Plant
2022; 10(3): 81-88
http://www.sciencepublishinggroup.com/j/plant
doi: 10.11648/j.plant.20221003.14
ISSN: 2331-0669 (Print); ISSN: 2331-0677 (Online)

Performance of Barley (*Hordeum vulgare* L.) Varieties to Organic and Inorganic Fertilizers on Yield, Yield Components and Soil Characteristics

Tariku Tefera[*], Hailu Hameso[*], Hailu Tontosha

Department of Plant Science, Bensa Daye Campus, Hawassa University, Daye, Ethiopia

Email address:

hailuhameso@hu.edu.et (Hailu Hameso)

[*]Corresponding author

To cite this article:

Tariku Tefera, Hailu Hameso, Hailu Tontosha. Performance of Barley (*Hordeum vulgare* L.) Varieties to Organic and Inorganic Fertilizers on Yield, Yield Components and Soil Characteristics. *American Journal of BioScience.* Vol. 10, No. 3, 2022, pp. 81-88.
doi: 10.11648/j.plant.20221003.14

Received: August 20, 2022; **Accepted**: September 8, 2022; **Published**: September 21, 2022

Abstract: In the increasing population, there is a growing need to improve crop productivity. The aim of this study was to increase yield and yield components of barley production using organic and inorganic fertilizer in Bensa district. The experiment was laid out in Randomize Complete Block Design with factorial arrangement with three replication total twelve treatments. The treatments in the experiment were two levels of varieties (HB-1307 and EH-1493), and six level of organic and inorganic fertilizer (control, 100% NPS, 100% FYM, 50:50% NPS: FYM, 66.6: 33.3% NPS: FYM, and 33.3: 66.6% NPS: FYM. The analysis of data revealed significant difference due varieties and organic and inorganic fertilizer on phenological and growth parameters of barley significantly ($P<0.001$) affected. The results of this study indicated that organic and inorganic fertilizer significantly improved yield and yield components of barley. Higher biomass yield (10.45 ton ha^{-1}) and grain yield (7.1ton ha^{-1}) of barley were obtained from application of 66.6:33.3% NPS: FYM. The highest marginal rate of return (MRR%) 545.5 was obtained from 66.6% NPS; 33.3% FYM. Given the fact that yield performance between the organic and inorganic fertilizer combination, application of 66.6:33.3% NPS: FYM was recommended for optimum grain yield and economical profitable barley production in Bensa Daye district, Sidama Region, Ethiopia.

Keywords: Barley Varieties, Inorganic Fertilizers, Organic Fertilizers, Soil Acidity

1. Introduction

Barley (*Hordeum vulgare* L.) is a grass of the family Poaceae, the subfamily Pooideae and the tribe triticeae [1]. Barley is thought to have originated in the Fertile Crescent area of the Near East from the wild progenitor *Hordeum spontaneum* [2]. Barley is one of the most important cereal crops in the world, ranking fourth in production area next to wheat, maize and rice [3]. Barley is a staple food grain, especially for Ethiopian highlanders. It can be grown in diverse agro ecologies being grown from 1800 to 3400m altitude in different seasons and production systems [4]. Barley ranks as fifth important crop after maize, teff, sorghum and wheat in the country [5]. Barley can serve as a substitute for wheat when wheat prices are high. Recent researches have established several health benefits of barley, predominantly because of its β-glucans content; hypocholesterolemic, hypoglycemic, obesity controlling, prebiotic, and anticancerous effects [6]. The national average yield of barley in Ethiopia is low (2.157 t/ha) [5]. There are several factors that contributing to low productivity of barley in the country such as genetic, environmental and socioeconomic constraints [6]. Its grain contains carbohydrate, starch, protein and small amount of fat. Barley is also among the major grain cereals dominantly cultivated in the central and southern highlands of Ethiopia where the soils are often acidic. Barley can be cultivated and gives better yields in the diverse environmental conditions, except in extreme high rainfall areas, which limit the [7]. Declining soil fertility is one of the major challenges to barley production and productivity in Ethiopia [8]. Depletion of soil nutrients especially N and P could be one of the major reasons for the observed decreases in grain yield of barley.

Some of the emerging research findings are also proving that K is indeed becoming a limiting nutrient in some Ethiopian soils [9]. Similarly, nutrients such as sulfur and boron are also, found to be limiting nutrient in many soils of Ethiopia. They further reported that Zn and Cu deficiencies were, observed in 40 and 85% of maize crop samples, respectively. Ethiopian soil information system (EthioSIS) project is currently engaged in assessing the soil fertility status of Ethiopian soils to develop soil fertility map of Ethiopia soils. It also reported wide spread occurrence of several micronutrient deficiencies in addition to macronutrients such as N and P. Based on such recent results, production and uses of blended fertilizers containing three or more nutrients have already been started in Ethiopia regardless of the past fertilizer application.

Mineral fertilizer is an essential component in integrated nutrient management [10], and fertilizer interventions are prominent in rural poverty reduction programs in Africa. Many studies find positive returns to mineral fertilizer use [11], but degraded soils can limit the marginal return to fertilizer and mineral fertilizer application can be unprofitable at high commercial prices. The integrated nutrient management paradigm in general and the program specifically, emphasize the importance of thoughtful application of small amounts of mineral fertilizer [10]. Mister of Agriculture use of farm yard manure with low rates of mineral fertilizers could be one alternative solution for sustainable soil fertility management and barley production [12]. Limited agronomic studies in line to integrated nutrient management practices and recommend best practices in order to maximize yield [13]. Therefore, low-cost effective and environmentally friendly approaches are in high demand. In this regard, the application of mineral nutrition and use of organic fertilizer such as farm yard manure, compost and etc. would be a suitable strategy for minimizing yield reduction. Smallholder farmers are suffering from nutrient limitations and low nutrient use efficiencies of particularly nitrogen (N) as a consequence of soil degradation [14]. In addition to soil degradation, climate change is further challenging the agriculture-based societies of SSA [15]. Therefore, this experiment will be done to examine the response of integrated nutrient management on growth, yield and yield components of barley and evaluate and validate organic and inorganic fertilizer sources for the study area and to investigate the effects of inorganic and organic fertilizers rates on growth, yield and yield components of barley at Alo district Sidama, Ethiopia.

2. Materials and Methods

2.1. Description of Study Area

This study was conducted at Bensa District, in Sidama Region, Ethiopia during the main cropping seasons of 2021. It is located at 38° 27’44’’E longitude and 06° 26’59’’, N latitude. The altitude of the experimental area is 2700 meter above sea level. The climate of the area is sub-humid type with bi-modal rainfall pattern. The main rainy season is extends from June to September and the area receives an annual rainfall of 1208.5mm. The average annual temperatures of the area is 19°C. The dominant soil type is clay loam. According to Ethiopian agro-ecological classification the area is grouped under highland with intensive rainfall. The area is potential to grow pulse, cereals and horticultural crops. Among the cereals crops, the major crops grown in the area barley is one.

2.2. Treatments, Experimental Design and Procedures

The experiment was laid out in randomized complete block design (RCBD) factorial arrangement with three replications. The FYM (Cattle manure and urine composited) were used for the experiment applied all four weeks before planting while NPS (N=18, P=38 and S=7 composition). The five of integrated nutrient management rates and control are as follows: 0% (control); 100% NPS; 100% FYM (12 t FYM ha^{-1}); 50:50% NPS: FYM; FYM; 66.6:33.4% NPS: FYM; 33.4:66.6% NPS: FYM and the two improved seed of food barley varieties (HB-1307 and EH 1493) obtained from Agricultural Research Center; total twelve treatments were used. The experimental field was prepared by using local plough (Maresha) according to farmer’s Conventional farming practices. In accordance with the specification of the design, a field layout was prepared and then each treatment was assigned randomly to the experimental units within a block or plot. The plot size will be 1.6 x 2 m (plot size 3.2 m^2), with 0.2 m spacing between rows, 0.5 m spacing between plots and 1 m spacing between block with a gross area of field 204m^2. In order to avoid boarder effects (10 cm) from both sides of plots were left. Seeding was carried out by hand drilling.

2.3. Pre-sowing and Post-Harvest Soil Analysis

For pre-sowing soil analysis surface soil samples (0-20 cm) 15 samples were collected randomly by Auger sampler in a zigzag pattern from the entire experimental field and composited into one sample. Soil samples after harvesting was taken with treatments base and a sample weighing 1 kg per sample was taken. Air-dried soil sample was ground with a wooden pestle and mortar under shading. Before analysis, the sample was sieved through a 2-mm sieve mesh. The soil analyses were made at the Soils Laboratory of Hawassa University College of Agriculture. Soil pH was determined by glass electrode pH meter method in 1:2.5 soil water suspensions as described by [16]. Organic carbon was determined by Walkley and Black’s rapid titration method [17]. The available nitrogen in soil was determined by alkaline potassium permanganate method. Available phosphorus was estimated by the ascorbic acid method as described by Olsen *et al.,* [18].

2.4. Data Collected

Days to emergence, Days to heading and Days to 90% maturity was determined by counting the number of days based on visual observation. Plant height and Spike length was measured at physiological maturity from the ground level to the tip of panicle from ten randomly five selected plants in each plot. The numbers of tillers was determined by counting the tillers from an area of 1 m x 1 m plants by throwing a quadrant into the middle portion of each plot. The weight of 1000 seeds was determined by carefully counting the grains and weighing them using a sensitive balance. Grain yield was measured after harvesting the crop from the net plot area of 2.2 m^2 and from six rows to avoid border effects. Biomass yield was measured by weighing the sun dried total above ground plant biomass (straw yield +grain yield) of the net plot. After threshing the grain yield and straw yield will be measured; by subtracting the grain yield from the total above ground biomass yield. Harvest index was calculated by dividing grain yield by the total above ground air dry biomass yield.

2.5. Data Analysis

The collected data was subjected to the analysis of variance (ANOVA) using the SAS computer package version 9.0 (SAS Institute, 2002). Mean separation was carried out using least significance difference (LSD) test at 5% or 1% probability level depend on ANOVA result. Moreover, correlation analysis was also carried out to study the nature and degree of relationship between yield and yield components of barley genotype and liming. A correlation coefficient value (r) was calculated and test of significance was analyzed using Pearson correlation procedure found in SAS software.

3. Results and Discussion

3.1. Soil Physicochemical Properties of the Experimental Site

The physical properties of soil or textural class of the soil were 25% sand, 32% silt and 43% clay dominated. The soil chemical properties of the experimental site are summarized in Table 1. The soil pH was higher (5.5) with application of 100% NPS and others ranged from were 4.5-5.2 with pre-soil test was 4.7. The suitable pH range for most crops is between 6.5 and 7.5 in N availability is optimum [19]. The organic Carbon (2.98) of the soil was higher with application of 100% FYM. Higher 0.358% total Nitrogen was obtained with application of 33.3:66.6% NPS: FYM (Table 1). The total nitrogen of the soil ranged from 0.150 to 0.358 found in low to medium. Similarly, the highest soil available P (23.14 mg kg^{-1}) was recorded from plots treated with full doses of farm yard manure and the lowest recorded from control treatment 16.48%. Though the values of OC were generally rated as medium, the highest OC, (2.98%) and (2.81%) were recorded from plots treated with full doses of farm yard manure and NPS respectively and the least (1.65%) was from the plot which received control treatment (Table 1). The above findings are in line with the reports of Eghball *et al*. [20] that the residual effects of cattle manure and compost applications significantly increased electrical conductivity, plant available P and NO_3-N and pH levels concentrations where the lowest pH and nutrient content were observed on plots not treated with organic fertilizer. Sharma *et al*. [21] also observed that the use of organic fertilizer might have made the soil more porous and pulverized, to allow better root growth and development, thereby resulting in higher root cation exchange capacity (CEC). According to Vanlauwe *et al.* [10] the direct interactions between inorganic fertilizer and organic matter can improve soil fertility by restocking nutrients lost through leaching and by modifying the pH of the rhizosphere and making unavailable nutrients available. Generally, thus above results indicate that integrated use of fertilizer sources have significant improvement in the overall condition of the soil as well as agricultural productivity if best alternative option is adopted in the area.

Table 1. *Selected Physico-Chemical Properties of the Experimental Site Soil before Sowing and after Harvesting.*

Treatment		PH	N%	CEC (Meq 100g soil $^{-1}$	P (mg Soil $^{-1}$	OC%
HB -1307	0% (Control)	4.80	0.150	10.32	16.48	1.65
	100% NPS	5.50	0.271	16.23	22.42	2.81
	100% FYM	4.98	0.243	17.23	23.14	2.98
	50:50% NPS:FYM	5.10	0.255	16.81	21.25	2.70
	66.6% NPS; 33.3% FYM	5.20	0.281	16.53	22.12	2.77
	33.3% NPS; 66.6% FYM	4.99	0.358	17.12	22.56	2.72
EH-1493	0% (Control)	4.80	0.150	10.32	16.48	1.65
	100% NPS	5.50	0.271	16.24	22.42	2.81
	100% FYM	4.98	0.243	17.23	23.14	2.98
	50:50% NPS:FYM	5.10	0.255	16.82	21.25	2.70
	66.6% NPS; 33.3% FYM	5.20	0.281	16.53	22.12	2.77
	33.3% NPS; 66.6% FYM	4.99	0.358	17.12	22.56	2.72
	Pre soil test	4.70	0.221	10.66	17.23	1.72
	FYM test	8.50	5.20	41.23	45.45	18.21
	Physical properties of soil					
	Soil Textural class	Sand 25% Silt 32% Clay 43%		Clay Loam		

3.2. Effects of Organic and Inorganic Fertilizer on Phonological Parameters of Barley Production

Main effects of varieties significantly ($P \leq 0.05$) affected days to heading. Longer (75.22) and shorter (72.44) days to heading of barley was observed EH-1493 and BH-1307 respectively Table 2 The significant difference among the varieties for these phenological traits might be attributed to their genetic difference of the barley varieties. Main effects of fertilizer highly significantly (P ≤ 0.001) affected days to heading. Longer (84.66) and shorter (67.00) days to heading of barley was observed under control and 100% NPS respectively (Table 2). According to, Ofosu and Leitch [22] reported the application of fertilizers of any source, regardless of their doses accelerated days to heading as compared to no fertilizer application. Similarly, Rashid *et al*. [23] reported that NP application significantly affect days to heading of barley. In additionally this finding also agreement with Damene *et al* [24] who reported that increase in P rate decreased time to heading. Therefore, application of fertilizer was reduced the number of days to heading of barley.

Main effects of fertilizer highly significantly (P ≤ 0.001) affected days to 90% maturity. Days to 90% maturity higher (104.83) and lower (88.00) days to 90% maturity; of barley was obtained from control and combined application of 66.6% NPS; 33.3% FYM respectively (Table 2). Days to maturity decreased with increasing rate of P fertilizer. 66.6% NPS; 33.3% FYM fertilizer applied, the lower days to maturity. Similarly, The application of integrated nutrient significantly affected the number of days to maturity of barley. [25] According to, Ofosu and Leitch [22], however, the application of fertilizers of any source, nevertheless of their doses speeded days to maturity as compared to no fertilizer application treatment.

3.3. Effects of Organic and Inorganic Fertilizer on Growth Parameters of Barley Production

The analysis of data revealed significant difference due varieties on plant height significantly (P<0.0001) affected. The taller (87.77) and shorter (83.00) cm plant height of barley was observed BH-1307 and EH-1493 respectively (Table 2). Main effects of fertilizer highly significantly (P ≤ 0.001) affected plant height. The treatment (66.6:33.3% NPS: FYM) produced the tallest plants (98.5 cm) and the minimum (67.83 cm) plant height was recorded for the no fertilizer applied. The results indicated that increased organic and inorganic fertilizer application rates have obviously increasing vegetative growth of crop pants. This result of experiment agreed with the finding of Amanuliah and Maimoona [26] who reported that the use of increased rates of FYM and N increased plant height and the shortest plants recorded from the control treatment. Similarly, Haris [27] reported that the use of organic manures in combination with inorganic fertilizers maximized the plant height than the application of inorganic fertilizers alone. Similarly, Woubshet *et al*. [28] reported higher plant height of barley with the integrated application of lime, balanced fertilizer, and compost in Wolmera district.

The analysis of data revealed significant difference due varieties on spike length significantly (P<0.0001) affected. The longer (10.19 cm) and shorter (9.11 cm) spike length of barley was observed BH-1307 and EH-1493 respectively (Table 2). Similarly, result was reported by Kumar *et al*. [29]. The same to this result the yield increase was to the extent of 33.4 percent over local and the increased yield of genotype DWRB-73 was mainly due to significant increase in spike length (9.4 cm) compared to BH-902 [29]. Main effects of fertilizer highly significantly (P ≤ 0.001) affected spike length. The treatment (66.6:33.3% NPS: FYM) produced the longer (13 cm) and the shorter (6.8 cm) was recorded for the no fertilizer applied. Similarly, Shekhawat *et al*. [30] reported that considerable increase of spike weight of barley due to application of only potassium. Therefore, application inorganic and organic fertilizer alone or integrated were produced taller spike length of barley.

3.4. Effects of Organic and Inorganic Fertilizer on Yield and Yield Component of Barley Production

Main effects of fertilizer highly significantly (P ≤ 0.001) affected number of effective tiller. The treatment (66.6:33.3% NPS: FYM) produced the higher mean number of effective tiller (8) and the minimum (2.5) mean number of effective tiller was recorded from the no fertilizer applied (Table 2). Similarly, Mittiku *et al. [*31] reported greater tillering as well as higher percentage of survival of the tillers due to application of both integrated inorganic and FYM were gave significantly higher number of tillers as compared to non-fertilized barley. The result agrees with the Prystupa *et al*. [32] who reported that number of productive tillers/plant was affected by NP fertilizer application. Similarly, application of 5 t ha^{-1} FYM combined with 75% inorganic NP gave the highest number of productive tiller m^2 (227 and 215) [31]. Kumar *et al*. [29] reported that the number of total tillers $plant^{-1}$ was significantly increased with application of nitrogen fertilizer. Generally, the higher number of tillers was contributed to increased production and productivity of grain yield and total dry matter of barley.

Table 2. *Main Effects of Organic and Inorganic Fertilizer on DE, DH, DM, PH, SL, and NET, of Food Barley during 2022 cropping season.*

Treatments	DE	DH	DM	PH (cm)	SL (cm)	NET^{-1}
Varieties						
HB- 1307	7a	72.44b	92.72a	87.77a	10.19a	5.16a
EH-1493	7a	75.22a	95.55a	83.00b	9.11b	4.83a
Fertilizers						
0% (Control)	7a	84.66a	104.83a	67.83e	6.83e	2.50d
100% NPS	7a	67.83d	88.67c	93.50b	10.91b	5.5b
100% FYM	7a	77.50b	96.83b	86.83c	9.08cd	4.00c
50:50% NPS:FYM	7a	71.33cd	91.50c	86.66c	9.58c	5.00b
66.6% NPS; 33.3% FYM	7a	67.00c	88.00c	98.50a	13.00a	8.00a
33.3% NPS; 66.6% FYM	7a	72.66c	93.33bc	79.00d	8.50d	5.00b

Treatments	DE	DH	DM	PH (cm)	SL (cm)	NET^{-1}
Varieties	NS	*	NS	***	***	NS
Fertilizers	NS	***	***	***	***	***
Varieties x Fertilizers	NS	NS	NS	NS	NS	NS
LSD (5%)	0.00	4.73	4.99	4.45	0.72	0.62
CV%	0.00	5.35	4.43	4.36	6.77	10.44

DE days to emergence, DH days to heading, DM days to maturity, PH plant height, SL spike length and NET^{-1} number of effective tillers per plant, LSD list significant difference CV coefficient of variance. Means within a column followed by the same letter are not significantly different at 5% probability level *, **, *** and NS, significant, highly significant and non-significant; respectively.

The analysis of data revealed significant difference due varieties on number of seeds per spike significantly (P<0.001) affected. The mean number of seeds per spike varied between 24.94 and 22.72 of HB-1307 and EH-1493 respectively (Table 3). According to, Arif*et al*. [33] reported spikes density variety were higher in organically managed field than as well as increases in spike per plant could be the consequence of the increase in number of tillers per plant. Main effects of fertilizer highly significantly (P ≤ 0.001) affected seeds per spike. The treatment (66.6:33.3% NPS: FYM) produced the highest seed number (31.5) and the minimum (14) seed number was recorded for the no fertilizer applied. Similarly, Arif *et al*. [33] have reported significant increases in the number of grain spike-1 by applying organic manures and inorganic fertilizer application alone. Sepat *et al. [*34] reported significantly enhanced early vegetative growth, more number of spikes which consequently increased the number of spike of barley. Godara *et al*. [35] reported neither inorganic fertilizers nor organic sources alone can result in sustainable productivity. Therefore, a combination of both inorganic and organic fertilizers, where the inorganic fertilizer provides readily available nutrients and the organic fertilizer mainly increases soil organic matter and improves soil structure and buffering capacity of the soil.

Thousand seed weight significantly affected due to varieties (P<0.05) higher 1000 seed weight (40.36) was obtained from HB-1307 and lower from EH-1493 (37.44g) (Table 3). Main effects of fertilizer highly significantly (P ≤ 0.001) affected thousand seed weight. The highest significant difference was obtained from between non fertilized treatments and 66.6: 33.3 NPS: FYM where produced 26.66 g and 47.58 g respectively. Similarly, Saidu *et al*. [36] also obtained the highest 1000 grain weight, from application of 5 t ha^{-1} FYM in combination with 50%inorganic NP while the lowest 1000 grain weight was recorded from no fertilizer application. This justifies integrated application of inorganic and organic fertilizers had considerable contribution for thousand seed weight of barley, which might be due higher nutrient concentration both fertilizer sources when integrated.

The above ground biomass yield of barley was significantly (P<0.0001) affected by application of organic and inorganic fertilizer (Table 3). Significantly higher above ground biomass yield was obtained from treatment (66.6:33.3% NPS: FYM) produced the highest above ground biomass yield (10.45 ton ha^{-1}) and the minimum (6.05 ton ha^{-1}) above ground biomass yield was recorded for the no fertilizer applied, which was in agreement with [37]. Likewise, the application of 5 t ha^{-1} FYM in combination with 75% inorganic NP gave the highest biomass yield of barley [31]. Application of higher nitrogen increased dry matter of plants. According to, Shata *et al* [38] suggested that by the use of mixed chemical and bio fertilizers production can be kept at optimum level, the amount of chemical fertilizer to be used can be reduced.

The grain yield of barley was significantly (P<0.01) affected due to varieties. Significantly higher grain yield was produced fromHB-1307 the highest grain yield (2.77 ton ha^{-1}) and the lower (2.58 ton ha^{-1}) grain yield was recorded from EH-1493 variety (Table 3). The grain yield of barley was significantly (P<0.0001) affected by application of organic and inorganic fertilizer. Significantly higher grain yield was obtained from treatment (66.6:33.3% NPS: FYM) produced the highest grain yield (3.35 ton ha^{-1}) followed by recommended 100% NPS (3.15ton ha^{-1}) and the minimum (1.53 ton ha^{-1}) grain yield was recorded for the no fertilizer applied treatment. Similar observations were reported by [37]. This result was in agreement with [31]. Who reported application of inorganic fertilizers (NP or NPK) with FYM gave a better yield of barley than the application of 100% inorganic fertilizers alone. Likewise, increase in grain yield by combination of both inorganic and organic fertilizers, where the inorganic fertilizer provides readily available nutrients and the organic fertilizer mainly increases soil organic matter and improves soil structure and buffering capacity of the soil (to holding water capacity, to control soil erosion, to keep soil moisture, to control soil cracking and drying then soil come to rehabilitation) [35].

The straw yield of barley was significantly (P<0.0001) affected by application of organic and inorganic fertilizer. Significantly higher straw yield was obtained from treatment (66.6:33.3% NPS: FYM) produced the highest straw yield (7.1 ton ha^{-1}) followed by recommended 100% NPS and 50:50%NPS: FYM (6.8ton ha^{-1}) and the minimum (4.51 ton ha^{-1}) straw yield was recorded for the no fertilizer applied treatment (Table 3). Likewise, Gafar *et al*. [39] have demonstrated the beneficial effect of integrated nutrient management in justifying the deficiency of several macro and micro-nutrients which affected the straw yields. Application of optimum dose of integrated nutrients (50 N; 100 PS $kgha^{-1}$ and t ha^{-1} FYM) is fundamental for maintaining adequate supply of nutrients (OC, OM, P and N) for increased yield. The chemical fertilizer required to achieve optimum yield levels can be decreased with the application of organic fertilizer [40]. The present trend of increase in straw yield with the combined application of organic and inorganic fertilizers over the control was in conformity with [41].

The harvest index was significantly (P<0.0001) influenced by application of organic and inorganic fertilizer. Significantly higher harvest index of barley was obtained with 100% NPS application (0.32) followed by (66.6:33.3% NPS: FYM) and 50:50%NPS: FYM (0.31); lowest recorded from (0.25) non fertilized treatment (Table 3). Similarly, harvest index of about 50% with a positive trend due to increasing N rate was previously reported by [42]. Likewise, Mitiku *et al*. [31] reported harvest index of barley was significantly influenced by the combined application of organic and inorganic fertilizer sources and the highest harvest index.

Table 3. *Main Effects of Organic and Inorganic Fertilizer on NSS^{-1}, SW, ABM, SY, GY and HI%, of Barley during 2022 cropping season.*

Treatments	NSS^{-1}	1000GW (g)	ABMtha^{-1}	SYtha^{-1}	GY tha^{-1}	HI%
Varieties						
HB- 1307	24.94a	40.36a	8.97a	6.20a	2.77a	0.30a
EH-1493	22.72b	37.44b	8.95a	6.36a	2.58b	0.28b
Fertilizers						
0% (Control)	14.00d	26.66d	6.05d	4.51c	1.53d	0.25c
100% NPS	26.66b	42.91b	9.51b	6.80a	3.15a	0.32a
100% FYM	23.00c	39.08bc	8.91c	6.11b	2.70bc	0.28b
50:50% NPS:FYM	24.16c	40.16bc	9.50b	6.80a	2.80b	0.31a
66.6% NPS; 33.3% FYM	31.50a	47.58a	10.45a	7.10a	3.35a	0.31a
33.3% NPS; 66.6% FYM	23.66c	37.00c	8.91c	6.36b	2.55c	0.26bc
Varieties	**	*	NS	NS	**	*
Fertilizers	***	***	***	***	***	***
Varieties x Fertilizers	NS	NS	NS	NS	NS	NS
LSD	2.31	4.22	0.42	0.40	0.20	0.02
CV	8.13	9.06	3.93	5.42	6.54	8.15

NSS^{-1} number of seed per spike, 1000GW thousand grain weights, ABM above ground biomass, SY straw yield, GY grain yield and HI harvest index LSD list significant difference CV coefficient of variance. Means within a column followed by the same letter are not significantly different at 5% probability level *, **, *** and ns, significant, highly significant and non-significant; respectively.

3.5. Integrated Use of Inorganic and Organic Fertilizer on Economic Profitability of Barley Production

Based on partial budget analysis, the highest marginal rate of return (MRR%) 545.5 and 391.6 were obtained from 66.6% NPS; 33.3% FYM and 100% FYM respectively, but the lowest marginal rate of return (MRR%) 25.2 was obtained from 33.3% NPS; 66.6% FYM. This means that for every 1.00 birr invested for both fertilizers in the field, producers can expect to recover the 1.00 Birr and obtain an additional of 54.5and 39.1 Birr from fertilizers 66.6% NPS; 33.3% FYM and 100% FYM, respectively.

Table 4. *Economic Profitability of Barley Production under Integrated use of inorganic and Organic Fertilizer.*

Treatments	Av.GY t ha^{-1}	Ad. GY t ha^{-1}	GFB (Birrha^{-1})	TVC (Birrha^{-1})	NB (Birrha^{-1})	MRR%
Varieties						
EH-1493	2.58	2.32	116,000	39,500	76,500	-
HB- 1307	2.77	2.49	124,500	39,500	76,500	-
Fertilizers						
0% (Control)	1.53	1.37	68,500	25,000	43,500	-
33.3% NPS; 66.6% FYM	2.55	2.29	114,500	38,828.5	75,671.5	25.2
100% FYM	2.70	2.43	121,500	39,000	82,500	391.6
50:50% NPS:FYM	2.80	2.52	126,000	38,750	87,250D	-
100% NPS	3.15	2.83	141,500	38,500	103,000D	-
66.6% NPS; 33.3% FYM	3.35	3.01	150,500	38,662	111,838	545.5

N.B Prices of Urea = 40 birr kg^{-1} NPS =45, FYM =100 birr 100kg^{-1}, prices of barley 50 birr kg^{-1}. Labor cost was vary on each treatment.

4. Conclusion

In the increasing population, there is a growing need to improve crop productivity. However, the majority of tropical soils like Ethiopia have limited capacity of producing high crop yields because of production constraints like soil acidity and lack of soil fertility. Due to such constraints, yield is usually below the genetic potential of crops alternatives ways to overcome such problem is application of organic and inorganic fertilizer use of nutrient efficient. The results of this study indicated that organic and inorganic fertilizer significantly improved yield and yield components of barley. The phenological and growth parameter of barley were improved with application of organic and inorganic fertilizer. Higher biomass and grain yield of barley were obtained from application of 66.6:33.3% NPS: FYM show that organic and inorganic fertilizer contributed for soil nutrient status improvement. The highest marginal rate of return (MRR%) 545.5 was obtained from 66.6% NPS; 33.3% FYM. Given the fact that yield performance between the organic and inorganic fertilizer combination, application of 66.6:33.3% NPS: FYM was recommended for optimum grain yield and economical profitable barley production in Bensa Daye district, Sidama Region, Ethiopia.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no competing interests.

Acknowledgements

The authors are very grateful to Daye campus for providing all necessary equipments and logistics during the research work.

References

[1] Voltas, J., Romagosa, I., Lafarga, A., Armesto, A. P., Sombrero, A. and Araus, J. L. 1998. Genotype by environment interaction for grain yield and carbon isotope discrimination of barley in Mediterranean Spain. *Australian Journal of Agricultural Research.* 50: 1263–1271.

[2] Saisho, D. and Purugganan, M. D. 2007. Molecular phylogeography of domesticated barley traces expansion ofagriculture in the Old World. *Genetics*. 177: 1765-1776.

[3] USDA (United States Department of Agriculture).. World Agricultural Production U.S. Department of Agriculture Foreign Agricultural Service / Office of Global Analysis International Production Assessment Division (IPAD) Ag Box 1051, Room 4630, South Building Washington, DC 20250-10512017.

[4] Muluken bantayehu, 2013. Study on malting barley genotypes under diverse agro ecologies of north western Ethiopia: Adet agricultural research center, p. O. Box 08, Bahirdar, Ethiopia.

[5] CSA (Central Statistical Agency). Central Statistical Agency agricultural sample survey report on area and production of major crops private peasant holdings, meher season. Addis Ababa, Ethiopia. Volume I. 2018.

[6] Mulatu, B. & Grando, S. 2011. Barley Research and Development in Ethiopia. Proceedings of the 2nd National Barley Research and Development Review Workshop. 28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, PO Box 5466, Aleppo, Syria. pp xiv + 391.

[7] Getaneh W. 2007. The barley leaf rust in the high land of Ethiopia: Significance, virulence spectrum and sources of partial resistance. PhD Dissertation, Haramaya University, Ethiopia.

[8] T. A and D. Tanner. Effect of fertilizer application on N and P uptake, recovery and use efficiency of bread wheat grown on two soil types in central Ethiopia. *Ethiopian Journal of Natural Resources*. 3 (2): 219-244. and N and Pfertilizers in acidic soils 2001.

[9] Wassie H and Shiferaw B. 2011. Response of Irish potato (Solanum Tuberosum L.) to the application of potassium at acidic soils of Chencha, Southern Ethiopia. Int. J. Agric. Biol, 13: 595–598.

[10] Vanlauwe, B., J. Wendt and J. Diels, 2001. Combined application of organic matter andfertilizer. pp 247-280. In: Tian, G. F. Ishida and J. D. H. Keating (eds.) Sustaining soilfertility in West Africa. SSSA Special Publication, No. 58. Soil Science Society ofAmerica. Madison, USA.

[11] M. S, Black, R., Jayne, T. S. Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research. Food Policy. 41, 39-52.2013.

[12] MoA (Ministry of Agriculture) Ministry of Agriculture. Animal and Plant Health Regulatory Directorate. Crop variety register, Addis Ababa, Ethiopia. 2012.

[13] Abera T, Molla A, Feyissa A, Liben M, Woyema A, et al. (2011) Research achievements in barley cultural practices in Ethiopia. Barley Research and Development in Ethiopia, p: 113.

[14] Cairns JE, Hellin J, Sonder K, Araus JL, MacRobert JF, Thierfelder 2013. Adapting maize production to climate change in sub-Saharan Africa. Food Secur.; 5 (3): 345–360. https://doi.org/10.1007/s12571-013-0256-x

[15] Zougmore RB, Partey ST, Oue´draogo M, Torquebiau E, Campbell BM. 2018. Facing climate variability in sub-Saharan Africa: analysis of climate-smart agriculture opportunities to manage climate-related risks. Cah Agric.; 27 (3): 34001 https://doi.org/10.1051/cagri/2018019

[16] M. L. Jackson, Soil Chemical Analysis, practice Hall of India, New Delhi, India, 1958.

[17] A. Walkley and C. A. Black, "An examination of different methods for determining soil organic matter and the proposed modification by the chromic acid titration method," Soil Science, vol. 37, pp. 29–38, 1934.

[18] Olsen, S., Cole, C., Watanabe, F., Dean, L 1954. Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate. USDA Circular No. 939, US Gov. Print. Office, Washington, D.C..

[19] FAO (Food and Agriculture Organization) Plant Nutrition for Food Security. A Guide for Integrated Nutrient Management. Rome, Italy 2008.

[20] Eghball B, D. Ginting and J. E. Gilley, 2004. Residual effects of manure and compostapplications on corn production and soil properties. *Agronomy Journal*. 96: 442-447.

[21] P S. K., T. S. Verma, and J. P. Gupta. Ameliorating effects of phosphorus, limeand animal manure on wheat yield and root cation exchange capacity in degradedAlfisols of North- West Himalayas. *Fertilizer Research* 23: 7-131990.

[22] Ofosu-Anim J, Leitch M (2009) Relative efficiency of organic manures inspring barley (*Hordeum vulgare* L.) production. *Australian Journal of Crop Science* 3: 13-19.

[23] Abdur R, Khan RU (2008) Comparative effect of varieties and fertilizerlevels on barley (*Hordeum vulgare*). *International Journal of Agricultureand Biology* 10: 124-126.

[24] Alemu D, Kelemu K, Lakew B (2014) Trends and prospects of malt barleyvalue chains in Ethiopia. Addis Ababa, Ethiopia.

[25] Tariku B. Tolera A. and Ermiyias H. 2018. Effect of Integrated Nutrient Management on Growth and Yield of Food Barley (*Hordeum vulgare*) Variety in Toke Kutaye District, West Showa Zone, *Ethiopia. Advanced Crop Science Technology*; 6: 365.

[26] Jan A, Noor M (2007) Response of wheat to farm yard manure andnitrogen under rain-fed conditions. African J Crop Sci 8: 37-40.

[27] Haris. PB the effect of different rates and times of application of nitrogen on the yield and quality of whole crop barley. Experimental Husbandry 28: 1-6 1995.

[28] Wubshet M. Temedo T. Singh, T. N. and Teferi M., (2014) "Effect of integrated nutrient management on yield and yield components of barley (Hordium vulgare L.) in Keffa Zone, South western Ethiopia," Science Technology Arts Research Journal, vol. 3, no. 2, pp. 34–42, 2014.

[29] M. CP, Alagundagi SC, SalakinkopSRProductivity of barley (*Hordeum vulgare* L.) genotypes to integrated nutrient management andbroad bed and furrow method of cultivation in watershedarea. International Journal of Agriculture Sciences 7: 497-501. 2015.

[30] Shekhawat PS, Shaktawat RPS, Rathore DS (2013) Effect of nitrogen and potassium levels on growth and yield of barley (*Hordeum vulgare* L.) in loamy sand soil of Rajasthan. Environment and Ecology 31: 1303-130.

[31] Woldesenbet M, Tana T (2014). Effect of Integrated Nutrient Managementon Yield and Yield Components of Food Barley (*Hordeum vulgare* L.) in Kafa Zone, Southwestern *Ethiopia Science, Technology and Arts Research Journal* 3: 34-42.

[32] P. P, Slafer GA, SavinRLeaf appearance, tillering and theircoordination in response to NxP fertilization in barley. Plant and Soil 255: 587-5942003.

[33] Arif M, Ali S, Khan A, Jan T, Akbar M (2006) influence of farm yardmanure application on various wheat cultivars. Sarhad Journal ofAgriculture 22: 27.

[34] R. N. Sepat, R. K. Rai, and S. Dhar, "Planting systems andintegrated nutrient management for enhanced wheat (*Triticumaestivum*) productivity," *Indian Journal of Agronomy*, vol. 55, no. 2, pp. 114–118, 2010.

[35] A. S. Godara, U. S. Gupta, and R. Singh, "Effect of integrated nutrient management on herbage, dry fodder yield and quality of oat (*Avena sativa* L.)," *Forage Research*, vol. 38, no. 1, pp. 59–61, 2012.

[36] Saidu A, Ole K, Leye BO (2012) Performance of Wheat (Triticum aestivum L.) as influenced by complementary use of organic and inorganic fertilizers. International Journal of Science and Nature 5: 532-537.

[37] Ram H, Neha G, Balwinder K, Baljit S (2014) Progressive Res 9: 44-49. Prystupa P, Slafer GA, Savin R (2003) Leaf appearance, tillering and their coordination in response to NxP fertilization in barley. Plant and Soil 255: 587-594.

[38] Shata SM, Mahmoud SA, Siam HS (2007) Improving calcareous soil productivity by integrated eﬀect of intercropping and fertilizer. *Res J AgrBiolSci* 3: 733-739.

[39] Farah GA, Dagash YMI, Yagoob SO (2014) Effect of Different Fertilizers (Bio, Organic and Inorganic Fertilizers) on Some Yield Components ofRice (Oryza Sativa L.). Universal Journal of Agricultural Research 2: 67-70.

[40] Berecz K, Kismányoky T, Debreczeni K (2005) Effect of organic matter recycling in longterm fertilization trials and model potexperiments. Communications in Soil Science and Plant Analysis 36: 191-202.

[41] Parihar CM, Rana KS, Kantwa SR (2010). Nutrient management in pearl millet (Pennisetum glaucum)—Mustard (Brassica juncea) croppingsystem as affected by land configuration under limited irrigation. IndianJournal of Agronomy 55: 191.

[42] Bekele T, Ashagrie Y, Tulema B, Gebrekidan G (1996). Soil fertility management in Barley. In 1. Proceedings of the Barley Research Review Workshop, Addis Abeba (Ethiopia), 16-19 Oct 1993. IAR/ICARDA.