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EFFECT OF BEER BIOSLUDGE AND NPS BLENDED CHEMICAL FERTILIZERS ON YIELD AND YIELD COMPONENTS OF MALT BARLEY

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ABSTRACT

Ethiopia rank 21st in the world's with share of 1.2% and 2nd next to morocco with share of 26% in Africa in total barley production; however, it's productivity has been still low (2.18 tons) compared to 3.3 tons ha^{-1} in Kenya and 6 tons ha^{-1} in developed countries. This low productivity and quality has been resulted from soil fertility depletion and low rate use of organic and chemical fertilizers below the rate required and unbalanced application of nutrients. This experiment was conducted to test the effect of integrated use of organic Beer biosludge (0, 5, 10 and 15 t ha^{-1}) and inorganic blended NPS fertilizer (0, 75, 100 and 150 kg ha^{-1}NPS) on growth, yield and yield component of malt barley at Lemu-Bilbilo District in Arsi Zone in 2019 cropping season. The experiment was arranged in randomized complete block design having sixteen treatments in three replications. The analysis of variance showed that the main effect of blended NPS fertilizer significantly influenced seed per spike, plant height, moisture content of the grain, grain yield, biomass yield, harvest index and protein content. The main effect of Beer biosludge resulted significant differences on productive tillers, number of seed per head, spike length, biomass, plant height, grain yield, thousand kernel weight, harvest index, moisture content, 50% days to heading and protein content. The interaction effect of NPS fertilizer and Beer biosludge also brought significant differences on plant height, productive tillers, hectolitre weight, grain yield, thousand kernel weight, harvest index, seed per spike and moisture content of the grain. The highest (19.49 t ha^{-1}) and lowest (12.26 t ha^{-1}) mean biomass yield per hectare were obtained from plots fertilized with 15 t BBS along with 75 kg NPS ha^{-1} and 5 t BBS ha^{-1} alone, respectively; and similarly, highest grain yield (9.26 t ha^{-1}) was recorded from 15 t BBS application along with 150 kg NPS ha^{-1} and lowest (3.94 t ha^{-1}) from the control plot. Highest marginal rate of return (3981%) was obtained from plot treated with 100 kg NPS ha^{-1} along with 5 t BBS ha^{-1} and highest protein content from plot treated with 100 and 150 kg NPS ha^{-1}. Also growth, yields and quality parameters significantly and positively correlated to each other due to organic and inorganic fertilizers applied. Thus, application of 5 tons ha^{-1} of BBS along with 150 kg ha^{-1} is better to improve productivity of malt barley and can be used as an alternative soil management option for malt barley production at an experimental area and the like. However, to come to concrete recommendation, similar research should be done with the inclusion of more biosludge rates in combination with different blended inorganic fertilizers and different varieties of malt barley at different locations and seasons.

Keywords: Beer biosludge, blended NPS fertilizer, traveler malt barley, economic yield.

1. INTRODUCTION

Ethiopia has 1.12 million square Kilometres and located at 9.4969° N, 36.8961° E latitude and longitude respectively in the Horn of Africa and due to difference in location most parts of the country is vulnerable to drought. About 17% population lives in urban areas while 83 % population lives in rural area and engaged in agriculture which accounting for half of gross domestic product (GDP), 83.9% of exports, and 80% of total employment (Tarkegn, 2016). According to FAO report to meet the growing demand, World food production will need to increase by 50% by 2030 (FAO, 2014). Globally maize, rice, wheat and barley are the four leading crops in area and volume of production and the first three are leading global cereals that feed the world (Shiferaw *et al.,* 2011), however barley (*Hordium vulgar* L.*)* is the most ingredients for beer production.

Barley is grown in diverse ecologies being grown from 1800 to 3400 m.a.s.l in different seasons and production systems and it can be grown between 1500 to 3800 m. a.s.l under highly variable climatic and edaphic conditions (Asfaw, 2000) and it is hardy crops that can adapt to different agro ecology. It is one of the most important cereal crops in the world (Akar *et al*., 2013/14), ranking fourth after wheat, maize, and rice in terms of production (Lapitan *et al*., 2009) and 5th in Ethiopia next to Teff, Maize, Sorghum, and Wheat (CSA, 2017) and Globally barley production is estimated about 141.7 million tons (USDA, 2017). Morocco, Ethiopia, Algeria, Tunisia and South Africa are the top five largest barley producers in Africa and Ethiopia is ranked twenty-first in the world`s total barley production with a share of 1.2% and 26% of the World and Africa respectively (FAO, 2014) and according to the 2014/2015 forecasts from Ethiopia's Central Statistics Authority, of the 12.6 million hectares was under cereals which contributed 87.36% of the grain production and barley took up about 8 and 7 percent of the grain crop area, and between 2003/04 and 2018/19, the number of smallholders growing barley increased from 2.5 million to 3.07 million; yields increased from 1.17 metric tons per hectare to 2.18 metric tons per hectare; and total production grew from 1.0

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million tons in 2005 to about 1.9 million tons in 2017 and the average yield (2.11 t ha^{-1} at national and 2.41 tons as Oromia level); however productivity per hectare of land still relatively low compared to 3 t ha^{-1} in Kenya or 6 ton ha^{-1} in developed countries (Rashid *et al*., 2015; CSA, 2017) and this increment in Ethiopia had been brought from an increment of productivity from time to time which has been directly associated with the expansion of the breweries and introduction of new varieties.

Malt barley is the major (90%) raw material for beer production (MoARD, 2010) in the country and it's productivity is still low and it's area of coverage has been accounts 10-15 % of the total and we could not yet been expanded enough to satisfy need of malt factories and breweries (Berhane *et al.*, 2016) and the country faced shortage of malt barley to meet the demand of the local breweries (Mohammed and Getachew, 2003). According to information from ERCA, over the last seven years Ethiopia imported about 52,642 tons of malt barley and malt products per year. The country is not competitive in its malt and malt barley compared to imported in quality and even the price of imported malt barley and malt are lower than produced in the country. However productivities and the supply of malt barley still low and could not satisfy the current demand of the country, the demands is expected to grow to 274,480 tons of malt barley by 2020 (Tarekegn, 2016). Soils in the highlands of Ethiopia usually have low levels of essential plant nutrients, low availability of nitrogen and it is the major constraint to cereal crop production (Abebe *et al.,* 2017) and low rate of fertilizers use especially organic and nitrogen fertilizers in addition to lack of improved varieties and lack of best agronomic practices are among the major constraints responsible for the low productivity of malting barley in Ethiopia (Gete *et al*., 2010) and similarly ICARDA reported barley productivity constrained by poor yield-potential of varieties, diseases, insects, poor soil-fertility, water logging, drought, soil acidity, and weeds (ICARDA, 2012). Low soil fertility has been mostly resulted from farming without replenishing nutrients over time, continuous cropping of cereals, removal of crop residues, nutrient leaching, and low level of fertilizer usage and unbalanced application of nutrients. It is also enhanced through nutrient removal with harvest, during tillage, during weeding, and runoff which in average estimated that about 137 tons ha^{-1} $year^{-1}$ soil lost from agricultural lands through erosion (Gete *et al*., 2010). The problem of soil fertility degradation mostly pronounced in the highlands of Ethiopia, where most of human and livestock population concentrated, and malting barley is produced (Getachew *et al*., 2014b). Besides sever soil degradation, the use of external inputs to maintain soil fertility for increasing malting barley production is still low. From CSA report of 2014 indicating that fertilizer used in the district estimated to 65 kg ha^{-1} which was lower than the existing recommendation, which was 100 kg ha^{-1} NPS (CSA , 2014).

Research that explores opportunities to reuse and recycle wastes, including brewery by products, is important to improve the efficiency of production and consumption, and thereby make progress toward sustainable development goals (UN, 2015). Thus beer sludge is an alternative solution for soil amendments and to enhance yields. Other wastes from breweries, including spent grains, have been combined with additional organic materials (e.g. saw dust and horse manure) and used to produce compost, which has been shown to increase yields of crops (Crosier, 2014). A few previous studies indicate that BBS has high potential to increase the availability of nutrients to plants (Mathias *et al*., 2014) and research done in Harari region on BBS effect on sorghum indicated that application of brewery sludge's at 7.5 tons ha^{-1} increase plant height of sorghum by 11.06 and 26.9% (14cm and 29.8cm) over recommended chemical fertilizers and control respectively (Nano *et al*., 2016). Similarly, Aschalew *et al*. (2018) found that, 84.56 cm malt barley height was recorded from BBS at a rate of 15 t ha^{-1} while 80.19cm and 71.7cm plant height was obtained from plots which were treated by recommended rate of chemical fertilizers and control which indicated (3.7 3 % and 12.93%) increments and he also reported that 15 tons ha^{-1} Brewery bio sludge significantly increased the grain yield by 10.04 and 22.33 quintals from recommended rate of fertilizers and control plot respectively. When 15 t of breweries bio sludge's used which indicate that grain and bio mass yields of sorghum were increased by 375 and 561.47 % over control (32.23 and 52.88 quintals ha^{-1}) and by 130.75% and 205.59% (23.13 and 40.92 qt ha^{-1}) over chemical fertilization applied plots respectively (Nano *et al.,* 2016) and Aschalew *et al*. (2018) reported that 70.34, 60.31 and 48 quintals ha^{-1}malt barely grain yields from treated by breweries bio sludge's at rate of 15 tons ha^{-1}, recommended rate of Chemical fertilizers (100 kg NPS and 50 kg UREA) and Control respectively. The problems of soil fertility, removal of crop residues without replacing and productivity difference stated in this paper and current status of barley productivity differences between Ethiopia and developed countries. Thus, the objective of this study was to evaluate effect of breweries bio sludge (BBS) on malt barley growth, yield, yield components and quality attributes of malt barley.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

This research was conducted in Oromia regional state, Arsi zone Lemu-Bilbilo district specifically at Chiba Michael peasant association on farmer's field from June to December 2019. Lemu-Bilbilo is located about 235 km Southeast of Addis Ababa, 56 km South of Asella (Samuel *et al*., 2017) and Chiba Michael where this research was carried out is located about 2 km East of the town and geographically located at N 07^{0} 31.350' latitude and E 0397^{0} 17.112'and it was done during main cropping season of 2019 under rain-fed conditions. The area obtained an average of 800 to 1100 mm of rain fall and mostly occur from March to October and maximum rain found from June to August. Moreover, its climatic condition was cold with minimum, maximum and average

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temperatures of 7^{oC}, 21.5^{oC}and 14.25^{oC} (Kasu *et al*., 2017 and Lemu-Bilbilo agricultural and natural resource office). Soil textural class of the study area was clay with composition of 22% sand, 36% silt and 42% clay. The crops widely grown in the study area are barley and Faba Beans and Peas and Rape seed have been used as rotational crops. Productivity of malt barley in the area was ranged from 2.76 to 4.5 t ha^{-1} (Arsi Zone ANRO, 2017), which is low due to low level use of organic fertilizers as well as nitrogen fertilizers and removal of crop residues. Most of the farmers fallow their farmland and practice crop rotation of malt barley with pulses and oil crops rather than using nitrogen fertilizers and bio fertilizers in this area (Lemu-Bilbilo District, 2018).

2.2 Experimental Materials

Materials used for this experiments was improved malt barley variety called Traveler, chemical fertilizer (blended NPS), fresh Beer bio sludge's which was collected from Heineken breweries (Walia) found at Kilinto near Addis Ababa, augers and spades for taking soil samples, measuring tapes to measure the plot and block size, spike length and plant length, Ropes for delineating the plots and blocks, plastic and kaki bags for packing the soil sample and harvested yield , sacks which was carry harvested biomass and used for packing during threshing.

2.3 Treatments and Experimental Design

The experiment comprised 16 treatments of four Beer bio sludge rates (0, 5, 10 and 15 t ha^{-1}) and four NPS fertilizer rates (0, 75, 100 and 150 kg ha^{-1}) which was laid out in randomized complete block design (RCBD) in three replications.

2.4 Experiment Procedures and Managements

The total plots were 48 plots (16x3), each measuring 2m x 1.6m and the total working area was 153.6m^2 (2m x 1.6m x 48); while, the gross experimental area was 351m^2 (35.1m x10m), and space between the plots was 0.5m and 1m between the blocks. The bio sludge was applied a week before sowing the barley and incorporated in to soil and one malt barley variety “Traveler'' was planted in rows with inter spacing of 20 cm with seed rate of 150 kg ha^{-1}. Each block was consisting of 16 plots/treatments combination which was replicated three times. The farm or field was ploughed 3 times by oxen plough and beer sludge's was incorporated to soil depth of 2.5cm before a week by hand cultivation to avoid side movement of sludge's during ploughing. Seed was sown on the date of 16/07/19 in row of 3.5cm depth using mechanical row marker and the seed distributed evenly in the row at a seed rate 150 kg ha^{-1}. All field management practices was carry out from inspection of pests to its managements by manual and chemical methods and controlling of all pests before occurrences. Harvesting was carried out at optimum maturity stage, when moisture content drops to 17% and the patches was dried on the plot before threshing and threshing was done manually by hand by putting in sacks using sticks.

2.5 Data Collection

2.5.1 Soil physiochemical parameters and Beer biosludge chemical analysis

Soil physiochemical analysis was carried out by collecting samples from five spots of different positions from each block at depth of 0-30 cm and it was mixed to obtain one composite sample. It was dried under shade and grinded using pestle and mortar and sieved, using 2 mm sieve and analysed in Horti coops laboratory for physical and chemical characteristics; Such as soil texture (Particle size), soil pH, cation exchangeable capacity, organic carbon, total N, available P, S, B and exchangeable K. Particle size distribution was determined using the Bouzoukis hydrometer method (Bouzoukis, 1962). Organic carbon was determined by Walleye and Black oxidation method (Walleye and Black, 1934). Total nitrogen was analysed by Kjeldhal method (Bremen and Mulvane, 1982) and CEC was determined by ammonium acetate (NH4OAC). Available phosphorus was measured using the Olsen method (Olsen *et al*., 1954). Available S was determined by Turbdimetiric Similarly the compositing of Beer Bio sludge's macro nutrients were measured using similar method used for soil analysis and additionally to measure micro nutrients of heavy metals found beer used was mehlich-3 method.

2.5.2 Growth parameters

Growth components data were collected at their specific period. Days to 50% heading was determined as the number of days taken from the date of sowing to the date of 50% heading of the plants from each plot by visual observation; days to 90% physiological maturity (90%) was determined as the number of days from sowing to the date when 90% of the peduncle turned to yellow in straw color and when the grain became difficult to break with thumb nail; plant height (cm) was measured from the soil surface to the tip of the spike by selecting five plants randomly from sex rows by excluding one row from each side across block and 50 cm from each side across rows, rows at each side's maturity; and spike length (cm) was measured from the bottom of the spike to the tip of the spike excluding the awns from five randomly selected spikes from six central rows.

2.5.3 Yield and yield related parameters

Yield and yield components data were collected at their specific period. The mean number of seed per spike was determined from five randomly selected plants from central six rows; the mean numbers of productive tillers were determined from five plants of central rows by counting each productive tiller; thousand kernels weight (g) was determined by counting 1000 from sampled from the bulk grain yield of each treatment weighting it taken with an electronic balance and adjusted at 13.5% grain moisture content; grain yield (tons ha^{-1}) was measured from the harvested central unit areas of 1m^2 of six central rows (grains were cleaned following harvesting and threshing, weighed using electronic balance, and adjusted to 13.5% moisture content); above ground biomass (tons

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ha^{-1}) was determined at maturity (the whole plant parts) including leaves and stems, and seeds from the central six by leaving one rows from each side and 50 cm from both sides across the rows were harvested and after drying, the biomass was measured; and harvest index was calculated as the ratio of grain yield to total above ground biomass yield multiplied by 100.

2.5.4 Quality parameters

Protein content was calculated from the nitrogen composition of the seed; total nitrogen in the seed was analysed by putting about 48 grams of grain evenly distributed over protein measuring machine. Sieve test was carried out using 2.2, 2.5, 2.8 mm size sieves and proportion of the seed trapped by each sieve was weighed and converted to percentage, and finally, the sums of all the three sieve sizes were used for sieve test and the fourth which passed through 2.2 mm sieve was considered as sieve reject. Hectolitre weight is the flour density produced in a hectolitre of the seed and it was determined using hectolitre weight analyser.

2.6 Statistical Data Analysis

The collected data were subjected to analysis of variance (ANOVA) using SAS version 9.4 statistical software programs. Least significant difference (LSD) test at 5% probability was used for mean separation when the analysis of variance indicated the presence of significant differences and Correlation was also conducted using person's correlation coefficient (Gomez and Gomez, 1984).

2.7 Economic Analysis

Economic analysis was made considering the variable cost to produce malt barley and output revenue using price of malt barley at harvesting time. This study included only variable cost incurred to produce malt barley that might brought difference in return, such costs were used to purchase blended NPS fertilizers, transportation cost of beer bio sludge and labor cost for application of the fertilizers and harvesting but administration cost was included in the cost, based on partial budget analysis, with 10% increase in input price and with 10% decrease in output price. Partial budget was estimated for average yield of the different treatment combinations. Price of blended NPS fertilizers was (15 Birr kg-^{1}), transportation of BBS was (300 Birr ton^{-1}), and cost of harvesting 80 birr quintals^{-1} of the grain and the price of grain at open market prices of malt barley grain at Bokoji market were 14.50 Birr kg^{-1}. Treatment was considered worth to farmers when it's minimum acceptable rate of return (MAR) is 100% (CIMMYT, 1988), which is suggested to be realistic. This enables' to make farmer recommendations from marginal analysis. The economic analysis was based on the formula developed by CIMMYT (CIMMYT, 1988). In order to recommend the result of this research to producers, it is necessary to estimate the minimum rate of return acceptable to producers in the recommendation domain based on partial budget analysis, with 10% increase in input price and with 10% decrease in output price.

3. RESULTS AND DISCUSSIONS

3.1 Soil Properties and Beer Sludge before Sowing

The soil analysis result for the specific experimental site was found to be clay in texture having 22% sand, 36% silt and 42% clay and its pH value was 5.46 which indicated slightly acidic. Soil analyses of experimental site composed of 2.99% organic carbon and 5.35% organic matter, 9.12 mg kg^{-1} available phosphorous, 9.22 mg kg^{-1} total sulphate and 9.29 carbon to nitrogen ratio (C/N) were found which were below the standard range of 0-30 for phosphorus and 20-80 for sulphate, respectively; but it contained high amount of nitrogen (0.32%) and moderate organic carbon (2.99%) and its CEC was 20.99 meq/100g of soil which was moderate as it was found in the standard range of 15-25 meq/100g.

Before applying the bio sludge into the soil, the chemical properties of beer sludge found to contained major macro and micro nutrients which are important for the plant growth, yield and yield components. The laboratory analysis revealed that Beer biosludges contained 9.80g kg^{-1} OC, 3.58g kg^{-1} total N, 253.46 mg kg^{-1} available P, 1234 available K, 357.05 mg kg^{-1} available S, 582.58 ppm Fe, CEC of 70.86, and C:N ratio of 2.73 with a pH value of 6.31. Thus, BBS as a soil amendment may affect the availability of both macro- and micronutrients of the soil. Based on this research BBS may need to be combined with chemicals that lower pH, or for crops that tolerate alkalinity and it could be used to neutralize slightly acidic soils, as an alternative to liming. In line with this research beer bio sludge contained 309g kg^{-1} OC, 22g kg^{-1} total N, 415.91mg kg^{-1} available P, 3296.9 available K, 33.19 ppm Zn, 25.19ppm Cu and a pH value of 8.7 was reported by Gashaw *et al*. (2017). These pH values and NPK variations between different reports might be attributed to the variation of raw material used in the production and the chemical used during washing of the bottle and to purify the wastes (Alemnesh, 2019). Thus, BBS as a soil amendment may affect the availability of both macro- and micronutrients. This high value of macro and micro nutrients found in beer sludge might indicate importance for use for crop production and amendment of soil acidity.

3.2. Effects of NPS and Biosludge Fertilizers on Growth Parameters of Malt Barley

The analysis of variance indicated that main effect of blended NPS fertilizer and Beer bio sludge and their interaction were brought significant differences on most of growth, yield and quality of malt barely. Blended NPS fertilizer has brought significant ($p \leq 0.01$) differences on growth parameters like plant height and spike length; yield and yield components like productive tiller, plant population, biomass yield and grain yield; and quality parameters like hectolitre weight and moisture content of traveller malt barley. It also brought significant ($p \leq 0.05$)

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differences on harvest index, hectolitre weight and protein content of the crop. Similarly, main effect of Beer bio sludge resulted significant ($p \leq 0.01$) differences on plant height, productive tiller, seed per spike, plant population, spike length, biomass yield, grain yield, thousand kernel weight, harvest index and moisture content of the grain, and significantly ($p \leq 0.05$) affected the 50% days of heading (Table-1). Application of NPS and beer bio sludge was interactively affected significantly ($p \leq 0.01$) plant height, productive tiller, hectolitre weight and grain yield, thousand kernel weight and harvest index. Similarly, their interaction was brought significant ($p \leq 0.05$) differences on seed per spike, plant population and moisture content of the grain at harvest (Table-1).

Table-1. Mean square values for growth, yield and quality components as influenced by the main and interaction effects of inorganic NPS rates and beer bio Sludge rates.

Recorded Parameters	NPS	BSDS	NPS x BSS
Plant height /PH/	180.79***	120.20***	4.32***
Productive tiller/Ptil/	16.53****	9.84***	1.84***
Seed per spike /SPS/	9.16****	2.92***	1.09**
Plant population/Ppop/	9121.57***	74191.74***	20833.96*
Spike Length/SL/	1.76***	1.43***	0.09ns
50 Days of heading (50 H)	1.58ns	9.69*	3.32ns
90 Days of maturation (90 M)	2.85ns	8.3ns	5.34ns
Biomass yield (BY)	41.58**	11.49***	2.46ns
Days to harvesting(DTH)	2.85ns	8.3ns	5.34ns
Thousand Kernel weight (TKW)	1.74ns	13.24*	15.08**
Grain Yield/GY/	13.76***	8.14***	2.23***
Harvest index/HI/	7.51*	84.63**	85.05***
Protein content (Gp)	1.542*	1.087ns	0.658ns
Moisture content /MC/	30.63***	8.33**	2.39*
Hectolitre weight(HL)	1921.44*	2611.55**	2943.04***

Where, ns =non-significant, and *, **, ***, significant at $P < 0.05$, 0.01 and 0.001 LSD tests, respectively.

3.2.1 Plant height

Analysis of variance showed that plant height was significantly affected ($P \leq 0.01$) by the main effect of blended NPS, Beer bio sludge and their interaction (Tables 1 and 2). Their mean value ranges from 63.88cm on the control plot to 83.58cm on plot received 15 tha^{-1} Beer bio sludge and 150 kg NPS ha^{-1} combination. Plant height of traveler malt barley was increased by 30.84% due the interaction effect of both blended and Beer bio sludge as compared to the smallest plant height from the control (Table-2). Such an increment of plant height along with increased rates of beer bio sludge and NPS fertilizers might be related to the presence of macro and micronutrients as well as high organic matter present in the applied bio sludge which promoted vegetative growth of the crop. Tariku *et al.* (2018) also confirmed that application of integrated nutrient management was significantly affected mean plant height of barley with the tallest plant height (90cm) obtained from an integration of 75:25% NPS: FYM applied and minimum (47cm) from the control. Tolora *et al*. (2018) also reported that malt barley mean plant height was significantly affected by the sole and integrated use of inorganic and inorganic fertilizers application with taller (104cm) plant height from 64/46 kg NP ha^{-1} applied followed by 50:50% vermicomposting and conventional compost with NP fertilizer. Similarly, Mitiku *et al*. (2014) found a significant effect of combined application of organic and inorganic fertilizers produced highest plant height barley at with the application of 5 t ha^{-1} farm yard manure in combination with 75% of recommended NP.

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Table-2. Interaction effect of NPS fertilizer and Beer biosludge rates on plant height (cm) of malt barley in the cropping season of 2019.

Beer Biosludge (t ha^{-1})	NPS Fertilizer rate (kg ha^{-1})			
	0	75	100	150
0	63.88^{j}	70.19^{h}	73.32^{f}	74.75^{de}
5	68.67^{i}	71.53^{g}	75.31^{de}	76.74^{c}
10	72.04^{g}	74.63^{e}	76.98^{c}	78.94^{b}
15	73.48^{f}	75.72^{d}	78.594^{b}	83.58^{a}
SE	0.498			
LSD(0.05)	1.02			
CV (%)	0.80			

Mean values followed by the same letters in each column and treatment showed no significant difference, CV=coefficient of variance, LSD= Least significant difference, SE=Standard deviation.

3.2.2 Days to heading and physiological maturity

The number of days required to 90% physiological maturity was not significantly affected by both main and interaction effects of NPS and Bio sludge fertilizers. Similarly, days of 50% heading was not significantly affected by the main effect of NPS fertilizer and their interaction; only main effect of Beer bio sludge significantly ($p \leq 0.05$) affected it (Tables 1 and 3). The minimum and maximum mean days required to panicle heading were 91.92 and 93.83 days from the control plot and plot treated with 10 t ha^{-1} biosludge, respectively. This report was not similar to Tariku *et al.* (2018) who reported that days to 50% flowering significantly affected by integrated inorganic and organic fertilizers with longer (77) days to 50% flowering of barley was observed on non-fertilized plot and shorter days of heading (64) was observed from 75% NPS along with 25% FYM application.

3.2.3 Spike length

Beer bio sludge and blended NPS fertilizers significantly affected spike length ($p<0.01$); but their interaction did not (Tables 1 and 3). The tallest mean spike lengths (8.30cm and 8.43cm) were recorded from plot received 150 kg ha^{-1} NPS and 15 t ha^{-1} bio sludge, respectively. In line with this result, Tolera *et al*. (2018) reported higher spike length (7cm) of barley obtained from the application of sole NP and integrated use of 50:50% NP fertilizers along with organic sources. Similarly, Mohammed *et al*. (2011) reported that spike length of malt barley increased from 15cm to 18.25cm with an increasing application of NPS fertilizer rates from 0 to 60 kg ha^{-1}. Likewise the spike length of malt barley was significantly higher (8cm) in 100% NPS, and 50:50 NPS and FYM applied as compared to the lower (6cm) spike length recorded from non-treated plot (Tariku *et al.*, 2018).

Table-3. Main effect of different rates of NPS and Beer biosludge fertilizers on phonological and growth components of malt barley in the cropping season of 2019.

	Parameters		
Beer bio sludge (t ha^{-1})	**50% heading**	**Spike length(cm)**	**90% Days to maturity**
0	91.92^{b}	7.62^{d}	154.58^{a}
5	93.67^{a}	7.84^{c}	156.00^{a}
10	93.83^{a}	8.05^{b}	156.50^{a}
15	92.67^{ab}	8.43^{a}	155.58^{a}
SE	0.679	0.097	0.75
LSD(0.05)	1.39*	0.198**	1.70^{ns}
NPS (kg ha-^{1})			
0	93.33^{a}	7.44^{c}	155.42^{a}
75	93.^{33a}	8.03^{b}	156.33^{a}
100	92.75^{a}	8.17^{ab}	155.33^{a}
150	92.67^{a}	8.30^{a}	155.33^{a}
SE	0.679	0.097	0.75
LSD(0.05)	1.39^{ns}	0.198**	1.54^{ns}
CV (%)	1.80	3.00	1.20

Mean values followed by the same letters in each column and treatment showed no significant difference, CV= coefficient of variance, LSD= Least significant difference, SE =Standard deviation.

3.3 Effect of NPS and Biosludge Fertilizers on Yield and Yield Components of Malt Barley

3.3.1 Productive tillering

The analysis of variance showed that main and interaction effects of blended NPS and bio sludge fertilizers and their interaction were brought significant ($P \leq 0.01$) differences on productive tillers of traveler malt barley (Table-4). The highest (7.68) and the lowest(3.31) mean productive tillers were recorded from combined application of 150 kg ha^{-1} blended NPS fertilizer along with 15 t ha^{-1} beer bio sludge and from the control plots, respectively; but the treatments consisting of 15 t ha^{-1} beer bio sludge along with 0, 75, 100 and 150 kg ha^{-1} blended NPS fertilizer, 10 t ha^{-1} BBS along with 75, 100 and 150 kg ha^{-1} blended NPS, 5 t ha^{-1} BBS along with 100 and 150 kg ha^{-1} blended NPS were at par with the highest productive tillers (Table 4). Such an increment of effective tillers of malt barley is due to many nutrients availability in the two inorganic and organic fertilizers applied in combination which accelerated high vegetative growth of crops and also resulted in high number tillers. In line with this result, Tadesse *et al.* (2017) reported that number of tillers per plant and better stand of malt barley were significantly ($p < 0.01$) obtained by combined application of 33% from recommended rate of farm manure and 33% of recommended rate of compost along recommended rate of chemical fertilizers and the lowest 3.58 tillers per plant were obtained from control. Similarly, Tolera *et al. (*2018)reported higher number of tillers (5) per plant of barley from integrated application of NP and FYM (50:50%) fertilizers than least (4) tillers per plant from sole application of farm yard manure which indicated the easy availability of nutrients from inorganic fertilizers as compared to the gradually release of nutrients from organic fertilizer sources.

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Table-4. Interaction effect of blended NPS and Beer biosludge fertilizers rates on productive tiller of malt barley in the cropping season of 2019.

	Blended NPS (kg ha-^{1})			
Beer Bio Sludge's(t ha^{-1})	**0**	**75**	**100**	**150**
0	3.31^{d}	4.32^{c}	6.36^{b}	7.25^{a}
5	4.30^{c}	5.09^{c}	7.22^{a}	7.33^{a}
10	4.95^{c}	7.48^{a}	7.40^{a}	7.60^{a}
15	6.93^{ab}	7.23^{a}	7.53^{a}	7.68^{a}
SE	0.51			
LSD(0.05)	0.81			
CV(%)	7.6			

Mean values followed by the same letters in each column and treatment showed no significant difference, CV= coefficient of variance, LSD=Least significant difference, SE =Standard deviation

3.3.2 Number of grains per spike

Analysis of variance showed that number of grains per spike responded significantly ($p<0.01$) to the main effects of blended NPS, Beer bio sludge fertilizers and their interaction (Table-1). The highest mean seeds per spike (28.81) were obtained from the combined application of 15 t ha^{-1} of bio sludge and 75 kg ha^{-1} of NPS fertilizers without statistical difference from all levels of beer bio sludge along 75 kg ha^{-1} NPS; while, the lowest number of grains per spike (24.57) was recorded from the control plot (Table-5). Similarly, Aschalew *et al*. (2018) reported that use of beer sludge brought significant differences on number of seed per spike (29.06, 27.76 and 25.52 from plots fertilized with 15 t ha^{-1} beer bio sludge, recommended rate of chemical fertilizer and control, respectively). Likewise, application of 5 t ha^{-1} FYM along with 75% inorganic NP resulted in highest number (37 and 36.7) of grain number per spike (Tariku *et al*., 2018).

Table-5. Interaction effect of NPS and Beer biosludge fertilizers rates on seeds per spike of malt barley in the cropping season of 2019.

Blended NPS (kg ha^{-1})				
Beer bio sludge (t ha^{-1})	**0**	**75**	**100**	**150**
0	24.57^{g}	28.27^{abc}	26.77^{ef}	27.45^{cdef}
5	26.56^{f}	28.46^{ab}	26.88^{def}	27.39^{ef}
10	27.45^{bcdef}	28.18^{abc}	27.84^{abcd}	28.20^{abc}
15	26.65^{f}	28.81^{a}	27.75^{bcde}	27.33^{cdef}
SE	0.47			
LSD(0.05)	0.97			
CV(%)	2.10			

Mean values followed by the same letters in each column and treatment showed no significant difference, CV= coefficient of variance, LSD=Least significant difference, SE =Standard deviation.

3.3.3 Biomass yield

Biomass yield of traveler malt was statistically ($p<0.01$) affected by the main effect of beer bio sludge and blended NPS fertilizers; but not significantly affected by their interaction (Table-1). Maximum biomass yields (18.20 and 18.53 t ha^{-1}) were recorded from main effect of beer bio sludge at 15 t ha^{-1} and blended NPS at 150 kg ha^{-1} applied and the lowest (15.92 and 14.24 t ha^{-1}) biomass yield were obtained from the control plots of both bio sludge and NPS fertilizers, respectively. Highest biomass yields due to the different levels of bio sludge and NPS fertilizers application significantly increased by 3.32%, 7.22% and 14.32% when the Beer bio sludge application increased at rate of 5, 10 and 15 t ha^{-1}, and by 20.86%, 24.02% and 30.13% when NPS applied at rate of 75, 100 and 150 kg ha^{-1}, respectively as compared to the biomass yield obtained from the control plot (Table-6). This revealed that integrated soil fertility management involving the judicious use of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraints and contribute high crop productivity in agriculture. But, Tariku *et al*. (2018) reported that the

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dry biomass yield of barley was significantly affected by application of integrated nutrient management and the highest (15.92 t ha^{-1}) dry biomass of barley was obtained with an integrated application of blended NPS: FYM (66.6:33.4%). Similarly, Ram *et al*. (2014) found that yield of 8.26 of barley was obtained from the application of 5 t ha^{-1} FYM in combination with 75% inorganic NP fertilizers.

Table-6. Main effect of different rates of NPS and Beer Biosludge fertilizers on the above ground biomass yield of malt barley in the cropping season of 2019.

Beer biosludge (t ha^{-1})	Biomass yield (t ha^{-1})
0	15.92c
5	16.45bc
10	17.07b
15	18.20a
SE	0.433
LSD(0.05)	0.884**
NPS (kg $ha-^{1}$)	
0	14.24c
75	17.21b
100	17.66ab
150	18.53a
SE	0.433
LSD(0.05)	0.884**
CV (%)	6.30

Mean values followed by the same letters in each column and treatment showed no significant difference, CV = coefficient of variance, LSD= Least significant difference, SE =Standard deviation

3.3.4 Grain yield

The grain yield of malt barley was significantly ($p<0.01$) affected by different rates of main effect of organic (Beer bio sludge), inorganic (blended NPS) fertilizers and their combinations (Tables 1 and 7). The maximum grain yield (9.26 t ha^{-1}) was obtained from the combined effect of 150 kg NPS ha^{-1} and 15 t ha^{-1} bio sludge, and the minimum yield (3.94 t ha^{-1}) was obtained from the control plot (Table 7), However application of 15 t ha^{-1} of beer bio sludge in combination with 100 and 75 kg ha^{-1} of blended NPS were at par. This large grain yield variation among the treatments under different rates of organic and inorganic fertilizers could help in the selection of better combination of both fertilizers. The interaction effect of both beer bio sludge and blended NPS fertilizers at a rate 15 t ha^{-1} and 150 kg ha^{-1} NPS resulted in 135 % grain yield advantage as compared to the control plot (Table-7). This might be due to the use of integrated inorganic and organic fertilizers that revealed significant effect on yields of malting barley due to combined application of organic and mineral amendments resulted from positive changes to the soil, including increased soil pH, available P, S and total N, and possibly other macro- and micronutrients. Sulphur and nitrogen found in both fertilizers resulted in synergic that bring high accumulation of dry matter and grain yield of crop plants formed during photosynthesis. This is also in agreement with Kasu *et al.* (2017) who reported that application of 50% RNP from mineral fertilizers + 50% from compost resulted in grain yield advantages of 17% (0.65 t ha^{-1}), 18% (0.673 t ha^{-1}) and 39% (1.24 t ha^{-1}) as compared to RNP from compost, 1:1 ratio of compost and FYM, and the control treatment, respectively that indicated significant increases in grain yields of malt barley. Similarly, Aschalew *et al.* (2018) reported that malt barley grain yield was increased by 59% when 15 t ha^{-1} beer biosludge used as fertilizers (4.8 to 7.03 t ha^{-1}) than control. Application of organic fertilizers or composts for growing of barley malt, showed yield increment by 9% as compared to chemically fertilized plot (Edwards, 2000). Likewise, Tariku *et al*. (2018) reported that application of integrated nutrient management significantly ($P<0.05$) affected mean grain yield of barley with higher (6496 kg ha^{-1}) grain yield was produced from application of integrated nutrient application of NPS:FYM (66.6:33.4%) followed by sole application of recommended 100%NPS (6288kgha^{-1}).

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Table-7. Interaction effect of NPS and Beer biosludge fertilizers rates on grain yield (t ha^{-1}) of malt barley in the cropping season of 2019.

	Blended NPS (kg ha^{-1})			
Beer biosludge (t ha^{-1})	**0**	**75**	**100**	**150**
0	3.94^{k}	7.15^{i}	8.01^{gh}	8.67^{cde}
5	5.62^{j}	7.9^{h}	8.55^{def}	8.84^{bcd}
10	7.87^{h}	8.11^{gh}	8.35^{efg}	8.59^{cdef}
15	8.25^{fgh}	8.99^{abc}	9.09^{ab}	9.26^{a}
SE	0.06			
LSD(0.05)	0.41			
CV (%)	3.12			

Mean values followed by the same letters in each column and treatment showed no significant difference, CV =coefficient of variance, LSD= Least significant difference, SE =Standard deviation

3.3.5 Harvest index

Harvest index of test malt barley (Traveler) was significantly affected by main effects of blended NPS and bio sludge fertilizers and their interaction ($p \leq 0.05$) (Tables 1 and 8). The highest harvest index (52.52%) was recorded from 15 t ha^{-1} bio sludge application without blended NPS fertilizer and lowest (29.76%) from the control (Table-8); which indicated that as the rate of bio sludge increased from zero to the highest, the harvest index of this test malt barley was increased. Statistically mean values of harvest index from the interaction effect of both bio sludge and blended fertilizers are at par at all rates of combinations applied except the control and plot treated with 75 kg ha^{-1} NPS without bio sludge. This is might be due to increased nutrient use efficiency and supplying different available nutrients which more partitioned to grain when organic fertilizer sources are applied. This result is in line with Tariku *et al*. (2018) report that harvest index of malt barley was significantly affected by integrated use of both organic and in organic fertilizers and the highest harvest index was obtained by application of 100%FYM (46.54%) followed by 25:75% NPS:FYM (46.26%); whereas, the lowest significant harvest index was recorded from the control. Likewise, Abera *et al.* (2017) report indicated that harvest index of barley was affected with the integrated use of NP fertilizer and organic fertilizer sources with a mean ranged from 39 to 48% and significantly higher harvest index of barley was obtained from vermicomposting along with conventional compost (50:50%). Similarly, Mitiku *et al*. (2014) stated significantly effect of integrated use of organic and inorganic fertilizers on harvest index of malt barley with highest harvest of 47% at Adiyo and 45% at Ghimbo from the application of 5 t ha^{-1} FYM + 50%NP.

Table-8. Interaction effect of NPS and Beer biosludge fertilizers rates on harvest index of malt barley in the cropping season of 2019.

NPS Fertilizer rate (kg ha^{-1})				
Beer bio sludge (t ha^{-1})	0	75	100	150
0	29.76^{d}	42.51^{c}	51.8^{ab}	48.5^{ab}
5	46.88^{abc}	46.54^{bc}	48.76^{ab}	46.69^{abc}
10	50.00^{ab}	46.93^{abc}	48.87^{ab}	47.19^{abc}
15	52.52^{a}	46.37^{bc}	49.21^{ab}	48.52^{ab}
SE	2.87			
LSD(0.05)	5.86			
CV (%)	7.50			

Mean values followed by the same letters in each column and treatment showed no significant difference, CV=coefficient of variance, LSD=Least significant difference =Standard deviation

3.3.6 Thousand Kernel weight

Analysis of variance revealed that thousand-kernel weight was significantly ($P \leq 0.01$) differed due to the main effect of beer bio sludge and its interaction with blended NPS; whereas, blended NPS rates did not statistically affect thousand kernel weights (Table-1). Combined effect of both blended NPS at rate of 75 kg ha^{-1} and Beer bio sludge at rate of 10 t ha^{-1} produced highest thousand kernel weight (52g) and the lowest (45.33g) obtained at combined application of 75 and 150 kg NPS ha^{-1} along 0 kg ha^{-1} bio sludge (control) (Table-9). Significance observed due to the presence of macro and micro nutrients found in beer sludge (nitrogen, phosphorus, sulphur and potassium) resulted high photosynthesis process and improved water use efficiency and accumulations of carbohydrate in kernel to produce heavy kernels and consequently increased kernels weight. This result indicated that highest kernel weight was obtained at moderate plant population and lower at low level of fertilizers rate and higher plant population due nutrient competition among higher crop stands. This research was in line with Abay and Tesfaye (2012), who testified higher thousand grain weight of 45g was obtained with the application of 5 tha^{-1} FYM in combination with 25% recommended rate of inorganic and the lowest thousand grain weight was recorded from the control plot. Likewise, Saidu *et al*. (2012) reported higher 1000 grain weight was obtained from the application of 5 t ha^{-1} FYM in combination with 50% inorganic NP while the lowest from no fertilizer application.

Table-9. Interaction effect of NPS and Beer biosludge fertilizers rates on thousand kernel weight of malt barley in the cropping season of 2019.

	NPS Fertilizer rate (kg ha^{-1})			
Beer bio sludge (t ha^{-1})	0	75	100	150
0	46.33^{cde}	45.67^{de}	50.67^{ab}	45.67^{de}
5	48.67^{bcd}	48.00^{bcde}	49.33^{abc}	50.67^{ab}
10	49.33^{abc}	52.00^{a}	48.00^{bcde}	46.67^{cde}
15	48.67^{bcd}	45.33^{e}	46.67^{cde}	49.33^{abc}
SE	1.56			
LSD(0.05)	3.19			
CV (%)	4.0			

Mean values followed by the same letters in each column and treatment showed no significant difference; CV = coefficient of variance; LSD = Least significant difference; SE = Standard deviation

3.4 Effects of NPS and Biosludge Fertilizers on Quality Parameters of Malt Barley

3.4.1 Hectolitre weight

Hectolitre weight of malt barley variety traveler was significantly ($P \leq 0.05$) affected by main effects of beer bio sludge and NPS fertilizers rates and their interaction (Tables 1 and 10). The highest mean (643.53, 630.56 and 619.57 kg hl^{-1}) hectolitre weights were recorded from combined application of 15 t ha^{-1} bio sludge and 75 kg NPS ha^{-1}, 15 t ha^{-1} bio sludge and 150 kg NPS ha^{-1}, and 5 t ha^{-1} bio sludge and 100 kg NPS ha^{-1}, respectively; whereas, the lowest (535.39 kg hl^{-1}) hectolitre weight was obtained from control plot (Table-10). Application of integrated bio sludge and NPS fertilizers significantly improved hectolitre weight of barley as compared the non-fertilized plots.

Table-10. Main effect of NPS and Beer biosludge fertilizer rates on hectolitre weight of malt barley in the cropping season of 2019.

	NPS Fertilizer Rate (kg ha^{-1})			
Beer biosludge (cm)	0	75	100	150
0	535.4^{c}	616.00^{ab}	577.4^{abc}	615.3^{ab}
5	618.8^{ab}	617.6^{ab}	619.6^{a}	544.3^{bc}
10	587.6^{abc}	581.9^{abc}	604.4^{abc}	585.7^{abc}
15	576.5^{abc}	643.5^{a}	606.8^{abc}	630.6^{a}
SE	1.71			
LSD(0.05)	3.50			
CV (%)	3.50			

Mean values followed by the same letters in each column and treatment showed no significant difference, CV = coefficient of variance, LSD= Least significant difference, SE =Standard deviation.

3.4.2 Grain moisture content

The mean moisture content of malt barley was significantly differed due to both main and interaction effects of NPS and bio sludge fertilizers rates applied (Table-11). The highest mean moisture (20.37% and 19.80%) contents were obtained from plots treated by 5 t ha^{-1} of beer bio sludge without NPS and control plot; whereas, the lowest (14%) mean moisture content was observed from plot treated by 15 t ha^{-1} beer bio sludge along with 75 kg ha^{-1} NPS. The difference moisture content among treatments was due to present on blended NPS. Moisture levels need to be low enough to inactivate the enzymes involved in seed germination as well as to prevent heat damage and the growth of disease microorganisms. The moisture content of this study was in the acceptable range in treatments and in line with the standard as reported by different authors like Fox *et al*. (2003) reported that the maximum reasonable industrial specification of malt barley moisture content for safe storage is 12.5%, while the European Brewing Convention (EBC) standard moisture content lie 12-13.5% is accepted.

Table-11 Interaction effect of NPS and Beer biosludge fertilizers rates on grain moisture content of malt barley in the cropping season of 2019.

	NPS Fertilizer Rate (kg ha^{-1})			
Beer bio sludge's (cm)	0	75	100	150
0	19.80^{a}	15.93^{bcd}	16.10^{bcd}	15.63^{bcd}
5	20.37^{a}	15.43^{bcd}	15.00 ^{bcd}	16.17^{bc}
10	17.23^{b}	15.23^{bcd}	15.70^{bcd}	14.53^{cd}
15	16.53^{bc}	14.00^{d}	15.67^{bcd}	14.4^{cd}
SE	2.15			
LSD(0.05)	2.44			
CV (%)	9.11			

Mean values followed by the same letters in each column and treatment showed no significant difference, CV= coefficient of variance, LSD=Least significant difference, SE =Standard deviation

3.4.3 Grain protein content

Grain protein content of traveler malt barley showed significant difference ($p \leq 0.05$) due to the main effect of blended NPS fertilizer; but did not significantly affect by main effect of Beer bio sludge and their interaction (Tables 1 and 12). The largest mean protein contents (11.26% and 11.20%) were observed from main effect of NPS fertilizer at a rate of 150 and 100 kg ha^{-1} respectively, and the lowest (10.55%) protein content in dry bases were recorded from the plot applied with 75 kg ha^{-1} NPS. The research results were found in the accepted Ethiopian standard range of 9–12% (EQSA, 2006) of malt barley. The current research result is in line with the results reported by Kasu *et al.* (2018), that integrated application of organic and mineral fertilizers resulted in optimum concentrations of grain protein and applications of full dose of RNP (36 kg ha^{-1}) as compared to compost (5.8 t) or FYM (1.1 t) resulted in statistically lower grain protein contents of 9.7 and 9.5%, respectively. Similarly, Agegnehu *et al*. (2016b) reported significant improvements in the grain protein contents of malting barley owing to integration of mineral fertilizers with organic amendments such as bio char, cattle manure and composted manure. According to the Ethiopian standard authority and Asella malt factory, the protein level of the raw barely quality standard for malt should be between 9-12% (EQSA, 2006).

Table-12. Main effect of NPS and Beer Bio sludge fertilizers rates on grain protein content of malt barley in the cropping season of 2019.

	Protein content (%)
Beer sludge's (t ha^{-1})	
0	10.65^{a}
5	10.70^{a}
10	11.19^{a}
15	11.20^{a}
SE	0.296
LSD(0.05)	0.604^{ns}
NPS (Kg ha-^{1})	
0	10.71^{ab}
75	10.55^{b}
100	11.22^{a}
150	11.26^{a}
SE	0.296
LSD(0.05)	0.604*
CV(%)	6.60

Mean values followed by the same letters in each column and treatment showed no significant difference, CV= coefficient of variance, LSD=Least significant difference, SE =Standard deviation.

3.5 Correlation Analysis of Growth, Yields and Quality Attributes due Blended NPS and Biosludges Fertilizers Application on Malt Barley

Grain yield exhibited positive and significant correlations with plant height(r=0.872***), spike length(r= 0.777***), seed per spike(r=0. 616***), productive tillers (r=0.83**), biomass yield (r=0.812***) and protein content (r=0.349***); but negatively significant correlation with moisture content(r=0.716***). Plant height exhibited positive correction with spike length, seed peer spike, productive tillering, harvest index and grain protein (r=0.845***, 0.453**, 0.848***, 0.811**, 0 .610*** and 0.40.1**), respectively and non-significantly correlated with thousand kernel weight and hectolitre weight. Spike length of test crop also revealed positive and significant association with grain yield (r=53**), productive tiller (r=698***), plant population (r=0.68**), harvest index (r=0.585**) and showed no significance with thousand kernel weight, hectolitre weight and grain protein content. Also productive tiller was positively associated and correlated with plant population (r=0.777*), harvest index (r=0.605**), spike length (r=698***), seed per spike (0.447**) and grain protein content(r=0.492***) and positive but non-significantly correlated with thousand kernel weight and hectolitre weight. Hectolitre weight of traveler malt barley grain was positively correlated and showed significance with seed per spike(r=0.279*) and revealed positively non-significant with spike length, seed per spike, productive tillers, biomass yield, grain yield and harvest index. However, not significantly correlated with moisture content and thousand kernel weight. Grain protein content of this malt barley exhibited positively significant association with productive tillers (0.492***); while, it indicated positive non significantly correlated with spike length, seed per spike, thousand kernel weight, harvest index and hectolitre weight; and it showed no significance negative association with moisture content (Table-13).

Table-13. Correlation analysis of growth, yield and quality attributes due to NPS and bio sludge fertilizers application to barley crop.

Parameters	PH	SL	SPS	Ptil	Moisture	TKW	BY	GY	HI	HLW	GP
PH	1										
SL	0.845***	1									
SPS	0.453**	0.53**	1								
Ptil	0.848***	0.698***	0.447**	1							
Moisture	-0.644***	-0.555***	-0.469***	-0.601	1						
TKW	0.142ns	0.09ns	-0.036ns	0.181ns	0.139	1					
BY	0.758***	0.642***	0516***	0.7***	-0.75**	0.105ns	1				
GY	0.872***	0.777***	0.616**	0..830**	-0.716	0.16ns	0.812***	1			
HI	0.610***	0.585***	0.495***	0.605***	-0.716**	0.295*	0.278*	0.784***	1		
HLW	0.204ns	0.094ns	0.119ns	0.167ns	-0.035ns	0.056ns	0.3ns	0.266ns	0.128ns	1	
GP	0.401**	0.214ns	0.038ns	0.492***	-0.132ns	0.143ns	0.275*	0.349**	0.255	0.119ns	1

Whereas: PH= plant Heights= Spike Length, PS=Seed per spike, Pop =plant population, till = productive tillering, TKW=Thousand kernel weight, GP= Grain protein, HLW= hectolitre weight, BY=Bio mass yield, GY=grain yield; *,**,*** and NS significance at 5% probability level.

3.6 Economic Analysis

Result of this study indicated that highest cost (23,026.30 Birr ha^{-1}) was obtained from 15 t BBS and 150 kg ha^{-1} NPS followed by 5 t BBS and 150 kg ha^{-1} NPS (22047.67) application and the lowest cost (10,917.70 Birr per hectare) was recorded from the control plot with 12106.6Birr difference between highest and lowest. The highest (97816.70 birr) and lowest (40498.30 birr) net profits were obtained from combined application of 15 t ha^{-1} bio sludge and 150 kg ha^{-1} NPS fertilizers; and the control plot, respectively (Table-14). However, the highest marginal rate of returns (3987.07% and 3757.77%) were recorded from the combined application of 5 t ha^{-1} bio sludge along with 150 kg NPS ha^{-1} and sole application of 150 kg NPS ha^{-1}, respectively. This means that for every 1.00 Birr invested on 5 t and 150 kg ha^{-1} fertilizers and harvesting of the yield obtained, producers can expect to recover the 1.00 Birr and obtain an additional of 38.87 and 36.58 Birr, respectively (Table 14). Therefore, application of 5 tons of beer bio sludge and 150 kg NPS ha^{-1} fertilizer rate is profitable and is recommended for farmers in Lemu-Bilbilo districts and other areas with similar agro-ecological conditions and clay soil having low phosphate and sulphate and high nitrogen contents as well as moderate CEC. The result of this study was coincided with Tolera *et al.* (2018) who reported that malt barley production with application of 50:50% conventional compost along NP fertilizer gave net profit advantage of 25,484.00 EB with marginal rate return of 56%, and conventional compost gave net benefit of 25,356.00 EB ha^{-1}. Likewise, Tariku (2016) revealed that the highest net benefit of EB 58553.00 ha^{-1} and marginal rate of return 36.45% of barley was obtained from the application of NPS: FYM (66.6: 33.4%) followed by EB 57781.00 ha^{-1}and marginal rate of return 2153% of barley gained from the application of 100%.

Table-14 Marginal rate of return of traveler malt barley variety yield influenced by blended NPS fertilizer and beer biosludge's rates.

Treatment	VC (Birr ha^{-1})	NB (Birr ha-^{1})	CB(%)	MVC	MNB	MRR (%)
Control	10919.70	40497.30	26.96	0.00	0.00	0.00
5 t BBS ha^{-1}	14049.73	59315.41	23.69	3130.03	18818.11	601.21
75 kg NPS ha^{-1}	14982.19	78328.08	19.13	932.46	19012.67	2038.98
100 kg NPS ha^{-1}	16152.83	88400.41	18.27	1170.65	10072.34	860.41
75 kg NPS + 5 t BBS ha^{-1}	17297.74	85882.36	20.14	1144.90	-2518.05	-219.94
150 kg NPS ha^{-1}	17555.32	95561.84	18.37	257.59	9679.48	3757.77
10 t BBS ha^{-1}	17681.35	85070.33	20.78	126.02	-10491.51	-8324.95
100 kg NPS + 5 t BBS ha^{-1}	18280.24	93352.69	19.58	598.89	8282.36	1382.95
75 kg NPS + 10 t BBS ha^{-1}	19123.28	86660.01	22.07	843.04	-6692.68	-793.87
150 kg NPS + 5 t BBS ha^{-1}	19358.73	96033.32	20.16	235.45	9373.31	3981.07
15 t BBS ha^{-1}	19658.77	87948.35	22.35	300.04	-8084.97	-2694.64
100 kg NPS + 10 t BBS ha^{-1}	19750.51	89217.10	22.14	91.74	1268.75	1382.95
150 kg NPS + 10 t BBS ha^{-1}	20781.69	91243.49	22.78	1031.18	2026.38	196.51
75 kg NPS + 15 t BBS ha^{-1}	21553.11	95794.69	22.50	771.42	4551.20	589.98
100 kg NPS + 15 t BBS ha^{-1}	22047.67	96517.01	22.84	494.56	722.32	146.05
150 kg NPS + 15 t BBS ha^{-1}	23026.30	97816.70	23.54	978.63	1299.69	132.81

4. CONCLUSION AND RECOMMENDATIONS

Thus, it can be concluded that application of 5 t ha^{-1} of biosludge along with 150 kg ha^{-1} NPS is better to improve productivity of malt barley and can be used as an alternative soil management option for malt barley production at an experimental area and the like. However, similar experiment has to be repeated over multi locations, seasons and including other varieties of the malt barley and different organic and inorganic fertilizers in addition to blended NPS and beer biosludge to reach at a concrete recommendation.

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