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Research Article

EFFECT OF NITROGEN FERTILIZER RATES ON YIELD COMPONENTS, YIELD AND QUALITY OF GARLIC (*Allium Sativum* L.) VARIETIES AT KEDIDAGAMELA DISTRICT, SOUTHERN ETHIOPIA

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ABSTRACT. Garlic is one of the most significant vegetable crops for domestic and commercial consumption. Garlic productivity, on the other hand, is low due to a lack of better varieties and inadequate soil fertility. The experiment was done to examine the effect of nitrogen rates on garlic yield and yield components and identify the optimal level of nitrogen rate for garlic crops. Three improved varieties and five N rates (0, 23, 46, 69, and 92 kg N ha^{-1}) were arranged as 3 x 5 factorial in a three replication RCBD. The soil testing revealed the experimental site's poor chemical attributes, primarily fertility. The field experiment results demonstrated that the interaction of varieties and N substantially impacted the majority of garlic yield components, yield, and bulb quality. Variety Tsedey 92 (9.088 t ha^{-1}) produced the highest overall bulb output in response to 92 kg N ha-1 application. In comparison, variety Kuriftu (3.43 t ha^{-1}) had the lowest bulb yield without N. The highest proportion of nutrient concentrations such as phosphorus, potassium, and sulfur, were recorded from variety Tsedey 92, followed by variety Bishoftu Nech, which had the highest economic net benefit at 92 kg N ha-1 rates, according to the cost-benefit study. As a result, they can recommend growing both Tsedey 92 and Bishoftu Nech cultivars at 92 kg N ha^{-1} in the study area and other areas with similar agroecology.

Keywords: *Bulb yield, garlic varieties, inorganic N fertilizer*

INTRODUCTION

Garlic (*Allium sativum* L.) is the world's most important Allium crop, coming in second only to onion [1]. It is cultivated as a spice and medicinal plant throughout the world, from temperate to subtropical climates [2]. In Ethiopia, the Allium family of bulb crops (onion, garlic, and shallot) are major home-grown crops that provide income to many peasant farmers in various parts of the nation [3]. The garlic bulb consists of numerous cloves, which is the main economic organ consisting largely of swollen, bladeless storage leaves. It is one of the important and widely cultivated spice crops used for food as well as medicinal purposes which is well recognized in the control and against heart problems (hypertension), worms, germs, bacterial and fungal diseases, diabetes, headache, cancer, ulcer, rheumatism [4].

The lack of enhanced variety (ies) in required quality and quantity is the most significant barrier to garlic production and productivity in the country in general and in the research area in particular [3]. As a result, the low yield in the region is likely due to a lack of better and widely adopted garlic varieties, as well as low N-fertilizer treatment rates. Furthermore, nationally released garlic varieties are currently being introduced into the region, and some of the kinds have gained farmer favor due to their flexibility, increased production, and contribution to interrupting the life cycle of insect problems while also improving soil fertility. BishoftuNech (W-014) and Tsedey 92 (G-493) are two important garlic cultivars that are currently widely cultivated in Ethiopia [5]. It is critical to maintain or boost crop yield on low nitrogen fertilizer rate soils by applying suitable nitrogen fertilizer rates and using nitrogen-efficient garlic types. As a result, an experiment is planned with the following goals: to determine the optimal amount of nitrogen rate for better yield with good quality of garlic varieties; and to assess the reaction of garlic varieties to nitrogen rates on yield and yield components of garlic.

MATERIALS AND METHODS

Description of The Study Site

During the 2020 cropping season, the study was done at Durame Campus, Agricultural Research Field. The experimental site is 296 kilometers south of Addis Ababa and 125 kilometers southwest of Hawassa, the regional capital, with a geographical position of $7^0$7′30″ N to $7^0$21′30″ N latitude and $37^0$50′0″ E to $38^0$50′0″ E longitude, and an altitude of 1700 to 3028 meters above sea level. It receives about 1400 mm of annual rain, with a bimodal distribution pattern, and lowest and highest mean annual temperatures of 15^0 and 24^0 degrees Celsius, respectively, with clay soil type [6].

Experimental Materials and Design

As testing materials, three improved cultivars (Bishoftu Nech, Tsedey 92, and Kuriftu) is used by the DebreZeit Agricultural Research Center under the Ethiopia Institute of Agriculture Research [5] were employed. Nutrients were obtained from urea (46% nitrogen) and NPS 100 $kgha^{-1}$ fertilizers. The experiment was set up in a randomized complete block design (RCBD), using factorial configurations of 5 x 3 = 15 treatments, and it was repeated three times. One-third of N was administered during planting, one-third of N during active vegetative growth (three weeks after plant emergence), and the remaining one-third as a side dressing six weeks following plant emergence shortly before bulbing. The gross plot size was 2m × 1.5m, with a harvestable plot size of 1.70 m x 1.25 m, with spacing of 1m, 0.5m, 15cm, and 10cm between blocks, plots, rows, and plants in single rows, respectively. Borders were defined as the outermost one row from each side of a plot and 25 cm from each end of the rows. Other relevant agronomic management procedures like as weeding, disease and insect pest control, if any, were carried out uniformly for all treatments based on production package while conducting the experiment.

Data collection

Days to Physiological Maturity

Physiological maturity was recorded when 90% of the leaves of the plants in each plot change their green color to yellowish.

Plant Height (cm)

The average length of the plant in cm was measured from the soil surface to the tip of the ten randomly taken plants from the three central rows in each plot at physiological maturity.

Number of Leaf Per Plant

The total number of healthy leaves was counted from the ten randomly taken plants from middle three central rows at physiological maturity.

*Bulb Diameter (cm***)**

Bulb diameter was measured from randomly taken ten bulbs at the widest point in the middle portion of the bulb using graduated caliper in cm

Bulb Length (cm)

bulb length was measured form the bulbs which the bulb diameter was measured as indicated above. It was measured at the basal end point from the bottom scar of the bulb to the tip point of the bulb using graduated caliper in cm.

Bulb Dry Weight Per Plant (g)

The bulb dry matter weight of ten randomly take plants for which the average mature bulb weight was measured in gram after ten days of curing bulbs and drying in oven with a forced hot air circulation at temperature of 70 ^{0}C for 72 hours.

Number of Cloves Per Bulb

The total number of cloves per plant in ten plants was randomly selected from the three central row was counted after harvest.

Clove Length (cm)

The clove length was recorded as an average of five cloves of different sizes which will be measured from the base to the tip.

Clove Width (cm)

The width of the cloves was measured from which the cloves length was measured as indicated above. Clove width was measured at the widest point in the middle portion of the clove using graduated caliper in cm.

Total Yield Per Hectare (t ha^{-1})

total bulb yield of plants grown in three central rows were measured after bulbs were cured or exposed for ten days to sunlight. The yields obtained from plots were converted to hectares.
Dry Biomass Yield Per Plant (g): it was recorded as the sum of above ground dry biomass/shoot dry weight and bulb dry weight per plant.

Harvest Index (%)

It was determined as the ratio of bulb dry weight to the total plant dry biomass weight.

Bulb Chemical Composition

Random samples of 100 g bulbs from each treatment were obtained and dried at 70^{o}C until constant weight was reached, then powdered and wet digested to determine nitrogen (N), phosphorous (P), potassium (K), nitrate, and total carbohydrate contents, as described in [7 - 11]. Total protein, on the other hand, was computed by multiplying total nitrogen by 6.25.

Data Analysis

Using Gen Stat (15th edition) software, the data was subjected to analysis of variance (ANOVA) according to the experimental designs for each experiment. To determine differences between treatment means, the Least Significance Difference (LSD) approach was utilized at a 5% level of probability.

Partial Budget Analysis

Economic analysis was carried out to ascertain the economic feasibility of the treatments. We used partial budget and marginal analyses. The average bulb yield was lowered by 10% to reflect the difference between the experimental yield and the yield expected by farmers from the same treatment. For the analysis, the average open market price ETB kg^{-1} for garlic crop and the official prices of urea and NPS ETB kg^{-1} were used. When a treatment's minimum acceptable rate of return (MAR) is 100 percent [12], it is considered essential to farmers. This allows us to make farmer recommendations based on marginal analysis.

RESULTS AND DISCUSSION

Selected Physicochemical Properties of Experimental Soil Before Sowing

Soil PH results were found close to neutral soil property with a pH value of 6.8 (Table 1). According to [13] pH values classified as < 4.5 strongly acidic, 4.5-5.5 highly acidic, 5.6-6.5 moderately acidic, 6.6-7.3 neutral, 7.4-8.4 moderately alkaline, >8.5 strongly alkaline. The pH of the soil between (5.0-7.5) was found within the suitable range for crop production. So that the pH level of the study is conducive for garlic production as normal soil pH for garlic is recorded to be from pH of 6.5 –7.0 arrange appropriate condition for most garlic verities. The soil at the testing site exhibited a moderate cation exchange capacity (CEC) of 28 meq/100g, according to [14] (Table1). [15] classed soils with CECs of >40, 25-40, 15-25, 5-15, 5 cmol kg^{-1} as very high, high, medium, low, and very low. According to the results obtained from the soil laboratory, CEC was in the high range. The total nitrogen (TN) level of the experimental soil was 0.104% (Table 1). TN concentration of 0.1, 0.1-0.15, 0.15-0.3, 0.3-0.5, and >0.5, according to [13], was very low, low, medium, high, and very high, respectively. The results showed that N is a crop growth limiting factor. Available phosphorus of soil was categorized within very low (6.5 ppm) which was based on the ranges rated by [14](Table 1). Most vegetables will benefit from P fertilization if the soil test is less than 35-40 ppm.

Table 1. *Soil Physical and Chemical Properties of the Study Area*

	Soil parameters		
Soil Physical properties	Value	Soil Status	Sources
Sand (%)	63	High	
Silt (%)	28	Moderate	
Clay (%)	35	Low	
Textural class		Clay soil	[16]
Chemical properties			
pH (1:2.5 H_2O)	6.8	Neutral	[17]
Organic carbon (%)	0.99	Low	[14]
Organic matter (%)	1.7	Low	[14]
TN (%)	0.104	Low	[18]
Available P (ppm)	6.5	Very low	[14]
CEC meq/100g of soil	28	Moderate	[14]

CEC-cation exchange capacity: TN= total nitrogen: P-phosphorous: ppm = part per million

Phenology and Growth Parameters of the Crop

The interaction impact of garlic types had a very significant (P<0.001) effect on days to 90% physiological maturity, leaf width, and shoot dry weight, according to the analysis of variance (ANOVA) (Table 2). Under 92 kg N ha^{-1}, variety Tsedey 92 had the longest days to physiological maturity (142.00), the highest leaf width (2.617cm), and the highest shoot dry weight (5.620g); nevertheless, variety kuriftu had the lowest shoot dry weight (1.703 g) and leaf width (1.110 cm) at control treatment (Table 2). The increment of garlic plant in leaf width and shoot dry weight with the addition of higher level of N may be attributed to more availability of nutrients especially N, which enhances the leaf width and shoot dry weight by their simulative effect on cell division and cell enlargement that enhances protein synthesis leading to an increase in building up carbohydrates and this in turn resulted in increases in leaf width and shoot dry weight (Table 2).

The results are similar to [19]who reported that higher N levels resulted in delayed leaf senescence, sustained leaf photosynthesis and extended days to maturity.

The obtained results are in conformity with the findings of [20]who reported that the maximum shoot dry weights was achieved on the application of high nitrogen fertilizers which was while the lowest shoot dry weights was achieved at zero treatment of nitrogen fertilizer and [21]who observed highly significant differences of leaf width in their study among variety.

Table 2. *Interaction effect of varieties and nitrogen fertilizer on days to physiological maturity, leaf width and shoot dry weight of three garlic varieties.*

Variety	N rates (kg ha^{-1})	days to 90% physiological maturity	leaf width	shoot dry weight
Tsedey 92	0	132.7^{h}	1.430^{e}	1.790^{j}
	23	135.0^{fg}	1.460^{e}	3.960^{ef}
	46	138.0^{cd}	2.243^{abcd}	4.870^{c}
	69	140.0^{b}	2.433^{abc}	3.670^{fgh}
	92	142.0^{a}	2.617^{a}	5.620^{a}
BishoftuNech	0	130.0^{j}	2.051^{cd}	2.607^{i}
	23	136.3^{ef}	1.487^{e}	3.493^{gh}
	46	136.7^{de}	2.157^{bcd}	4.503^{cd}
	69	137.0^{de}	2.500^{ab}	3.770^{fg}
	92	139.0^{bc}	2.473^{ab}	4.523^{cd}
Kuriftu	0	131.3^{i}	1.110^{e}	1.703^{j}
	23	134.0^{g}	1.307^{e}	3.350^{h}
	46	136.0^{ef}	2.047^{cd}	5.260^{b}
	69	136.0^{ef}	2.023^{d}	4.170^{de}
	92	140.0^{b}	2.510^{ab}	4.037^{ef}
	LSD(0.05)	1.301	0.3574	0.3549
	CV (%)	0.65	10.7	5.6

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance LSD (5%) = least significant difference at 5% level and CV = coefficient of variation.

The major effect of nitrogen fertilizer treatment on plant height and leaf length was highly significant (P< 0.01). The main effect of varieties and interaction effects, on the other hand, had no significant effect on the garlic crop's plant height and leaf length (Table 3). Under 92 kg N ha^{-1}, variety Tsedey 92 had the longest days to physiological maturity (142.00), the highest leaf width (2.617cm), and the highest shoot dry weight (5.62g); nevertheless, variety kuriftu had the lowest shoot dry weight (1.703 g) and leaf width (1.110 cm) at control treatment (Table 3). The longest (63.81cm) and shortest (50.10 cm) plant height were recorded due to 92 and 0 kg N ha^{-1}, respectively, as well as the highest leaf length (55.09cm) was recorded by the application of 92 kg

N ha^{-1} however; the lowest leaf length (42.08cm) was measured in plot that did not receive nitrogen fertilizer (Table 3).

The increased plant height and leaf length at the highest nitrogen fertilizer level could be attributed to the increasingly adequate supply of nitrogen nutrients, which attributed to better vegetative development, which resulted in increased mutual shading and inter nodal extension, and the integral function of nitrogen in the leaves, which plays a greater role in synthesizing chlorophyll for photosynthesis, which improves cell division and growth, which in turn attributed to increased mutual shading and inter nodal extension, and the integral function of nitrogen in the leaves. These results were in line with the study of [22] who reported that the height of garlic plants was increased due to the highest rate of nitrogen application as compared to the shortest plants observed at zero nitrogen fertilizer and with the findings of [23] reported leaf length was significantly influenced by application of nitrogen fertilizer rates.

Table 3. *Mean leaf length and plant height of garlic as influenced by main effects of nitrogen fertilizer rates*

N fertilizer rates (kg ha^{-1})	Plant height(cm)	Leaf length(cm)
0	50.10^{c}	42.08^{c}
23	58.23^{b}	47.92^{c}
46	59.74^{b}	48.38^{c}
69	59.91^{b}	51.09^{b}
92	63.81^{a}	55.09^{a}
LSD(0.05)	3.052	2.688
CV (%)	5.4	5.7

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance LSD (5%) = least significant difference at 5% level and CV = coefficient of variation.

Yield and Yield Components

Varieties and nitrogen fertilizer rate interacted to influence the bulb length of garlic varieties significantly ($p < 0.05$) and nitrogen was very significant ($p< 0.01$) on the bulb length of the crop, according to analyses of variance (ANOVA) (Table 4). Tsedey 92 generated the longest bulb length (6.467 cm) when fed with the most nitrogen (92 kg N ha^{-1}); nevertheless, the shortest bulb length (4.290 cm) was produced by the variety kuriftu when no nitrogen fertilizer was used (Table 4). The findings of [24] and [25] corroborate these findings.

The major effect of nitrogen administration, as well as the interaction of variety and nitrogen rate, considerably enhanced bulb width and dry weight (Table 4). Tsedey 92 had the largest bulb diameter (5.987cm) and bulb dry weight per plant (10.790 g) at a rate of 92 N kg ha^{-1}, while variety Kuriftu had the lowest bulb diameter (3.777cm) and bulb dry weight per plant (4.016 g) with no fertilized treatment (Table 4).This is because nitrogen stimulates enzymatic activity and chlorophyll production, resulting in a larger garlic bulb.

Previous research findings [26] and [27] found similar effects. They found a substantial difference in bulb diameter and dry bulb weight when comparing low nitrogen rates to high nitrogen rates.

Table 4*.The interaction effect of varieties and nitrogen fertilizer on bulb length, bulb diameter and bulb dry weight of three garlic varieties.*

Variety	N rates (kg ha^{-1})	Bulb length(cm)	Bulb diameter(cm)	Bulb dry weight(g)
Tsedey 92	0	4.940^{df}	4.420^{ij}	4.919^{h}
	23	5.287^{bcd}	4.803^{eghi}	4.610^{hi}
	46	5.173^{bcd}	4.703^{hi}	7.154^{e}
	69	5.583^{b}	5.413^{bc}	10.245^{b}
	92	6.467^{a}	5.987^{a}	10.790^{a}
BishoftuNech	0	4.643^{ef}	4.230^{j}	4.346^{ij}
	23	5.377^{bcd}	4.967^{defgh}	4.546^{hi}
	46	5.357^{bcd}	5.605^{ab}	5.494^{g}
	69	5.640^{b}	5.233^{bcde}	6.600^{f}
	92	5.570^{bc}	5.230^{bcdef}	9.532^{c}
Kuriftu	0	4.290f	3.777^{k}	4.016^{j}
	23	5.033^{de}	4.687^{hi}	4.603^{hi}
	46	5.050^{cde}	5.158^{cdefg}	5.726^{g}
	69	5.287^{bcd}	5.353^{bcd}	6.449^{f}
	92	6.260^{a}	5.967^{a}	8.456^{d}
	LSD(0.05)	0.4609	0.3903	0.4894
	CV (%)	5.2	4.6	4.5

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance LSD (5%) = least significant difference at 5% level and CV = coefficient of variation.

The averages of yield components reported as number of cloves per bulb, dry biomass production per plant, and total bulb yield per hectare of garlic show substantial variances, according to the data in Table 5. Tsedey 92 reported the highest number of cloves (16.63) at 92 kg N ha^{-1} fertilizer application, while variety Kuriftu recorded the lowest number of cloves per bulb (6.30) in the control treatment (Table 5). [28, 20] revealed significant heterogeneity in the number of cloves per bulb among garlic cultivars in the current investigation. Tsedey 92 had the highest dry biomass output per plant (16.41g) and total bulb yield per hectare (9.088 t ha^{-1}) in response to the application of 92 kg N ha^{-1}. The lowest values of dry biomass output per plant (5.72g) and total bulb yield per hectare (3.43 t ha^{-1}) were obtained without nitrogen fertilizer application from variety Kuriftu (3.43 t ha^{-1}) (Table 5).

These findings could be attributed to the phenomenon that N fertilizer increases the reproductive potential of plants by increasing growth, reproduction, and stimulating enzymatic actions and chlorophyll formation and assimilation in meristematic tissue, which may have played an important role in overall plant growth that promotes growth and development, resulting in high plant yield [29]. The results obtained in this study support the findings of [30] where a significant increment in canopy dry matter yield of garlic was reported as N application increased. Similarly this result also agreed with the findings of [25] who reported that bulb yield of garlic increased with increased rate of nitrogen application.

Table 5. The interaction effect of varieties and nitrogen fertilizer on dry biomass yield per plantand total bulb yield per hectare of three garlic varieties.

Table 5. *The interaction effect of varieties and nitrogen fertilizer on dry biomass yield per plantand total bulb yield per hectare of three garlic varieties.*

Variety	N rates (kg ha^{-1})	Dry biomass yield per plant(g)	Total bulb yield (t ha^{-1})
Tsedey 92	0	6.71^{g}	4.905^{cde}
	23	8.57^{f}	5.378^{cd}
	46	12.02^{c}	6.013^{bcd}
	69	13.92^{b}	7.122^{b}
	92	16.41^{a}	9.088^{a}
BishoftuNech	0	6.95^{g}	4.576^{de}
	23	8.04^{f}	5.304^{cd}
	46	10.00^{e}	4.740^{de}
	69	10.37^{de}	6.533^{bc}
	92	14.06^{b}	8.788^{a}
Kuriftu	0	5.72^{h}	3.427^{e}
	23	7.95^{f}	4.424^{de}
	46	10.99^{d}	5.903^{bcd}
	69	10.62^{de}	6.077^{bcd}
	92	12.49^{c}	5.730^{bcd}
	LSD(0.05)	0.6021	1.510
	CV (%)	3.5	15.4

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance LSD (5%) = least significant difference at 5% level and CV = coefficient of variation.

Bulb chemical composition

The major effects of nitrogen fertilizer treatment had a highly significant ($p< 0.01$) effect on garlic bulb tissue nitrogen concentration, according to the analysis of variance. The major of varieties and interaction, on the other hand, were not substantial. The highest nitrogen content in garlic bulbs (3.046%) was obtained from the 92 kg N ha^{-1} plot, while the lowest nitrogen content in garlic bulbs (1.190%) was obtained from the control plot (Table 6). The increase in N content in response to increased nitrogen fertilizer rates could be attributed to the availability of optimum nitrogen fertilizer, which resulted in a high mean N content by facilitating plant height, leaf number, and leaf length, which have the physiological capacity to mobilize and translocate photosynthesis to economically valuable organs, thereby increasing N content. The findings are consistent with those of [31], who found that nitrogen fertilizer application increased N content.

Table 6. *Effect of nitrogen fertilizer on nitrogen content of garlic bulb*

N fertilizer rates (kg ha^{-1})	Nitrogen content (%)
0	1.190^{d}
23	1.661^{c}
46	2.368^{b}
69	2.601^{b}
92	3.046^{a}
LSD(0.05)	0.3459
CV (%)	16.5

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance LSD (5%) = least significant difference at 5% level and CV = coefficient of variation.

Interaction effects of cultivars and N fertilizers on phosphorus (P) and potassium (K) concentrations in garlic bulb tissues were substantial. Bishoftu Nech, which was fertilized at the highest rate of nitrogen, had the highest P (0.2959%) and K (1.914 %) concentration in garlic bulbs (92 kg N ha^{-1}). On the other hand, on the control plot, the lowest P (0.1315 %) and K (0.312 percent) concentrations in garlic bulbs were found in the Kuriftu and Tsedey 92 types, respectively

(Table 7). This was in agreement with the findings of [31] who reported a significant increment in P contents of garlic bulbs as N application increased. The present finding is supported by [31] who indicated that higher K content of garlic bulbs due to application of nitrogen was attributed to significantly higher bulb quality.

The main effect of nitrogen fertilizer had a highly significant ($p< 0.01$) impact on the protein content of garlic bulbs; however, the main effect of varieties, as well as their interaction effect, had no significant impact (Table 8). The garlic bulbs with the highest protein content (19.04%) were grown in the 92 kg N ha^{-1} treatment, while the garlic bulbs with the lowest protein content (7.44%) were grown in the control plot (Table 8). [31] Reported a considerable influence of nitrogen fertilizer on protein content, which is consistent with the current study's findings.

Table 7. *Interaction effect of varieties and nitrogen fertilizer on nutrients concentration (%) of three garlic varieties*

Treatment combination		Nutrient concentration (%)		
Varieties	Nitrogen rates (kg ha^{-1})	Phosphorus	Potassium	Sulphur
BishoftuNech	0	0.1657^{i}	0.465^{g}	0.1433^{e}
	23	0.1934^{h}	1.149^{e}	0.4220^{de}
	46	0.2773^{bcd}	1.206^{de}	1.5600^{c}
	69	0.2864^{ab}	1.729^{bc}	1.8897^{ab}
	92	0.2959^{a}	1.914^{a}	1.9433^{a}
Tsedey 92	0	0.1435^{j}	0.312^{h}	0.1800^{e}
	23	0.1640^{i}	0.820^{f}	0.3667^{de}
	46	0.2330^{fg}	1.149^{e}	0.5977^{d}
	69	0.2578^{de}	1.137^{e}	1.4810^{c}
	92	0.2658^{cd}	1.638^{c}	1.5767^{bc}
Kuriftu	0	0.1315^{j}	0.544^{g}	0.3113^{de}
	23	0.1818^{h}	0.858^{f}	0.4073^{de}
	46	0.2270^{g}	1.241^{de}	0.5600^{d}
	69	0.2444^{ef}	1.326^{d}	1.6673^{abc}
	92	0.2677^{cd}	1.815^{ab}	1.3600^{c}
	LSD(0.05)	0.01528	0.1215	0.3022
	CV (%)	4.1	6.3	18.7

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance
LSD (5%) = least significant difference at 5% level and CV = coefficient of variation.

Table 8. *Effect of nitrogen fertilizer on protein content of garlic bulb*

N fertilizer rates (kg ha^{-1})	Protein content (%)
0	7.44^{d}
23	10.38^{c}
46	14.80^{b}
69	16.26^{b}
92	19.04^{a}
LSD(0.05)	3.744
CV (%)	16.5

Means represented with same letter(s) in columns and rows are not significantly different at 5% level of significance
LSD (5%) = least significant difference at 5% level and CV = coefficient of variation.

CONCLUSIONS

The absence of increased variety in required quality and quantity, as well as poor nitrogen fertilizer rates, are the most significant constraints to garlic production and productivity in the country as a whole and in the research area in particular. It is critical to increase the productivity, bulb quality, and marketability of garlic on low nitrogen rate soils by using nitrogen-efficient garlic varieties and applying appropriate nitrogen fertilizer rates. In light of this, the current study was undertaken to identify the effect of nitrogen rates on garlic yield and yield components, as well as the suitable level of nitrogen rate for better yield and good quality garlic types. The results of the field experiment demonstrated that the interaction between types and nitrogen fertilizer had a substantial impact on most yield components, yield, and bulb quality of garlic.

Variety Tsedey 92 produced the highest total bulb yield in response to the application of 92 kg N ha^{-1}, while variety Kuriftu produced the lowest bulb yield in the absence of nitrogen fertilizer, but variety BishoftuNech produced the highest proportion of nutrient concentrations such as phosphorus, potassium, and sulphur. The following recommendations for identified restrictions were made based on the findings: According to the findings of this study, using improved garlic varieties with increased N rates is a practical way to addressing the problem of low crop productivity and bulb quality in the study area. In general, variety Tsedey 92 produced highest total bulb yields at 92 kg N ha^{-1} rates, together with the best economic benefit. Therefore, these treatments could be recommended for the farmers in the study area. However, as this study was carried out only in one location for one cropping season, so as conclusion, it is suggested to repeat the experiment once again in the study area to release the final packages before giving a conclusive recommendation.

Authors' Contributions. Tagesse A. was involved in conception, design, data collection, analysis, interpretation, and report and manuscript writing. Mulugeta A. was involved in the analysis, interpretation, and report writing. Both Authors read and approved the final manuscript.

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