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Influence of Plant Populations and N Fertilizer Rates on Growth, Development and Yield of Late Maturing Maize Parental Line (142-1-e) at Eastern Wellega Zone, Oromia Region, Ethiopia

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ABSTRACT

The experiment was conducted on 142-1-e maize unfixed parental line at Bako National Maize Research Center study site for the last three years (2019-2021). The objective of the study was to identify an optimum plant population density and N rate on 142-1-e maize parental line which gave the highest seed producibility and maximum net benefit. The experiment consisted of two factors: four level of N (111, 157, 203 and 249 kg ha^{-1}) and five level of plant population densities (44,444, 53,333, 66,666, 88,888 and 133,333 plants ha^{-1}). Totally, the experiment had twenty treatments (4*5) laid out in RCBD design in factorial arrangement each treatment was replicated three times. Different growth, phonological and yield characters of 142-1-e maize parental line were collected. Plant population densities significantly ($p<0.05$) affect plant, ear height, girth and barren plant percentage, number of kernels ear^{-1}, thousand seed weight and seed yield of 142-1-e maize parental line. Days to 50% female flowering of 142-1-e maize parental line was highly significantly ($p<0.01$) affected by both the main effect of N rates and plant population density. The tallest plant (253.1 cm) and ear height (158.3 cm) were observed at 133,333 plants ha^{-1}, followed by the plant and ear height recorded at plant population of 88,888 plants ha^{-1}. The thickest girth (21.72 mm) was recorded at the plant population densities of 44,444 plants ha^{-1}. The maximum barren plant percentage (24.6%) was recorded at plant population of 133,333 plants ha^{-1}. The highest seed yield (4123 kg ha^{-1}) was recoded at 88,888 plant population ha^{-1} followed by grain yield recorded at 133,333 and 66,666 plants ha^{-1}. Application of N at the rate of 157 kg ha^{-1} with of 133,333 plants ha^{-1} was the most profitable than all the other treatments, followed by net benefit obtained at plant population density of 88,888 plants ha^{-1}. However, 157 kg ha^{-1} of N with 133,333 plants ha^{-1} reduced the seed size extremely. Due to this, 88,888 plant population ha^{-1} with N rate of 203 kg ha^{-1} is recommended for 142-1-e maize parental line at Bako and Other areas with similar agro-ecologies.

Keywords: Lodging, Maize Parental line, plant and ear height, plants ha^{-1}, seed yield

1. Introduction

The crop maize (*Zea mays*) originated in Mexico, 7000 years ago from a wild grass, and Native Americans advanced maize into a good source of food (Ranum *et al.,* 2014). Currently, maize is grown throughout the world, United States, China, and Brazil being the top three maize-producing countries in the world (Ranum *et al.,* 2014). It is believed that the maize was comes from Kenya to Ethiopia. In the recent history, maize has emerged as a leading cereal crop in Ethiopia (Fufa and Hassan, 2006). Ethiopia is the second highest maize producer in Sub-Saharan Africa next to Nigeria [Jones and Thornton, (2003); Assefa *et al.,* (2020)].

Maize is serving as a potential food security crop in South America, Africa and China. In Africa, maize is used for making bread and as a starchy base in the form of grits, porridges, pastes and beer. Grain of green maize is eaten baked, parched, roasted or boiled and has an important role in combating the starvation after dry season. In sub-Saharan African countries, maize is a basic food for about 50 %

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of the population and provides 50 % calories (CGIAR, 2016). In case of Ethiopia, it constitutes about 60% of the caloric intake of household (Dawit *et al.,* 2014).

In Ethiopia, the mid and lowland sub-humid agro-ecologies are potential areas for production of maize (Alemu *et al.,* 2019). Maize cultivation is mostly by smallholder farmers; comprising of about 80% of Ethiopia's population and producing over 95% of the total maize. Indubitably, the crop has great importance in the livelihood of Ethiopian population. Of cereal crops, maize holds the lion shares (30.88%) with 10.56 million tonnes annual production (CSA, 2021). In Ethiopia, the production of maize was increased from 939 thousand tonnes in 1970 to 8500 thousand tonnes in 2019, growing at annual rate of 7.64% (FOA, 2020). Correspondingly, the Maize production increased from 8350 thousand tonnes in 2018 to 8500 thousand tonnes in 2019 with growing annual rate of 1.8% (FOA, 2020). Now, maize is cultivated on the area of about 2.52 million ha with average production of 10.56 million tonnes and national average yield of 4.18 t ha^{-1} (CSA, 2021); which is far below the world's average yield which is 5 .83 t ha^{-1} (FAOSTAT, 2019).

The low yield from farming could be ascribed to disappointment of the farmers to implement good agricultural practice. Moreover, crop production is encountered with various controllable dares like untimely planting, inappropriate plant spacing, wrong planting method, inappropriate sowing depth, weed infestation, insect pests and diseases problems, inappropriate use of fertilizers and untimely harvesting (Karaye *et al.,* 2017 and Zhou *et al.,* 2019). Also, poor soil fertility, nutrient management and low yielding cultivars are some of the principal factors limiting maize productivity in Ethiopia (Aticho *et al.,* 2011; Dawit *et al.,* 2014; Tena and Beyene, 2011).

Having recommended agronomic practices which help to boost production and productivity for released/cultivated varieties are very important. Optimal agronomic practices are varies with location, season and cultivars. So, to maximize maize productivity per unit area of land, location, season and cultivar based optimal crop management practices are too important. So far, Feyisa (2020) recommended 100 kg ha^{-1} of NPS in relatively uniform rainy areas; while in erratic and heavy rainy seasons, 125 kg ha^{-1} of NPS was suggested for BH661 maize hybrid. Moreover, Begizew *et al.,* (2019) found BH661 maize hybrid gave the highest yield at plant population of 53,333 plants ha^{-1} with 115 kg N ha^{-1}. Also, Abebe and Feyisa (2017) recommended 92 kg N ha^{-1} at 10–15 and 35–40 days after planting for BH661 maize hybrid. While, in the case of erratic and heavy rainy areas, application of 92N kg ha^{-1} at 1/3 N at 10–15, 1/3 N at 35–40 and 55–60 days after planting were suggested to get maximum profit and acceptable marginal rate of return.

However, for all agricultural crops, optimal agronomic practices are varies with species (even varieties), soil and atmospheric factors and production season. This truly stands for maize, as the productivity of maize genotypes (hybrid, OPV and inbred lines) varies with location, year, soil types, rainfall (distribution and amount), fertilizer rates, plant population density and the others. Even within the maize hybrid and inbred lines, the optimal package (fertilizer rate, plant population density, seed rate, N application time and cycle) varies between late maturing and intermediate maturing maize groups. Based on these researchable gaps, this study was focused on studying 142-1-e maize parental line against N levels and plant population densities. Thus, the objective of this research was to identify an optimum plant population density and N rate on 142-1-e maize parental line which may provide the highest seed producibility and maximum net benefit (acceptable marginal rate of return).

2. Materials and Methods

2.1. Description of Experimental Site

The experiment was conducted at Bako National Maize Research Center study site for the last three years (2019-2021 year). The study area has the following weather and geographic characters (Table 1)

Table 1: Study area's geographic and Weather description

Zone	Wereda	Annual Rainfall (mm)	Temp. (^{0}C)	Altitude (masl)	Latitude (N)	Longitude (E)
East Wellega	Gobu seyo at BNMRC study site	830-1658	13 - 27	1556-2580	9°01'01" - 9°20'33"	36°53'11" - 37°03'06"

Source: (Eshetu *et al.,* 2020; Urgessa and Fekadu, 2021)
BNMRC = Bako national maize research center

2.2. Soil sampling and physicochemical properties analyzed

Soil sample from experimental site was taken in a diagonal pattern at 5m interval. From each sampling spot, soil sample were taken at a depth of 20cm using soil sampling auger. The collected soil samples were mixed thoroughly, then nearly 1 kg soil was taken from the composite sample for physicochemical study at laboratory. Prior to start the study, the sample was air dried, ground to pass through 2 mm sieve and analyzed for texture class, available Phosphorus (ppm), Organic carbon (OC %), Cation exchange capacity (CEC cmol/100g soil), Total Nitrogen (N %), and potential of hydrogen (pH). However, for the rest soil chemical properties, the chemicals were not available. The result of soil physiochemical properties tested at BARC was is illustrated in (Table 2).

Textural class of the soil of the experimental area were analyzed using hydrometer method. The result indicated that the soil textural class of experimental area is sandy clay. The total nitrogen was analyzed using Kjeldahl method by digestion of soil (copper sulphate-potassium sulphate catalyst). The pH was measured by Potentiometer in the ratio of 1:2.5 soil to water suspension. Available P was examined using Bray-II process and calorimetrically used vanadomolybedate acid as an indicator. CEC was determined by using NH_4 AC extraction ammonia distillation method. OC was measured by wet oxidation Walkley-Black method (Hazeltonand Murphy, 2007) and converted to organic Matter (OM) by multiplying the value of OC by 1.724 (Nelson and Sommers, 1982).

Table 2: Soil Physiochemical Properties of experimental area.

SN	Result	Status
TN (%)	0.26	Very Low
Available P (%)	6.55	Very Low
CEC (cmol)	21	
OC (%)	2.96	Very Low
OM (%)	5.11	Very high
pH	4.85	
Clay (%)	40	
Sand (%)	53	
Silt (%)	7	
Soil textural class:	Sandy Clay	

TN = total nitrogen, CEC ($Cmolkg^{-1}$) = cation exchange capacity in cent mole per hundred gram of soil, Av. P. ppm = available phosphorus in parts per million, pH= hydrogen power, OC = organic carbon, OM = organic matter
Source: [Horneck *et al.,* (2011); Zhao *et al.,* (2012); Zhao *et al.,* (2019)]

2.3. Description of Experimental materials

Maize parental line 142-1-e was used for the study. 142-1-e is late maturing unfixed maize parental line. So far, it is used as male parent of BH6 series. As primary source of Nitrogen, urea (46% N) was used. Also, NPS (19 %N, 38% P2O5, and 7 % S) fertilizer were used as a source of Nitrogen, Phosphorus and Sulfur.

2.4. Treatments and Experimental Design

Two factors: Four N rate: 111, 157, 203 and 249 kg ha^{-1} in the form of urea and five plant population density levels 44,444, 53,333, 66,666, 88,888 and 133,333 plants ha^{-1} planted at intra row spacing of 75*30, 75*25, 75*20, 75*15 and 75*10 cm respectively. During the experiment, 142-1-e was planted at inter row spacing of 75cm. Uniformly, NPS at the rate of 100 kg ha^{-1} was applied at the time of planting.

The experiment was laid out in factorial RCBD design in (4*5) arrangement and each treatment was replicated three times. An experimental unit (a plot) has a length of 3m and width of 4.5 m (13.5 m^2 plot area). The treatments were randomly assigned to the experimental units within a block (replication). The blocks and plots were separated by 2 m and 0.5 m wide space respectively.

2.5. Experimental Procedures

Experimental area was ploughed three times from March to May by using tractor plough. Inter row spacing (distance between one furrow to another farrow) was manipulated at 75 cm distance. Seed sowing was done in the first week of June by placing two seeds per hole in furrows at a specified intra row spacing. During seeding, full dose of NPS was applied similarly to all experimental units at the depth of 2.5-5 cm around the seed with side-banding method (McKenzie, 2013). Before emergency, Primagram gold herbicide was applied to suppress weed emergency at the rate of 3l/ha. A week after full germination, seedlings were thinned to one plant per hole by keeping a vigor seedling. Half dose of N fertilizer was applied at 21-25 days after planting and the remaining half dose was applied at 40-45 days after planting in the same method of application, side-banding. Once N applied in the form of urea, it was immediately covered with soil to keep it not lost by through volatilization (www. extension. umn. edu).

Crop management practices were applied evenly to all plots at an appropriate time. Finally, maize in the central rows of the plot was used for data collection.

2.6. Data Collected

In this experiment data were taken from five representative randomly selected plants for some parameters and from net plot areas for the rest parameters. Generally, growth, phonological and yield parameters data were collected:

Days to 50% tasseling
Number of kernels per ear
Thousand kernels weight (g)
Grain yield (kg ha^{-1})
Barren plants
Girth
Days to 50% silking
Plant height (cm)
Ear height

2.7. Data Analysis

The collected data were analyzed using SAS software version 9.3 following a procedure appropriate to a randomized complete block design. Comparison of treatment means was done using the Fisher's least significant difference (LSD) test at 5% probability.

3. Results and Discussion

3.1. Growth parameters

3.1.1. Plant and Ear Height (cm)

Plant population densities significantly ($p<0.05$) affected plant and ear height of 142-1-e maize parental line. However, both these growth characters were not statistically significantly ($p \geq 0.05$) affected by the main effect of N rates and the interaction of N rates and plant population density (Table 3). Significantly, the tallest plant (253.1 cm) and ear height (158.3 cm) were recorded at 133,333 plants ha^{-1}, followed by the plant and ear height recorded at plant population of 88,888 plants ha^{-1}. At the rest all plant population densities, significantly similar plant and ear height were recorded and considered as the lowest (Table 3). In general, as the plant population increased, the plant and ear height of 142-1-e maize hybrid parental line increased. This might be due to high competition for sunlight at high plant population density.

Plant density influences the light quality (ratio of red to far-red) during the early growing period and impacts internode length in the lower canopy (Rajcan and Chandle 2004). The length of internodes below the ear increases as plant density increases, causing ear and plant height to increase. These are mainly and highly related with physiological function of plants in general. Rationally, light intensity reaching the maize canopy reduced as the plant population increased, which results in inhibition auxin photo destruction. Also, more Auxin rises the rate of internode elongation, causes extended internodes length which in turn highest plant height (Tetio-Kagho and Gardner 1988).

3.1.2. Girth and Barren Plant Percentage

Girth and barren plant percentage of 142-1-e maize hybrid parental line were highly significantly ($p<0.01$) and significantly ($p<0.05$) influenced by plant population density. However, both parameters were not statistically significantly ($p \geq 0.05$) affected by the main effect of N rates and the interaction of N rates and plant population density (Table 3). The thickest girth (21.72 mm) was recorded at the lowest plant population which is 44,444 plants ha^{-1}. At the highest plant population density (133,333), the smallest/thinnest girth (14.70 mm) was observed. In general, as the plant population increased, the girth thickness decreased (Table 3). In reverse to girth, the highest barren plant percentage (24.6%) was recorded at plant population of 133,333 plants ha^{-1}. Barren plant percentage recorded at the rest plant population was significantly similar and considered as low.

The main causes of increased barrenness and decreased girth at high plant densities is high interplant competition for space, light, water and nutrients. At high plant population density, maize is characterized as elongated plant height, thinnest girth, long anthesis to silking interval, and smaller ear size, producing relatively more ear less plants and low yield per plant. Maize grain yield normally revealed a quadratic response to plant density. Gradual decreased yield rate relative to density increase, and lastly a yield plateau at some relatively high plant population density [Ottman and Welch (1989); Novacek *et al.,* (2013)]. This might be due to an increased male sterility plants at higher plant population which inturn decreased the number of grains ear^{-1} (Sangoi *et al.,* 2002; Liu *et al.,* 2004).

Table 3: Main effect of nitrogen rate and plant density on days to 50% flowering, plant height, girth, barren plant percentage of ear height of 142-1-e line in 2019-2021 Production season

NR Kg/ha	Mean of growth and [phonological Characters					
	MF	FF	Girth	PH	EH	Bar percentage
111	90.53	93.93^{a}	18.24	243.2	146.7	17.9
157	90.67	93.20^{ab}	18.35	242.2	142.4	13.1
203	90.27	92.07^{b}	18.95	242.6	144.6	15.2
249	90.20	92.27^{b}	18.77	250.3	144.5	18.8
LSD (5 %)	ns	1.148	ns	ns	ns	ns
F-test		**				
PD/ha						
44444	90.25	91.58^{d}	21.72^{a}	237.3^{b}	133.7^{b}	13.1^{b}
53333	90.33	92.00^{cd}	19.38^{b}	243.3^{ab}	138.2^{b}	14.7^{b}
66666	90.58	92.92^{bc}	19.40^{b}	237.5^{b}	139.8^{b}	15.8^{b}
88888	90.33	93.42^{ab}	17.68^{b}	251.8^{a}	152.8^{a}	13.2^{b}
133333	90.58	94.42^{a}	14.70^{c}	253.1^{a}	158.3^{a}	24.6^{a}
LSD (5 %)	ns	1.283	1.74	14.20	22.26	7.48
F-test		**	**	*	**	*
CV	1.0	1.7	11.3	7.0	9.3	4.4

N Kg ha^{-1} = Nitrogen level in kg ha^{-1}, **PD ha^{-1}** = Planting density per hectare, **MF** = days to 50% male flowering, **FF=** days to 50% female flowering, **PH**=Plant height, **EH** = ear height, **Bar.** = Barren plant percentage,
Means within columns followed by different letter (s) for each variable are significantly different at *($p<0.05$)*
*, and **, significant at $P \leq 0.05$, $p \leq 0.01$ probability levels respectively; ns= not significant

3.2. Phenological Character

3.2.1. Days to 50% Male and Female Flowering

Days to 50% female flowering of 142-1-e maize parental line was highly significantly ($p<0.01$) affected by both the main effect of N rates and plant population density. However, days to 50 % male flowering was not significantly ($p \geq 0.05$) affected by both the main factor of N rates plant population density and the interaction of both factors. The lowest N rate (111 kg ha^{-1}) delayed days to 50% female flowering. While, days to 50% female flowering reduced as N rate increased up to a certain extent. This might be due to sufficient N taken up from the soil keep plant's leaves green and enhances photosynthesis rate. This ensures enough photo assimilate and amino acid which possibly enables the plant to flower earlier than the lowest N rates. However, greater than optimum/sufficient N also enhances the vegetative growth and delay the development phase as in the case of lowest N rate.

Days to 50% female flowering was prolonged up to 94.42 days at plant population of 133,333 plants ha^{-1} followed by days to 50% female flowering observed at plant population of 88,888 plants ha^{-1}. While, significantly the shortest (91.58) days to 50% female flowering was recorded at 44, 444 plant population ha^{-1} followed by result observed at 53,333 plants ha^{-1} with average number of days of 92.00. The result indicate that days to flowering and plant population density are positively associated (as plant population increased, days to maize flowering is delayed).

In agreement with this finding, Shrestha *et al.,* (2018) reported that days to tasseling under 55555 plants ha^{-1} was significantly lower than that obtained under 83333 plants ha^{-1}. High plant population increased barrenness and delayed reproductive processes. Light is critical to measure day length and phenology of plants. Competition for light and water delayed silking and results in anthesis silking synchronization problem [Smith *et al.,* (1982); Westgate (1994)]. This indicate that in case of high plant density, there is extreme competition for light which result elongated plant height and delay the appearance of male and female flowering. At high plant population, many kernels may not develop due to poor pollination resulting from long anthesis silking interval (Karlen and Camp, 1985; Otegui, 1997).

3.3. Yield attributor Characters

3.3.1. Thousand kernels weight (g) and Number of kernels per ear

The number of kernels ear^{-1} and thousand kernel weight were significantly ($p<0.05$) affected by the main factor of plant population density, while, both characters were not significantly affected by the main effect of N rates and the interaction of both N rates and plant population density. The highest number of kernels per ear (337.6) and thousand seed weight (309.2 gm) were noted at 44,444 plant population density which is followed by number of kernels ear^{-1} recorded at plant population hectare^{-1} of 53,333 and 66,666. While, the lowest number of kernels ear^{-1} and thousand kernel weight were recorded at 133,333 plants hectare^{-1} followed by kernels number ear^{-1} observed at 88,888 and 66,666 plant population ha^{-1}.

At high plant population density, cob size, kernel size and number of kernels ear^{-1} of maize is decreased. These is positively associated with kernels weight and food storage of kernels. The more seed size, the more kernel food storage it be. Various agronomic factors significantly affect seed size, which in turn influence the germination percentage and seed vigor and seedling survival as it depends on the accumulation of starch (Sulewska *et al.,* 2014).

3.3.2. Seed yield (kg ha^{-1})

Seed yield of 142-1-e maize parental line was statistically significantly ($p<0.05$) affected by the main effect of plant population density. However, it was not significantly ($p\geq0.05$) affected by the main effect of N rates and the interaction of N rates and plant population densities. Seed yield of 142-1-e maize parental line ranges from 2699 to 4123 kg ha^{-1} due to changes in plant population from 44,444 to 133,333 plants ha^{-1}. The highest seed yield was recoded at plant population 88,888 plants ha^{-1} with mean value of 4123 kg ha^{-1} followed by grain yield recorded at 133,333 and 66,666 plants ha^{-1}. At the lowest plant population ha^{-1}, the lowest seed yield was noted. In general, seed yield of 142-1-e maize parental line increased as plant population hectare^{-1} increased up to a certain extent (Table 4).

Table 4: Main effect of nitrogen rate and plant density on thousand seed weight and grain yield of 142-1-e line in 2019-2021 Production season

NR Kg/ha	Mean of Characters		
	KPE	TSW	SY
111	332.0	292.0	3373
157	283.4	284.0	3669
203	293.0	299.3	3680
249	330.9	296.7	3614
LSD (5 %)	ns	ns	ns
F-test			
PD/ha			
44444	337.6^{a}	309.2^{a}	2699^{c}
53333	324.2^{ab}	298.3^{ab}	3279^{b}
66666	304.1^{abc}	301.7^{ab}	3850^{a}
88888	297.8^{bc}	280.8^{ab}	**4123^{a}**
133333	285.3^{c}	275.0^{b}	3970^{a}
LSD (5 %)	38.11	28.58	946.1
F-test	*	*	*
CV	14.9	11.8	28.4

N Kg ha^{-1} = Nitrogen level in kg ha^{-1}, PD ha^{-1} = planting density per hectare, KPE = number of kernels ear^{-1}, TSW = thousand seed weight, SD (kg ha^{1}) = seed yield in kilogram hectare, Means within columns followed by different letter (s) for each variable are significantly different at *(p<0.05)* *, and **, significant at $P\leq0.05$, $p\leq0.01$ probability levels respectively; ns= not significant

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In agreement with current finding, Abd-Alkream Hussain *et al.,* (2018); Taressa *et al* (2020) reported that, plant population have significant influence on yield of maize. Seed yield increment of 142-1-e maize parental line with increased plant population density up to a certain extent, then after decreased beyond the optimum population density is due to an increase in barrenness at high plant population density. Since it is naturally less vigor and low leaf canopy, the seeds of inbred lines need less inter and intra row spacing compared to certified seeds of hybrid maize (Abd-Alkream Hussain *et al*., 2018; Abuzar *et.al*., 2011). Akbar *et al.,* (2016) reported that optimum plant population density gave greater yield due to soil nutrients utilization more powerfully. Higher plant population increases plant sterility and extends the interval between male and female flowering, and resulted decreased the number of grains ear^{-1} (Sangoi *et al.,* 2002; Liu *et al.,* 2004). Yield attributes that is affected most negatively by greater than optimum population is the number of kernels per ear (Duncan, 1984; Lemcoff & Loomis, 1986, 1994; Jacobs & Pearson, 1991).

3.4. Partial Budget Analysis

3.4.1. Net Benefit and Marginal Rate of Return Analysis

Production of 142-1-e at plant population of 133,333 plants ha^{-1} in combination of 157 kg ha^{-1} N rate gave the maximum net benefit (243770.89 ETBr.). Following this, 142-1-e planted at 88.888 plants ha^{-1} with N rate 203 kg ha^{-1} gave 232,103.09 ETBr net benefit. In general, the lowest net benefit was recorded at 44,444 plant population (Table 5).

Partial budget analysis indicated that, application of N at a rate of 157 kg ha^{-1} with combination of 133,333 plants ha^{-1} was the most profitable than all the other treatments, followed by net benefit obtained at plant population density of 88.888 plants ha^{-1} in combination with 203 kg ha^{-1} of N rate. However, as plant population affect the size of seed hence endosperm, it may affect the seed germination and seedling vigor. Thus, using the second most profitable treatment (88.888 plants ha^{-1} with N rate of 203 kg ha^{-1}) is suggested until the seed germination parameters and seedling vigorousity of seed obtained at 133,333 plants ha^{-1} studied.

Table 5: Net benefit, Dominance and marginal rate of return analysis for 142-1-e maize parental line under different plant population and N rates at Bako National Maize Research Centerstudy site from 2019 – 2021 production year.

N	PP	TC	GY	AGY	TC	GFB	NB	B:C	MRR%
111	44444	62466.9	2194	1974.6	62466.9	161917	99450.3	1.59205	
111	53333	63466.9	3044	2739.6	63466.9	224647	161180	2.5396	61.73
111	66666	64766.9	3544	3189.6	64766.9	261547	196780	3.03828	27.3846
111	88888	65966.9	3600	3240.0	65966.9	265680	199713	3.02747	2.444
157	44444	66466.9	2667	2400.3	66466.9	196825	130358D	1.96124	
157	53333	67466.9	3116	2804.4	67466.9	229961	162494	2.4085	32.1362
111	133333	68166.9	3801	3420.9	68166.9	280514	212347	3.1151	71.2186
157	66666	68766.9	3667	3300.3	68766.9	270625	201858D	2.93539	
157	88888	69966.9	4035	3631.5	69966.9	297783	227816	3.25605	21.632
203	44444	70666.9	2081	1872.9	70666.9	153578	82910.9D	1.17326	
203	53333	71666.9	3584	3225.6	71666.9	264499	192832	2.69067	109.921
157	133333	72166.9	4281	3852.9	72166.9	315938	243771	3.37788	101.877
203	66666	72966.9	4092	3682.8	72966.9	301990	229023D	3.13872	
203	88888	74166.9	4150	3735.0	74166.9	306270	232103	3.12947	2.567
249	44444	74766.9	2575	2317.5	74766.9	190035	115268D	1.5417	
249	53333	75766.9	2939	2645.1	75766.9	216898	141131	1.8627	25.8632
203	133333	76366.9	4104	3693.6	76366.9	302875	226508	2.96605	142.295
249	66666	77066.9	3878	3490.2	77066.9	286196	209129D	2.71361	
249	88888	78266.9	4082	3673.8	78266.9	301252	222985	2.84903	11.546
249	133333	80466.9	4043	3638.7	80466.9	298373	217906D	2.70803	

D = Dominance, N = nitrogen in kg per hectare, pp = plant population hectare^{-1}, GY = Grain yield in kg per hectare, AGY = Adjusted grain yield in kg per hectare, TC = Total cost, GFB =Gross field benefit, NB =Net benefit, MRR = Marginal rate of return in percent.

4. Conclusion

The result obtained from an experiment indicated that most of the growth and development and yield attributes of 142-1-e maize parental line was significantly ($p<0.05$) affected by plant population density. But, the main effect of N rate was not exerted significant effect on most of the characters. All the growth, development and yield component of 142-1-e maize parental line were not significantly affected by the interaction of N rates and plant population densities. Plant height, ear height, days to 50% female flowering, girth and barren plant percentage, thousand seed weight, number of kernels ear^{-1} and seed yield of 142-1-e maize parental line were significantly ($p<0.05$) influenced by the main effect of plant population densities. Main effect of N rates also significantly influence days to 50% female flowering. The tallest plant (253.1 cm) and ear height (158.3 cm) were recorded at 133,333 plants ha^{-1} followed by the plant and ear height recorded at plant population of 88,888 plants ha^{-1}. The thickest girth (21.72 mm), the maximum number of kernels per ear (337.6) and thousand seed weight (309.2 gm) were recorded at plant population densities of 44,444 plants ha^{-1}. The highest barren plant percentage (24.6%) was recorded at plant population of 133,333 plants ha^{-1}. The highest seed yield was recoded at plant population density of 88,888 plants ha^{-1} with mean value of 4123 kg ha^{-1} followed by grain yield recorded at 133,333 and 66,666 plants ha^{-1}.

Application of N at a rate of 157 kg ha^{-1} with combination of 133,333 plants ha^{-1} was the most profitable than all the other treatments, followed by net benefit obtained at 88,888 plants ha^{-1} in combination with 203 kg ha^{-1} of N rate. However, as plant population affect the size of seed hence endosperm, it may affect the seed germination and seedling vigor. Thus, using the second most profitable treatment (88.888 plants ha^{-1} with N rate of 203 kg ha^{-1}) is recommended for 142-1-e maize parental line growers around Bako and other areas having similar agro ecological conditions.

References

Abebe, Z. and H. Feyisa, 2017. Effects of Nitrogen Rates and Time of Application on Yield of Maize: Rainfall Variability Influenced Time of N Application. International Journal of Agronomy. 1 (1):1-10.

Aghdam S., F. Yeganehpoor, B. Kahrariyan, and E. Shabani, 2014. Effect of Different Urea Levels on Yield and Yield Components of Corn 704. International journal of Advanced Biological and Biomedical Research, 2(2):300-305

Alemu A., D. Abakemal, T. Keno, 2019. Validation of Maize Product Concepts. Research Report No. 124

Anderson, E.L., 1984. Corn root growth and distribution as influenced by tillage and nitrogen fertilization. Agronomy Journal, 79: 544 - 549.

Assefa, B.T., J. Chamberlin, P. Reidsma, J.V. Silva, M. K. van Ittersum, 2020. Unravelling the varability and cause of small holder maize yield gaps in Ethiopia. Food Security, 12: 83-103.

Aticho, A., E. Elias, and J. Diels, 2011. Comparative analysis of soil nutrient balance at farm level: A case study in Jimma zone, Ethiopia. International Journal of Soil Science, 6(4): 259-266.

CGIAR (Consultative Group on International Agricultural Research), 2016. Research Programme on Maize, Why maize CIMMYT Web, Mexico

CSA (Central Statistical Agency), 2021. Area and Production for Major Crops (Private Peasant Holdings, Meher Season), Volume I, Statistical Bulletin 590, Addis Abeba, Ethiopia.

Dawit, A., Y. Chilot, B. Adam, and T. Agajie, 2014. Situation and Outlook of Maize in Ethiopia, Ethiopian Institute of Agricultural Research, Addis Ababa

Duncan, W.G.A., 1984. Theory to explain the relationship between corn population and grain yield. Crop Science, Madison, 24 (4):1141-1145.

FAOSTAT, 2019. Food and Agricultural Organization of the United Nations: Crop harvested area, yield and production, 28-30.

Feyisa, H., 2020. The Response of Maize Yield to Blended NPS Fertilizer Rates: Seasonal Rainfall Variation Affected Fertilizer Application Rates. Middle East Journal of Scientific Research 28 (5): 401-408. DOI: 10.5829/idosi.mejsr.2020.401.408.

FAO, 2020. Food and Agriculture Organization of the United Nations country Ethiopia. FAO, UN.

Fufa, B., and R.M. Hassan, 2006. Determinants of fertilizer use on maize in Eastern Ethiopia: A weighted endogenous sampling analysis of the extent and intensity of adoption. Agrekon, 45: 38-49.

Golla, B., M. Biya, and L. Yadessa, 2019. Effect of Plant Density and Nitrogen Fertilizer Rate on Grain Yield of Late Maturing Maize Hybrid BH661. Acad. Res. J. Agri. Sci. Res. 7(7): 577-588.

Jacobs, B.J., and C.J. Pearson, 1991. Potential yield of maize determined by rates of growth and development of ears. Field Crops Research, Amsterdan, and 27(1): 281-298.

Jones, P.G., and P.K. Thornton, 2003. The potential impacts of climate change on maize production in Africa and Latin America in 2055. Global Environmental Change, 13: 51-59.

Karaye A.K., B.B. Sabo, A.M. Chamoc and A. M. Rabiu, 2017. Influence of agronomic practices on crop production. International Journal of Sciences Basic and Applied Research (IJSBAR), 31(1): 61-66

Karlen, D.L., and C.R. Camp, 1985. Row spacing, plant population, and water management effects on corn in the Atlantic Coastal Plain. Agron. J., 77: 393-398.

Lemcoff, J.H., and R.S. Loomis, 1994. Nitrogen and density influences on silk emergence, endosperm development, and grain yield of maize (*Zea mays* L.). Field Crops Research, Amsterdan, 38(1): 63-72.

Lemcoff J.H. and R.S. Loomis, 1986. Nitrogen influences on yield determination in maize. Crop Science, Madison, 26 (5):1017-1022.

Liu, W., M. Tollenaar, and G. Smith, 2004. Within row plant spacing variability does not affect corn yield. Agron. J., 96: 275-280.

Novacek, M.J., S.C. Mason, T.D. Galusha, and M. Yaseen, 2013. Twin rows minimally impact irrigated maize yield, morphology, and lodging. Agron. J., 105: 268- 276.

Otegui, M.E., 1997. Kernel set and flower synchrony within the ear of maize: plant population effects. Crop Sci., 37: 448-455.

Ottman, M., and L. Welch, 1989. Planting patterns and radiation interception, plant nutrient concentration, and yield in corn. Agron. J., 81: 167-174.

Ping, X., Y. Liyun, L. Moucheng, and P. Fei, 2014. Soil Characteristics and Nutrients in Different Tea Garden Types in Fujian Province, China. Journal of Resources and Ecology, 5(4):356-363.

Rajcan, I., and K.J. Chandle, 2004. Red-far-red ratio of reflected light: A hypothesis of why early-season weed control is important in corn. Weed Science, 52: 774-778.

Ranum, P., J.P. Pena-Rosas, and M.N. Garcia-Casal, 2014. Global maize production, utilization, and consumption. Annals of The New York Academy of Sciences, 105-112.

Sangoi, L., M.A. Gracietti, C. Rampazzo, and P. Bianchetti, 2002. Response of Brazilian maize hybrids from different ears to changes in plant density. Field Crops Research, 79: 39-51.

Shrestha, J., D.N. YaDav, L.P. Amgain, and J.P. SharMa, 2018. Effects of nitrogen and plant density on maize (*Zea mays* L.) phenology and grain yield. Current Agriculture Research Journal, 6(2):175.

Smith, C.S., J.J. Mock, and T.M. Crosbie, 1982. Variability for morphological and physiological traits associated with barrenness and grain yield in maize population, Iowa Upright Leaf Synthetic. Crop Science, 22: 828: 832.

Sulewska, H., K. Śmiatacz, G. Szymańska, K. Panasiewicz, H. Bandurska, and R. Głowicka-wołoszyn, 2014. Seed size effect on yield quantity and quality of maize (*Zea mays* L) Cultivated in South East Baltic region, 101: 35–40. https://doi.org/10.13080/z-a.2014.101.005

Taressa, B., M. Dabale, G. Negasa, and Z. Abebe, 2020. The Effect of Plant Population and Nitrogen Rates on Yield and Seed Quality of CML-395 x CML-202 Female Basic Seed for Production of BH-661 and BH-546 Hybrid Maize Seed at Bako, Western Ethiopia. Advanced Journal of Seed Science and Technology, 6 (1): 168-175.

Tena, W. and S. Beyene, 2011. Identification of growth limiting nutrient(s) in Alfisols: Soil physico-chemical properties, nutrient concentrations and biomass yield of maize, American Journal of Plant Nutrition and Fertilization Technology, 1(1): 23-35.

Tetio-Kagho, F, and F.P. Gardner, 1988. Responses of maize to plant population density. I. Canopy development, light relationships, and vegetative growth. Agronomy Journal, 80: 930–935.

Tsai, C.L., and C.Y. Tsai, 1990. Endosperm modified by cross pollination corn to induce changes in dry matter and nitrogen accumulation. Crop Science, 30: 804-808.

Tsedeke, A., S. Bekele, M. Abebe, W. Dagne, K. Yilma, T. Kindie, K. Menale, B. Gezahegn, T. Berhanu, and K. Tolera, 2015. Factors that transformed maize productivity in Ethiopia. Food Security, 7:965-981.

Westgate, M.E., F. Forcella, D.D. Reicosky and J. Somsen, 2017. Rapid canopy closure for maize production in the northern US Corn Belt: radiation-use efficiency and grain yield. Field Crops Res., 49: 249–258.

Zhao, J.L., Y.A. Xue, H. Yang, L.S. Huang, and D.Y. Zhang, 2012. Evaluating and Classifying Field-Scale Soil Nutrient Status in Beijing using 3S Technology. International Journal of Agriculture & Biology, 14(5).

Zhao, Z., C. Chu, D. Zhou, Z. Sha, and S. Wu, 2019. Soil nutrient status and the relation with planting area, planting age and grape varieties in urban vineyards in Shanghai. Heliyon, 5(8): p.e02362.

Zhou B., X. Sun, D. Wang, Z. Ding, C. Li, and W. Zhaoa, 2019. Integrated agronomic practice increases maize grain yield and nitrogen use efficiency under various soil Fertility conditions. The Crop Journal, 7: 527–538