5.38	4.54

LSD = Least Significant Difference at 5% level; CV= Coefficient of Variation. Means in column and row followed by the same letter(s) are not significantly different at 5% level of significance RS= Row spacing; NEP= Number of ears per plant; ED= Ear diameter; NKE= Number of Kernels per Ear; NKRE= Number of Kernel Rows per Ear; NKR = Number of Kernels per Row; TKW = Thousand kernel weight;GY =Grain-yield

utilized efficiently. The lowest kernel weight in narrower row spacing is probably due to less availability of growth resources needed for grain development on relation of high inter-specific competition, which resulted in low rate of photosynthesis and high rate of respiration as a result of mutual shading. Similar to this result, Abuzar et al. [26] reported that plant spacing had significant effect on 1000 kernel weight of maize where they reported maximum (350 g) kernel weight in (60 x30 cm) plant spacing and the minimum (166.7g) 1000 kernel weight in (45 x 25 cm)plant spacing.

4.7 Effect of Varieties and Row Spacing on Yield of Maize

Grain yield was affected highly (*P<0.01*) and significantly due to interactions between varieties and row spacings. The variety 'Lemu' produced the maximum (8.96 t ha^{-1}) grain yield at 65 cm row spacing, while variety 'BH-540' produced the lowest (4.46 t ha^{-1}) grain yield at 45 cm row spacing (Table 1). This might be because of the varietal difference among varieties. The maximum yield was statistically at par with Lemu at 65 cm and BH-540 at 65 and 75 cm row spacing; which might be due to the fact that more photo-assimilates were directed to the production of seed than vegetative parts. The highest grain yield, which was obtained from the variety 'Lemu', might also be attributed to the highest 1000 kernel weight recorded for this variety. The yield reduction at the lowest row spacing (45 cm) for all the varieties might be due to intense interplant competition for resources, such as nutrients, water and solar radiation as manifested by high plant mortality at the highest plant density or low plant row spacing.

In agreement with this result, Maqsood et al. [32] reported that there was higher grain yield of maize (6.6 t ha^{-1}) at wider spacing of 60 cm x 25 cm against the lower grain yield (3.28 t ha^{-1}) at narrow spacing of 50 cm x 15 cm. Similarly, wider spacing combinations had significant effect on maize grain yield and the highest grain yield was obtained from 65 cm x 20 cm than 25 cm x 45 cm spacing [33]. Moreover, Mahmood et al. [30] reported that narrower spacing of 60 cm x 20 cm produced lower grain yield of maize (4.30 t ha^{-1}), while spacing of 60 cm x 30 cm produced 5.1 t ha^{-1}.

The reason for deviation of this linearity in case of grain yield per unit area is that the yield does not solely depend on the performance of individual plants, but is also dependent on total number of plants per unit area and yield related parameters. This study revealed that a plant row spacing of 65 cm by Lemu maize variety would be the optimum for maximum grain production for the row spacing and varieties tested. Akbar et al. [34] reported that optimum plant spacing produced greater yield due to utilization of available soil nutrients more efficiently coupled with other growth factors. They also observed lowest grain yield with narrower row spacing;

because of smaller ear size, less number of ears per plant due to more competition for growth factors. Porter et al. [35] suggested that plant distribution was a yield limiting factor when other [34] limiting factors, such as nutrient deficiencies, were eliminated.

5. CONCLUSION

The results of the present study indicated that varieties and row spacing had a significant influence on most of the yield and yield attributing traits of maize. The results have shown that significantly highest number of kernel per row, number of ear per plant, kernels per ear, ear diameter, ear length and thousand kernel weight were recorded for varieties Lemu at row spacing of 65 cm followed by BH-540 at row spacings of 75 cm. Similarly, significantly highest grain yield was produced by maize variety Lemu grown at row spacing of 65 cm, which is also statistically similar with variety BH-540 grown at row spacing of 65 and 75 cm.

In general, the result of this study had shown production of maize varieties (Lemu and BH-540) at row spacing of 65-75 cm can increase grain yield of maize per unit area of land. Therefore, from this finding, it can be tentatively concluded that under irrigated condition Lemu and BH-540 maize varieties at 65-75 cm row spacing can result in higher grain yield of maize and may be used by farmers of the area. However, this tentative generalization is based only in one season and one location experimental results. Hence, repeating the experiment with more potential maize varieties in different seasons and across different locations is imperative to obtain reliable information and research outcome.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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