Original Research Article

Effect of Blended Fertilizer Rate on Yield and Yield Components of Hybrid Maize (*Zea mays* L.) Varieties under Irrigation Condition in Low Land Area of South Omo Zone

ABSTRACT

Maize is an important cereal crop in Ethiopia. However, the yield of this crop is limited due to the lack of varieties and blended fertilizer for varieties and site specifications. The use of a right amount of fertilizer based on crop requirement has significant importance for sustainable crop production. A study was undertaken to investigate the effects of NPSB blended fertilizer rate for maize yield production at a Dasenech and Nyangatom districts in the lowland area of South Omo Zone, Southern Ethiopia during the 2019/ 2020 cropping season. The experiment was factorial with three maize varieties (BH-140, BH-540 and MH-140) and four NPSB blended fertilizer rate including kg ha^{-1}(none fertilizer, 50 NPSB, 100 NPSB, and 150 NPSB). Factorial combinations were used as twelve treatments laid out in a randomized complete block design with three replications. Phenological and growth parameters, as well as yield and yield components data, were collected and subjected to analysis of variance using the SAS software program. The result of analysis of variance revealed that the interaction effect of varieties and blended fertilizer rate highly significant difference in grain yield. The result indicated that the highest grain yield (3624.0 kg ha^{-1}) and net benefit (45,324 Eth-birr ha^{-1}) with MRR of 2123.5 % were obtained from BH-540 variety treated with 100 kg ha^{-1} of NPSB fertilizer rates at Dasenech location. Whereas, at the Nyangatom location, the highest grain yield (4324 kg ha^{-1}) and net benefit (54,774 Eth-birr ha^{-1}) with MRR of 2968.5 % were obtained from MH-140 variety treated with 100 kg ha^{-1} of NPSB fertilizer rates. Therefore, based on the yield response and, cost and return analysis indicated, it is recommended BH-540 variety treated with 100 kg ha^{-1} of NPSB blended fertilizer rates for Dasenech location, while MH-140 variety treated with 100 kg ha^{-1} of NPSB blended fertilizer rates for Nyangatom location and their similar soil conditions and agro-ecology.

Key words: blended fertilizer, hydride maize varieties, profitability, maize grain yield

BACKGROUND AND JUSTIFICATION

In Ethiopia agriculture, maize is one of the pillar cereal crops ranking first in total production and productivity, and second to teff in area coverage (FAOSTAT, 2017). Maize in Ethiopia is used directly for human consumption as food or local drinks. In addition, maize leaves are used for feed to animals and dry stalks are used as fuel and for the construction of fences (Akalu, 2015).

In the year 2017, maize was grown on about 322,714.36 ha of land in SNNP Region from which 1,085,725.3 tons were produced, with a regional average yield of 3.36 t ha^{-1}. During the same year, 22,396.77 ha was covered with maize in South Omo Zone and about 53,973.28 tones were produced, making the zonal average yield 2.41 t ha^{-1} (CSA, 2017). This yield is far less than the attainable yield (7 to 8 t ha^{-1}) under good management conditions (MOANR, 2017). The low yield of maize in Ethiopia is attributed to several production constraints which include shortage of improved varieties, poor crop management practices, unbalanced nutrient application, diseases and insect pests (Orkaido, 2004).

Low soil fertility highly negatively affects the growth and development of maize as compared to other crops. As a result, it is often said "maize speaks" implying that maize cannot produce maximum yields unless sufficient nutrients are available (Delorite et *al*., 1997). When the soil does not supply sufficient nutrients for normal plant growth application of supplemental nutrients is required. In fact, the response of maize plants to the application of fertilizers varies from variety to variety, location to location, and also depends on the availability of the nutrients (Onasanya *et al*., 2009).

Better matching fertilizer application recommendations to local climate, soil, and management practices helps ensure that production can be intensified cost-effectively and sustainably Chimdessa (2016). Hence, understanding the plant nutrients requirement of a given area has a vital role in enhancing crop production and productivity on a sustainable basis. However, in the current study area all agro-pastoralist use their local variety with no fertilizer application which results in poor grain yield in quality and quantity. Therefore, the main objective of the study was to evaluate the effects of NPSB blended fertilizer rates on yield, yield component and its profitability of selected maize varieties under irrigated conditions in the lowland area of south Omo zone.

MATERIALS AND METHODS

Description of the Study Area

The field experiment was implemented in Dasenech and Nyangatom woreda of the lowland area of the South Omo zone during the 2019/20 cropping season. Astronomically, Dasenech woreda found lying roughly between 4°37′–4°48′ North latitude and 35°56′–36°20′ East longitude, and Nyangatom between 5°05′–5°21′ North latitude and 35°55′–36°14′ East longitude, respectively. The altitude of the areas varies between 353m.a.s.l-606m.a.s.l for Dasenech, and 380m.a.s.l-497m.a.s.l for Nyangatom district, respectively. According to the districts' agricultural and natural resource office, the climate in these areas is dominantly a semiarid type. The district has very small, erratic and variable rainfall and high ambient temperature. But at Nyangatom woreda no agro metrological data due to the absence of an agro-metrology station. In Dasenech districts the rainfall pattern is bimodal, with a primary rainy season between March to May and secondary small rain between September to December (see figure 2). In these two woredas (administrative districts) the major livestock raring, agro-pastorals widely practice rain-fed, flood retreat (nowadays very rarely) and irrigated agriculture. They grow Sorghum in number one place followed by Maize and horticultural crops like a banana.

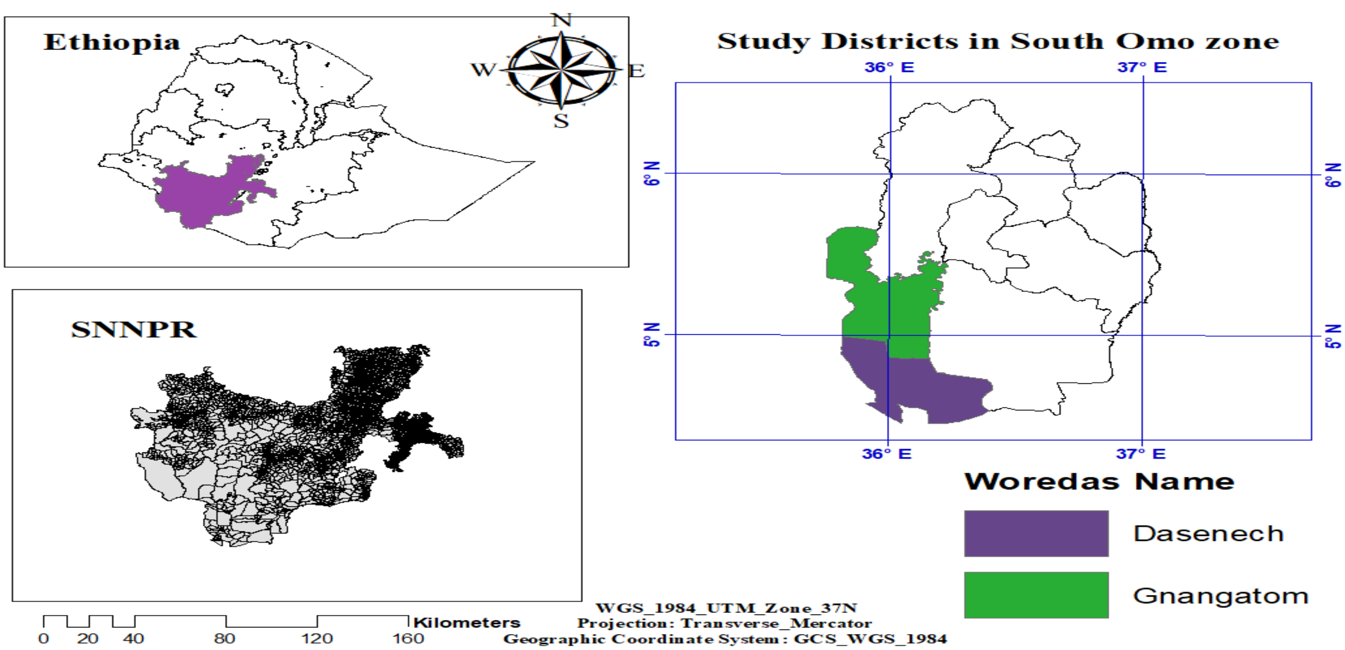

Figure 1. The study area map of Dasenech and Gnangatom woreda

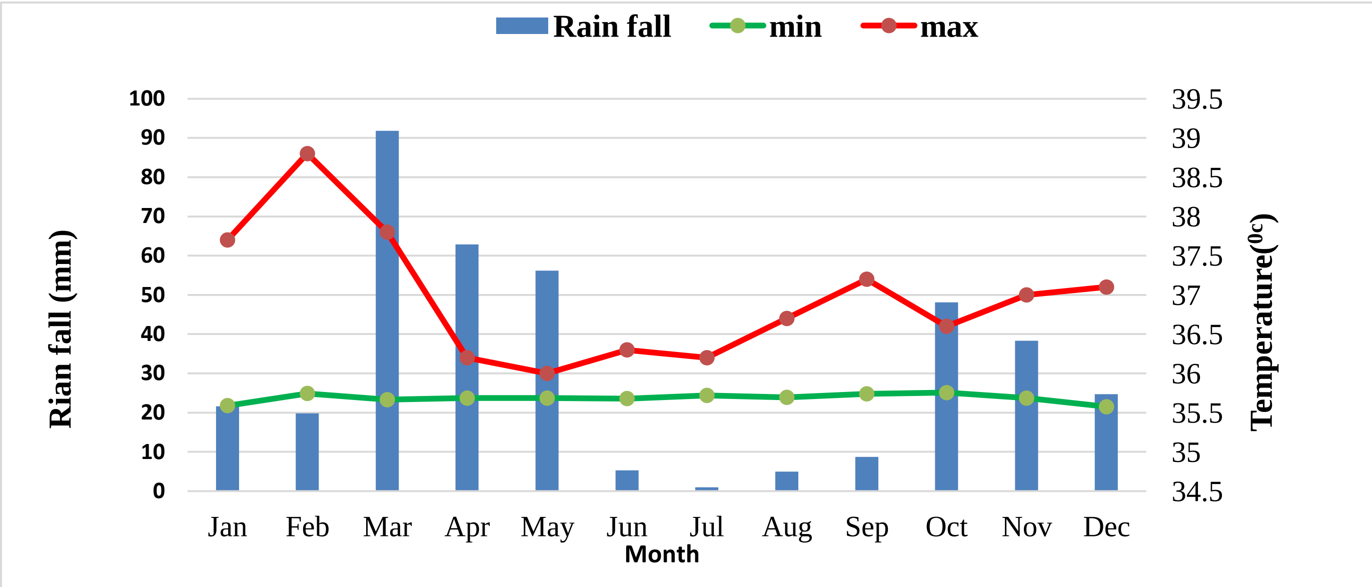

Figure 2. Monthly rainfall, minimum and maximum temperature at Dasenech distinct (2000-2019 G.C)

Experimental Design and Treatments

The experiment was laid out factorial with three Open-pollinated maize varieties (Melkassa-6Q Melkassa-4 and Melkassa-2) and fertilizer rate formulated by four blended fertilizer rates including kg ha^{-1} (none fertilizer, 50 NPSB + 100 Urea, 100 NPSB + 100 Urea and 150 NPSB + 100Urea). Factorial combinations were used as twelve treatments laid out in a randomized complete block design (RCBD) with three replications.

Experimental Procedure and Management

The land was ploughed twice, disked and harrowed once and ridged with 75cm by tractor, after which the furrow was corrected by labor. The two seeds were sown at 25 cm intra-row spacing and 75 cm inter-row spacing. Thinning was done 15 days after emergence to maintain the target plant densities. Blended fertilizer rate was applied at planting and urea fertilizer was applied at stem elongation in a constant rate (i.e. 50 kg ha^{-1}). The gross plot size of the experiment was 5m x5m ($25m^2$). The spacing between replications and plots was 2.0 m. Plots were furrow irrigated every 5-7 days from planting up to flowering and then every 8-10 days up to physiological maturity according to weather condition at Omorate location while at Weyito location, 6-8 days from planting up to flowering and then every 9-11 days up to physiological maturity according to weather condition. Three-time Ethiozinon (Diazinon) 60% E.C was applied at the rate of 1.5 L ha^{-1} into the leaf using a knapsack sprayer to control fall armyworm. The first, second and third weeding and hoeing were performed 20, 45 and 65 days after emergence, respectively. The net harvestable row was 5 (five) excluding the border two rows.

Data Collection

Soil Data

The soil sample was collected in which 1 kg composite soil sample from each location for reprehensive of all experimental plots before planting. Collected soil samples were air-dried at room temperature, grounded using mortar and pistil, and passed through a 2 mm diameter sieve for the analyses of selected physico-chemical soil properties using conventional laboratory methods. The laboratory analysis was carried out in Areka Agricultural Research Center, and the analyzed soil parameters include soil texture, soil pH, Total Nitrogen (TN), Organic carbon, available Phosphorus, available Potassium, available Sulfur and available Boron. Soil texture was determined by the Boycouos hydrometric method (Bouyoucos, 1962; Van Reeuwijk, 1992) after destroying OM using hydrogen peroxide (H_2O_2) and dispersing the soils with sodium hexametaphosphate $(NaPO3)_6$. The pH of the soil was measured potentiometric ally using a digital pH meter in the supernatant suspension of 1:2.5 soil to water ratio. Total N was analyzed using the Kjeldahl digestion, distillation and titration method as described by Black (1965) by oxidizing the OM in concentrated sulfuric acid solution (0.1N H_2SO_4), and whereas organic carbon was determined following the Walkley-Black wet digestion method as described by Ranst *et al.* (1999). Available phosphorus was determined by the Olsen procedure (Olsen *et al*., 1954), and that of sulfate ($SO4^{2-}$) of soil samples was analyzed turbidimetrically by calcium chloride dehydrate using the method described in the soil survey manual (USDA, 1984). Available Potassium was determined after extracting the soil samples by ammonium acetate (1N NH_4OAc) at pH 7.0, and Boron in soil was done by dilute HCl methods.

Plant Data

Growth Parameters

Plant height was measured at the time of physiological maturity from central rows as the mean height of five randomly taken sample plants from the ground level to the apex of each plant. Ear height of five random plants was measured from the base of plants to the node bearing the uppermost useful ear and the average value was recorded in cm. The ear length of five randomly taken ears was measured from ears attached to the stalk to the tip of the ear in cm and the average was used.

Yield Components

The number of ears per plant was determined from five randomly sampled plants and the average value was considered**.** Total above-ground dry biomass yield (kg) was determined by taking the total weight of the harvest including the seeds from five central rows and sun drying the biomass to constant weight and converted to t ha^{-1}. Hundred seed weight (g) was weighed by taking the weight of hundred randomly sampled seeds from the five harvested central rows and adjusted to 12.5% moisture content.

Grain Yield

The five central rows per plot were harvested, sun-dried and threshed. The grain yield in kg from each plot was weighed using an electronic balance. Seed moisture content was measured with a moisture meter (DRAMINSKI SN: 10-860 Olsztyn**)** after which the grain weight was adjusted to 12.5 % moisture level content and converted to t ha^{-1}. The adjusted yield was calculated using Kenneth (1995) formula.

$$\text{Adjusted grain yield (kg)} = \frac{\text{Actual yield (kg)} * (100 - \text{Actual moisture content})}{[100 - \text{standard moisture content of cereal } (12.5\ \%)]}$$

Harvest index (HI) was computed as the ratio of adjusted grain yield to total above-ground dry biomass (Donald,1962).

$$\text{HI} = \frac{\text{Adjusted grain yield ton/ha}}{\text{aboveground dry biomass ton/ha}}$$

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) appropriate to factorial experiment in a randomized complete block design (RCBD) using SAS software program version 9.2 (SAS, 2008) with a generalized linear model (GLM) procedure. Means were separated using the least significant differences (LSD) test at 5 % level of significance.

Cost and return Analysis

The cost of other production practices like, watering and weeding was assumed to remain the same or insignificant among the treatments. Analysis of the marginal rate of return (MRR %) was carried out for non-dominated treatments, and the MRRs were compared to a minimum acceptable rate of return (MARR) of 100% to select the optimum treatment (CIMMYT, 1988). The net benefit per hectare for each treatment is the difference between the gross benefit and the total variable costs. The average yield was adjusted downward by 10% to reflect the difference between the experimental field and the expected yield at farmers' fields and with farmer's practices from the same treatments (CIMMYT, 1988)

RESULT AND DISCUSSION

3.1: Physico-Chemical Properties of the Experimental Soil Before Planting

Laboratory analysis result of selected soil Physico-chemical properties before planting was indicated in table 2 below. The result indicated that soil texture class of the study site in Dasenech was sandy clay loam (sand 44 %, silt 28% and clay 28%), and in the Nyangatom sites, it was found to be clay loam (sand 38%, silt 30% and clay 32%) (Table 1). The pH of the sites was in the moderately to slightly acidic range (6.0-6.6) (Ethio SIS, 2014; Tekalign, 1991). The organic carbon content of the soils was 0.9% and 0.23% for Dasenech and Nyangatom sites, respectively. In addition, the soils of the study sites contained total nitrogen content of 0.08% for Dasenech and 0.02% for Nyangatom; and available Phosphorus contents of 6.15 mg kg^{-1} for Dasenech and 6.68 mg kg^{-1} for Nyangatom, respectively. The result showed that available Potassium, Sulfur and Boron content; for the Dasenech site was 58.90 mg kg^{-1}, 2.14 mg kg^{-1} and 0.16 mg kg^{-1}, respectively and For Nyangatom was 54.43 mg kg^{-1}, 18.19 mg kg^{-1} and 0.26 mg kg^{-1}, respectively. As it can be observed from the table below, soils of the Dasenech sites was dominated by sand fractions or coarse texture until 20 cm depth, and hence they consequently retain few nutrients and have a low water-holding capacity (Berry *et al.*, 2007). Therefore, soil management practices which lead to an increase in the fine fraction, lighter but more frequent irrigation and fertilization are generally helpful in improving soil properties and crop productivity (FOA, 2014). In addition, as per the ratings by Ethio SIS (2014), total nitrogen, available phosphorus and potassium were found to be very low and organic carbon was found to be low in the two study sites. Similarly, available Sulfur and Boron are also in a very low to low range (Ethio SIS, 2015). Therefore, this, in general, tells us that getting crop yields from all these two study locations would no more be easy without significant fertilization of the soil

Table 1. Laboratory Analysis Result of Selected Soil physico-Chemical Properties Before Planting

	Dasenech	Nyangatom
Physical parameters	**Value**	**Value**
soil texture		
Sand (%)	44.00	38.000
Silt (%)	28.00	30.00
Clay (%)	28.00	32.00
Textural class	**sandy clay loam**	**clay loam**
Chemical parameters		
pH	6.03	6.25
Total Nitrogen (%)	0.08	0.020
Available Phosphorus (mg/kg)	6.15	6.68
Available Potassium (mg/kg)	58.90	54.43
Available Sulfur (mg/kg)	2.41	18.19
Available Boron (mg/kg)	0.16	0.26
Organic Carbon (%)	0.90	0.23

Effects of Blended Fertilizer Rate on Growth Parameters of Maize Varieties

Plant Height at Maturity (cm)

In this study at Dasenech and Nyangatom location, plant height was significantly ($P<0.01$) affected by the main effects of varieties and blended fertilizer rate, while was not significantly ($P<0.05$) affected by their interaction of varieties with blended fertilizer rate (Table 2). The tallest plant height of 204.0cm and 245.7cm were measured from BH-540 and MH-140 variety at Dasenech and Nyangatom site, respectively. Whereas, the lowest plant height of 186.8cm and 221.13cm were measured from MH-140 and BH-140 variety at Dasenech and Nyangatom site, respectively. This specifies that morphological variation was observed among maize varieties in different locations. The possible reason for varieties showed different responses for different locations might be due to environmental influences causes of their significant differences. This result was in agreement with finding of Tolera *et al*, 2017 who reported that hybrid maize varieties different responses for a different locations.

With regards to NPSB blended fertilizer rate. The tallest plant height of 218.7cm and 246.3cm were measured from 150 kg NPSB/ha blended fertilizer rate at Dasenech and Nyangatom site, respectively. While, the shortest plant height of 171.1cm and 208.3cm were measured from zero fertilizer application at Dasenech and Nyangatom locations, respectively (Table 2). In general, these results showed that, an increase in plant height with an increased blended fertilizer rate from 0 to 150 kg NPSB/ha blended fertilizer application (Table 2). This increment in plant height might be due to an increase in cell elongation and more vegetative growth attributed to different nutrient content. This result was in line with Landon (2991) who indicated that plant growth and development retarded significantly if any of the nutrient elements is less than its threshold value in the soil or not adequately balanced with other nutrient elements. Similarly, Jeet *et al.* (2012) obtained that, the tallest plant height at the highest fertilizer rate might be fertilizer has a beneficial effect on plant metabolism which affects the physiological process of the crop and thereby increases the growth parameters.

Ear Height (cm)

Analyst of variance showed that ear height was significant variations ($p \leq 0.01$) among the main effect of varieties blended fertilizer rate, whereas their interaction was not significantly influenced at both sites (Table 2). Maximum ear height of 108.08cm and 121.6cm were measured from BH-540 and MH-140 variety at Dasenech and Nyangatom site, respectively. Whereas, the minimum ear height of 82.00cm and 114.5cm were measured from MH-140 and BH-540 variety at Dasenech and Nyangatom site, respectively. As blended fertilizer rates increased from 0 to 150 kg ha^{-1} ear height was increased (Table 2). This study was conforming to the finding by Mekuannet & Kiya (2020) reported that, blended fertilizers increased similarly ear height of maize increased.

Ear Length (cm)

Analyst of variance showed that, ear length was significant variations ($p \leq 0.01$) among the main effect of varieties blended fertilizer rate, whereas their interaction was not significantly influenced at both sites (Table 2). Maximum ear length of 27.33cm and 28. 88cm were measured from BH-540 and MH-140 variety at Dasenech and Nyangatom site, respectively. Whereas, the minimum ear height of

24.00cm and 26.98cm were measured from BH-140 variety at Dasenech and Nyangatom site, respectively. This trait also showed that, blended fertilizer rates increased from 0 to 150 kg ha^{-1} ear length was increased (Table 2). This result was in agreement with the finding by Onasanya (2009) who reported that, the height ear length was obtained from fertilizer treated with compared to zero fertilizer on maize crops.

Table 2. Main effect of mean value for plant height and ear height of hybrid maize research conducted in south Omo zone during 2020 cropping season

Treatments	Dasenech location		Nyangatom location	
	Plant height (cm)	Ear height (cm)	Plant height(cm)	Ear height (cm)
Varieties				
MH-140	186.75b	82.00b	245.65a	121.58a
BH -140	199.33a	104.83a	221.13b	119.72ab
BH-540	204.00a	108.08a	221.70b	114.53b
LSD (0.05)	6.57	3.95	17.36	6.11
Blended Fertilizer Rate (kg/ha)				
0	171.11d	82.17d	208.31b	110.64c
50 NPSB + 100Urea	190.33c	93.17c	229.31a	112.53c
100 NPSB +100Urea	206.67b	104.17b	234.02a	119.60b
150 NPSB +100Urea	218.67a	113.72a	246.33a	131.67a
LSD (0.05)	7.59	4.57	20.04	7.06
CV (%)	3.95	4.75	8.93	6.09

Table 3. Main effect of the mean value for plant height and ear height of hybrid maize research conducted in south Omo zone during 2020 cropping season

Treatments	Dasenech location		Nyangatom location	
	Ear length (cm)	Dry biomass (kg/ ha)	Ear length (cm)	Dry biomass (kg /ha)
Varieties				
MH-140	26.25ab	12883b	28.88a	13897a
BH -140	24.0b	12175c	26.98b	12205c

BH-540	27.33a	13658a	28.12ab	13268b
LSD (0.05)	1.188	414.69	2.52	433.89
Blended Fertilizer Rate (kg/ha)				
0	25.08c	11633d	21.18c	12105c
50NPSB+ 100Urea	26.93bc	12333c	25.38b	13383b
100 NPSB+100Urea	28.98ab	13400b	25.49b	12422c
150 NPSB+100Urea	30.78a	14256a	31.39a	14583a
LSD(0.05)	2.53	478.84	2.92	501.01
CV (%)	9.25	3.8	11.52	3.91

3.3. Yield and Yield Components

3.3.1: Above Ground Dry Biomass Yield (kg ha^{-1})

The main effects of varieties and blended fertilizer rate showed a highly significant (P<0.01) effect on above-ground dry biomass, while their interaction effect was not significantly influenced on above-ground dry biomass (Table 3). The highest above-ground biomass (13658 kg/ha) and (13897 kg/ha) were recorded from BH-540 and MH-140 variety at Dasenech and Nyangatom location, respectively. Whereas, the lowest above-ground biomass (12175 kg/ha) and (13897 kg/ha) were recorded from BH -540 and MH-140 variety at Dasenech and Nyangatom location, respectively. Above ground (11733 kg/ha) and (12205 kg/ha) was recorded from BH-140 variety at Dasenech and Nyangatom location, respectively (Table 3). This result showed that the responses of above-ground biomass yield to locations is quite different among and within varieties. This result was in agreement with Ahmed *et al*. (2003) who report that above-ground biomass was affected by the main effect of varieties and locations.

The highest above-ground biomass (14256 kg/ha) and (14583 kg/ha) were recorded from 150 kg/ha of NPSB fertilizer rate at Dasenech and Nyangatom location, respectively. Whereas, the lowest above-ground biomass (11633 kg/ha) and (12105 kg/ha) were recorded from zero NPSB fertilizer rate at Dasenech and Nyangatom location, respectively. Above ground (11733 kg/ha) and (12205 kg/ha) was recorded from BH-140 variety at Dasenech and Nyangatom locations, respectively (Table 3). This result is in accordance with Mekuannet and Kiya (2020) who reported that, the significant disparity was observed in biomass yield of maize due to blended fertilizer rate and the highest blended fertilizer rate level was given higher above-ground biomass yield, whereas the lowest biomass yield was found where treated with the lowest NPSB level.

3.3.2: Grain Yield (kg ha^{-1})

The main effects of varieties and blended fertilizer rate as well as their interaction showed a highly significant ($P< 0.01$) effect on grain yield (Table 3). This result showed that the responses of grain yield to blended fertilizer rate are quite different among and within varieties. Tolera *et al.* (2017) reported that, there is a genetic variability for maize grain yield to fertilizer level and obtained the genotype with fertilizer level interaction was significant. The highest grain yield (3624 kg/ha) and (4324 kg/ha) were recorded from BH-540 and MH-14 variety with 100 kg NPSB/ha at Dasenech and Nyangatom location, respectively and the lowest grain yield (1900 kg/ha) and (2002 kg/ha) were recorded from BH-140 variety with 0 kg NPSB/ha at Dasenech and Nyangatom location, respectively (Table 3). All tested varieties produced significantly higher mean grain yield as compared to maize varieties planted without blended fertilizer application rate. The higher mean grain yield advantage which was ranged from 22.4 to 90.7% was achieved with 100 kg/ha blended fertilizer application as compared to maize varieties planted without fertilizer application in Dasenech location, while in Nyangatom location mean grain yield advantage of 10.7 to 115.9% were achieved from hybrid maize varieties planted with blended fertilizer application as compared to zero (Table 4). This result was in agreement with Tolera *et al.* (2017) who obtained that, mean grain yield advantage of 24 to 66% was achieved from hybrid maize varieties planted with blended fertilizer application as compared to control. Mekuannet and Kiya (2020) reported that, grain yields were increased from in maize varieties at fertilizer application levels compared to without fertilizer application. Similarly, Singh and Daoudi (2017) reported that the grain yield of maize varieties was increased as fertilizer increased until a certain level. Dagne (2016) also verified that application of blended fertilizer on maize crops as brought significantly the highest grain yield as compared to control, standard control of NP and recommended NP + Cu +Zn. Additionally, Jafer (2018) found better grain yield from the application of blended fertilizer compare to recommended NP fertilizer and unfertilized plot.

3.3.2: Hundred Seed Weight (g)

The main effects of varieties and blended fertilizer rate as well as their interaction showed a highly significant (P< 0.01) effect on grain yield (Table 3). The maximum hundred seed weight (36.17g) and (39.83g) were recorded from BH-540 and MH-14 variety with 100 kg NPSB /ha at Dasenech and Nyangatom location, respectively and the minimum hundred seed weight (26.50g) and (29.17g) were recorded from BH-140 variety with 0kg NPSB /ha at Dasenech and Nyangatom location, respectively (Table 3). This finding was slightly similar with Onasanya et al. (2009) who found that the lowest thousand seed was obtained from zero blended fertilizer application with compared to fertilizer application.

Table 4. Mean values for the effect of the interaction of blended fertilizer rate on the grain yield of hybrid maize varieties at Dasenech and Nyangatom, South Omo Zone during 2019/ 20 cropping season

Varieties	Blended fertilizer arte (kg/ha)	Dasenech location		Nyangatom location	
		Grain yield (kg/ha)	Hundred seed weight (g)	Grain yield (kg/ha)	Hundred seed weight (g)
BH-140	0	1900.0g	26.50j	2002.3f	29.17f
	50NPSB+ 100Urea	2325.3de	28.50i	2215.7de	31.97def
	100 NPSB+100Urea	2314.7de	30.50g	2157.3ef	33.66cde
	150 NPSB+100Urea	2242.7defg	34.00def	2086.7ef	38.00ab
	0	2450.7cd	33.50ef	2008.0f	35.17bcd
BH-540	50NPSB+ 100Urea	2293.3def	29.83h	2392.0def	33.67cde
	100 NPSB+100Urea	3624.0a	36.17a	3000.0c	31.50ef
	150 NPSB+100Urea	2726.7bc	35.67ab	2309.3def	31.00ef
MH-140	0	1938.0fg	34.50cd	2417.3def	36.83abc
	50NPSB+ 100Urea	2224.0defg	33.33f	3480.0b	32.83de
	100 NPSB+100Urea	3080.0b	35.17bc	4324.0a	39.83a
	150 NPSB+100Urea	2020.0efg	34.18de	3020.0c	33.17de
	LSD (0.05)	362.91	26.50j	465.25	3.48
	CV (%)	8.87	1.21	10.54	6.07

3. 3.5. Harvest Index

Harvest index is a measure of the physiological productivity potential of a variety. A crop can convert the dry matter into economic yield. The main effects on harvest index were significant for both varieties and plant densities (P < 0.01) while, the interaction effect was not significant (Table 3). The maximum harvest index of 0.232 and 0.239 were recorded from BH-540 and MH-140 variety at Dasenech and Nyangatom location, respectively. The minimum harvest index (0.164) and (0.175) were recorded from BH-540 variety at Dasenech and Nyangatom locations, respectively. With regards to NPSB blended fertilizer rate, the maximum harvest index (0.208) and (0.232) were recorded from 50 NPSB kg/ha and 100 NPSB kg/ha at Dasenech and Nyangatom location, respectively and the minimum harvest index (0.165) and (0.117) were recorded from 150 NPSB kg/ha fertilizer rate at Dasenech and Nyangatom location, respectively. Similarly, Ahmad *et al.* (2003) indicated that there was a significant variation on harvest index due to varieties. Orkaido (2004) also found that different rates of inorganic fertilizer rates had a significant effect on the maize harvest index.

Table 5. Main effect of the mean value for harvest index of hybrid maize research conducted in south Omo zone during 2020 cropping season

	Dasenech Location	**Nyangatom Location**
Treatments Varieties	**Harvest index**	**Harvest index**
BH-140	0.164b	0.175b
BH-540	0.232a	0.178b
MH-140	0.175b	0.239a
LSD (0.05)	0.016	0.019
Blended Fertilizer Rate (kg/ha)		
0	0.183b	0.177b
50 NPSB+ 100 Urea	0.208a	0.214a
100 NPSB+100 Urea	0.206a	0.232a
150 NPSB+100 Urea	0.165c	0.167b
LSD (0.05)	0.018	0.022
CV (%)		

Cost and Return Analysis

The most important step in performing partial budget analysis is the proper identification of data on the costs and benefits associated with the alternative technologies. It is known that farmers apply fertilizer so as to get a profit. Achieving the goal of yield increment depends not only on the kind and amount of fertilizer but also on the cost of the fertilizer, seed and price of the yields (Black, 1992). All variable costs were calculated based on the current price of grain yield, Labor to apply fertilizer and blended fertilizers and urea as per the information obtained from local markets. The cost of Labors was 50 Birr/day, while NPSB and Urea were 17, 16 and 15 Birr kg^{-1}, respectively. The selling price of maize at the local market around the South Omo Zone area was taken as Birr 15 kg^{-1} for grain yield. The highest net benefit (45324 Eth-birr) and MRR value of (2123.5%) were obtained from BH-540 variety with treated with 100 kg ha-^{1} of NPSB blended fertilizer rate for Dasenech location (Table 6). Whereas at Nyangatom location, the highest net benefit (54774 Eth-birr) and MRR value of (2968.5%) were obtained from MH-140 variety with treated with 100 kg ha-^{1} of blended fertilizer rate (Table 9). The result shows the highest MRR has highest net benefit per ha.

Table 6. Summary of partial budget analysis of the effects of blended fertilizer rates on maize varieties at Dasenech location

Varieties	Blended fertilizer rate (kg/ha)	**Av. Yield kg/ha**	**10% Adj. yield**	**Gross Field Benefits (ETB/ha)**	**Total variable cost (ETB/ha)**	**Net Benefit (ETB/ha)**	**Dominance analysis**	**MRR%**
BH-140	0	1900	1710	25650	0	25650	D	
	50NPSB+ 100Urea	2325.3	2092.77	31391.55	2750	28641.55	D	
	100 NPSB+100Urea	2314.7	2083.23	31248.45	3600	27648.45	D	
	150 NPSB+100Urea	2242.7	2018.43	30276.45	4,450	25826.45	D	

	0	2450.7	2205.63	33084.45	0	33084.45		
BH-540	50NPSB+ 100Urea	3080	2772	41580	2750	38830		479.3
	100 NPSB+100Urea	3624	3261.6	48924	3600	45324		2123.5
	150 NPSB+100Urea	2726.7	2454.03	36810.45	4,450	32360.45	D	
MH-140	0	1938	1744.2	26163	0	26163	D	
	50NPSB+ 100Urea	2224	2001.6	30024	2750	27274	D	
	100 NPSB+100Urea	2293.3	2063.97	30959.55	3600	27359.55	D	
	150 NPSB+100Urea	2020	1818	27270	4,450	22820	D	

Where: Av.Yield =Average yield, 10% Adj. yield = Adjusted yield, TVC=Total Variable Cost and MRR% = Marginal rate of return, MRR = change in net income / change in cost x 100 Costs and returns (income) are described in Birr ha

Table 7. Summary of partial budget analysis of the effects of blended fertilizer rates on maize varieties at Nyangatom location

Varieties	Blended fertilizer rate (kg/ha)	Av. Yield kg/ha	10% Adj. yield	Gross Field Benefits (ETB/ha)	Total variable cost (ETB/ha)	Net Benefit (ETB/ha)	Dominance analysis	MRR%
BH-140	0	2002.3	1802.07	27031.05	0	27031.05	D	
	50NPSB+ 100Urea	22157.3	19941.57	299123.6	2750	296373.6	D	
	100 NPSB+100Urea	2157.3	1941.57	29123.55	3600	25523.55	D	
	150 NPSB+100Urea	2086.7	1878.03	28170.45	4,450	23720.45	D	
	0	2008	1807.2	27108	0	27108	D	
BH-540	50NPSB+ 100Urea	2392	2152.8	32292	2750	29542	D	
	100 NPSB+100Urea	3000	2700	40500	3600	36900	D	
	150 NPSB+100Urea	2309.3	2078.37	31175.55	4,450	26725.55	D	

MH-140	0	2417.3	2175.57	32633.55	0	32633.55	
	50NPSB+ 100Urea	3480	3132	46980	2750	44230	625.4
	100 NPSB+100Urea	4324	3891.6	58374	3600	54774	2968.5
	150 NPSB+100Urea	3020	2718	40770	4,450	36320	1270.2

Where: Av. Yield=Average yield, 10% Adj. yield= Adjusted yield, TVC=Total Variable Cost and MRR% =marginal rate of return, MRR = change in net income/change in cost x 100 Costs and returns (income) are described in Birr ha

CONCLUSION AND RECOMMENDATION

The current study was undertaken to investigate the effects of NPSB blended fertilizer rate for maize yield production at Dasenech and Nyangatom districts in the lowland area of South Omo Zone during the 2019/ 2020 cropping season. The experiment was factorial with three maize varieties (BH-140, BH-540 and MH-140) and four NPSB blended fertilizer rate including kg ha^{-1} (none fertilizer, 50 NPSB, 100 NPSB, and 150 NPSB). Factorial combinations were used as twelve treatments laid out in a randomized complete block design (RCBD) with three replications. Phenological and growth parameters, as well as yield and yield components data, were collected and subjected to analysis of variance using the SAS software program.

The result of analysis of variance revealed that the interaction effect of varieties and blended fertilizer rate highly significant difference in grain yield. The result showed that, the highest net benefit (45324 Eth-birr) and MRR value of (2123.5%) were obtained from BH-540 variety with treated with 100 kg ha^{-1} of NPSB blended fertilizer rate for Dasenech location. Whereas at Nyangatom location, the highest net benefit (54774 Eth-birr) and MRR value of (2968.5%) were obtained from MH-140 variety with treated with 100 kg ha^{-1} of blended fertilizer rate. Therefore, based on the yield response and, cost and return analysis indicate that BH-540 variety and MH-140 variety treated with 100 kg ha^{-1} of NPSB blended fertilizer can be recommended to Dasenech and Nyangatom location, respectively and other similar agro-ecologies

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely

no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

References

Ahmad, A., Usman, M., Ullah, E., & Warraich, E. A. (2003). Effects of different phosphorus levels on the growth and yield of two cultivars of maize (Zea mays L.). International Journal of Agriculture & Biology, 5(4), 632-634. http://www.ijab.org.

Akalu T. (2015) On-farm Evaluation of Improved Maize Varieties in Ethiopia https://www.researchgate .net/publication/237309549.

Black, C.A, (1965)Methods of soil analysis. Part I, American Society of Agronomy. Madison, Wisconsin, USA. 1572p.

Bouyoucos J (1962). Hydrometer method improved for making particle size analysis of soil. Agronomy Journals 54:464-465.

Chimdessa, D. (2016). Blended fertilizers effects on maize yield and yield components of Western Oromia, Ethiopia. Agriculture, Forestry and Fisheries, 5(5), 151–162. https://doi.org/10.11648/j.aff.20160505.13.

CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo/International Maize and Wheat Improvement Center). (1988). from agronomic data to farmer's recommendations: an economics training manual. Completely revised edition, CIMMYT, Mexico. D.F. 79 pp.

CSA (Central Statistical Agency). (2017). Report on area and production of crops (private peasant holdings '*Meher'* season) 2016/2017. Addis Ababa Ethiopia, the FDRE statistical bulletin, Vol. I. Statistical Bulletin 584, Addis Ababa Ethiopia, April, 2017.Pp.1-12.

Dagne C (2016). Blended fertilizers effects on maize yield and yield components of Western Oromia, Ethiopia. Agriculture, Forestry and Fisheries 5(5):151-162. doi:10.11648/jaff.20160505.13

Donald C. M., (1962). In search of yield. Journal of Australian Institute of Agricultural Science, 28: 171-178. Egbe O., Alibo S. and Nwueze I. 2010.Evaluation of some extra-early and early maturing cowpea varieties for intercropping with maize in Southern Guinea Savanna of Nigeria. Agriculture and Biology Journal, 1:845-458.

Dowswell, C. R, R. L Paliwal and R. P. Cantrell. (1996). *Maize in 3rd World*. West Views press, Inc. Colorado, USA.

Ethio SIS (2014). Soil fertility status and fertilizer recommendation atlas for Tigray regional state, Ethiopia. July 2014, Addis Ababa, Ethiopia.EthioSIS.2015.http://www.ata.gov.et/highlighted-deliverables/ethiopian-soil-information-system-ethiosis/. Date accessed: 19 July 2019.

FAO (Food and Agricultural Organization). (2014). The world reference base for soil resources. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome.

FAOSTAT (Food and Agriculture Organization Corporate Statistical Database).(2017). Statistical databases and data-sets of the Food and Agriculture Organization of the United Nations.
http://faostat.fao.org/default.aspx.

Haffanaghel, H. P. (1961). *Agriculture in Ethiopia*. FAO, Rome.

Jafer D (2018). Validation of blended fertilizer for maize production under limed condition of acid soil. Journal of Natural Sciences Research 8 (23):52-58.

Kenneth Hellevang.(1995). Grain Moisture Content Effects and Management. North Dakota State Extension Publication AE-905. http://www.ag.ndsu.edu/extension-aben/documents/ae905.pdf. [accessed March 2021].

Mekuannet Belay and Kiya Adare (2020). Response of growth, yield components, and yield of hybrid maize (Zea mays L.) varieties to newly introduce blended NPS and N fertilizer rates at Haramaya, Eastern Ethiopia. Cogent Food &Agriculture .6:1771115. https://doi.org/10.1080/23311932.2020.1771115

MOANR (Ministry of Agriculture and Natural Resources). (2017). Plant variety release, protection and seed quality control directorate. Addis Abeba, Ethiopia**.**

Onasanya, R. O., Aiyelari, O. P., Onasanya, A. S., Oikeh, F. E., & Oyelakin, O. O. (2009). Growth and yield response of maize (Zea mays L.) to different rates of nitrogen and phosphorus fertilizers in Southern Nigeria. IDOSI Publications, 5(4), 400–407.

Orkaido Olte (2004) Effects of Nitrogen and Phosphorus Fertilizers on Yield And Yield Components of Maize (*Zea Mays L*.) on Black Soil of Regede Konso Alemaya University at Konso special wereda, southern Ethiopia. M.Sc. Thesis Presented to Haramaya University, Ethiopia.

Ranst, V.E., M. Verloo, A. Demeyer and J.M. Pauwels, (1999). Manual for the Soil Chemistry and Fertility Laboratory. Belgium. 245p.

Singh, R., & Daoudi, M. (2017). Effect of nitrogen and Sulphur on growth and yield of hybrid maize (Zea mays L.). International Journal of Current Microbiology and Applied Sciences, 6(6), 1930–1935. https://doi.org/10.20546/ijcmas.2017.606.225

Tekalign M (1991). Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa.

Tolera A, Tolessa D and Dagne W. (2017). Effects of Varieties and Nitrogen Fertilizer on Yield and Yield Components of Maize on Farmers Field in Mid Altitude Areas of Western Ethiopia. International Journal of Agronomy. https://doi.org/10.1155/2017/4253917

USDA (United States Department of Agriculture), (1984). Procedures for Collecting Soil Samples and Methods of Analysis for Soil Survey. Soil Survey. Invest. Rep. 1. (Rev.) U.S. Gov. Print Office, Washington, DC.

Van Reeuwijk, L.P., .(1992). Procedures for soil analysis, 3rd Ed. International Soil Reference and Information Center (ISRIC), Wageningen, the Netherlands. 34p.

W. R. Raun, I. Ortiz-Monasterio, and J. B. Solie, (2009) “Temporally and spatially dependent nitrogen management for diverse Environments, *Wheat Science and Trade*, pp. 203–214.