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Growth and Phenological Response of Maize (Zea Mays L) Varieties to Row Spacing Under Irrigation at Geleko, of a Woreda, Wolaita Zone, Southern Ethiopia

Dereje Shanka

Department of Plant Science, Wolaita-Sodo University, Wolaita-Sodo, Ethiopia

***Corresponding Author:** Department of Plant Science, Wolaita-Sodo University, Wolaita-Sodo, Ethiopia, Email: drjshanka2011l@gmail.com*

ABSTRACT

Maize is among the most important cereal crops in Ethiopia in general and in the study area in particular. However, the yield of the crop is low due to lack of recommendation on appropriate plant row spacing and use of local cultivars. A field study was conducted at Ofa district-Geleko irrigation site during the off-season of 2016/17 cropping season with the objectives 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 by three replications. Data on phonology, and growth of the crop were recorded. The result indicated that most of the parameters such as days to 50% tasling, days to 50% silking, anthesis silking interval, days to maturity, leaf area index were significantly influenced by the interaction effect of row spacing and varieties. Hence, maize variety Jabi at row spacing of 65 cm found to be early maturing. Further, variety Lemu at row spacing of 45 cm produced highest leaf area index. Based on these results, it can be concluded that under irrigated condition Jabi maize variety at 65 cm row spacing showed growth performance and can be recommended for the farmers in the study area. However, since the study was only at one location for single cropping season and should be repeated at diverse locations and years to reach at conclusive recommendations.

Keywords: *Interaction, Growth parameters, Row spacing, Varieties, leaf area index*

INTRODUCTION

Maize is a major crop in Ethiopia in production, consumption and income generation for both resource constrained men and women. In Ethiopia, currently maize grows in all parts of the country with major production in western, south-western, southern regions and eastern highland of Hararghe. It grows from moisture stress to high rainfall areas and from lowland to the highland areas (Mosisa et al. 2001). Accordingly at national level the area allocated for maize production is estimated at 2,069,267.23 ha of land with annual production of 6673386.82 tons (CSA 2015).

Maize is used as food for human, feed for livestock and raw material for industrial purposes (Dowswell et al. 1996). Millions of people depend on maize for their daily food in sub-Saharan Africa. In Ethiopia, maize is staple food and one of the main sources of calorie in the major maize producing regions (Kebede et al. 1993).

Despite of the importance of the crop in the country in general and in the study area in particular, the average productivity (3.2 tons ha^{-1}) of the crop in the country (CSA 2015) is far below the world average yield for maize, which is 4.5 tons ha^{-1} (FAOSTAT 2015). The average yield in developing countries is 2.5 tons ha^{-1}. The productivity of maize to be highly affected by agronomic practices like variety selection, row spacing and time of sowing, in addition to biotic and abiotic factors (Anderson et al. 2004).

Maize is more affected by variation in row spacing than any other member of the grass family (Vega et al. 2001). Maize differs in its responses to row spacing. Luque et al. (2006) reported that maize yield differs significantly under varying row spacing levels due to difference in genetic potential. Correspondingly, maize also responds differently in quality parameters like crude starch, protein and oil contents in grains (Munamava et al. 2006). Row spacing affect most growth parameters of maize even under optimal growth conditions and therefore it is considered a major factor determining the degree of competition between plants (Sangakkara et al. 2004). The grain yield per plant is decreased in response to decreasing light and other environmental resources available to each plant (Ali et al. 2003; Luque et al. 2006).

Among agronomic practices, inter row spacing has a special significance since it affects root development, plant growth and fruiting (Davi et al. 1995). Generally, the most appropriate spacing is one which enables the plants to make the best use of the conditions at their disposal (Lawson and Topham 1985; Malik et al. 1993).

The optimum row spacing of maize cultivars varies with environmental factors, such as soil fertility, moisture supply, genotype, planting pattern, plant population and harvest time (Gonzelo et al. 2006). The architecture of maize has been changed to favor plants with more erect leaves (Duvick, 1984). Currently grown maize hybrids have more erect leaves, often withstand environmental stresses better and are grown at high plant populations in an attempt to intercept more solar radiation (Tollenar, 1991). At narrower row spacing, many modern maize hybrids do not tiller effectively and quite often produce only one ear per plant. Therefore, maize does not share the trait of most tillering grasses of compensating for low leaf area and small number of reproductive units by branching (Gardner et al. 1985). On the other hand, the use of high populations heightens interplant competition for light, water and nutrients (Sangoi and Salvador, 1998).

Different workers have reported that growth parameters of maize responded to row spacings. Ahamed et al. (2006) reported higher leaf area index (LAI) of maize (6.45) under narrower row spacing (55 cm) unlike at wider row spacing (75 cm). Yousaf et al. (2007) reported that a difference in LAI between maize row spacing was significant and the highest value of 5.33, 5.83 and 6.19 were recorded at 75, 65 and 45 cm row spacing respectively. Dry matter increased by a 9% for forage maize grown at row spacing of 38 cm as compared with 76 cm row spacing. Similarly maize dry matter yield decreased by 4% when row width decreased below 38 cm (Lakew et al., 2014). Further, differential response to row spacing in maize cultivars has been also reported by Xue et al., (2002).

In spite of immense potentials to maximize the productivity of the crop in the study area by adopting improved agronomic practices such as row spacing and improved varieties of maize, there is no research recommendation on row spacing and high yielding cultivars maize in the study area. Hence, farmers are producing maize using low performing cultivars without appropriate row spacing. Therefore, the objective of this study was to investigate the effect of intra row spacing on phenology and growth of maize varieties under irrigation at Offa.

MATERIALS AND METHODS

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, 45 º 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 28°C, respectively (Ofa District Agricultural Office (ODAO), unpublished report). The rainfall has a bimodal distribution pattern with two distinct main rainy seasons *Belg* (long rainy season) and *Meher* (short rainy season).

Treatments and Experimental Design

Treatments consisting 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. Blocks and plots were separated by a 1.5 and 0.5 m wide space. Each treatment was randomly applied to the experimental unit within a block.

Experimental Materials

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 (EARO 2004; Mosisa et al., 2001).

Agronomic Practices

The first, second and third ploughing was done in mid September, October and November 2016, respectively, using a pair of oxen and the maize seed was shown 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 (ATA, 2013). 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 the river through motor pump. The trial was irrigated with furrow method of irrigation with a depth of 1.5 m at weakly interval that is for germination phase there irrigations, vegetative phase three irrigations, flowering phase four irrigations and maturity phase two irrigations which was recommended as optimum for maize production (Mandafro et al. 2009).

Data Collection and Measurements

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 (Day 1965). The soil pH was measured with standard glass electrode pH meter (Van Reeuwijk 1992). The Walkley and Black (1934) 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 Cottenie (1980). The cation exchange capacity was determined by Jackson (1967) method and the available phosphorus was determined by Olsen et al., (1954) method.

Crop Data

Phenological Parameters

Days to taselling - was recorded as the number of days from planting to when 50% of the plants produced tassel in each net plot.

Days to silking **-** was recorded as number of days from planting to when 50% of the plants in each net plot started silking.

Anthesis silking interval - was cared out from days of sowing minas days of anthesis**.**

Days to maturity stage - was recorded as number of days from planting to when 90% of the plants in each net plot formed black layer at the point where the kernel was attached to the ear.

Growth Parameters

Leaf area per plant (cm^2):- All available leaves of five plants per net plot were collected at 50% milking stage and leaf length and width was measured and the leaf area was calculated by using methods described by Mckee (1964) as: Leaf area (LA) =Length x Maximum width of leaf (cm) x 0.733.

Leaf area index (LAI): was calculated as the ratio of total leaf area per five plants (cm^2) per area of land occupied by the plants (Diwaker and Oswalt, 1992).

Plant height: Plant height of maize was measured in centimeter as the distances from ground level to the point where the tassel starts to branch and five plants sampled randomly from the net plot was used for this purpose.

Results and Discussion

Physico-Chemical Properties of Experimental Soil

Physical and chemical properties of the soil were analyzed for the surface composite soil taken from the experimental field. The result of the laboratory analysis revealed that the textural class of the soil is sandy loam with particle size distribution of 70% sand, 22% silt and 8% clay. The chemical analysis of the experimental soil showed pH of 6.1, available phosphorus of 0.76 mg/kg, CEC of 18.04 mol (+)/kg), organic carbon of 1.95%, and total nitrogen of 0.17%. The soil of experimental site is slightly acidic with pH of 6.1 based on the rating given by Tisdale et al. (2002). This value falls in the pH range that is very conducive for maize production as normal soil pH for maize is recorded to be from 5-8, probably being an optimal for most varieties (Martin, 1993). The soil texture of the experimental site was sandy loam. According to Purseglove (1972) this is the best suitable maize crop.

Phenological Parameters

Days to 50% Tasseling

The results revealed that varieties by row spacing interaction resulted significant (P<0.01) difference on days to tasseling (Table 1). Almost all varieties tended to shorten the days to tasseling with wider row spacing (Table 1). The longest days to tassaling (75) was recorded for variety Jabi at row spacing of 45 cm followed by variety Lemu at the same row spacing with mean days to tasseling of (74.7). The shortest days to tasseling (69) was recorded for variety BH-540 at row spacing of 65 and 75 cm and Jabi at row spacing of 75 cm. It might be the existence of genetic differences among the varieties, resource computations at narrower row spacing and optimum growth resources at wider row spacings. This result was in contrary with Sikandar et al., (2007) where they reported non-significant differences on days to tasseling among maize hybrids, row spacings and their interaction.

Days to 50% Silking

Days to 50% silking also showed a highly significant (P< 0.01) difference due to the interaction effects of row spacing's and varieties (Table 1). The variety 'Jabi with 45 cm row spacing' took maximum days (78) to reach 50% silking while the variety 'BH-540'with 65 cm row spacing took minimum (72) days (Table 3). This might be due to the genetic variation among the varieties and resource computations at narrower row spacing and optimum growth resources at wider row spacings. This result was in contrary to Sikandar et al., (2007), who reported non-significant interaction effects of maize hybrids and row spacings on days to silking.

Anthesis Silking Interval

The results also revealed that varieties by row spacing interaction resulted in significant difference on anthesis silking interval (Table 1). The longest days to anthesis silking interval (5.34) was recorded for variety Jabi at row spacing of 55 cm followed by variety Lemu at the row spacing (65 cm) and Jabi at row spacing of 75 cm with mean anthesis silking interval of (4.0). The shortest days to anthesis silking interval (2.67) was recorded for variety Lemu at row spacing of 45 cm. It might be the existence of genetic differences among the varieties, resource computations at narrower row spacing and optimum growth resources at wider row spacings. Contrary to this Sikandar et al., (2007) reported non-significant interaction effects of maize hybrids and row spacings on anthesis silking interval.

Days to Physiological Maturity

The interaction effects of varieties and row spacing had a highly significant (P<0.01) effect on crop physiological maturity (Table 1).The variety 'Lemu' took the longest days (143.67 days) to reach physiological maturity at row spacing of 55 cm, while the variety 'Jabi' took the shortest days (133.34 days) at row spacing of 65 cm and the variety Lemu similarly responded in all row spacings (Table 1). This might be because of genetic variation among varieties and the abundance of growth resources varies between row spacings. In conformity with the result EARO (2004) reported that 'BH-540' takes 145 days to reach physiological maturity and it was categorized as medium maturing variety, while ' Jabi' was categorized in early maturing and 'Lemu' was under late maturing varieties categories at 75 cm row spacing.

Table1. *Interaction effect of varieties and row spacing's on number of days to 50% tasseling, silking, anthesis siking interval and Days to 90% physiological maturity at Geleko in 2016/17 cropping season.*

Maize varieties	Row spacings (cm)	Days to tasseling	Days to silking	Anthesis silking interval	Days to physiological maturity
BH-540	45	74.0^{a}	77.67^{a}	3.67^{bc}	138^{b}
	55	73.0^{a}	76.67^{a}	3.67^{bc}	137^{b}
	65	69.0^{b}	72.0^{c}	3.0^{bc}	135.67^{bcd}
	75	69.0^{b}	72.34^{bc}	3.34^{bc}	136^{bcd}
Lemu (P3812W)	45	74.7^{a}	77.34^{a}	2.67^{c}	143^{a}
	55	74.0^{a}	77.34^{a}	3.34^{bc}	143.67^{a}
	65	70.4^{b}	73.34^{b}	4.0^{b}	142.34^{a}
	75	70.7^{b}	74.34^{b}	3.67^{bc}	142.34^{a}
Jabi (PHB3253)	45	75.0^{a}	78.0^{a}	3.34^{bc}	136^{bcd}
	55	73.4^{a}	77.67^{a}	5.34^{a}	136.67^{bc}
	65	70.0^{b}	73.34^{b}	3.34^{bc}	133.34^{d}
	75	69.0^{b}	73.0^{bc}	4.0^{b}	133.67^{cd}
	LSD (5%)	2.02	2.06	1.28	3.20
	CV (%)	1.67	1.63	21.15	1.37

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

Growth Parameters

Plant Height

The results also revealed that statistically significant (P<0.05) difference was observed in plant height among maize varieties (Table 2). This reveals the existence of genetic differences among the varieties. The variety 'BH-540' gave the highest plant height (254.4 cm), while the variety 'Jabi' gave the lowest plant height (219.22 cm) (Table 2). Similar results have been reported by Raouf et al., (2009), where there had been significant plant height differences among maize cultivars. Although it is not significant, plant height was decreased at all row spacing except at 65 cm when row spacing increased from 45 cm to 65 cm. This may be due to crowding effect of the plant and higher intra-specific competition for resources. In conformity with the result, Matthews et al., (2008) also reported that maize planted with plant spacing of 25 cm and row spacing of 50 cm had significantly shorter plants than those planted with 30 cm plant spacing and 75 cm row spacing.

Leaf Area

The results also showed significant differences among maize varieties for leaf area (Table 2). Accordingly, the highest leaf area per plant (4983.8 cm^2) was recorded for variety Lemu followed by variety Jabi with mean leaf area per plant of (4622 cm^2). The lowest leaf area per plant (4617 cm^2) was seen for variety BH-540 (Table 2). The difference in leaf area among the varieties might be attributed to their inherent genetic variations. Similarly, Ahmad et al., (2006) who reported significant differences among maize varieties for leaf area.

Table2. *Main effect of varieties and row spacings on Leaf Area plant-1 and plant height of maize at Geleko in 2016/17 cropping season.*

Treatment	Leaf Area $plant^{-1}$ (cm^2)	Plant height (cm)
Maize Varieties		
BH-540	4617.2^{b}	254.4^{a}
Lemu	4983.8^{a}	239.43^{ab}
Jabi	4622^{b}	219.22^{b}
LSD (0.05)	301.24	28.66
Row spacings (cm)		
45	4500^{b}	219.51^{b}
55	4668.5^{ab}	229.16^{b}
65	4856.2^{a}	262.49^{a}
75	4937.4^{a}	239.6^{ab}
LSD (0.05)	347.84	33.09
CV (%)	7.62	14.46

Significant at 5% level of significance; LSD (0.05) = Least Significant Difference at 5% level; CV= Coefficient of variation; NS= Non-significant.

Means in column within a parameter followed by the same letter(s) are not significantly different at 5% level of significance

Leaf Area Index

Leaf area index (LAI) showed highly significant (P<0.01) difference among varieties and row spacing and their interaction (Table 3). The narrowest row spacing of 45 cm by Lemu maize variety resulted in highest leaf area index (3.58), while the lowest leaf area index of (2.1) was recorded under wider row spacing (75 cm) by BH-540 maize variety (Table 3). Leaf area index decreased with increase in row spacings. This could be due to high number of plants per unit area than under higher leaf area and genotype effect. This result was in agreement with Ahmad *et al.*, (2006) who reported higher leaf area index of maize (6.45) under narrower row spacing (55 cm) unlike at wider row spacing (75 cm and 65 cm). Yousaf *et al.*, (2007) reported that a difference in LAI between maize row spacing was significant and the highest value of 5.33, 5.83 and 6.19 were recorded at 75 cm, 60 cm and 45 cm row spacing, respectively. Similarly, Sangoi *et al.*, (2001) reported higher leaf area index (4.6) at 50 cm than at 75 cm (3.64) in maize cultivars. In the current study, increase in LAI at narrower row spacing explains that the general crop trends that decreasing row spacing increases LAI on account of more area occupied by green canopy of plants per unit area. Valadabadi and

Farahani (2010) investigated that leaf area is influenced by genotype and plant population. They further reported that highest physiological growth indices are achieved under narrow row spacing, because photosynthesis increases by development of leaf area. The current study is also in agreement with previous research findings, which indicated that in lower maize row spacing, LAI increased more than wider maize row spacings (Saberali, 2007).

Table3. *Interaction effect of varieties and row spacing on leaf area index at Geleko in 2016/17 cropping season.*

Maize Varieties	Row spacings (cm)			
	45	55	65	75
BH-540	3.29^{ab}	2.78^{cde}	2.52^{efg}	2.1^{h}
Lemu	3.58^{a}	2.96^{bcd}	2.55^{efg}	2.34^{hg}
Jabi	3.14^{bc}	3.14^{bc}	2.4^{fg}	2.24^{hg}
LSD (0.05) V x RS = 0.36; CV (%) =7.85				

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

Conclusion

The result of this study had shown that maize variety BH-540 at 65 or 75 row spacing is a fast growing and early maturing giving advantage for farmers to cope up changing climate by avoiding the effects of terminal drought stress. Further, the variety Lemu at row spacing of 45 cm is better performing variety interms of leaf area index. Therefore, from this finding, it can be concluded that under irrigated condition Lemu and BH-540 maize varieties at 65-75 cm row spacing found to be best performing maize varieties in terms of phonological traits and growth.

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