

## Research Article

# Effects of Farm Yard Manure and NPS Fertilizer Rates on Growth and Yield of Garlic (*Allium sativum* L.) at Bale Highlands and Mid-Altitude

Chala Gutema\*, Gemechu Ijigu

Oromia Agricultural Research Institute, Sinana Agricultural Research Centre, Bale Robe, Ethiopia

## Abstract

Garlic is one of the most vital plant in the world, coming in second after onions in terms of significance and production. However, due to inadequate agronomic methods, a lack of enhanced varieties, diseases, and insect pests, productivity per hectare is low. Hence, an on-farm experiment was conducted to evaluate the impact of various NPS fertilizer and FYM rates on the growth and yield of garlic, as well as to determine the most cost-effective amounts of farm yard manure and NPS fertilizer for garlic cultivation. Four levels of factorial combinations were used in the treatments of FYM (0, 0.5, 1, and 1.5 tons  $\text{ha}^{-1}$ ) and five rates of NPS (0, 50, 100, 150, and 200 kg  $\text{ha}^{-1}$ ), and were set up using three replications by randomized complete block design (RCBD). The greatest plant height (70.50 cm) was noted at 150 kg NPS  $\text{ha}^{-1}$ , which was statistically comparable with 200 and 100 kg NPS  $\text{ha}^{-1}$ . The maximum bulb weight (30.77 g) was achieved from 0.5 tone FYM  $\text{ha}^{-1}$  and 150 kg NPS  $\text{ha}^{-1}$ . The highest yield (12.91 tone  $\text{ha}^{-1}$ ) was obtained from 0.5 tone FYM  $\text{ha}^{-1}$  and 150 kg NPS  $\text{ha}^{-1}$ , while the lowest yield (9.76 tone  $\text{ha}^{-1}$ ) was obtained from garlic that did not receive any FYM or NPS. The economic evaluation also indicated that the maximum net return of 2,316,300 ETB  $\text{ha}^{-1}$ , with a marginal rate of return of 308.84%, was achieved using 0.5 ton FYM  $\text{ha}^{-1}$  and 150 kg NPS  $\text{ha}^{-1}$ . Consequently, depending on the findings of the yield, growth and economic evaluation, the use of 0.5 ton FYM  $\text{ha}^{-1}$  and 150 kg NPS  $\text{ha}^{-1}$  can be provisionally suggested to farmers cultivating in the research region.

## Keywords

Garlic, Rates, Growth, FYM, Bulb Yield

## 1. Introduction

Garlic (*Allium sativum* L.) is one of the most important crops worldwide ranking second after onion in order of importance and cultivation [1]. Garlic is rich in sugar, protein, fat, calcium, potassium, phosphorus, sulfur, iodine, fiber, silicon and vitamins [2]. The demand on garlic crop in Ethiopia as well as worldwide is increasing due to its medicinal value and economic importance. Garlic is one of the im-

portant and widely cultivated spice crops used for food as well as medicinal purposes. It has been valued for its thrombotic, lipid lowering cardiovascular and anticancer effects [3]. Moreover, it contains considerable amounts of Ca, P and K and its leaves are sources of protein, vitamin A and vitamin C [4]. The world average yield of garlic is about 10 tons  $\text{ha}^{-1}$ , but can be increased up to 19 tons  $\text{ha}^{-1}$ . Several studies in

\*Corresponding author: [chalagutema@gmail.com](mailto:chalagutema@gmail.com) (Chala Gutema)

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various parts of the world have shown that garlic production can be improved through appropriate agronomic practices and other management methods [5, 2].

Imbalanced use of fertilizers is a factor contributing to low crop yields. Rising costs of chemical fertilizers, especially nitrogen, and concerns regarding pollution have directed attention towards the combined application of organic and inorganic nutrients. The physical, chemical, and biological qualities of soil are improved by organic manures; are cost-effective and environmentally friendly but are constrained in their availability [8]. The integrated claim of chemical fertilizers and organic manures may provide an option for delivering sufficient nutrition [9]. The synergistic benefit of utilizing both inorganic and organic nutrient sources has generally been shown to be more effective than using each component independently. The importance of farm yard manure (FYM) in promoting the efficient utilization of chemical fertilizers is well-established. Fertilizer needs for garlic range from moderate to high, and banding is the most popular way to apply it. Among the essential nutrients, nitrogen, phosphorus, and sulfur are the most frequently needed by garlic [10].

In the Bale Zone's highlands and mid-altitudes, garlic is among the most crucial and widely cultivated vegetable crops. It is grown using local varieties for both local market sale and home use, using both rain-fed and irrigated methods. However, because of inadequate agronomic practices, absence of enhanced varieties, illnesses, and insect pests, its productivity is low.

There is minimal information regarding the effect of farmyard manure and various kinds of fertilizers apart from nitrogen and phosphorous on garlic yield and other characteristics. According to the soil fertility map created for 124 Woradas of Oromia, the majority of soils are deficient in seven nutrients (N, P, K, S, Cu, Zn, and B) [11]. According to the EthioSIS (Ethiopian Soil Information System) soil analysis report from 2014, the soil in the Ginir and Sinana districts is deficient in S and B, alongside N and P. The objectives of this research were:

- (1) to decide the influence of FYM and NPS fertilizer rates on growth and yield of garlic; and
- (2) to suggest optimal and cost-effective rates of FYM and NPS fertilizer for garlic cultivation

## 2. Materials and Methods

### 2.1. Description of Study Area

The research was conducted at Sinja and Ginir during the 'Bona' cropping season over two consecutive years from 2021-2022. All the sites experience bimodal rainfall patterns. All primary crops were cultivated at all locations both under rain-fed and irrigated conditions.

### 2.2. Experimental Materials and Treatments

The experiment was composed of four quantities of FYM (0, 0.5, 1 and 1.5 tons' ha<sup>-1</sup>) and five levels of NPS (0, 50, 100, 150, and 200kg ha<sup>-1</sup>) and was arranged using a Randomized Complete Block Design (RCBD) in three replications. Improved variety 'MM-98' variety used as planting material.

### 2.3. Experimental Procedure and Field Management

The experimental area was cultivated and tilled by tractor and ground to a fine texture through manual digging. The cultured plot size of 1.8m x 1.5m (2.7m<sup>2</sup>) which contain six rows and the cloves was planted at a spacing of 30cm and 10cm between rows and plants, respectively. The four centermost rows will be utilized for data gathering. Before planting (approximately two weeks before planting), the amounts of FYM (0, 0.5, 1 and 1.5 tons' ha<sup>-1</sup>) were mixed into the soils using the broadcasting method for each treatment designated to the plots except the control plots. The preparation of land, sowing, and other management techniques were performed according to the recommendations of the crop.

### 2.4. Soil Sampling and Analysis

Before planting, soil samples (0-30cm depth) were gathered diagonally from five locations across the complete experimental field and combined to create a single composite sample. The composite sample was air-dried, crushed using a pestle and mortar, and permitted to pass through a 2-mm sieve. Working samples were derived from the submitted bulk samples and taken to Sinana Agricultural Research Centre Soil Testing Laboratory for analysis of soil PH, soil texture, organic carbon, total N, available P and organic matter.

### 2.5. Data Collected

Data such as days to physiological maturity, plant height (cm), leaf length (cm), leaf number per plant, bulb length (cm), average bulb weight per plant (g), number of cloves per bulb, average clove weight (g), clove length (cm) and total bulb yield per hectare (t ha<sup>-1</sup>) were collected.

### 2.6. Statistical Data Analysis

The gathered data underwent an analysis of variance (ANOVA) procedure utilizing GenStat 16th edition software. Comparisons between treatment means that exhibited significant differences for evaluated characteristics were carried out using Fisher's protected Least Significant Difference (LSD) test at a 5% significance level.

## 2.7. Economic Analysis

Yield from experimental plots was decreased by 10% for management variation, to indicate the distinction between the experimental yield and the yield that farmers might anticipate from the same treatment. Consequently, the average seed yields for FYM and NPS treatment combinations were analyzed economically using the method suggested by [12].

Finally, from the non-dominated treatments, the treatment that provided the greatest net return and a marginal rate of return exceeding the minimum deemed acceptable to farmers

(100%) was chosen for approval.

## 3. Results and Discussion

### 3.1. Soil Physico-Chemical Properties of the Experimental Site

Selected physico-chemical properties of the soil were established for composite soil (0-30cm depth) samples gathered prior to planting (Table 1).

**Table 1.** Selected soil physico-chemical properties of the experimental sites before planting.

Properties	Ginir		Sinja		References
	Result	Rating	Result	Rating	
1. Physical properties					-
Sand (%)	20		22		-
Silt (%)	26		27		-
Clay (%)	54		51		-
Textural Class	Clay		clay		-
2. Chemical properties					
pH (1: 2.5 H <sub>2</sub> O)	6.82	Neutral	6.01	neutral	[13]
Organic Carbon /OC/ (%)	1.18	Low	1.32	medium	[13]
CEC (cmol kg <sup>-1</sup> )	47.46	very high	38.46	High	[14]
Total nitrogen /TN/ (%)	0.16	Medium	0.12	Low	[13]
Available phosphorus /P/ (ppm)	10.23	Medium	4.2	Low	[14]

**Table 2.** Chemical properties of farm yard manure.

FYM	PH	Total (N%)	OC%	OM (%)	Available P (ppm)
Value	6.4	0.49	5.66	9.75	2.3
Rating	slightly acidic	very high	very high	very high	low

Where; FYM= farm yard manure; OC = organic carbon; OM = organic matter; N= Nitrogen

**Table 3.** Mean squares of ANOVA for agronomic parameters and yield of garlic influenced by FYM and NPS fertilizer.

Source	df	Mean squares									
		DM	PH	NLPP	LL	BL	BW	NCPP	CL	CW	BY
Block	2	5.55	0.78	2.04	10.19	0.69	4.47	3.21	0.27	0.86	0.39
FYM	3	37.80 <sup>*</sup>	6.97 <sup>ns</sup>	0.86 <sup>*</sup>	18.76 <sup>**</sup>	0.09 <sup>ns</sup>	21.44 <sup>ns</sup>	3.04 <sup>**</sup>	0.05 <sup>**</sup>	0.43 <sup>**</sup>	7.22 <sup>**</sup>

Source	df	Mean squares									
		DM	PH	NLPP	LL	BL	BW	NCPP	CL	CW	BY
NPS	4	14.02*	19.40**	2.72**	15.94**	0.08 <sup>ns</sup>	16.48**	7.55*	0.01 <sup>ns</sup>	0.73**	4.79**
FYM × NPS	12	4.27 <sup>ns</sup>	4.53 <sup>ns</sup>	0.40 <sup>ns</sup>	2.07 <sup>ns</sup>	0.11 <sup>ns</sup>	4.08**	0.51 <sup>ns</sup>	0.02 <sup>ns</sup>	0.44*	0.44*
Error	38	1.73	5.07	0.46	1.42	0.10	4.57	1.42	0.01	0.35	0.25
CV (%)		1.0	3.2	7.5	2.5	8.9	7.0	6.7	4.3	6.2	4.3

Where; FYM=farm yard manure; df=degree of freedom; DM= maturity date; PH=plant height; NLPP=number of leaves per plant; LL=leaf length; BL=bulb length; BW=bulb weight; NCPP=number of cloves per plant; CL=clove length; CW=clove weight; BY=bulb yield

### 3.1.1. Days to 90% Physiological Maturity

The analysis of variance signposted that the main effect of FYM and NPS fertilizer had a significant ( $p < 0.05$ ) impact on the number of days needed to reach physiological maturity, whereas the interaction between FYM and NPS had no discernible effect on the number of days needed to reach 90% physiological maturity (Table 3).

The quickest times (130.8 and 131.2 days) to reach 90% maturity were noted when no fertilizer was applied, whereas the longest times (134.4 and 133.8 days) to do so were noted when 1.5 FYM ha<sup>-1</sup> and 200 kg NPS ha<sup>-1</sup> were applied, respectively (Table 4). In response to the rising rates of both FYM and NPS fertilizer usage, the duration necessary for garlic to reach maturity was extended. The postponement in days to maturity with elevated levels of FYM and NPS N could be linked to the postponed dying of the crop's (garlic's) canopy and prolonged physiological activity, as well as continued photosynthesis. The nitrogen present in both fertilizers may have had a beneficial impact on the chlorophyll levels within the leaves. This, in turn, could have resulted in an increased production of photosynthates, which may have been further employed for enhancing cell growth, leading to an extended maturity period for garlic. Consistent with this finding, [15] indicated a lengthening of maturity days for garlic with the application of 5 tons of vermi-compost per hectare.

### 3.1.2. Plant Height

The plant height highly significantly ( $p < 0.01$ ) affected by the main effect of NPS fertilizer. However, neither the main effect of Farm yard manure nor the interaction effect of NPS and Farm yard manure significantly influenced this parameter (Table 3). The highest plant height (70.50 cm) was observed from 150 kg NPS ha<sup>-1</sup>, which was statistically similar to 200 and 100 kg NPS ha<sup>-1</sup> while the minimum plant height (67.15 cm) was recorded without fertilization with NPS fertilizer (Table 4). One possible explanation for the increase in plant height is because to the primary nutrients provided by the inorganic fertilizers, which the crop would rapidly use,

while all other micro and macronutrients obtainable from organic manures would be gradually released, and the enhanced root system of the plants may have led to greater nutrient absorption that was utilized in photosynthesis [6]. This theory is corroborated by the results of [15] who stated fertilizers leading to an increase in plant height.

### 3.1.3. Number of Leaf per Plant

Based on analysis of variance the main effect of farm yard manure application significantly ( $p < 0.05$ ) and NPS highly significantly ( $p < 0.01$ ) affect the number of leaves while the interaction between farm yard manure and NPS fertilizer application non-significant for this parameter (Table 3).

The plants that received 0.5 tons of FYM ha<sup>-1</sup> and 150 kg of NPS ha<sup>-1</sup> fertilizer produced the most leaves (9.23) and 9.65 per plant, respectively, whereas the plants that received no FYM or NPS fertilizer produced the fewest leaves (8.68) and (8.40) (Table 4).

This is due to the presence of a greater amount of nutrients, enhancement in the physical characteristics of soil, and elevated activity of microbes with increased levels of organics, which may have contributed to a rise in the number of leaves. FYM may have improved the effectiveness of chemical fertilizers. This outcome is consistent with the findings of [16] in onion.

### 3.1.4. Leaf Length

The main effects of FYM and NPS were highly significantly ( $p < 0.01$ ) influenced the leaf length while the interaction between FYM and NPS fertilizer did not show significant effect on leaf length of garlic (Table 3). The longest leaf length (48.91) and (48.75) were obtained from 1.5 tone FYM ha<sup>-1</sup> and 150 Kg NPS ha<sup>-1</sup> respectively, while the shortest leaf length was obtained in without using of FYM and NPS fertilizers in garlic (Table 4). The explanation for the longest leaf length resulting from FYM and NPS fertilizer application was a rise in the quantity of leaves due to these nutrients, leading to an enhancement in leaf length. The findings of this research are consistent with the results from [17] and [18] in garlic cultivation.

### 3.1.5. Bulb Length

The influence of FYM, NPS fertilizer and their interaction did not show significant effect on bulb length (Table 3).

**Table 4.** Main effects of FYM and NPS fertilizer on height, number of leaves per plant, leaves length, bulb length, number of cloves per bulb, cloves length and Yield of garlic.

Treatment	Date of maturity	Plant Height (cm)	Number leaves per plant	Leaves length (cm)	Bulb length (cm)	Number cloves per bulb	Cloves length (cm)
FYM (t ha <sup>-1</sup> )							
0	130.8 c	68.69	8.68 b	46.41 b	3.51	17.12 b	2.36 b
0.5	132.6 b	68.73	9.23 a	47.12 b	3.52	17.68 ab	2.49 a
1	133.8 a	69.92	9.11 ab	48.25 a	3.67	18.21 a	2.47 a
1.5	134.4 a	69.87	9.11 ab	48.91 a	3.52	17.79 ab	2.48 a
LSD	0.97	NS	0.5	0.88	NS	0.88	0.079
NPS rate (kg ha <sup>-1</sup> )							
0	131.2 c	67.15 c	8.40 c	45.92 c	3.47	16.30 b	2.40
50	132.4 b	68.47 bc	8.75 bc	47.30 b	3.48	18.07 a	2.45
100	133.2 ab	69.53 ab	9.22 ab	47.77 ab	3.62	18.23 a	2.48
150	133.8 a	70.50 a	9.65 a	48.75 a	3.65	17.87 a	2.47
200	133.8 a	69.97 ab	9.13 ab	48.63 a	3.55	18.03 a	2.44
LSD	1.1	1.86	0.56	0.98	NS	0.99	NS
CV (%)	1.0	3.2	7.5	2.5	8.9	6.7	4.3

Where; FYM=farm yard manure; NPS= nitrogen phosphorous sulphur; kg ha<sup>-1</sup>) = kilogram per; cm=centimeter; t=tonnes; LSD=Least significance difference at 5% probability level; CV=Coefficient of variation.

### 3.1.6. Bulb Weight per Plant

Variance analysis indicated that the main effects of NPS fertilizer and the interaction between FYM and NPS fertilizer were highly significantly ( $p < 0.01$ ) affect the weight of bulb per plant. However, considerable variation was not detected as a result of the primary impact of farm yard manure application on bulb weight (Table 3). The maximum bulb weight (30.77g) was gained from 0.5 tonnes FYM ha<sup>-1</sup> and 150kg NPS ha<sup>-1</sup> which is statistically equivalent to 100 and 150kg NPS ha<sup>-1</sup> whereas the minimum bulb weight (22.50g) was gained from the absence of both FYM and NPS on garlic (Table 5).

This could be attributed to sufficient nutrient availability which supported the growth of the bulb, consequently elevating the bulb's weight. The outcome aligns with the observations made by [19] who noted that the use of both potassium and sulphur, whether separately or together, enhanced plant height, leaf production, bulb weight, and bulb yield.

**Table 5.** The interaction influence of FYM and NPS fertilizer on bulb weight.

NPS rates (kg ha <sup>-1</sup> )	FYM rates (tonnes ha <sup>-1</sup> )			
	0	0.5	1	1.5
0	22.50 e	23.00 de	25.27 bcde	25.37 bcde
50	22.90 e	26.50 bcd	24.99 bcde	25.30 bcde
100	25.33 bcde	28.20 ab	26.63 bc	23.73 cde
150	25.00 bcde	30.77 a	25.93 bcde	25.53 bcde
200	25.90 bcde	27.73 ab	26.93 bc	25.07 bcde
LSD <sub>0.05</sub>	2.96 CV (%) = 7.0			

Where; FYM=farm yard manure; NPS= nitrogen phosphorous sulphur; kg ha<sup>-1</sup>) = kilogram per; t=tonnes; LSD=Least significance difference at 5% probability level; CV=Coefficient of variation



### 3.1.7. Number of Cloves per Bulb

The analysis of variance showed that the main effect of FYM was highly significant ( $p < 0.01$ ) on number cloves per bulb. Also, significant difference ( $p < 0.05$ ) was detected due to application of NPS fertilizer. However, the interaction between FYM and NPS fertilizer is not influenced this parameter (Table 3). The highest number cloves per bulb (18.21) and (18.23) were obtained from 1 tone FYM  $\text{ha}^{-1}$  and 100kg NPS  $\text{ha}^{-1}$  while the lowest number cloves per bulb (17.12) and (16.30) were obtained without application of farm yard manure and NPS fertilizer (Table 4).

### 3.1.8. Clove Length

The analysis of variance revealed that the main effect of farm yard manure was highly significantly ( $p < 0.01$ ) affect the clove length, whereas NPS and the interaction between FYM and NPS did not display a significant effect on clove length (Table 3). The longest clove length (2.49) was noted from 0.5 tone FYM  $\text{ha}^{-1}$ , which is statistically comparable to 1 and 1.5 tones FYM  $\text{ha}^{-1}$  while the minimum clove length (2.36) was obtained without using FYM (Table 4).

FYM and NPS significantly affected influenced dry matter content and increased progressively with increasing bulb size of garlic. This might be possible due to extreme vegetative growth which enhanced maximum photosynthesis and accumulation of more dry matter [20]. Comparable results were also reported by [21].

### 3.1.9. Clove Weight per Bulb

According to the analysis of variance, the primary influences of FYM and NPS was highly significantly ( $p < 0.01$ ) influenced the clove weight per bulb while the interaction between FYM and NPS fertilizer significantly ( $p < 0.05$ ) affect this parameter (Table 3). The top clove weight (2.83g) was gained from 0.5 tones FYM  $\text{ha}^{-1}$  and 100kg NPS  $\text{ha}^{-1}$  whereas the lowest clove weight (1.77g) was gained from absence of FYM and NPS fertilizer on garlic (Table 6).

Increasing in average clove weights is due to the escalating combined rates of the fertilizers may be attributed to the presence of ideal nitrogen and other nutrients found in manure, which resulted in elevated mean clove weight by enhancing leaf growth and photosynthetic processes, thus increasing the allocation of assimilates to the storage organ [22].

**Table 6.** The interaction influence of FYM and NPS fertilizer on clove weight per bulb.

NPS rates (kg $\text{ha}^{-1}$ )	FYM rates (tones $\text{ha}^{-1}$ )			
	0	0.5	1	1.5
0	1.77 g	2.37 ef	2.63 abcde	2.47 cdef
50	2.30 f	2.53 abcdef	2.70 abcd	2.57 abcdef

NPS rates (kg $\text{ha}^{-1}$ )	FYM rates (tones $\text{ha}^{-1}$ )			
	0	0.5	1	1.5
100	2.40 def	2.83 a	2.63 abcde	2.60 abcdef
150	2.50 bcdef	2.80 ab	2.70 abcd	2.70 abcd
200	2.47 cdef	2.80 ab	2.767 abc	2.70 abcd
LSD <sub>0.05</sub> = 0.26 CV (%) = 6.2				

Where; FYM=farm yard manure; NPS= nitrogen phosphorous sulphur; kg  $\text{ha}^{-1}$  = kilogram per; t=tones; LSD=Least significance difference at 5% probability level; CV=Coefficient of variation.

### 3.1.10. Total Bulb Yield

The analysis of variance indicated that the main effects of FYM and NPS were highly significantly ( $p < 0.01$ ) influenced the bulb yield while the interaction between FYM and NPS fertilizer significantly ( $p < 0.05$ ) affect this parameter (Table 3).

The maximum yield (12.91 t  $\text{ha}^{-1}$ ) was achieved with the application of 0.5 tones FYM  $\text{ha}^{-1}$  and 150Kg NPS  $\text{ha}^{-1}$ , while the minimum yield (9.76 tone  $\text{ha}^{-1}$ ) resulted from the absence of FYM and NPS application on garlic (Table 7).

This advocates that for increased garlic yield with the use of a higher amount of organic manure. [7] Indicated that organic manures greatly enhanced the bulbs. This is due to the fact that farm yard manure and NPS fertilizer may have supplied sufficient nutrients and reduced nutrient competition, thus resulting in improved clove and bulb production that leads to better bulb. Similarly, [21] found that a 50% recommended dose of NPK and 120 q  $\text{ha}^{-1}$  FYM applied together increased garlic yield.

**Table 7.** The interaction influence of FYM and NPS fertilizer on yield of garlic.

NPS rates (kg $\text{ha}^{-1}$ )	FYM rates (tones $\text{ha}^{-1}$ )			
	0	0.5	1	1.5
0	9.76 g	10.61 f	10.80 ef	10.99 ef
50	10.67 f	10.96 ef	12.29 abc	11.11 def
100	10.64 f	12.07 abc	12.56 abc	11.90 bcd
150	10.91 ef	12.91 a	12.79 ab	11.69 cde
200	12.31 abc	12.51 abc	12.42 abc	12.03 abc
LSD <sub>0.05</sub> = 0.83 CV (%) = 4.3				

Where; FYM=farm yard manure; NPS= nitrogen phosphorous sulphur; kg  $\text{ha}^{-1}$  = kilogram per; t=tones; LSD=Least significance difference at 5% probability level; CV=Coefficient of variation.

### 3.2. Economic Evaluation

According to economic evaluation the highest net benefit (2316300 ETB ha<sup>-1</sup>) with marginal rate of return (308.84%) was obtained from using 0.5 tons of FYM ha<sup>-1</sup> and 150Kg NPS ha<sup>-1</sup> (Table 8). Treatments that were dominated, based on the dominance analysis, were excluded from further economic evaluation.

The use of 0.5 tons of FYM per hectare and 150Kg of NPS per hectare, with a marginal rate of returns (308.84%) for garlic cultivation, exceeded the least acceptable return rate. Hence, the application of 0.5 tons of FYM per hectare and 150Kg of NPS per hectare represented highly rewarding practices, and these fertilizer levels are advisable for garlic cultivation in Ginir, Sinja, and additional regions with comparable agro-ecological conditions.

**Table 8.** Economic evaluation for FYM and NPS fertilizer rate.

FYM tones (ha <sup>-1</sup> )	NPS rate (kg ha <sup>-1</sup> )	Average yield (kg ha <sup>-1</sup> )	Adjusted yield by 10% down (kg ha <sup>-1</sup> )	GFB (ETB ha <sup>-1</sup> )	TVC (ETB ha <sup>-1</sup> )	NB (ETB ha <sup>-1</sup> )	MRR (%)
0	0	9.76	8.784	1756800	0	1756800	254.00
0.5	0	10.61	9.549	1909800	600	1909200	56.00
1	0	10.8	9.72	1944000	1200	1942800	56.00
1.5	0	10.99	9.891	1978200	1800	1976400	136.65
0	50	10.67	9.603	1920600	2300	1918300	D
0.5	50	10.96	9.864	1972800	2900	1969900	D
1	50	12.29	11.061	2212200	3500	2208700	20.13
1.5	50	11.11	9.999	1999800	4100	1995700	D
0	100	10.64	9.576	1915200	4600	1910600	D
0.5	100	12.07	10.863	2172600	5200	2167400	D
1	100	12.56	11.304	2260800	5800	2255000	36.06
1.5	100	11.9	10.71	2142000	6400	2135600	D
0	150	10.91	9.819	1963800	6900	1956900	D
0.5	150	12.91	11.619	2323800	7500	2316300	308.84
1	150	12.79	11.511	2302200	8100	2294100	D
1.5	150	11.69	10.521	2104200	8700	2095500	D
0	200	12.31	11.079	2215800	9200	2206600	D
0.5	200	12.51	11.259	2251800	9800	2242000	D
1	200	12.42	11.178	2235600	10400	2225200	D
1.5	200	12.03	10.827	2165400	11000	2154400	D

Note: Cost of NPS 4000.00 Birr 100 kg<sup>-1</sup>; Labour cost for NPS fertilizer application = 1, 2, 3, 4 persons to apply NPS 50, 100, 150, 200 kg ha<sup>-1</sup> day<sup>-1</sup>, at 300 ETB per day respectively; sale price of garlic 200 Birr per 1kg during harvest on farm

### 4. Conclusion and Recommendation

Analysis of variance revealed that plant height was significantly influenced by NPS fertilizer while clove length was significantly influence by FYM. On the other hand, days required to reach 90% of physiological maturity, the number of leaves per plant, leaf length and number of cloves per bulb were significantly affected

by both FYM and NPS fertilizer. The shortest days (130.8 days) and (131.2 days) to reach days to 90% maturity was attained without using fertilizers while the tallest days (134.4 days) and (133.8 days) to reach days to 90% maturity was attained at 1.5 FYM ha<sup>-1</sup> and 200kg NPS ha<sup>-1</sup> using respectively. The tallest plant height was observed with 150kg NPS ha<sup>-1</sup>, which was statistically equivalent to 200 and 100kg NPS ha<sup>-1</sup>, whereas the shortest plant height was noted in the absence of fertilization.

Bulb weight, clove weight, and overall bulb production were all

significantly impacted by the interaction between FYM and NPS fertilizer. The maximum bulb weight was gained from 0.5 tones FYM ha<sup>-1</sup> and 150kg NPS ha<sup>-1</sup> whereas the lowest bulb weight was gained from the absence of FYM and NPS on garlic. The highest clove weight was gained from 0.5 tones FYM ha<sup>-1</sup> and 100kg NPS ha<sup>-1</sup> whereas the lowest clove weight was obtained using FYM on garlic. The highest yield was gained from 0.5 tones FYM ha<sup>-1</sup> and 150Kg NPS ha<sup>-1</sup> whereas the lowest yield was gained from without application of FYM and NPS on garlic.

The economic evaluation also indicated that the maximum net benefit/return with highest marginal rate of return was gained from application of 0.5 tones FYM ha<sup>-1</sup> and 150Kg NPS ha<sup>-1</sup>. The findings suggested that rising expenses for chemical fertilizers and worries regarding pollution have shifted focus towards the collective use of chemical and organic fertilizers.

Depending on the results of yield, growth and economic evaluation application of 0.5 t FYM ha<sup>-1</sup> and 150Kg NPS ha<sup>-1</sup> can be tentatively recommended for cultivation of garlic in the study area and the same agro-ecology condition.

## Abbreviations

NPS	Nitrogen Phosphorous Suphur
FYM	Farm Yard Manure
ETHIOSIS	Ethiopian Soil Information System
RCBD	Randomized Complete Block Design
ANOVA	Analysis of Variance
LSD	Least Significant Difference
OC	Organic Carbon
OM	Organic Matter
Kg ha <sup>-1</sup>	Kilogram Per Hectare
t	Tone
ETB	Ethiopian Birr

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## Conflicts of Interest

The authors declare no conflicts of interest.

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