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# Response of nitrogen and bio-fertilizer rates on yield, yield components and seed quality of Maize (*Zea mays* L.) at Kedida Gamela District, Kambata Tambaro Zone, Southern Ethiopia

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**Key words:** Inorganic N fertilizer, Bio-fertilizer, Maize, Grain yield

**Abstract**

Low soil fertility is one of the major factors limiting maize productivity. The objectives of this study were to evaluate the response of nitrogen and bio-fertilizer (BF) rates on yield components and yield of maize. Five levels of nitrogen (0, 23, 46, 69, and 92kg N $ha^{-1}$) and three levels of BF (0, 5 and10kg BF $ha^{-1}$) were tested by using a randomized complete block design with three replicates. Gen Stat software was used to analysis of variance which revealed almost all parameters were significantly ($P \leq 0.01$) affected by the main effects of nitrogen and BF, except BF had no significant effect on number of kernel rows per ear. On other hand, their interaction effect also had highly significant effect on all parameters, except days to 50% tasseling. The maximum seed yield was obtained at the combination rate of 92kg N $ha^{-1}$ and 10kg BF $ha^{-1}$, which was superior to the yield obtained at the control treatment by about 277.88%. This shows that higher inorganic nitrogen and BF inputs are required for maximum grain yield of maize in the study area.Therefore, it could be concluded that the combination of 92kg N and 10kg BF $ha^{-1}$ could be recommended as best for maximum seed yield of maize. However, the experiment was carried out only in one location for one cropping season, further studies at different locations for at least three years or seasons should be conducted in the study area.

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**Introduction**

Maize (*Zea mays* L.) is the third most important crop worldwide following wheat and rice (Kandil, 2013). It is known as queen of cereals because it has the highest genetic yield potential among the cereals (B. A. Bennett, 1985). It is cultivated throughout the world 58°N latitude to 40°S latitude (Muhidin *et al.,* 2019). Maize plays a key role in the food security and livelihoods of millions of poor farmers as well as industrial grain crop (CGIAR, 2016). The maize food systems consultative research group focuses on sub-tropical maize in the low and middle-income countries that provide 64% of total maize production and where maize plays a key role in the food security and livelihoods of millions of poor farmers (CGIAR, 2016). It is also one of the major crops grown by small farmers in the semi-arid low-rainfall areas of Ethiopia. It is a warm season, short duration and quick growing crop (Muhidin *et al.,* 2019).

Low soil fertility is one among the major factors limiting maize production and productivity in the lowland areas of the country in general and in southern Ethiopia in particular, where inadequate crop management practices, imbalanced nutrition and weed infestation are becoming a common happening (Wakene *et al*., 2005). The major causes of the low soil fertility are low levels of nutrient inputs, continuous cropping, overgrazing, deforestation, and poor soil and water conservation measures (Tittonell and Giller 2013). Sustainable crop productionrequires integrated soil fertility management involving the judicious use of combinations of organic and inorganic resources in a feasible approach to overcome soil fertility constraints. Combined organic with inorganic fertilization both enhanced carbon storage in soils and reduced emissions from nitrogen fertilizer use while contributing to high crop productivity in agriculture (Abbasi and Yousra 2012). Approaches that increase the yield of the maize crop on low soil fertility especially, low nitrogen soilby the application of appropriate rates of bio-fertilizer in combination within inorganic nitrogen fertilizer are therefore essential to sustain productivity and avoid soil fertility constraints. Thus, the main objective of the study was on the response of nitrogen and bio-fertilizer rates on yield components, yield and seed quality of maize.

**Material and methods**

*Description of the Study Area*

An experiment was conducted in Durame Campus, Agricultural research farm in 221, located in Kambata Tambaro Zone, (SNNPRS) Southern Nations, Nationalities and People's Regional State, Southern part of Ethiopia during main cropping season (March–July). The site is located on geographic coordinates of 7º7′30″ N to 7º21′30″ N Latitude and 37º50′0″ E to 38º5′0″ E Longitude at altitude of this District ranges from 1700 to 3028 meters above sea level. The annual rainfall varies from 1000 to 1400mm, while the annual mean temperatures also vary from 15ºC to 24ºC (*Kedida Gamela Woreda Agricultural Office,* 2020).

*Soil Sampling and Analysis*

The soil sample was collected from experimental plots to determine some physical and chemical properties. The prepared soil sample was composited to one sample and air dried, ground, and sieved using 2mm sieve. Then, these composited soil sample was analyzed for the determination of soil texture, soil pH, organic carbon (OC), total nitrogen (N), available phosphorus (av. P), and cation exchange capacity (CEC) according to the standard laboratory procedures at Wolaita Sodo Soil laboratory.

Soil texture was expressed by using Bouyoucos hydrometer method (Day, 1965). OC content was determined by the wet digestion method of Walkleyand Black (1934) and total N by the semi-micro-Kjeldahl method of Bremner and Breitenbeck (1983). CEC of the soil was determined by the neutral ammonium acetate ($CH_3COONH_4$) saturation method (Rhoades, 1982). The av. P was extracted with a sodium bicarbonate solution at pH 8.5 following the procedure described by Olsen and Khasawneh (1980). The pH of the soil was measured potentiometrically in the supernatant suspension of a 1:2.5 soil: water mixture by using a pH meter (Van Reeuwijk, 1992).

*Experimental Materials and Experimental Design*

Maize variety (BH-660) was used which was released by DTMA (Drought Tolerant Maize for Africa) project in Ethiopia in 2011 by Bako Agricultural Research Center (CIMMYT, 2014). The treatments consisted of five levels of nitrogen (0, 23, 46, 69 and 92kg $ha^{-1}$) and three levels of *Azotobacter* (0, 5, and 10kg $ha^{-1}$). The experiment was laid in a randomized complete block design with three replications. Gross plot size was 3m x 2.5m, consisted 4 rows of maize plants.The seeds were sown in rows of 75cm at the spacing of 25cm between seeds. Spacing of 1m and 0.5m were maintained between adjacent blocks and plots, respectively. Seeds were treated with bio-fertilizers before planting and then manually planted in April 2021 using seed rate of 25kg $ha^{-1}$. The full dose of blended NPS (uniform rate of 100kg NPS) for all plots and half dose of N were applied at planting time and the remaining half amount of N was applied at knee height. The outermost one row from each side of a plot and 25cm from each end of the rows were considered as border, thus the net plot size was 2.5m x 1.5m.

*Maize Data Collection*

Days to 50% (tasseling and silking) were recorded as the number of days from sowing to the date on which 50% plants develop tassel and 50% ears of plants develop silks, respectively. Days to maturity was recorded as the number of days from date of sowing till 90% of the plants in each plot change their green color to yellow. Plant heightwas measured fromthe ground level to the top-most leaf of 6randomly selected plants, from two central rows.Thousand grain weights was determined based on the weight of 1000 seeds sample from the cobs of the two central rows of each sub plot and weighing with an electronic balance and the yield was adjusted to 12.5% moisture level.When the plants attain full maturity, the total aboveground biomasses (AGB) per plots were removed, sun-dried, and the weight was recorded.The grain yield was taken by husking and cleaning the grain yield from net plot area and converted to inkg $ha^{-1}$. The harvest index (%) was calculated by dividing the grain weight by the total biomass weight and multiplying by hundred.

$$\text{Germination percentage (GP)} = \frac{SNG}{SNo} \times 100$$

Where, GP is germination percentage, SNG is the number of germinated seeds and SNo is the number of experimental seeds sown. Purity of seed was calculated by weight of pure seed (g)/Total weight of sample (g) ×100.

## Results and discussion

*Physicochemical Properties of the Experimental Soil*

Soil textural class is clay loam; the soil pH is slightly alkaline. Both organic carbon content and total N (%) are medium, low in av. P mg/$kg^{-1}$, High in CECcmol+/kg. OC, N, Av. P, and CEC are organic carbon, organic matter, nitrogen, available phosphorous, and cation exchange capacity, respectively.

**Table 1.** Physicochemical properties of the experimental soil.

| | Soil parameters | | |
|---|---|---|---|
| Physical properties | Value | Soil Status | Sources |
| Sand (%) | 62 | | |
| Silt (%) | 31 | | |
| Clay (%) | 34 | | |
| Textural class | | Clay loam | |
| Chemical properties | | | |
| pH (1:2.5 $H_2O$) | 7.6 | slightly alkaline | Hazelton and Murphy (2007) |
| Organic carbon (%) | 1.53 | Medium | TekalignTadese (1991) |
| Total N (%) | 0.142 | Medium | Bashour (2007) |
| Available P mg/$kg^{-1}$ | 5.6 | Low | Bashour (2007) |
| CECcmol+/kg | 38.23 | High | Hazelton and Murphy (2007) |

*Growth, Phenology and Yield of maize*

*Days to 50% tasseling*

The analysis of variance (ANOVA) showed that a day to 50% tasseling was significantly (p level ?) affected by the main effects of nitrogen and bio-fertilizer, and their interaction. The maximum number of days to 50% tasseling was obtained with the application of 10kg $ha^{-1}$ bio-fertilizer (BF) with 92kg $ha^{-1}$ nitrogen fertilizer (Table 2). On the other hand, the lowest number of days to 50% tasseling was obtained from control treatment (Table 2). The result is in line with the established fact that excess supply of nitrogen might delay 50% tasseling by promoting vigorous vegetative growth of the plant Bradyand Weil (2008).

**Table 2.** Mean days to 50% tasseling of maize as influenced by the interaction of N with bio-fertilizer applied.

| Bio-fertilizer (kg ha⁻¹) | N fertilizer rates (kg ha⁻¹) | | | | |
|---|---|---|---|---|---|
| | 0 | 23 | 46 | 69 | 92 |
| 0 | $64.33^{j}$ | $71.00^{g}$ | $71.00^{g}$ | $72.67^{efg}$ | $73.67^{cde}$ |
| 5 | $67.00^{i}$ | $71.33^{fg}$ | $73.00^{def}$ | $74.67^{bcd}$ | $76.33^{b}$ |
| 10 | $68.67^{h}$ | $72.67^{efg}$ | $74.67^{bcd}$ | $75.33^{bc}$ | $80.67^{a}$ |
| | LSD(0.05) 1.636 | | | | |
| | CV (%) 1.4 | | | | |

*Days to 50% Silking*

The ANOVA showed that the main effects of N and bio-fertilizer had a highly significant (p <0.01) effect on this parameter. However, interaction effect did not significantly affect days to 50% silking of the maize crop. The significantly maximum and minimum days to 50% silking (DS) were obtained due to 92 and 0kg N ha⁻¹, respectively (Table 3). In terms of bio-fertilizer, the maximum and minimum DS were observed due to the 10 and 0kg bio-fertilizer ha⁻¹, respectively (Table 3). Similar results are reported by (Dolan M.S, *et al*,2006) who stated that higher nutrient availability and favorable soil conditions due to N fertilizer may cause vigorous crop growth and delay phenology such as silking.

**Table 3.** Mean days to 50% silking of maize as influenced by main effects of nitrogen and bio-fertilizer rates.

| N rates (kg ha⁻¹) | Days to 50% silking |
|---|---|
| 0 | $81.11^{d}$ |
| 23 | $83.33^{bc}$ |
| 46 | $81.67^{cd}$ |
| 69 | $85.22^{b}$ |
| 92 | $88.78^{a}$ |
| LSD (0.05) | 1.890 |
| Bio-fertilizer rates (kg ha⁻¹) | |
| 0 | $83.00^{b}$ |
| 5 | $83.67^{b}$ |
| 10 | $85.40^{a}$ |
| LSD (0.05) | 1.464 |
| CV (%) | 2.3 |

Means represented with same letter(s) in columns are not significantly different at 5% level of significance according to Duncan's multiple range Tests, LSD (5%) = least significant difference at 5% level and CV = coefficient of variation.

*Days to 90% physiological maturity*

The analysis of variance showed that the main effects of N and BF as well as the two-factor interactions of N x BF were significantly (p< 0.001) influenced days to 90% physiological maturity of maize.

The highest number of days to physiological maturity was observed due to 92kg N fertilizer ha⁻¹ with 10kg bio-fertilizer ha⁻¹, whereas the lowest were observed from control treatment (Table 4). This result is supported by (Shrestha, 2007) who reported that increased physiological maturity with increasing levels of nitrogen in open pollinated varieties of maize.

**Table 4.** Days to 90% physiological maturity of maize as influenced by the interaction of nitrogen fertilizer with bio-fertilizer.

| Bio-fertilizer (kg ha⁻¹) | Nitrogen fertilizer (kg ha⁻¹) | | | | |
|---|---|---|---|---|---|
| | 0 | 23 | 46 | 69 | 92 |
| 0 | $140.3^{j}$ | $143.0^{hi}$ | $143.3^{gh}$ | $145.7^{de}$ | $145.3^{def}$ |
| 5 | $142.0^{i}$ | $144.3^{fg}$ | $145.0^{ef}$ | $146.3^{d}$ | $150.3^{b}$ |
| 10 | $142.0^{i}$ | $145.0^{ef}$ | $147.7^{c}$ | $149.7^{b}$ | $153.7^{a}$ |
| | LSD(0.05) 1.0745 | | | | |
| | CV (%) 0.4 | | | | |

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance according to Duncan's multiple range Tests at 5% level and CV = coefficient of variation.

*Plant height*

Plant height was highly significantly (p <0.001) affected by main effects of N fertilizer rate and bio-fertilizer. Likewise, the interaction effect of the two factors also significantly (p <0.001) influenced the plant height. The maximum values of plant height obtained with the application of nitrogen fertilizer at 92kg ha⁻¹ with 10kg ha⁻¹ bio-fertilizer (Table 5).

On the other hand, the lowest values of plant height obtained from control treatment (Table 5). The increased plant height at the highest level of N fertilizer with bio-fertilizer rates could be attributed to the increasingly adequate supply of nitrogen and bio-fertilizer nutrients, which attributed to better vegetative development that resulted in increased mutual shading and inter nodal extension.

**Table 5.** Plant height (m) of maize as influenced by the interaction of nitrogen fertilizer with bio-fertilizer.

| Bio-fertilizer (kg ha⁻¹) | Nitrogen fertilizer (kg ha⁻¹) | | | | |
|---|---|---|---|---|---|
| | 0 | 23 | 46 | 69 | 92 |
| 0 | 2.197[h] | 3.123[f] | 3.2[ef] | 3.320[cd] | 3.397[bc] |
| 5 | 2.307[g] | 3.127[f] | 3.243[de] | 3.277[de] | 3.330[cd] |
| 10 | 3.120[f] | 3.317[cd] | 3.293[de] | 3.457[ab] | 3.527[a] |
| | LSD(0.05) 0.081 | | | | |
| | CV (%) 1.5 | | | | |

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance according to Duncan's multiple range Tests at 5% level and CV = coefficient of variation.

*Thousand grain weight (g)*

As presented in Table 6, the mean values of both main effects of nitrogen fertilizer and bio-fertilizer and interaction between them on 1000 grain weight were highly significant (p value). The significantly highest thousand kernels weight was obtained due to 92kg N ha⁻¹ with 10kg BF ha⁻¹, whereas the lowest thousand kernels weight was obtained from control treatment (Table 6). This result may be due to photosynthetic material exchange activity is stimulated through symbiosis with microorganisms in inoculated plants that increases the efficiency of photosynthetic phosphorus. This result is similar to previous research findings (Shekh, 2006); El-Kholy *et al.,* 2005); Sarig *et al.,* 1990).

**Table 6.** Thousand grain weight (g) of maize as influenced by applied N and bio-fertilizer levels.

| Bio-fertilizer (kg ha⁻¹) | Nitrogen fertilizer (kg ha⁻¹) | | | | |
|---|---|---|---|---|---|
| | 0 | 23 | 46 | 69 | 92 |
| 0 | 268.4[j] | 279.0[h] | 282.5[gh] | 293.0[ef] | 306.0[bc] |
| 5 | 272.0[ij] | 283.7[gh] | 288.7[fg] | 304.5[cd] | 304.2[cd] |
| 10 | 277.0[hi] | 286.0[g] | 298.2[de] | 312.2[b] | 325.2[a] |
| | LSD(0.05) 6.287 | | | | |
| | CV (%) 1.3 | | | | |

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance according to Duncan's multiple range Tests at 5% level and CV = coefficient of variation.

*Aboveground dry biomass yield*

The recorded results indicate that AGB of maize was significantly ($p < 0.01$) affected by the main effects of nitrogen and bio-fertilizer rates as well as by their interaction. The maximum values of aboveground dry biomass yield was obtained using of bio-fertilizer at 10kg ha⁻¹ with nitrogen fertilizer 92kg ha⁻¹, whereas the lowest values of aboveground dry biomass yield was obtained due to 0 Nkg ha⁻¹ with 5kg ha⁻¹ bio-fertilizer (Table 7). The result showed increment in AGB with the application of N and bio-fertilizers. The possible reason for this response could be due to adequate supply of N and bio-fertilizer application and their assimilation in meristematic tissue which might have played an important role plant growth. This finding is similar to the results of Eidizadeh *et al.* (2010) that the application of chemical and bio-fertilizers increased the biological yield of maize plants.

**Table 7.** Interaction effect of nitrogen and bio-fertilizer on aboveground dry biomass of maize.

| Bio-fertilizer (kg ha⁻¹) | Nitrogen fertilizer (kg ha⁻¹) | | | | |
|---|---|---|---|---|---|
| | 0 | 23 | 46 | 69 | 92 |
| 0 | 5702[i] | 6415[h] | 8279[f] | 8852[de] | 9162[cd] |
| 5 | 5662[i] | 6824[h] | 8456[ef] | 9544[bc] | 9594[bc] |
| 10 | 5797[i] | 7717[g] | 8650[ef] | 9858[b] | 10764[a] |
| | LSD(0.05) 429.4 | | | | |
| | CV (%) 3.2 | | | | |

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance according to Duncan's multiple range Tests at 5% level and CV = coefficient of variation.

*Grain Yield*

The analysis of variance indicated highly significant ($p < 0.01$) grain yield differences due to the use of nitrogen, bio-fertilizer and their interactions. The highest maize grain yield (7903kg ha⁻¹) was obtained from the highest levels of N (92kg ha⁻¹) and bio-fertilizer (10kg ha⁻¹) applied in combination, whereas the lowest grain yield was obtained from control treatment (Table 8). Thus, compared with grain yield obtained from control treatment, the highest grain yield obtained at 92 Nkg ha⁻¹ combined with bio-fertilizer (10kg ha⁻¹) was higher by 277.88% (Table 8).The increment in grain yield in response to increased rates of the bio- fertilizer and mineral nitrogen may be attributed to plant compensate the deficiency of the nutrients and maize plants increased the vegetative growth and improved the yield. The result obtained from this study is in line with the findings of Senthil-Kumar *et al.* (2006) who reported that there is high potential to increase maize yield through application of biological.

*Harvest Index (HI)*

The result of analysis indicated that harvest index (HI) was highly significantly ($p < 0.01$) affected by the application of inorganic nitrogen and BF and their interaction. The highest HI was obtained due to 92kg N ha⁻¹ combined with 10kg bio-fertilizer ha⁻¹, whereas the lowest HI was obtained due to 0kg N ha⁻¹ with 10kg bio-fertilizer ha⁻¹ (Table 9). Lawrence *et al* (2008) and Zeidan *et al.* (2006) had reported that the harvest index in maize increases when nitrogen rates and BF increase.

**Table 9.** Harvex index (%) of maize as influenced by applied nitrogen and bio-fertilizer levels.

| BF (kg ha⁻¹) | Nitrogen fertilizer (kg ha⁻¹) | | | | |
|---|---|---|---|---|---|
| | 0 | 23 | 46 | 69 | 92 |
| 0 | $49.87^{j}$ | $55.40^{i}$ | $65.39^{f}$ | $67.71^{cd}$ | $68.76^{c}$ |
| 5 | $49.60^{j}$ | $58.07^{h}$ | $66.21^{ef}$ | $70.04^{b}$ | $70.20^{b}$ |
| 10 | $50.65^{j}$ | $62.92^{g}$ | $66.95^{ef}$ | $70.95^{b}$ | $73.32^{a}$ |
| | LSD(0.05) 1.229 | | | | |
| | CV (%) 1.2 | | | | |

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance according to Duncan's multiple range Tests at 5% level and CV = coefficient of variation.

*Physical purity seed quality of maize*

The main effects of both N and bio-fertilizer as well as interaction effect were highly significant ($p \leq 0.01$) on purity of maize seed. The highest purity percentage was recorded at the combination rate of 69kg N ha⁻¹ and 10kg bio-fertilizer ha⁻¹, whereas the lowest purity percentage was recorded from control treatment (Table 10).

**Table 10.** The interaction effect of nitrogen and bio-fertilizer on purity of maize crop.

| BF (kg ha⁻¹) | Nitrogen fertilizer (kg ha⁻¹) | | | | |
|---|---|---|---|---|---|
| | 0 | 23 | 46 | 69 | 92 |
| 0 | $85.20^{h}$ | $85.23^{h}$ | $93.53^{ef}$ | $95.33^{d}$ | $96.07^{d}$ |
| 5 | $85.77^{gh}$ | $92.73^{f}$ | $97.00^{c}$ | $98.07^{b}$ | $98.37^{ab}$ |
| 10 | $86.57^{g}$ | $93.77^{e}$ | $96.70^{c}$ | $99.20^{a}$ | $98.37^{ab}$ |
| | LSD(0.05) 0.9679 | | | | |
| | CV (%) 0.6 | | | | |

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance according to Duncan's multiple range Tests at 5% level and CV = coefficient of variation.

*Germination percentage (GP)*

The main effects of both nitrogen and BF fertilizers as well as the interactions significantly ($p \leq 0.01$) affected the germination percentage of the maize crop. The highest germination percentage was obtained at the combination rate of 92kg with 10kg BF N ha⁻¹, whereas the lowest germination percentage recorded for control treatment (Table 10). These results agree with those of Sozharajan (2014) and Aliu *et al.* (2015).

**Table 10.** Mean germination percentage of maize as influenced by the interaction effect of nitrogen and bio-fertilizer.

| BF (kg ha⁻¹) | Nitrogen fertilizer (kg ha⁻¹) | | | | |
|---|---|---|---|---|---|
| | 0 | 23 | 46 | 69 | 92 |
| 0 | $93.20^{i}$ | $95.60^{fgh}$ | $95.50^{gh}$ | $97.60^{bcde}$ | $97.40^{bcde}$ |
| 5 | $94.33^{hi}$ | $97.33^{cde}$ | $96.60^{efg}$ | $96.93^{ef}$ | $98.43^{abcd}$ |
| 10 | $94.73^{h}$ | $97.20^{de}$ | $98.73^{ab}$ | $98.67^{abc}$ | $99.10^{a}$ |
| | LSD(0.05) 0.7015 | | | | |
| | CV (%) 0.4 | | | | |

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance according to Duncan's multiple range Tests at 5% level and CV = coefficient of variation.

Both nitrogen and bio-fertilizer had highly significant ($p \leq 0.01$) main effects on normal seedling percentage, but there was no significant interaction effect of the two fertilizers on the percentage of normal seedlings of maize. The lowest percentage of normal seedlings was observed at the control treatment and the highest percentage was obtained at the rate of 92kg N ha⁻¹. Similarly, main effects of nitrogen and bio-fertilizer were highly significant ($p \leq 0.01$) on abnormal seedling percentage (Table11). However, the interaction was not significant on the percentage of abnormal seedlings of maize. The highest percentage of abnormal seedlings was obtained at 92kg N ha⁻¹ and the lowest percentage was obtained at 0kg N ha⁻¹ (Table 11).

In terms of bio-fertilizer, the highest and lowest percentages of abnormal seedlings were observed due to the 10 and 0kg bio-fertilizer ha⁻¹, respectively (Table 11). The main effect of bio-fertilizer had significant effect ($p \leq 0.05$) on percentage of unfermented seed of maize.

However, the main effect of nitrogen and the interaction effect of nitrogen and bio-fertilizer were not significant on percentage of ungerminated seed of maize. The highest percentage of ungerminated seed was obtained at 10kg bio-fertilizer ha$^{-1}$and the lowest percentage was obtained control treatment (Table 11). The main effects of nitrogen as well as that of bio-fertilizer were highly significant ($p \leq 0.01$) on the percentage of dead seed. However, the interaction effect of the two factors was not significant on this parameter. The highest percentage of dead seed was obtained at 0kg N ha$^{-1}$ and the lowest percentage was obtained at 92kg N ha$^{-1}$ (Table 11). In terms of bio-fertilizer, the highest and lowest percentages of dead seed were observed due to the 0 and 10kg BF ha$^{-1}$, respectively (Table 11). The increment in response to increased rates of the bio- fertilizer and mineral nitrogen may bedue to the importance of nitrogen in physiological development of plants.Supporting this result, Khan *et al.* (2005) indicated that there was a positive relationship between nutrient supply and seed weight simply as a reflection of a higher growth rate of the seed during the filling period.

**Table 11.** Effect of nitrogen and phosphorus on speed germination, shoot length and root length.

| Nkg (kg N ha$^{-1}$) | Percentage of normal seedling | percentage of abnormal seedling | Percentage of ungerm inated seed | percentage of deed seed |
|---|---|---|---|---|
| 0 | 87.71$^{e}$ | 5.723$^{a}$ | 0.1833$^{a}$ | 6.383$^{a}$ |
| 23 | 90.53$^{d}$ | 4.384$^{b}$ | 0.1406$^{ab}$ | 4.945$^{b}$ |
| 46 | 92.44$^{c}$ | 3.819$^{b}$ | 0.1302$^{ab}$ | 3.607$^{c}$ |
| 69 | 94.84$^{b}$ | 2.554$^{c}$ | 0.1222$^{ab}$ | 2.486$^{d}$ |
| 92 | 95.92$^{a}$ | 1.729$^{d}$ | 0.0569$^{b}$ | 2.290$^{d}$ |
| LSD | 1.058 | 0.5890 | 0.0908 | 0.750 |
| Bio-fertilizer kg ha$^{-1}$ | | | | |
| 0 | 90.59$^{c}$ | 4.490$^{a}$ | 0.1217$^{ab}$ | 4.802$^{a}$ |
| 5 | 92.65$^{b}$ | 3.403$^{b}$ | 0.1833$^{a}$ | 3.767$^{b}$ |
| 10 | 93.63$^{a}$ | 3.034$^{b}$ | 0.0749$^{b}$ | 3.258$^{b}$ |
| CV (%) | 1.2 | 16.7 | 74.2 | 19.7 |
| LSD | 0.819 | 0.4563 | 0.0703 | 0.581 |

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance according to Duncan's multiple range Tests 5% level and CV = coefficient of variation.

## Conclusion

The low productivity of maize in Ethiopia is attributable to declining soil fertility. In addition, the use of inorganic fertilizers alone is one of the most important constraints limiting the yield of maize. Therefore, to increase the productivity the judicious use of combinations of organic and inorganic fertilizer is a feasible approach to overcome soil fertility constraints. In view of this, a field experiment was conducted to assess the response of inorganic nitrogen and bio-fertilizer rates on yield components and yield of maize; and to determine the economically optimum fertilizer rate for higher yield of maize. The results of the field experiment revealed that all parameters were significantly affected by main effects of nitrogen and bio-fertilizer, except bio-fertilizer had not main effect on number of kernel rows per ear. The different rate of nitrogen and bio-fertilizer influenced on growth, seed yield components and seed yield quality of maize. On other hand, interaction effects of nitrogen and bio-fertilizer also had highly significant effect on all parameters, except days to 50% tasseling.

In addition, the two fertilizers had also main effects on seed quality of maize in terms of purity, germination, dead seed and normal seedling percent. However, nitrogen fertilizer had not main effect on ungerminated seed. In general, the highest seed yield and seed quality of the plant occurred at the higher rates of nitrogen and bio-fertilizer fertilizer application. The maximum seed yield was obtained at the combination rate of 92kg N ha$^{-1}$ and 10kg bio-fertilizer ha$^{-1}$, which were superior to the yield obtained at the control treatment by about 277.88%. This treatment had also the highest seed quality of maize in terms of purity, germination, dead seed and normal seedling percentation. Therefore, it could be concluded that the combination rate of 92kg N and 10kg bio-fertilizer ha$^{-1}$ could be recommended as best for maximum seed yield and quality of maize in the study area.

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